GROW: the way to eco-driving

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Abstract
Autonomous driving offers great advantages in terms of energy-efficient driving. However, people can still make choices, contributing to the drainage of their electrical car's battery. These choices may relate to route choice, climate control, and general electricity usage.

This report outlines the design process that led to the design of GROW, a product that supports people in making sustainable choices related to the aforementioned aspects. I designed GROW in collaboration with a client from The BMW Group. It is a plant game that rewards sustainable choices by acting as both a game and a decorative feature.

During GROW's design process, I applied an iterative design cycle, called design thinking. It included the phases empathize, define, ideate, prototype, test, and implement. In total, I created two prototypes, demonstrating GROW's general aim. Important validation methods I applied include a focus group session and in-depth interviews.

Author Keywords
Sustainability; eco-driving; adaptive mobility; game design.

Prologue

In this report, I, as a student of the Industrial Design department of the Technical University of Eindhoven, will guide you through my project which involves the design of GROW. During the execution of this project, I was part of the Adaptive Mobility squad. This squad aims to "tackle major mobility challenges through applying novel technologies, such as sensing, big, data, internet of things and ubiquitous computing [24]." Aside from keeping this vision in mind, I designed GROW for the car company BMW.

Initially, I chose the Adaptive Mobility squad because my former vision focused on wellbeing through personalized environments. Before I actually started my project, I, however, revised this vision. My current vision is focused on sustainability and unconscious behavior change [Appendix 1]. I believe this vision also fits my current squad and project direction. Naturally, not everyone may relate sustainability to mobility. I do however believe that particularly the car industry is challenged to make radical changes towards becoming more sustainable. Contributing to this change is of great value to me.

I hope you enjoy your reading

Doortje Marković

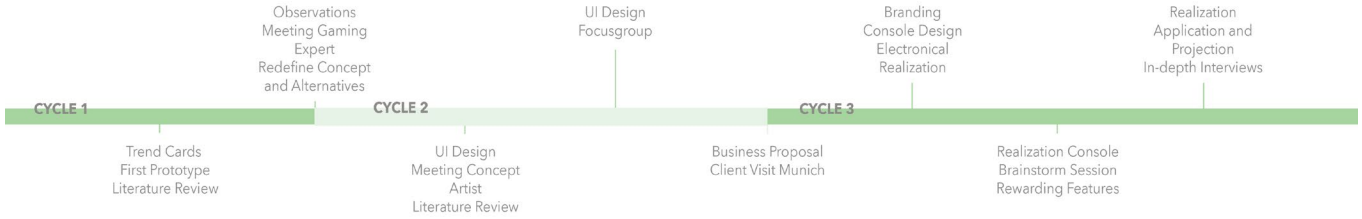

Figure 1: Timeline of GROW's design process, divided into three cycles.

Introduction

Autonomous driving offers great advantages in terms of energy-efficient driving. However, people can still make choices, contributing to the drainage of their electrical car's battery.

In 2015, Mcllroy and Stanton [41] found that acceleration was one of the factors impacting fuel-efficient driving. Another study by Tesla demonstrated that battery efficiency drops when their car's constant speed increases [43]. Choosing different routes may lead to differences in acceleration, speed, and driving distance and therefore route choice impacts a car's total electricity usage.

Other activities that can lead to extra energy consumption may be using climate control and charging or using devices such as a laptop. In 2018, Fröhlich et al. found that activities in an autonomous car can include relaxing, reading, exercising or working [28], which can result in increased use of devices.

I designed the product GROW to support people in making sustainable choices related to the mentioned aspects of climate control, route choice, and general electricity usage.

Many existing products that support eco-driving mainly display numeric data about fuel savings and driving behavior itself [Appendix 5A].

I believe these numbers may not always sufficiently motivate people to change their behavior. Therefore, GROW rewards sustainable choices by acting as both a game and a decorative feature. The decorative aspect entails having digital plants in one's car. This connects to the idea of future car interiors becoming more like personalized living rooms [67]. Finally, the gaming aspect concerns taking care of your digital plants, impacting their aesthetic appeal.

In the following chapters, I will outline the design process leading to GROW's current design. I designed this product in collaboration with my client from The BMW Group. During this process, I used an iterative design cycle, referred to as "design thinking" [44]. This cycle consists of the following phases: empathize, define, ideate, prototype, test, and implement, and took place three times (see Figure 1).

Figure 2: Using trend cards for coming up with new ideas.

Figure 3: Applying the C-Box method.

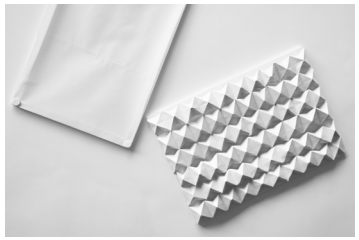

Figure 4: Origami prototype of car exterior. One could draw lines by following the folds with one's hand.

1. Pressure-cooker

At the start of my project, I conducted a pressure-cooker. I did this to quickly run through all design phases and to get an initial overview of the field of car-entertainment. Moreover, it proved to be an effective tool for receiving early client feedback.

Idea Generation

For coming up with initial ideas, I was inspired by trend cards (see Figure 2), existing literature, and several websites. With the trend card method, one combines different cards to each other, after which one comes up with new product ideas. All trends from the trend card method were provided by a coach from the department of Industrial Design.

An example of a trend found by Perterer et al. was that in the future, drivers could have increased communication with other road users [53]. Furthermore, vehicles could become more like future market places [61]. Another trend would be applying mixed-reality to show location-specific information while driving [32].

Based on these trends, I created several ideas fitting the categories of location-based gaming, social gaming, shape change, and sustainability. I based the category of shape change on a different trend. Namely, that modular car design could play a prominent role in the future of mobility [10]. I, however, created the category of sustainability because it fitted my vision as a designer.

Eventually, I chose the (to me) most promising ideas by using the C-Box method (see Figure 3) [6]. This method focuses on rating ideas based on innovativeness and feasibility. Executing this method means having two axes for both qualities. For innovativeness, the axis ranges from not innovative to very innovative. For feasibility, from easy to difficult. The ideas are then mapped to these axes, after which the ideas with optimal qualities are picked. As a result, I chose the following three ideas:

1. Being able to customize a car's exterior by creating art on the go
2. Creating an environment suiting a game, movie or audiobook that is being played
3. Ordering food from your car

The pleasure of creating art

I decided to continue working on the first idea, for it could have both a gaming aspect and the relaxing aspect described by Frölich et al. [28]. The final concept was inspired by the pleasure of creating art, a form of entertainment (see Figure 4) [Appendix 2B]. It was also related to the trend of identity and self-expression, found by using the trend-card method.

Apart from fitting this trend, I thought the concept would fit the target group of gen-Zers as influencers [61]. gen-Zers refer to the generation that comes after the Millennials. They could be interested in sharing their art via social media. After coming up with the described concept, I created a business canvas [Appendix 2C] to assess whether it would be valuable to both users and my client BMW. From this, I still found it questionable whether people would spend their money on it.

Validation
After the execution of the pressure-cooker, I evaluated it with my client. During this evaluation, we, first of all, discussed the concept's main requirements. From my client's perspective, the concept should be interactive, but should also have a gaming aspect. Moreover, the concept should suit at least level 3 of automation. This means that the concept should also fit the scenario in which people could drive for themselves. Finally, it should fit the regular BMW brand.

From my point of view, I wanted to create a product suiting my vision about sustainability. To me, it was also important that the product would fit my visual identity, meaning I wanted to create a product in which one could recognize geometric shapes. As a final requirement, I intended to create both a physical and a virtual prototype. I preferred this combination, as this allowed me to show my knowledge of both electronics, technical realization and programming.

After the discussion of the main requirements, we both agreed that I would proceed with the concept of location-based gaming. To illustrate, one idea from this category was about having location-based learning of foreign languages. When one would visit a certain location, one could learn a certain language spoken in the area. I could also think of combining location-based gaming with the earlier idea of creating art [Appendix 2D].

2. Ideate and emphasize

Creating Personas
In hindsight, the pressure-cooker helped to get a better overview of the client's wishes and perspective. After the pressure-cooker, I chose to go back to the first phase of the design thinking process. During this phase, I first composed numerous personas. I expected they would be supportive in communicating my future concept's intended target group.

Ultimately, I designed the personas called Jack, Amy and Lucas [Appendix 3A]. What they have in common is that they care about luxury, that they are environmentally aware and that they work fulltime. After presenting them to both my coach and client, I found that the personas themselves clearly communicated their commonalities and that this target group was realistic.

Based on the different personas, I created several storyboards to find interesting scenarios I could possibly design for (see Figure 5)[Appendix 3B]. With these storyboards, I could communicate how I came to future concepts and what value they could have in the described context. Creating storyboards provided me with some (fictional) insights about what people would be engaged in when driving autonomously. From Lucas's storyboard, for example, I found that his family could be engaged in getting food on the go. They could also have conflicts about what music to play.

Figure 5: Storyboards based on the personas of Jack, Amy, and Lucas.

Observational study
For acquiring a more realistic perspective, I conducted a small observational study [see Appendix 3C]. There are also papers referring to autonomous driving-related activities. Yet, I also wanted to conduct a short study myself to look for unexpected behavior that could inspire later concept development.

The observation's specific goal was to look at what kind of entertainment people were involved in when taking the bus or train. I, therefore, observed whether there were any unexpected activities by acting as a "fly on the wall". During the actual observations, I did however not notice any unexpected events. Nevertheless, I got reminded of some aspects that could be helpful for defining my concept directions. For instance, I found that many people preferred to use their phones for entertainment. I then considered taking the phone as a starting point for creating new concepts as people were already familiar with its use [see Appendix 3D].

Different concepts for location-based gaming
As mentioned before, I decided to focus on the concept of location-based gaming. Based on my personas and observational study, I came up with three, more concrete concepts, each combining the aspect of location-based gaming with another, distinctive aspect [see Appendix 3E]. These aspects included Pictionary, sustainability, and weather

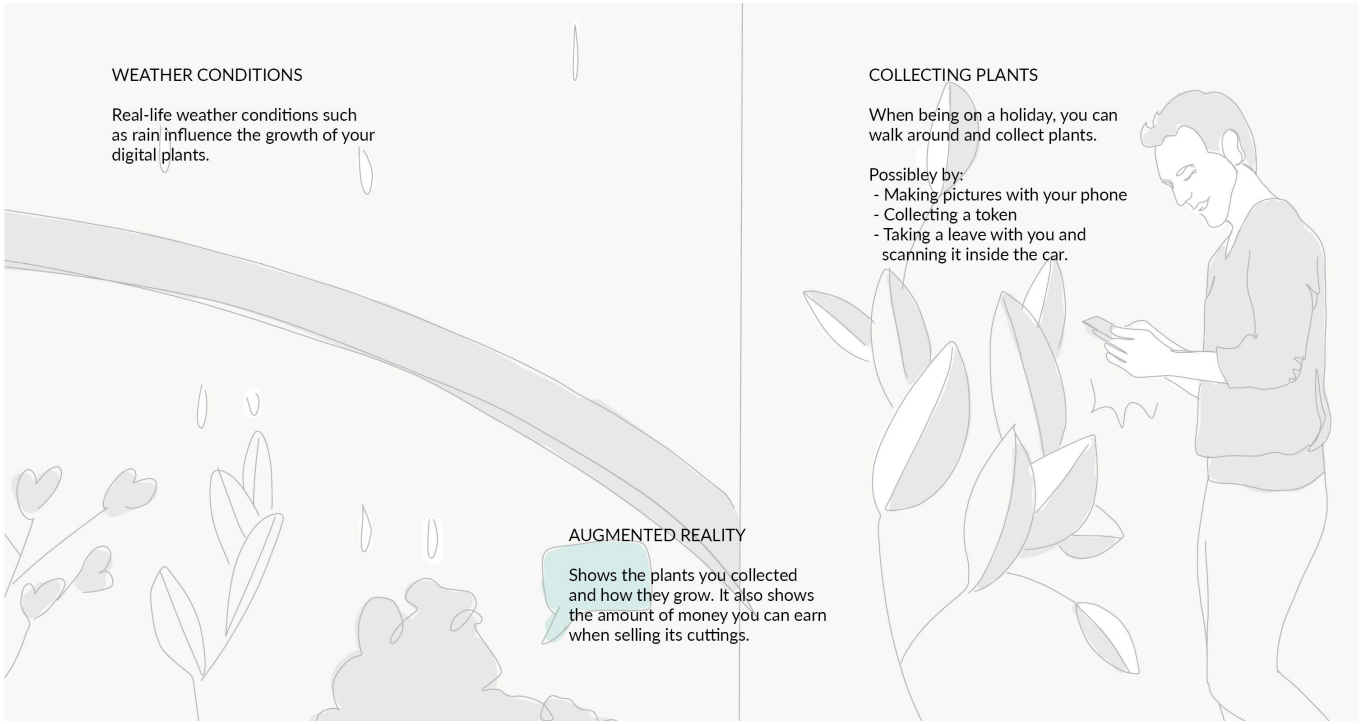

Figure 6: Plant game concept, combining weather conditions and location-based gaming.

conditions and were based on the client feedback I received earlier [see Appendix 2D]. Moreover, I thought of scenarios illustrating the value of these concepts. Each scenario was again based on the earlier created storyboards.

Plant game

Initially, my client was interested in all three concepts. Yet, the final two concepts were found more innovative as they also connected to sustainability [Appendix 3F]. The second concept about combining sustainability and location-based gaming, entailed a car suggesting dining places part of an organization involved in sustainable practices. The third concept was about taking care of digital plants projected onto a car's window. These plants could be collected via a phone's GPS and their growth would be influenced by weather conditions outside of the car.

Eventually, I decided to work on the final plant concept (see Figure 6). The second concept mainly focused on calculations and digital elements, whereas the third concept also had a gaming aspect. Moreover, I was interested in designing a product that could offer interactions other than the basic screen interaction. Finally, the final concept could be more fun to users as it was not merely about sustainability but also about decoration and memories.

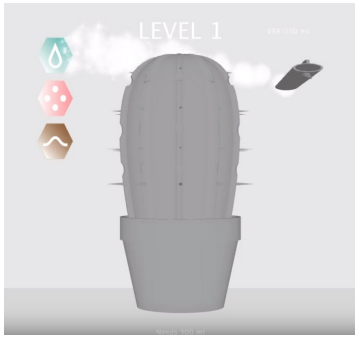

Figure 7: Plant interface.

3. Prototyping and validating

After choosing to proceed with the concept of a location-based plant game, I consulted both my coach [Appendix 4A, 4B] and a gaming expert. His expertise was with the intersection of games, user research, data analytics, and information visualization. After receiving feedback, I believed that the concept of just having a plant game did not fully relate to my vision about sustainability. Hence, I thought of combining the plant concept with the earlier concept related to sustainability and autonomous driving [Appendix 3E].

Sustainable behavior and autonomous driving

I decided to place emphasis on rewarding eco-driving via tools one could earn in the plant-collection game. In particular, I aimed to support drivers in diminishing unsustainable behavior, exposed while driving autonomously. Because of autonomous driving, I thought of rewarding behavior related to activities that did not comprise driving styles.

In total, I found three significant behavioral aspects, non-related to driving styles. They included power usage, car sharing, and route picking. As mentioned before, I thought of rewarding sustainable behavior via tools one could earn in the plant-collection game. I came up with the following ways for rewarding sustainable choices:

1. Power usage: By making less use of the heating or air conditioning, one can earn points in the plant game.
2. Car sharing: One can use a smartphone app that allows multiple people to connect to the plant game. The more people connect to the game, the more one can earn.
3. Route picking: Choosing a route that is marked as more sustainable will generate extra points.

To create a more structured and motivating rewarding system, I thought of having smaller goals connected to the choices related to the three behavioral aspects. For each newly reached goal, users could gain points with which they could buy plant food. The initial plant food I thought of included water, nutrition, and extra soil.

A focus group session

After coming up with a more elaborate concept, I decided to run a focus group [Appendix 4C]. My main reason was to gather user input to validate my concept early on in the process. At the time, my concept was also somewhat rough. Thinking about the session's aim forced me to think about what prototype I could present to both participants and my client.

AIM

The focus group session was divided into two parts: an exploratory part and a confirmatory part. The first part's aim was to motivate participants to come up with their own ideas related to digital gardens. These ideas could then inspire later concept development. The aim of the second part, however, was to validate the plant game's three vital aspects. Originally, these comprised plant hunting, gaming and relating sustainable behavior to (electrical) power needs. I decided not to include the aspect of route picking, as my client recommended to focus on one of the three aspects non-related to driving styles.

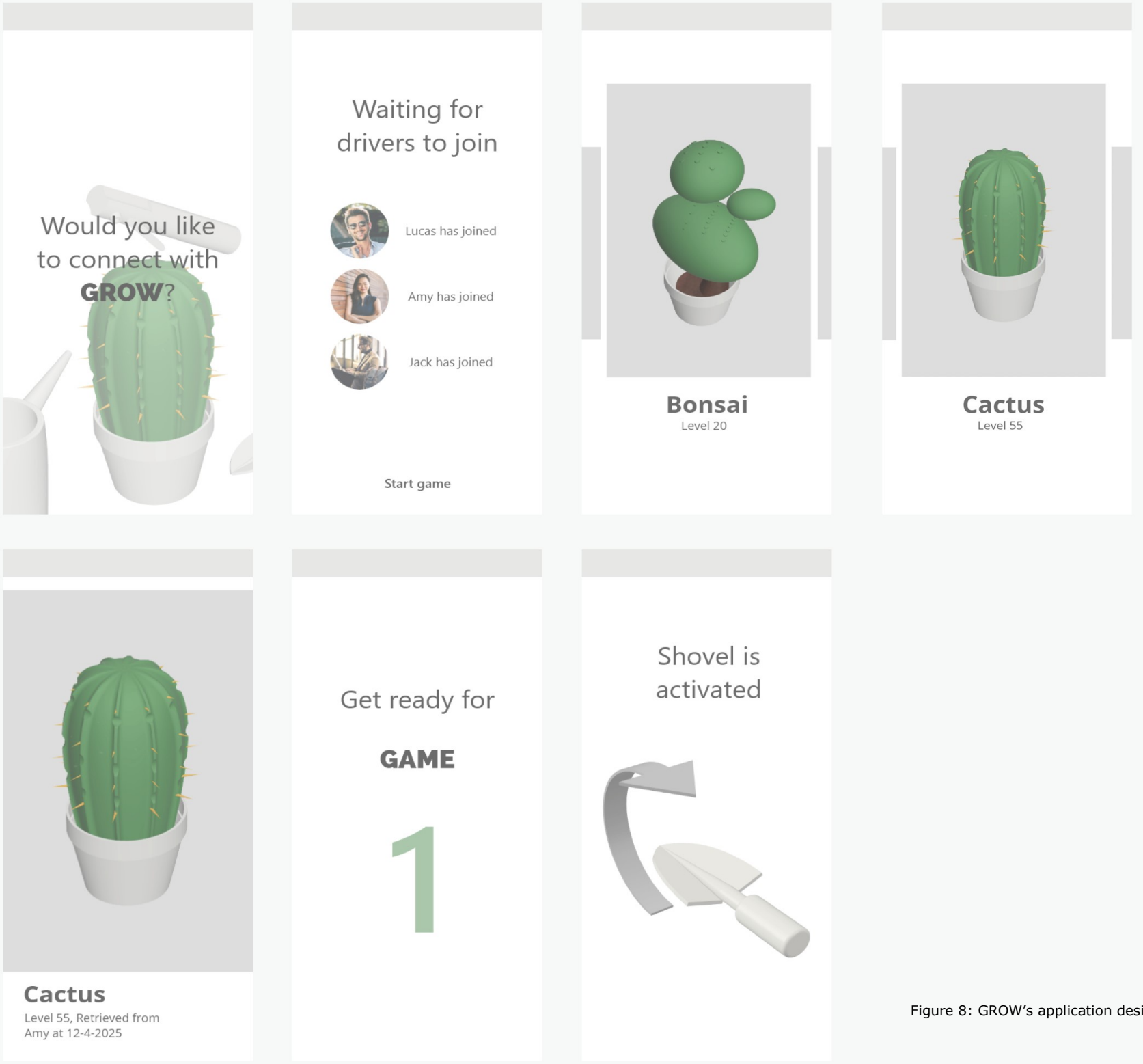

Figure 8: GROW's application design.

Figure 9: Two of the drawings participants made to illustrate their ideal digital garden.

made an initial setup for the focus-group session, I discussed this and the plant game concept with my coach and client. Afterward, I created a clear and consistent description of my intended concept, which I called GROW, by focusing on these five questions: why, how, where, who and when to play GROW [Appendix 4D]. I then adjusted the aim of the focus group's confirmatory part by focusing on validating the assumed answers to the aforementioned questions [Appendix 4C].

PROTOTYPE

One of the reasons for creating a description of GROW, was because I wanted to clearly communicate my intended concept during the focus-group session. I also created an experimental prototype to validate the game's interaction styles and to support my communication. This experiential prototype consisted of a heads-up display, visualizing the intended game (see Figure 7) [Appendix 4E]. One could interact with the game by moving a smartphone into different directions (see Figure 8). Although this interaction was not exactly the same as the intended interaction, it did communicate the use of a smartphone as an interaction tool.

Before I created the heads-up display, I thought of (future) ways of realizing GROW. Consequently, I consulted a concept artist [Appendix 4F]. He helped me think about a visual style and to assess the feasibility of using 3D-models, or more specifically, loading models in Unity. After this assessment, he recommended me to either make a 2D game or a low-poly game, as this would best fit the game's purpose and my previous experience. I already applied this visual style while designing the plants that could be nurtured via GROW's prototype (see Figure 8).

METHODS

Participants

Eventually, I ran a focus group with seven participants. This number was lower than the usual eight participants that are present in a typical group [11, p. 7]. However, one goal of my focus group was to acquire in-depth feedback on the concept of GROW and having a smaller group could lead to more in-depth feedback from each participant.

All participants were between 40 and 60 years old. As discussed with my coach during a meeting in the fourth project week [Appendix 4A] my ideal persona would be 53 years old. However, it was quite hard to find people with this exact age and I, therefore, decided upon taking a bigger sample.

Procedure

During the actual session [4C.1], participants were first introduced to the topic of automated vehicles. Afterward, they engaged in a brain drawing session, during which they drew their ideal digital garden. Subsequently, I presented the prototype I made to then discuss the "why, how and who" questions. Finally, I arranged a small feedback session during which all participants could come up with concept suggestions and tips related to the execution of the session.

RESULTS

I documented the focus group by means of video recording, after asking my participants' specific consent [Appendix 4C.2]. I later analyzed these records by

documenting the key aspects of what each participant said [Appendix 4C.3]. Based on this documentation, I came up with a list of design implications and procedure-related improvements [see Appendix 4D.4]. One of the design implications includes adding smell and sound, as participants found these interesting modalities. As an example, one participant mentioned the following:

"And there would be the water, and then the forest and then the smell of flowers around me…"

On the one hand, I thought of adding smell and sound, but on the other, I thought of discarding the idea of growing plants based on weather conditions. Participants were not as enthusiastic about this idea, for they found The Netherlands' weather conditions quite monotonous. Therefore, weather conditions would not sufficiently change during the game and would not deliver a surprising element.

Apart from aspects that were added or discarded, there were also some aspects that were simply confirmed. Amongst others, they included gaining knowledge about new plants, being motivated to act sustainably and having a decorative aspect. To illustrate the value of decoration, one participant said:

"I think it would be very cozy, it is not in your way and you can really benefit from it: it is beautiful and green."

Furthermore, most participants liked the idea of competition and plant sharing. One final thing that got confirmed was the intuitiveness of the different interaction styles I came up with (for interacting with the shovel, the sprayer and the watering can). Participants did however also mention that they would prefer to have more ways of interacting with GROW.

4. Business proposal

By looking at the design implications I came up with, I adjusted the initial description of GROW [Appendix 4D]. Afterward, I presented this concept to several coaches from my study Industrial Design. One question that was raised included whether the concept of nurturing plants would provide enough value to potential customers. Not all people are interested in nurturing plants and might therefore not want to buy GROW. Therefore, it would be questionable whether GROW would provide satisfactory value to both potential customers and BMW itself.

Vision statement

To address the aforementioned question, I decided to come up with a business proposal. I first looked at competitive products. Based on the value these competitors offered, I created the following vision statement, including GROWs objective, advantage, and scope:

"GROW is a new plant game, supporting people owning autonomous vehicles in becoming eco-drivers and car sharers. Many existing products that support eco-driving mainly display numeric data about fuel savings and driving behavior itself. We understand that just numbers do not always sufficiently motivate people to change their behavior. With GROW we look further, by rewarding eco-driving with tools that can get you further in a plant game which is not just about fun, but also about ambiance."

As part of validating customer value, I defined the design aspects required to address the value described in the vision statement. By using the MoSCoW principle [12] [Appendix 5B], I determined that GROW's must-haves would be:

1. A system keeping track of sustainable behavior: One of the core aspects of GROW is to reward eco-driving, so there should be the basic functionality of tracking this behavior.
2. Visual output representing sustainable behavior: As stated in GROW's vision, GROW's competitive advantage is to not just presenting numerical data about sustainable driving behavior. During the focus group, participants confirmed that having digital plants as digital output would add to the reward of ambiance.
3. A digital plant that can be nurtured: The wish of BMW is to create a concept fitting gaming in autonomous vehicles. Being able to nurture a plant is the basic concept behind the gaming aspect of GROW.
4. A phone as interaction tool: Initially, I chose the phone for its use makes it easy to detect the presence of multiple people. This could, for instance, be achieved by using Bluetooth or WIFI. Moreover, it allows for picking your plants via a personal interface instead of a shared and crowded interface. Finally, using your phone allows for detecting personal movements.
5. Being able to share plants with other players: The focus group participants were quite keen on the idea of sharing plants. They thought it could be a great starting point for talking with unfamiliar people they would share a car with.

Business model

Before coming up with GROW's business model, I analyzed the business models of GROW's two main competitors. These competitors are the app Ecodriver by EcoDrive and Ambiance Interior by Volvo [Appendix 5C]. Analyzing the model of Ecodriver did not provide me with many interesting insights. However, their customer base of over 500.000 users did prove the potential existence of a large customer base, interested in eco-driving.

Analyzing Ambiance Interior's business model was more fruitful than analyzing Ecodriver's model. What was interesting about their business model was that Volvo most likely used their key partners, the perfumer Byredo and Bowers & Wilkins, to position their product as being luxurious. I thought of applying the same idea when looking at GROW's key partners.

The business model I eventually came up with, was not just based on the models of competitors but was also based on BMW's current luxurious brand identity. Simply said, this business model was made by filling out the different aspects of the business canvas developed by Osterwalder and Pigneur [52].

Pricing [Appendix 5D]

The initial question leading GROW's business proposal mainly focused on customer value. What I found interesting, is what BMW could actually charge for GROW. What they can charge again relates to what customers would actually pay for their perceived value. Before applying a pricing strategy, I first determined the most appropriate one by referring to the work of Ingenbleek, Frambach, and Verhalle [36].

For GROW the first objective was to enhance market performance, as it is a new product that needs to acquire a customer base. According to Ingenbleek et al, one should, in this case, rely on value-based pricing [38,p.568]. One first needs to gain an understanding of customers' willingness to pay, which prevents one from overpricing. As GROW also gets launched in an unstable market, one could also focus on cost-informed pricing.

For executing the value-based pricing strategy, I first considered conducting a conjoint analysis. One can use this analysis to determine the actual price people are willing to pay for a product's components [16]. Even though this analysis could be valuable, I decided to postpone its execution. Conducting a conjoint analysis could be quite time-consuming, and I decided to prioritize other design steps such as high-fidelity prototyping.

Besides looking at a conjoint analysis, I executed the cost-based pricing strategy. I firstly calculated GROW's minimal unit costs. For this calculation, I made a distinction between variable costs and fixed costs. After I estimated these costs, based on secondary research, I applied the following formula:

$$\text{Minimal unit costs*} = \text{Variable costs} + \frac{Fixed\ costs}{Maximum\ unit\ sales}$$

*One unit consists out of costs for both the GROW app and the physical product (consisting out of projection devices, sound systems, and smell dispensers).

Finally, I found that the GROW's estimated minimal unit costs would be between €350 and €400.

5. Defining and ideating

Visiting BMW Munich

From writing an initial business proposal, I found that GROW could provide sufficient value to both potential customers and BMW itself. To gain more realistic insights regarding the value for BMW itself, I visited one of their research offices in Munich. There, I pitched GROW in order to receive feedback from multiple design professionals [Appendix 6A]. One question I received, was what the long-term effects of the game would be. I kept this question in mind for future design phases. A positive aspect that was mentioned was that the game would really fit the idea of personalizing a car's interior. They found this especially important when sharing a car.

Visual identity

After my visit to Munich, I decided to create GROW's visual identity. As one of GROW's key values is to provide a decorative aspect, GROW should have an aesthetic appeal. Logo's present a recognizable visual style used throughout the entire concept. Therefore, I logo design as a starting point.

LOGO DESIGN

I wanted GROW's logo to have an organic shape that would reflect the idea of growing plants. Moreover, I wanted it to remind people of GROW's name and therefore created logo sketches based on its first letter. The final logo became a simple, organic representation of the letter "g".

Figure 10: Overview of the process leading to GROW's logo design. 1. Creating sketches. 2. Creating a logo based upon a geometric structure. 3. Choosing a font.

This logo ties in with the trend "New Age Geometry" described by Shelly Jordan for 99 Designs [37]. This is about creating friendlier geometric compositions. This also ties in with my visual identity, focusing on using geometry as a tool for creating a well-balanced and structured form-giving. As one can see by looking at the second phase of the logo design, the logo was roughly based upon circles but was made slightly more friendly and organic by small deviations.

Plant Aesthetics

Eventually, GROW's logo served as an inspiration for the plant's aesthetics in later prototypes (see Figure 18, Chapter 6). The plants' pots, for instance, are also assembled out of geometric shapes and have been decorated with geometric patterns. For the plants themselves, I, however, let go of the strict geometric shapes as plants tend to grow in an unorganized way (see Figure 18). Still, I applied the colors already present in GROW's logo and used them for both plants and pots. All subsequential visualizations I made also contained these same colors.

Redefining GROW

After I created GROW's first prototype and validated its concept via a focus group, I thought of realizing two more parts to better illustrate the full concept. Firstly, this included the phone application with which one could interact with the game. Secondly, this included a central console which would usually be located between a car's two front passenger seats. This console would serve as an interaction tool with which one could start using energy as being into an actual car (see Figure 11 and 14). With GROW, I aim to encourage people to use less energy, and this energy usage could be reflected in the game's difficulty and the plants' aesthetic quality.

Before creating the console, I first re-determined different types of energy usage that would mostly impact an electrical car's energy consumption. I did this because I wanted to provide rational evidence for my choice of the different types of energy usage GROW would reward. These included speed, the charging of devices and turning the air-conditioning or heating on or off. As mentioned before, my first thought was to reflect over-usages by looking at both the game's difficulty and the plants' aesthetics, as illustrated in Figure 12.

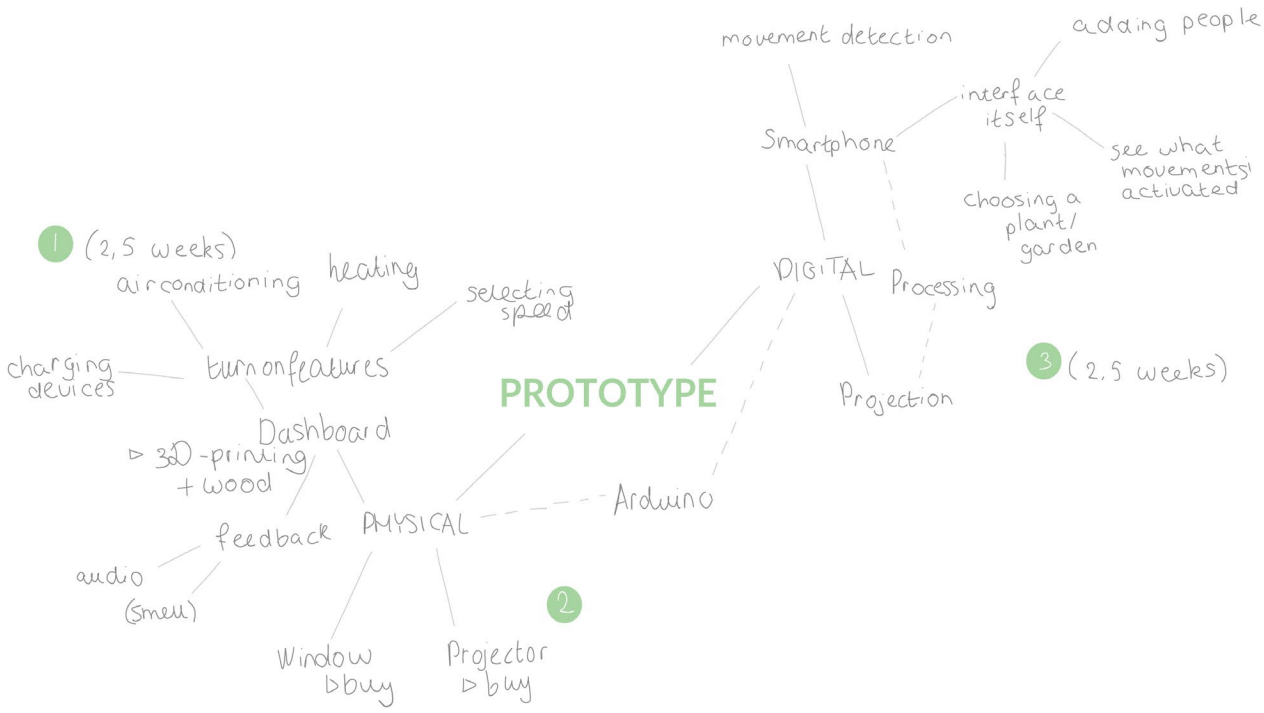

Figure 11. Overview of the planning I made for the realization of GROW's new prototype

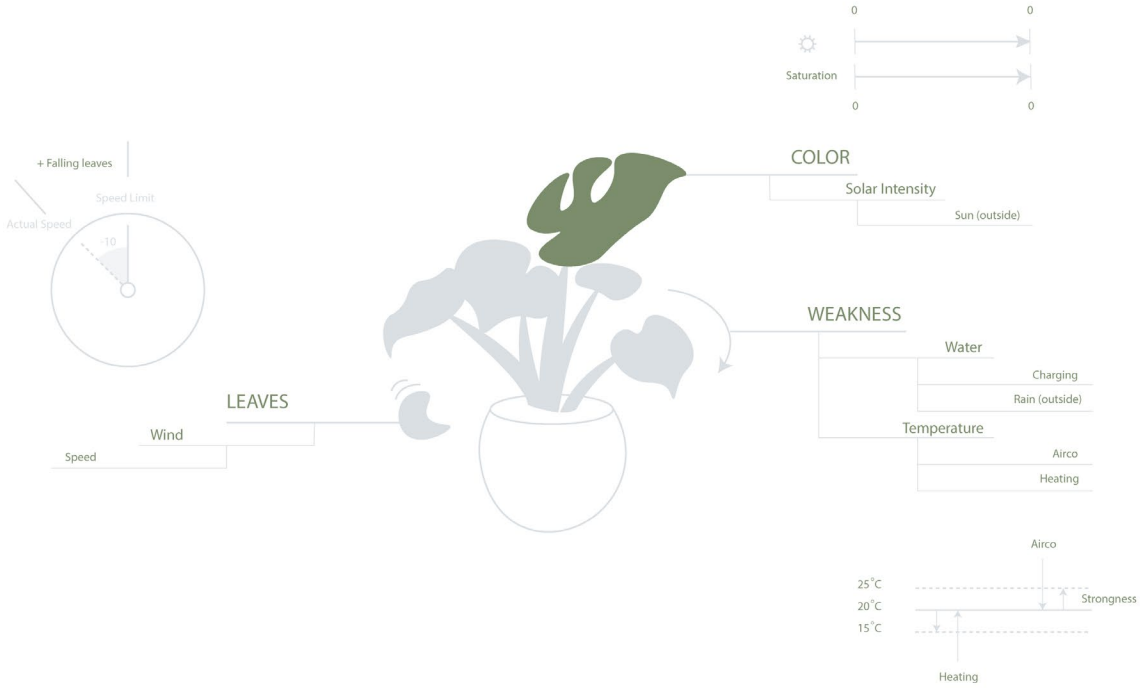

Figure 12. Schematic overview of how over-usages are reflected in the game's difficulty and the plants' aesthetics.

DIFFERENT TYPES OF ENERGY USAGE

Driving at an energy-efficient speed

In level 3 of autonomous driving, speed, influencing battery efficiency, can still be determined by the driver. A study by Tesla demonstrated that battery efficiency drops when their car's constant speed exceeds 22.5 mph [43]. In general, one could say that driving slower leads to higher battery efficiency and driving range.

In reality, one could not motivate people to always drive as slow as possible to achieve higher battery efficiency. Therefore, GROW would reward them for driving at speeds that are slightly lower than the encountered speed limitations. When driving at lower speeds (to minus 10 km/h) the leaves of the plants that would be nourished would not fall off as quickly.

Climate control

Overall, turning on the heating or air-conditioning can negatively impact the car's energy consumption. GROW wants to encourage people to make less use of these features, as only the air-conditioning can already decrease the car's autonomy by 33% [66]. Again, it would not be realistic to ask people to not use it at all. Severe climate conditions may require a necessary amount of heating or air-conditioning.

When making a trade-off between comfort and energy usage, one could look at a temperature range. When turning the heating or air-conditioning on and when staying at 20 degrees up to minus 5 degrees for heating or 20 plus 5 degrees for air-conditioning, people would experience that their plants would become less weak.

Charging

As the interior of cars can become more like living rooms, people will probably also make more use of electrical devices. These devices may be charged or integrated. To encourage people to make less use of this energy, they could retrieve extra water in a minigame about watering plants.

In GROW, people would, for instance, receive a starting bonus of 300 ml water. For each 7 Wh used for charging devices, they would receive 60 ml less water. 7 Wh roughly corresponds to the electricity used for charging an iPhone 7 [50].

Validation

After I made an initial outline of how I envisioned GROW to reward sustainable choices related to the aspects of charging, speed, and climate control, I still had some doubts related to the effectiveness and consistency of rewarding.

Coupling factors and gaming aspects

In Figure 11, one can see that using energy would mainly influence the aesthetic qualities of the plant. By playing minigames, one could then try to improve these qualities. It was not sure yet what these minigames would exactly look like. To illustrate, extensive charging could lead to a weaker plant. To make it less weak, one would have to give extra water by playing a virtual minigame.

One of the problems with this approach would be that people could compensate for their unsustainable choices by becoming better at the game or by simply playing more often. This was also mentioned by the gaming expert I met earlier. He recommended me to not directly link choices to the plant's aesthetic qualities.

Another problem would be the inconsistency of coupling both sustainable choices and external factors (such as outside weather conditions) to GROW's gaming aspects. I initially chose to add external factors because my client found outside weather conditions an appealing factor. However, I found that adding this factor would not help to achieve GROW's aim of supporting people in using less energy.

Figure 13: Overview of the brainstorm's results. In the middle, one sees the most important types of energy usage linked to aspects that make nurturing digital plants more fun.

The different types of energy usage

After I discovered some flaws in the initial framework I came up with, I decided to conduct a brainstorm session. With this brainstorm session, I wanted to review the different types of choices GROW rewards. Moreover, I intended to come up with new, creative ways of rewarding these choices. I, therefore, conducted a session together with four other students.

We then focused on the following questions (see Figure 13):

1. What types of energy usage in autonomous vehicles can one influence?
2. What is the desired behavior for each of these types and which behavior is most impactful in relation to energy usage?
3. How to make nurturing your plans more fun and interactive?
4. How to link sustainable behavior to gaming aspects?

During the brainstorm session, we linked the three most impactful and influenceable types of energy usage to aspects that would make nurturing plants more fun and interactive. We decided upon the following types: ride-sharing, navigation and general electricity usage, including climate control and miscellaneous aspects such as charging devices. These types generally correspond to the types I earlier defined in Chapter 3, namely power usage, car sharing, and route picking.

We first linked navigation to receiving bonus plants and extra bees in a minigame, that could be collected by choosing sustainable routes. Then, we connected climate control to obtaining extra time in a pruning game. In this game, the pruning scissors would be electrical. By using more energy in the real car, one would have less energy left to prune digital plants. Apart from climate control, we also linked the charging of devices to a game in which one would catch water. Charging more devices would lead to fewer raindrops that could be caught.

In contrast with navigation and general electricity usage, we linked ridesharing to gaming aspects unrelated to minigames. Instead, we rewarded this by having people to share plants with each other, which was also a feature included in GROW's first concept description (see Figure 14) [see Appendix 4D].

6. Prototyping

GROW as a connected system

For creating a second prototype, I decided to focus on rewarding general electricity usage. As mentioned before, I thought of adding a physical console as an interaction tool with which one could start using energy. To get an overall grasp of GROW's full concept, I aimed at creating a connected system via which people could truly experience how their energy usage would be reflected in the game. To achieve this, I created the setup as shown in Figure 14. The full prototype, therefore, consists of an application, a console, and a projection.

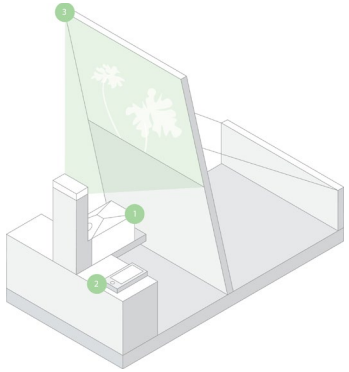

Figure 14: Setup of the connected system of the console (1), application (2), and projection (3).

The console

FUNCTIONALITY

With the rotary knob of the console (see Figure 16) [Appendix 7], one can turn on two small fans that represent a car's air-conditioning. The state of the air-conditioning is represented by a LED-ring. The state of the air-conditioning gets forwarded to GROW's application. Apart from air-conditioning, one can also use it to charge an abstract device that fits the shape of the recess in the top part of the console.

Figure 15: When a plant reaches a certain level, its cuttings can be shared with other people.

CREATING THE CONSOLE

Before I created the console, I made an initial 3D-model (see Figure 16) [Appendix 7]. For this model, I also thought of creating support for the different electronic components [Appendix 7]. Out of practical considerations, I decided to 3D-print the console's top-part. The top-part was made out of PLA, a biologically degradable filament. After printing this part, I simplified the bottom part to make it suitable for laser cutting. For this, I used a 100% recycled plastic sheet from the brand Greencast [31]. I used recycled and biodegradable materials as this fits GROW's aim and sustainability vision.

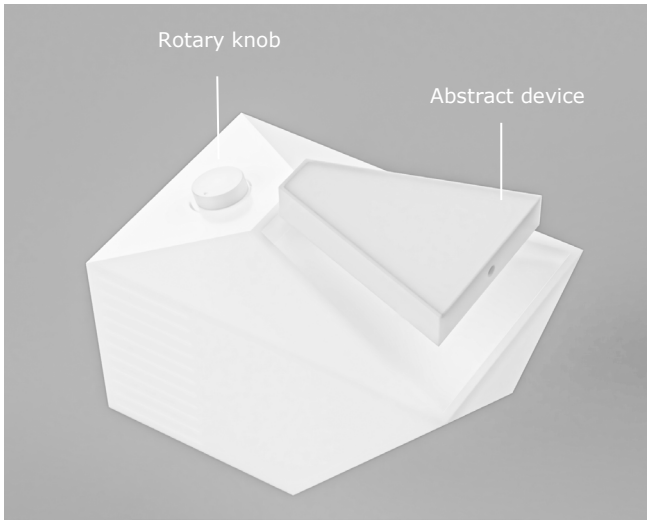

Figure 16. Original 3-D model of the console.

Figure 17: Assembly parts of the console.

The application

After I came up with a new way of rewarding sustainable choices, I decided to redesign the application with which one could play GROW (see Figure 18). While developing the application, I mainly looked at the single-use perspective. I realized an application for the scenario in which a person joins GROW with other people in the same car, but in which one takes care of only their own plant by playing different minigames.

I decided to work from this perspective, as creating an application with a fully functional multiplayer mode was not yet feasible. This situation is further elaborated on in Chapter 9. By simulating the presence of other players, one could however still understand the concept of being in a car with others.

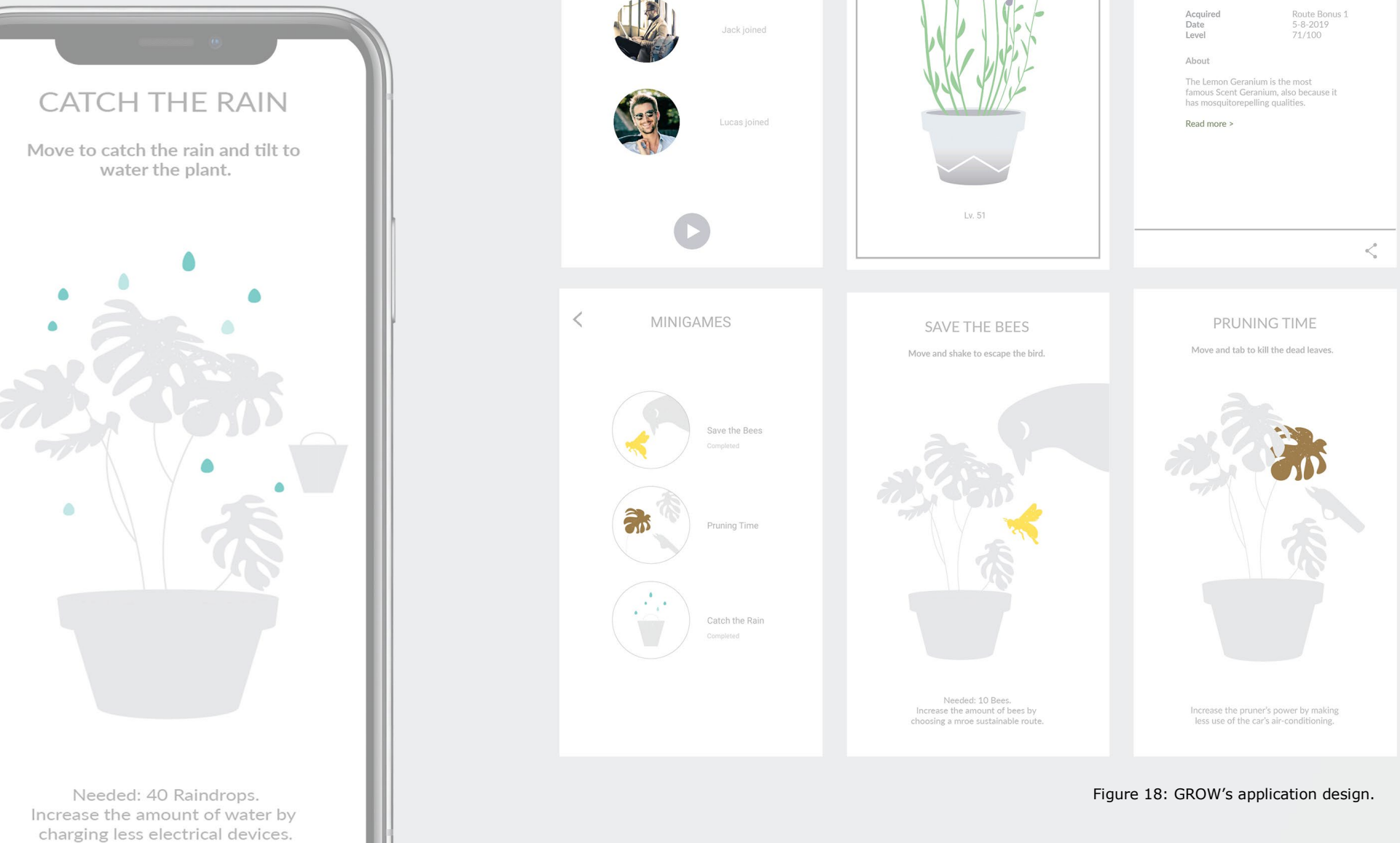

Figure 18: GROW's application design.

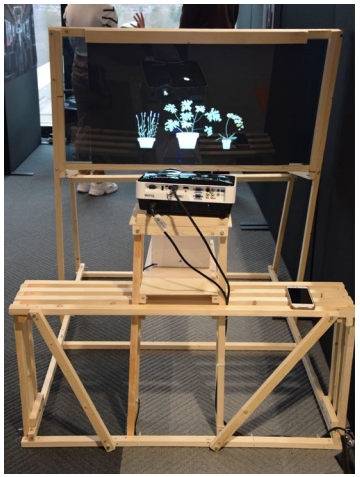

Figure 18: GROW's full setup [73].

FUNCTIONALITY

Minigames

With GROW's application, one can, as mentioned in Chapter 5, interact with the game by moving one's phone in different directions. It also serves as an interface for picking the desired plants and minigames. As mentioned in Chapter 5, we came up with three different minigames, that have been called "Save the bees", "Pruning time" and "Catch the Rain" respectively.

Figure 19: The different plants that can be grown through GROW's prototype [73].

Other than showing the selected minigame, the application displays the number of resources one has to collect in order to finish the minigame. Finally, it provides an overview of the number of resources that are initially available. To illustrate, one can see that one has collected 15 bees but would have to get 10 bees to the plant itself in order to finish a level.

Plants

Before drivers are able to play a minigame, they first pick a plant. When completing all minigames with one plant, the plant will level-up and grow. In this prototype, one can pick three different plants (see Figure 19). For this prototype, they exist of a lavender plant, a lemon geranium, and an orchid. After picking this plant, players can view information about how they acquired them and when they acquired them. Other than acquiring them via other players, they can acquire them through bonuses, for instance when picking the most sustainable route a few times in a row (see Figure 20).

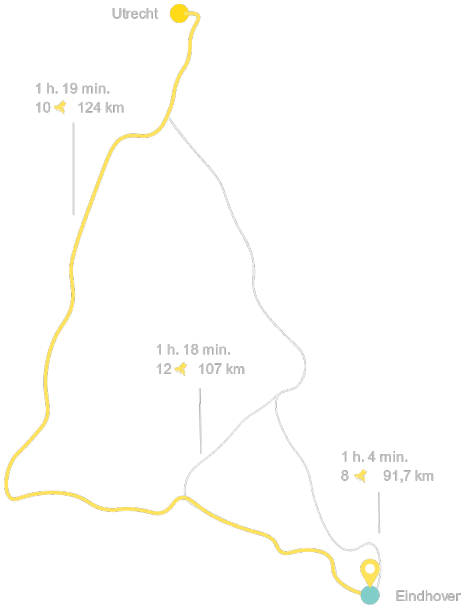

Figure 20: Illustration of how picking different routes during navigation could lead to the collection of different amounts of bees.

Default projection when not playing

The state of the airconditioning determines the amount of pruning time

There is more pruning time when the air-conditioning is low

One has to prune all rotten leaves in time

After completing all minigames with a plant, it will level-up

When failing a level, one's plant will become more rotten

Figure 21: Explanation projection GROW. Image background road [25]

In GROW's first prototype, I created a small projection by having a heads-up display. Now, I chose to project it with a beamer as this provided images with a higher resolution. I intended to project the actual plants onto the car's front window, found to be a suitable place during the focus group ran earlier. Concept wise, these plants would disappear when layers would drive themselves, which could be possible in level 3 of autonomous driving.

The projection of plants is connected to both the console and the application. Via the console, it retrieves information about the level of air-conditioning that is used (see Figure 21). This is then reflected in the amount of time left for playing the pruning game. In the pruning game, one gets rid of rotten lives by targeting the leaves by moving their phone. These phone movements include moving up and down to move the pruning scissors in the y-direction. For the x-direction, this is left and right. After targeting the leaves, one has to touch their phone screen in order to prune a leave.

7. Coding

The code of the projection, made with the Processing IDE, collects data from both the console and application [Appendix 7C]. For the application, this happens via the Ketai library which supports communication over Wifi. The connection with the console happens via serial communication.

The most complex piece of code is related to processing the accelerometer data received from the application. For this, a walking average was used. Another complex part relates to centering the pruning scissors when out of the projection window. This can be the case when a car makes a sharp turn, which also makes a phone turn.

A Walking Average

The projection code retrieves accelerometer data about the rotation in the x- and y-directions. Of this data, we take a walking average of the x-rotation to retrieve smoother movements. This is done by having the function *getAverageX*, which first decomposes the x-rotation in the (x, y) cartesian coordinates:

```
for(int I = 0; I < nrDataPoints; i++){
    avgCos += cos(xSamples[i]);
    avgSin += sin(xSamples[i]);
  }
```

These cartesian coordinates are then added to two separate arrays. Afterward, we use the fuction *convertToDegrees* to compute the average rotationangle in the x-direction:

```
static float convertToDegrees(float sin, float cos){
  float angle = 0;
  if (cos > 0) {
    angle = degrees(atan(sin / cos));
  } else if (cos < 0){
    angle = degrees(atan(sin / cos)) + 180;
  } else {
    angle = sin / abs(sin) * 90;
  }
  return angle; }
```

To compute the average rotation angle, we make a distinction between three cases. This is due to the fact that when the cosine is smaller than zero, the function *atan* will give the opposite angle. When the cosine is 0, the angle should be 90 degrees when sin>0 and -90 degrees when sin<0.

Therefore, we use the function *sin / abs(sin)*, which will output 1 or -1. Both the x- and y-rotation angles are directly mapped to the projection's width and height.

Back to the center

In the code, *updateCenter* is used to set the x-value of the pruning scissors back to the center of the window. The center of the window usually corresponds to the where the phone originally pointed when starting the program. This is done when the scissors have been out of the window for too long:

```
if (screenX < threshHold * width) {
   // The pointer is too far to the left on the screen
   tooFarLeftCount ++;
   if (tooFarLeftCount > maxCountBeforeAdjustment) {
     // Perform an adjustment to the right
     centerX = ((centerX - 1f) + 360f) % 360f; }
```

In the code above, one can see that centerX will become smaller when the scissors are left of the window. CenterX will, in this case, be updated to a smaller number, meaning the phone rotated counterclockwise. When the scissors are on the right side of the window, centerX moves clockwise.

EXAMPLE

We take the original centerX to be at 270 degrees of rotation. When the phone is outside the screen on the left side, the centerX gets reset to where the phone is pointing. The angle of centerX thus needs to become smaller, as it could for instance change to 180 degrees (see Figure 22). CenterX will then be incremented as follows:

centerX= ((270 -1f)+360f)%360f

= (269+360)%360

= 629%360

= 269

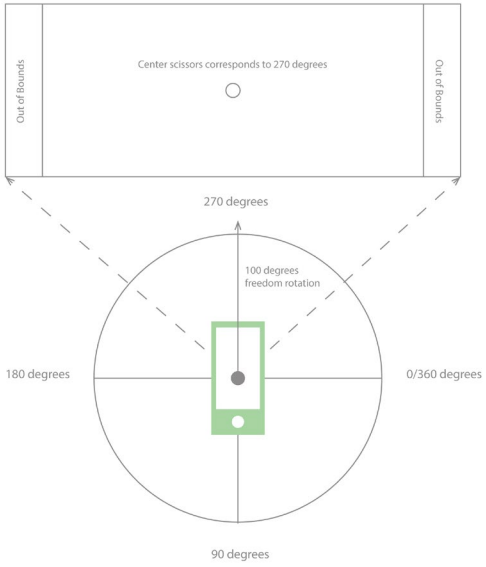

Figure 22: Explanation of the mapping between the phones x-rotation and the scissors' location.

8. User testing

After I created GROW's new prototype, I decided to conduct a user test, fitting the testing phase in the second design cycle. With this test, I aimed to obtain insights into whether GROW's decorative and gaming aspect would motivate drivers to make more conscious choices. My other objectives included the validation of the existing design features and the identification of new design possibilities.

In-depth Interviews

Previously, I conducted a focus group, during which I gathered multiple user perspectives and ideas related to GROW's earlier concept. As GROW's concept had become more concrete, I preferred to have in-depth discussions to discuss more detailed concept features. Personal interviews also allowed me to provide a more guided and structured user experience.

Method

PARTICIPANTS

During my user test, I conducted interviews with six participants. They were between 20 and 30 years old and were taken from a convenience sample. They all owned a driver's license and had more than 2 years of driving experience. They were recruited via personal requests, which were conducted face-to-face or via social media.

PROCEDURE

Before asking any questions, I generally explained GROWs concept, while also demonstrating it via the earlier made prototype. During this introduction, participants were also encouraged to play GROW for themselves.

For the in-depth discussions, I came up with several questions, that related to game-specific rewards, decorative and miscellaneous aspects [Appendix 8A]. To further illustrate some of these questions, I created some extra visualizations such as the visualization of newly received cuttings. Another visualization included that of different routes that one could take during navigation. For each route, the number of collected bees was given, together with its duration and length (see Figure 20).

Results

All interviews were audio-recorded after again asking all participants' specific consent [Appendix 8C]. These records were then transcribed and analyzed via a method based on a thematic analysis. In a regular thematic analysis, one usually makes a distinction between different themes, namely basic themes, organized themes and global themes [1]. As I was not really looking for emerging themes, but rather to answers to the questions I came up with, I focused on grouping codes providing answers to the same questions, which I identified as themes [see Appendix 8D].

One example of such a theme would, for instance, be called "Aesthetics", consisting out of the subthemes *Modern Aesthetics, Personalization Pots, Animations* and *Miscellaneous*, referring to what participants mentioned about it. After coming up with these themes I found some general conclusions that were supported by at least two codes [Appendix 8E].

One important conclusion included that there was a group that thought bees would have been sufficiently rewarding. Half of the participants would however

always pick the shortest route if there would be no other rewards than bees. As an example, one participant mentioned:

"I am someone who would always pick the fastest route. So I would still go for eight bees."

Another participant, however, mentioned that the most sustainable route would become more attractive if the amount of saved energy and money would also be visible:

"…so if it would also cost less electricity or gasoline…I could think about it, but this is not really visible, so I would pick the shortest route. Well, the fastest I mean."

In contrast to these dispersed opinions, most participants agreed upon having updates that would include having extra minigames that would become more difficult over time. Many participants also liked GROW's modern and clear aesthetics. Furthermore, they liked the idea of adding the feature of personalizing pots.

9. Limitations and future steps

Other Use Cases
While developing GROW's prototype, I mainly looked at the single-use perspective. This, however, means that GROW is not optimized for a multi-user scenario, which is likely to occur as people are together in the same car. For the future concept, it would be better to create an application with which different users could connect to the same game. Then, the different minigames could also be adjusted for multiplayer scenarios. One could, for instance, adjust the minigame "Pruning Time" in a way that everyone can benefit from the falling raindrops collected during a joined drive.

Motivation
As a user group, I focus on Dutch people that care about luxury, are environmentally aware and work fulltime. That they are environmentally aware does however not mean that they will also be motivated to play GROW over longer periods of time. It would, therefore, be necessary to further design and test additional motivational elements. One of the features that could, for instance, be added are notifications for reminding people to play. Moreover, one could choose to automatically start the game during navigation.

Improved and added Functionality
In case GROW would be fully developed, several features could be improved. From the in-depth interviews and testing, it appeared that the connection between the phone-movements and the actual scissor movements in the game "Pruning time" could still be improved. In the future, this could become smoother and other types of interaction could be further explored, such as gesture recognition, proved successful during the focus group session.

From the in-depth interviews, it also appeared that there were still some features that could be added in order to make GROW a more convincing concept. First of all, small animations could be added, which could make the current static plant visualization more interesting to look at. Furthermore, picking the most sustainable route could be made more attractive by adding extra rewards or information about the different routes (e.g. saved energy and money). Finally, adding more personalization possibilities, such as the option to personalize pots, would make the game more fun.

Real-world scenarios

GROW's first and the second prototype did not represent GROW's fully developed concept. As a result, it was not possible to validate all aspects of GROW's use. An example of an aspect that was not included yet was the presence of smell. Another limitation related to its validation is that GROW has not been tested in a real-world scenario. This is necessary, as the applied validation methods included discussions about hypothetical scenarios. In the future, GROW's further developed concept could be tested in a real car, over a longer period of time. After the testing phase, one could review GROW's influence on participants' sustainable choices.

10. Implications

As mentioned before, I designed GROW to support people in making sustainable choices related to climate control, route choice, and general electricity usage. I designed this product in collaboration with my client from The BMW Group. They asked me to design a product, focused on future gaming as entertainment related to autonomous driving. Before I came up with GROW's current concept, I executed all phases of the design thinking process approximately three times.

All individual design phases influenced the design decisions I have made. The design of GROW became especially more concrete after I executed validating design activities. Examples of vital activities included conducting the focus group session and in-depth interviews. Overall, all validations vastly influenced the development from an initial location-based game to a game focused on rewarding eco-driving by acting as both a game and a decorative feature.

From a client perspective, the concept of GROW is important as it fulfills BMW's wish of developing and researching innovative entertainment possibilities for autonomous vehicles. The design also fits their requirements discussed during the validation phase of the pressure cooker. To illustrate, it matches my client's wishes of having a concept with both interactive and gaming aspects. It also fits level 3 of automation or higher and suits the regular BMW brand.

From a user's perspective, GROW supports people in becoming eco-drivers and car sharers. Other than helping them to achieve their personal sustainability-related goals, GROW provides them with fun and ambiance. Ultimately, widespread usage of GROW could lead to increased societal awareness regarding the need for sustainable behavior.

11. Conclusion

Before, I stated that autonomous vehicles can provide advantages in terms of energy-efficient driving. Nevertheless, people can still make choices that affect an electrical car's battery. Therefore, I designed GROW, supporting people in becoming eco-drivers and car sharers. A trend that influenced the design of GROW was the trend of car interiors becoming more like living rooms.

In this report, I presented my main design activities, leading to GROW's current concept. During all design activities, I kept BMW's whish of developing entertainment possibilities in mind. To recap, I conducted a pressure cooker during the first design phase, to clearly phrase my design challenge. The outcome of the pressure cooker was a concept focused on creating art via a car's exterior.

After discussing this concept with my client, I decided to focus on location-based gaming. I then created three concepts related to this type of gaming, of which a plant game proved to be most desirable. By running a focus group and applying other validation methods, I validated GROW's first prototype. Subsequently, I redefined GROW's concept and created a second prototype, consisting out of a connected console, application, and projection.

The final step of my current design process included validating GROW's new concept via in-depth interviews. Although this activity marked the end of the current design process, there are still opportunities to further develop and refine GROW's concept. This could, for instance, be done by looking at more elaborate user-scenarios or added functionality.

Acknowledgments

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All images are made by Doortje Marković unless references are included.

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Appendix

1. Vision

Link: https://doormarkovic.myportfolio.com/

2. Pressure-cooker

A. Ideas

Location-based Gaming

Gamify visits
One does not know one's final destination and gets clues from a car. A clue can, for instance, be sound or smell, but it could also be an image.

Have location-based learning of foreign languages
When visiting a certain location, one can learn a certain language that is spoken in the area.

Have location-based learning about the area
When visiting an area, one gets interesting information based on a personal profile which states information preferences

Have location-based online shopping
A driver can have a list of items that he or she is looking for. When driving through an area with a shop that has this item in stock, the car will notify the driver.

Goal achievement
One could mention a preferred activity, and the car would recommend a route for visiting associated locations. Visiting this location could lead to a reward.

Social Gaming

Communicate a car-journey via social media
When visiting a location one would like to share via social media one could ask the car to create pictures or movies and to post these.

Gamify meeting others in a shared car
Upfront, one receives information about people that get into the car. By asking questions, one has to find out which information fits all car users.

Create a dating service
Via an app, one can see which people are driving near. One can then ask them on a date or can have a skype session in the car.

Find certain objects in the environment
Together with one's friends, one can create certain challenges: these can be objects that need to be photographed, or they can be physical objects that need to be collected.

Shape Change

Adapt the car's exterior based on music
Based on music that is being played, the car's exterior can change. When listening to a happy song, the exterior can, for example, have a brighter color or vibrant pattern.

Convert the car into a sleeping or picknick place
After request, the car's interior could automatically change into a sleeping place. When taking a small break, one might change the car into a picknick place. A way to achieve this could be by turning the chair towards the outside environment or by creating a table.

Customize a car's exterior
One might find joy in customizing a car's exterior. This could be achieved by creating patterns or by changing its color.

Connect cars
One could connect multiple cars with each other to meet new people or to play multiplayer games.

Create an environment suiting a game/movie/audiobook that is being played
When involved in an activity, one might adjust the environment in order to become more motivated or submerged.

Miscellaneous

Create an escape room
When waiting, for example when the car's battery is being charged, one could participate in a private escape room.

Gamify new car usage
When sharing a car, one might be driving a different car every time. One could, therefore, gamify new car usage.

Gamify car-search
Get to drive in different cars in a VR environment and reach targets. In this way, people can try out different cars in a playful way.

Get special car parts for appropriate driving behavior
When driving according to the rules, one can get rewarded.

Order food upfront
One can order food from inside the car. When arriving at the chosen restaurant, one does not have to wait until the food is ready.

Sustainability

Earn points when driving sustainably
When driving in a more sustainable way, one could earn coupons from companies that are working on sustainable solutions.

B. ART CONCEPT

Video link: https://youtu.be/px-0vvrbRUk

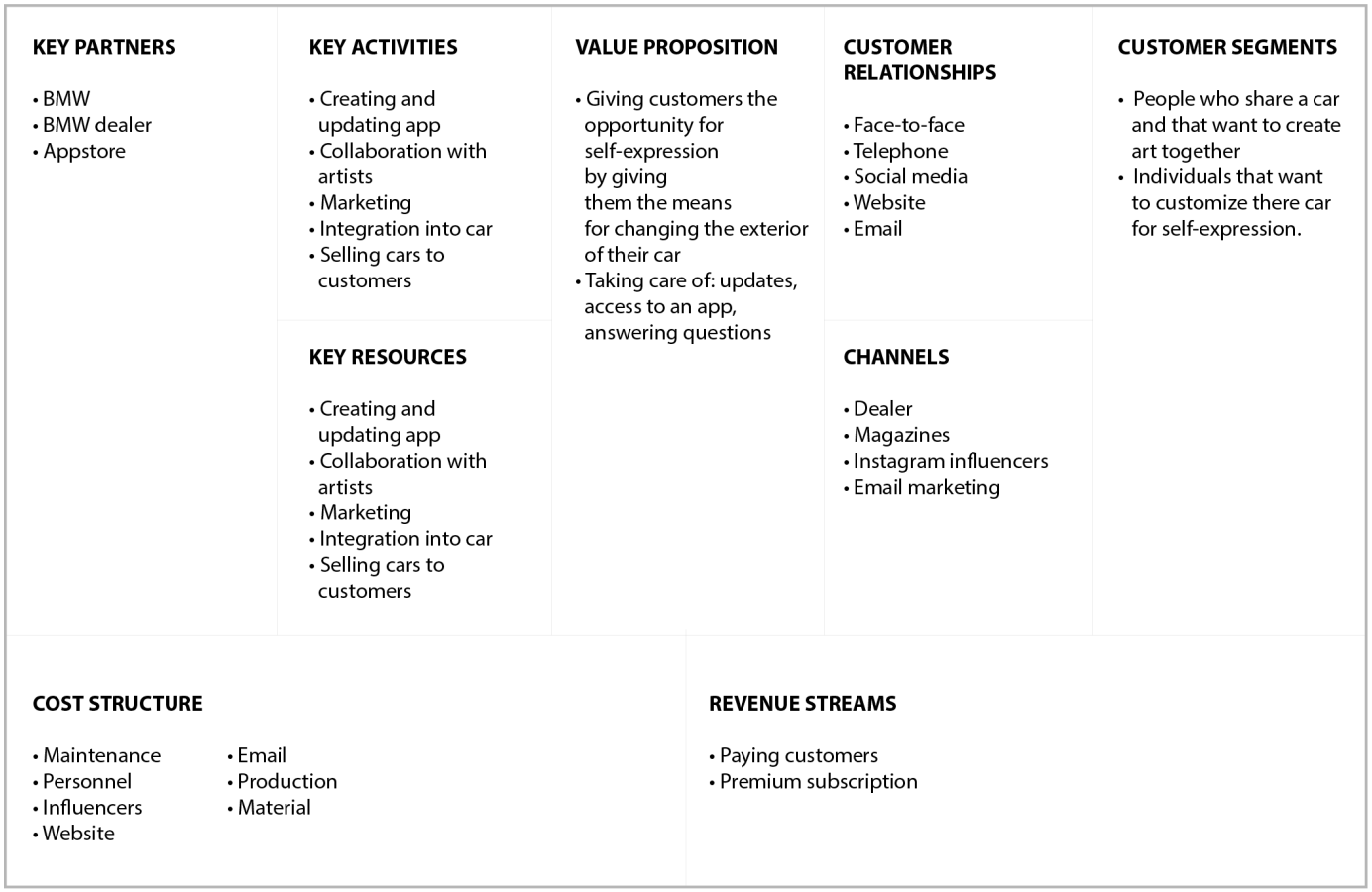


Figure 1. Business canvas art concept.

C. BUSINESS CANVAS [52]

D. Client feedback 1

Being able to customize a car's exterior by creating art
It is interesting to not only look at the interior of the car but also to aspects outside of the car. Yet, changing the car's exterior might be quite tricky, as it is also the number one buying reason. You mentioned that people could create art when for example charging their car's battery. It might be interesting to look at the scenario in which people are actually not driving but are still near their car. For instance, one might be waiting for a friend or for someone who they are sharing a car with. Lastly, using the changing exterior idea would need to have some extra playful interaction to make it suit the topic of gaming.

Creating an environment suiting a game, movie or audiobook that is being played
This idea does not really fit the idea of gaming. Currently, we are also already working on such solutions.

Ordering food from your car
You can proceed with the concept of location-based gaming. Maybe you could even combine it with the idea of drawing. I would pay attention to respecting the context of the driver. Things that make driving special in comparison to a regular room, for instance, speed and weather.

If you would like to proceed with this concept, I would also recommend coming up with two or three more concrete ideas. Also, try to think of different levels. Where are people driving (e.g. in what country)? Where are people seated, left or right?

3. Ideate and Emphasize

A. PERSONAS

Figure 2: Persona Jack.

Figure 3: Persona Lucas.

Figure 4: Persona Amy.

B. STORYBOARDS

Figure 5: Storyboard Amy.

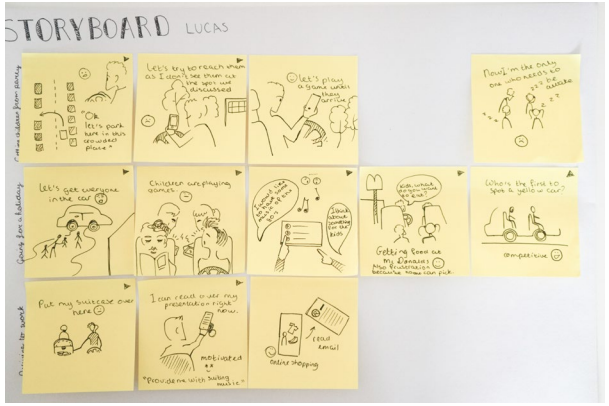


Figure 6: Storyboard Lucas.

Figure 7: Storyboard Jack.

C. OBSERVATIONAL STUDY

Goal of observation

<u>What</u>

1. What are people doing when waiting on the bus or train?
2. What are people doing when they are actually inside the train?
3. Are there people that are doing things together (e.g. listening to music)?
4. Are there people that are doing nothing (e.g. staring out of the window) and how long does it take before they get bored?

<u>Who</u>

Ordinary people that are taking the bus or train.

How
Making notes in my notebook.

Where
On my journey from ----- to -----. This trip takes 3 hours and 20 minutes.

Notes
Waiting on the bus to the station

- Girl and guy (+-30), the guy is on phone, started talking (not Dutch), they are laughing
- A guy with lots of luggage, guitar, etc. looking at street
- Man calling someone
- Two women: one busy with nails and appearance (gets a hand through hair) when waiting. They are talking when they are on the bus

On the bus

- A guy with two phones
- Couple talking and looking outside
- A guy with music that is super loud. You can hear the music through his earphones.
- Girls talking to each other about a party
- Two boys are talking about soccer
- Two girls are talking about buildings in ----- and experiences they had there

At the train station (Eindhoven)

- Group of middle-aged women standing together (with suitcases) and talking

In the train to -----

- Girl on the phone: talks about her journey home. She thinks it takes a long time
- There is a man on his phone for 10 min. He looks outside five minutes before his destination
- Guy watching Netflix
- Group of young people talking about the canals in Amsterdam
- Women reading a book with sticky notes, probably learning something
- Girl on phone
- Girl on phone

Waiting for the bus

- Three people who are smoking and looking at bus direction
- People reading papers in a coffee shop
- People working on laptops in a coffee shop
- People visiting the toilet

In the bus to -----

- Guy staring through the window
- Boy listening to music

D. FINDINGS

What people are doing on the train or bus

I found that a group of people on the train were actually involved in some action with their phone. When people were not using their phones, they were often staring out of the window. Amongst the people using their phone, I saw approximately three people that were calling someone. Furthermore, there were even more people listening to music. Other activities entailed watching a movie or browsing through social media. Apart from people using their phones, I saw only one woman that was reading a physical book. I found it odd to see only one person using a tool other than a phone. No one used other devices such as laptops or tablets, or physical tools such as pen and paper.

People doing things together

All people that seemed to know each other held some kind of conversation, be it continuously or for a short amount of time. I observed two guys talking about sports, but also a couple and a group of four people that were talking about sights in Eindhoven and Amsterdam.

Waiting on the bus or train

The things people did when waiting on the bus or train were not that different from the things they did when being inside. There was still a group of people holding conversations and a group looking to their phones. Yet, one thing that was different was that people looked after food or that they visited the toilet. When I visited a coffee shop I also found more people using other tools than a phone, such as reading a paper or working on their laptops.

Own experiences

Whilst being on the bus from Breda to Clinge, I tried to work on my laptop. I found myself being quite productive at first, as a changing environment always helps me to get in the right mood. However, when entering a more urban area near Antwerpen, my productivity slowly vanished. This was due to the fact that I was distracted by things happening on the streets or by interesting sights. Moreover, became slightly nauseous which further decreased my productivity.

Another thing I noticed during my trip, was that I felt quite uncomfortable making pictures or videos about my journey. I think was due to the fact that I did not really want other people to think I wanted to exhibit my – to them – uninteresting journey.

Conclusion

Looking back at this small observational study, I would say that it did not provide me with the intended results. This as a result of a journey, during which I did not observe any unexpected activities. This was partly for I often take the bus or train. Nevertheless, I got reminded of some aspects that could be helpful for defining my concept directions. For instance, there are many people prefer to use their phone for entertainment.

I could take the phone as a starting point for creating new concepts as people are already familiar with its use. There are already multiple gaming apps available for our phone. However, the phone could also become a part of a more innovative interaction with other products related to entertainment in the car. This idea is supported by Rivas, Olivares, and Alonso, who state

that "The utilization of mobile phones has been revealed as a fundamental element in user experience due to its ease of use and its widespread adoption among society [49,p. 1].

E. Concepts location-based gaming

1. Combining Pictionary and location

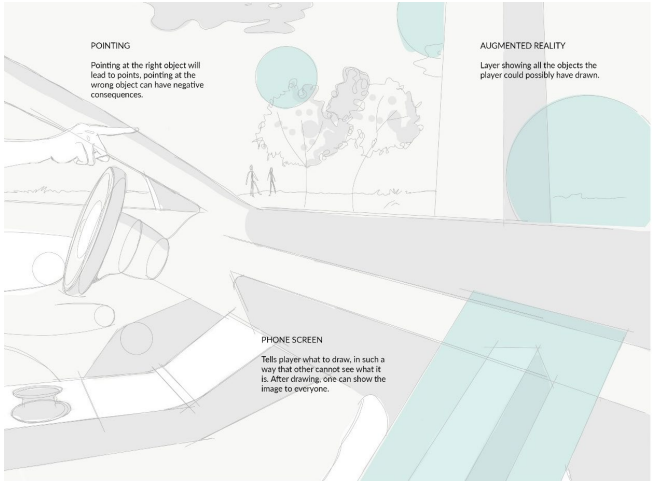


Figure 8: Drawing combining Pictionary and location.

Scenario

Imagine sitting in an autonomous car with your wife, during a drive towards your favorite holiday destination. No one in the car has said anything over the past fifteen minutes. You think it is getting rather dull, and you look outside to search for something you could start a conversation about. This fits you as you are all into discovering new sights in the area. What if the car could help you make these moments easier, more memorable, but also fun?

Concept

The car could recognize one's location, for instance via GPS, and suggest an object (e.g. a building, a special tree or statue) from the area. This can then be drawn by one of the players. If someone guesses which building or object is meant, they can add it to their collection and earn points. Their collection also provides them with a little description of the object.

Connects to:

- Playing "Yellow car" with the family, social interaction (relates to Lucas' and Amy's storyboard)
- Joy of creating
- Long travels on the highway during autonomous driving
- Interest in the environment, learning and creating memories

2. Combining sustainability and location

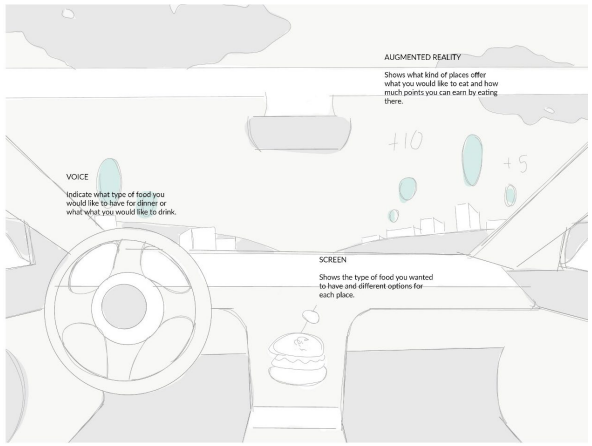


Figure 9: Drawing combining sustainability and location.

Scenario

When traveling, it is often hard to find a restaurant or coffee shop that fits your vision about sustainability. You might want to eat at a place that serves organic food or vegetarian dishes. This is often the case because you are unfamiliar with the area. However, you cannot stop to compare all menus or to ask about the place's policies.

Concept

Based on one's location, a car could suggest places that are marked as being "involved in sustainable practices". It might be hard to judge whether this is the case, also partly caused by the fact that sustainability itself has a broad definition. Therefore, one could think of the following:

- Set up an organization for dining places that are involved in sustainable practices. An example of a website that is already providing an overview of such places is https://thesra.org [70]
- Identify what potential places are actually doing in terms of sustainable practices and rate them based on a set of criteria.
- Involve all places that meet the set criteria.
- Recommend affiliated places to drivers, fitting their personal wishes.

After eating at one of these places, one could earn points, with which you could get a discount or free drink at one of the affiliated places. One could also use these points to show others that you are thinking about sustainable dining.

Connects to:

- Eating while traveling (relates to Lucas' and Amy's storyboard).
- Thinking about your identity.
- Gamifying sustainable dining, by getting rewarded for choosing sustainable options.

Combining location, weather, and fun

Figure 10: Drawing combining location, weather, and fun.

<u>Scenario</u>
When traveling to a holiday destination, you might encounter some unfamiliar plants or trees. Out of boredom or interest, you wonder what type of plants they may be, or how they can thrive. It is not possible to search for information on the internet, because you just do not know where to start. Moreover, monotonously reading articles about trees in the area might not spark the most fun.

<u>Concept</u>
Keeping one's plants alive. When driving autonomously, the car will determine the weather conditions. One starts with a small plant and after keeping it alive for a certain amount of time, one can sell its cuttings. With the earned money, one can buy other plants that are area-specific. One could also buy a greenhouse, keeping plants alive. One could also sell plants to other drivers.

Connects to:

- Gaining knowledge about the flora of the area.
- The joy of competition and social interaction (relates to Lucas and Amy's Storyboard)
- Car specific benefits: you can play a game related to weather conditions and a changing environment.

F. CLIENT FEEDBACK 2

Concept 1
Maybe you could send the drawings to other people. Are there are enough things to draw when driving on the highway? It would therefore indeed be better to use the car's smartness in order to initiate an assignment.

Concept 2
The first concept is more like a light game. This concept and its emphasis on sustainability fit the future vision of cars. Maybe you could also add some extra points for taking a route that avoids the city or for driving slower/faster.

Concept 3
The third concept and the idea of decoration inside the car are nice. You could also think about having this small companion with you that you need to keep alive. These can be plants, but can also be something else. Collecting plants can also be a nice idea as it reminds of Pokémon Go. The aspect of trading your plants could be an add-on, but I would first focus on the collection and nurturing of the plants (or other things).

4. Prototyping and Validating

A. COACH FEEDBACK

Location-based gaming
I do not think the concept is ready yet. I would recommend looking at other dimensions than the plants just being decorations in the car to create a more convincing and integrated use case. You could have a game that supports people in driving sustainably (e.g. the speed they drive, taking someone else with them). You can also focus on decreasing negative habits inside a car.

Target group
Although BMW presents itself as a young brand, most people that buy BMW are actually in their 50's as they have the money to spend. As you are looking at 2025 but also at users right now, you can find people that become 53 (as the persona of Jack) in the middle between now and 2025.

The difficulty with cars is that all people need to be able to operate it: people from 18 who just got their driver's license, but also your grandmother.

B. FEEDBACK GAMING EXPERT
To motivate people to keep playing, you need to engage players and keep them motivated by giving them new things, for example, a new gun.

You need to be careful not to give people unlimited resources. Choices need to be interesting. Do not give people endless water or options.

C. FOCUS GROUP SESSION

1. Setup

Exploratory focus group

Aim
Let participants come up with their own ideas related to digital gardens and see how this could inspire the development of a more detailed concept.

Questions
1. Assume you would have digital plants in your car, what type of plants would you then imagine to have and what would they look like (relates to decoration, aesthetics and plant preferences)? Where in the car would they be located?

2. What aspects of plants would you like to talk about with other people (relates to gaining new knowledge)?

Confirmatory focus group

Aim
Validate important aspects of the current concept

Questions

1. Why

- Would you be interested in getting to know more about different plants and why or why not?
- Do you think receiving plants as a reward for sharing a car with others is a logical reward or do you think something else would be more appealing?

- What type of decoration do you currently have in your car and do you think digital plants could be added to achieve a more decorative effect?

2. How

- Do the current interaction styles seem logical to you (the different movements for giving water, and soil)?
- Can you think of other interaction styles with your plants than the ones presented right now? Would you like to give your plant extra nutrition that is not available right now?
- Which plant would you pick for each scenario of a drive and how do you pick the plant? Currently, is there any information missing to base your decisions on?

3. Who

- When sharing a car with others, would you feel comfortable playing a game together or not? (relates to possible burdens for playing the game).
- What type of games do you currently play and could this game be a valuable addition to the games you are already engaged in?

Wrap-up

- Is there anything that you would still like to mention?
- Can you all give me your tips and tops related to this session and the concept we discussed?

2. Planning

Participants
All participants I selected were between 40 and 60 years old. They all owned a driver's license and a car.

Date and Time
The focus group session took place between 19:30 and 21:30. It was most convenient to have this session during the evening as most selected participants had jobs to attend from Monday up to Friday.

Incentives
All my participants received small incentives to thank them for their participation. This incentive included a small plant, as this matched GROW's concept.

Timeline

Time	Activity	Probes
19:30 19:45	Introduction	-
19:45 20:15	Brain drawing Let people draw and compose their own ideal "digital" garden and take them outside, over to a real car, to ask them where they would envision their garden to be. Let people write down the aspects of plants they would like to talk	Magazines about gardening Color pencils Scissors Glue Forms for drawing

Time	Activity	Probes
	about by annotating the earlier drawn gardens.	
20:15 20:30	Present prototype	Prototype: Interface with which you can grow plants by adding nutrition
20:30 20:45	Start discussion "Why" Give examples of plants and ask them whether they would like to know more about them.	Six images of special plants. Description of plants, only shown when people have indicated their interest.
20:45 21:00	Start discussion "How" Ask to match the six plants with weather scenarios.	Scenarios and the form with the six different plants.
21:00 21:15	Start discussion "Who"	-
21:15 21:30	Wrap-up. Ask people for feedback about the session and concept: let them write down tips and tops. Give them incentives.	Forms tips and tops

Table 1: Planning focus group.

Forms

Form 1. Tips and tops

Tops concept
To me, reasons to play GROW would be:

Cross the option that is most applicable.

Having fun playing the game

Question	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree

Feeling more motivated to share my car

Question	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree

Gaining new knowledge about plants

Question	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree

Decoration

Question	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree

Other

Tips concept
Things I would like to add to the concept of GROW or that I would like to improve or see differently.

Tops session

Tips session

Form 2. Brain drawing

Assume you would have digital plants in your car, what type of plants would you then imagine to have and what would they look like?

Form 4. Images and description 6 plants [35,23,55,56,48,56]

Figure 11: Different plants

1. African milk tree

Scientific name: Euphorbia trigona

Origin: West-Africa

Interesting fact:

"The botanical name of this plant is Euphorbia trigona. It is sometimes also referred to as African milk bush, African milk tree, candelabra cactus, cathedral cactus, friendship cactus, good luck plant or good luck cactus. Although it resembles one, the African milk tree is not a cactus at all, nor is it a bush or a tree either. It's a succulent plant native to Africa [68]."

Thrives at:

Average Temperature: >15 °C
Solar intensity: 2-8

Humidity: 70%
mm Rain: 0-1 mm
(wind) Force: 1-11

2. Bonsai tree

Scientific name: Cedrus libani

Origin: Japan

Interesting fact:

"Bonsai does not just refer to the tree itself but also to a practice, a Japanese art form using cultivation techniques to produce, in containers, small trees that mimic the shape and scale of full size trees [75]."

Thrives at:

Average Temperature: >15 °C
Solar intensity: 6/8
Humidity: 73%
mm Rain: 2-3 mm
(wind) Force: 1-6

3. Lemon tree

Scientific name: Citrus limon

Origin: India or Europe

Interesting fact:

"Lemon trees were around as early as the ancient Greeks and Romans, who depicted lemons in their writings and murals. Where the lemon tree originated is still a matter of debate. Some botanists believe the lemon tree is indigenous to the Indus Valley in India, but others think it is native to Europe and possibly southern Italy where it existed around the year 200" [38].

Thrives at:
Average Temperature >13 °C
Solar intensity: 7/8
Humidity: 47%
mm Rain: 0-1 mm
(wind) Force: 1-7

4. Lakanthurium plant

Scientific name: Anthurium andraeanum

Origin: Tropical America

Interesting fact:

"All parts of the anthurium plant, are poisonous. If ingested, may cause mild stomach disorders. The anthurium plant's sap can cause skin irritation" [69].

Thrives at:
Average Temperature: >16 °C
Solar intensity: 5/8
Humidity: 87%
mm Rain: 3-4 mm
(wind) Force: 1-5

Figure 12: City environment [13].

Figure 13: Road through a forest [54]

Figure 14: Countryside [59]

5. Bamboo Plant

Scientific name: Bambusoideae

Origin: China

Interesting fact:

"Guinness World Records states that the world record for the fastest growing plant on earth belongs to a certain bamboo species that grows up to 91 cm (35") per day, which is almost 4 cm (1.5") and hour, or at a speed of 0.00003 km/h" [64].

Thrives at:
Average Temperature: > -20 °C
Solar intensity: 4/8
Humidity: 83%
mm Rain: 9 mm
(wind) Force: 8/12

6. Tulip

Scientific name: Tulipa

Origin: Persia

Interesting fact:

"Tulips are native to central Asia. It wasn't until 1594 that the first tulip 'officially' bloomed in Holland after the Flemish botanist, Carolus Clusius, director of Leiden University's new Hortus Botanicus, planted some of his own tulip bulbs" [27].

Thrives at:
Average Temperature: 16 °C
Solar intensity: 3/8
Humidity: 50%
mm Rain: 4 mm
(wind) Force: 5/12

Form 4. Scenarios

1. Sunny and windy
Average Temperature: 20 °C
Solar intensity: 5/8
Humidity: 70%
mm Rain: 0 mm
(wind) Force: 7/12
Location: City (see Figure 21)

2. Wet, hot and cloudy
Average Temperature: 30 °C
Solar intensity: 7/8
Humidity: 85%
mm Rain: 9,3 mm
(wind) Force: 2/12
Location: Road through a forest (see Figure 22)

3. Foggy and cold whether
Average Temperature: 5 °C
Solar intensity: 3/8
Humidity: 90%
mm Rain: 2 mm
(wind) Force: 4/12
Location: Countryside (see Figure 23)

Form 3. Informed consent

Toestemmingsformulier Focus Groep Sessie

Gaming in Zelfrijdende Auto's

Vink alstublieft de juiste vakjes aan.

Deelname interview
Ik ben voldoende geïnformeerd over deze focus groep sessie (met als datum (11/10/2019) en ik begrijp wat deze sessie inhoudt. Ik ben in de gelegenheid gesteld vragen over deze sessie te stellen en mijn vragen zijn naar behoren beantwoord.

Ja	Nee

Ik geef mijn vrijwillige toestemming om aan deze sessie deel te nemen en ik begrijp dat ik kan weigeren vragen te beantwoorden of op verzoeken in te gaan. Ook begrijp ik dat ik me op elk moment zonder reden te geven uit de sessie terug kan terugtrekken.

Ja	Nee

Ik begrijp dat deelname aan de focus groep sessie het volgende inhoudt:

- Opnames: De sessie zal worden geanalyseerd met behulp van video opnames. Het onderzoek zelf zal worden gebruikt voor een designproject met als focus gaming in zelfrijdende auto's. Het project wordt uitgevoerd als onderdeel van de bachelor Industrial Design van de TU/e en heeft als opdrachtgever het automerk BMW.
- Sessie: Tijdens de sessie zullen deelnemers tijdens een groepsdiscussie (± 80 min.) en brainstormsessie (± 40 min.) vragen en opdrachten krijgen die gerelateerd zijn aan een ontwikkeld design concept. De sessie zal ongeveer 1,5 tot 2 uur in beslag nemen. Aan deelname aan de sessie zijn geen directe risico's verbonden.
- Beloning: Als beloning voor deelname aan de sessie volgt een kleine verassing die te maken heeft met het gepresenteerde design concept.

Ja	Nee

Informatieverwerking
Ik begrijp dat de informatie die ik verstrek gebruikt zal worden voor een designproject en dat het doel van deze studie het valideren van een concept gerelateerd aan gaming in zelfrijdende auto's inhoudt.

Ja	Nee

Ik begrijp dat de persoonlijke informatie die over mij verzameld kan worden (video-opnames) en iets zegt over mijn identiteit (zoals mijn naam of woonplaats), niet gedeeld zal worden met derden buiten mijzelf en mijn supervisor. Het is wel mogelijk dat de data geanonimiseerd gedeeld wordt indien het onderzoek in aanmerking komt voor publicatie.

Ja	Nee

Toekomstig gebruik en hergebruik van informatie door anderen

Ja	Nee

Ik geef toestemming de informatie die tijdens de sessie verzameld worden en die ik verstrek om gearchiveerd te worden in de beveiligde ICT infrastructuur van de TU/e.

Naam deelnemer

_____

Handtekening

_____

Datum

Ik heb de informatie over deze sessie voorgelezen aan de potentiele deelnemer en heb zo goed als mogelijk vastgesteld dat de deelnemer begrijpt waar deze zich vrijwillig voor aanmeldt.

Naam deelnemer

_____

Handtekening

_____

Datum

Contact gegevens voor verdere informatie over het onderzoek:

Designer: ----------

Supervisor: ----------

3. Results Focusgroup

Introduction

	Playing games	**Carsharing**
1	Does not play games.	Sometimes shares his car: mainly with his wife. In general, he never shares it when driving for work as he works by himself. Sometimes he does take someone when driving back from work. When he does give his har to someone, he expects to get a car in return.
2	Yes, but is more into physical games: Monopoly, Ludo. She used to play a lot of Yahtzee because she used to win very often. Also likes the social aspect. She does not play that often because she does not have time left.	Yes, if she goes to the choir. She thinks it is nice when sharing a car. She often shares the car with the same people. Other than sharing a car with people from the choir, she also shares her car with her husband and plans on doing so when her child gets her driver's license.
3	Does not play games.	He never shares his van with someone else as he often needs it and as he works by himself.

4	-	Only when she has to do something for her family and when she has to visit a job-related workshop. She has a car from her work so she is unable to share it with others.
5	Yes, especially Candy Crush to relax. She likes to do it at a "soup moment" around 16:15-16:30. She likes to play games on her tablet, bus she is not into extensive games (when you are a character playing against others).	Yes, if she pretends to be a taxi driver. This often happens when she takes her (older) parents somewhere. She also shares her car or someone else's when visiting job-related workshops.
6	Yes both physical and digital, Ludo, Connect 4, Yahtzee. Also plays Just Dance on the Wii. Also plays Mario (reminds of Packman).	Shares her car with her husband, friends and her grandchildren. Isn't keen on sharing it with someone she isn't familiar with for she wants it to be available 24/7 for visiting her family if needed.
7	-	She doesn't share her car that often. She doesn't know when to do so. Actually, she only shares it when going for groceries.

Table 2: Relevant results focus group introduction (per participant).

Brain drawing

	Place in car	**Quotes**
1	Projected on front window.	It's a partly Versailles and partly an English garden. And here, we have a Chinese cherry tree. Front window: You can look through it and enjoy it.
2	Near the back window.	How did you do that with those apples? That is quite nice. And we have a path over here… I also want a horse in my garden! At first, I thought having it at the ceiling, but then you can only have ivy. Now everything can grow without you touching or destroying it.
3	On the roof.	We can change the car into a garden! I would want plants hanging down.
4	On the roof.	-
5	She would like to have her garden from the front window over to the roof.	And there would be the water, and then the forest and then the smell of flowers around me…
6	Front window and hood.	I would use the front window as French doors. So my garden would be over there (on the hood). The rest of the car will then stay functional.
7	Back window.	It is very simple, but also very clear: an apple tree, isn't it beautiful. So … you can get apples. And a

	Place in car	Quotes
		fountain of course. A water feature! I often look at a series from Australia, which is about garden design, and they call it this way. O and we have a rabbit over here. I think he will love a garden in his car! If people look inside your car, they always see the garden. I think it would be very cozy, it is not in your way and you can really benefit from it: it is beautiful and green.

Table 3: Relevant results brain drawing (per participant).

Discussion why and how

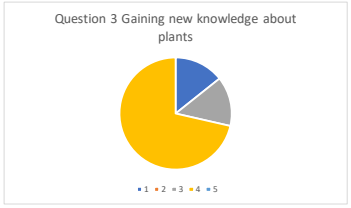
	Decoration	Scenarios
1	The only thing he can do is change the color of lighting. He does it when feeling bored.	(Participants 1 and 6 worked together). For scenario 1 they both had the cactus and for scenario 2 both the bamboo. For scenario 3 they also picked the same plants. They did not miss an aspect to base their decisions on, they thought it was just "logical thinking".
2	Had a blanket in the car because it fitted the car's general aesthetics. She also had real flower and a colorful puppet made out of plastic strings.	-
3	Would really like to have a small Christmas tree inside of his van.	(Participants 3 and 4 worked together). Both participants based their decisions on the plant's specifications. Participant liked picking the plants but he would not do it for fun himself.
4	-	-
5	Had a Christoffel, it's a patron taking care of you arriving home safely.	-
6	She doesn't have anything in the car.	-
7	Thinks it would be nice if plants or background changes color based on emotions. You could also have plants that change based on seasons.	(Participants 2,5,7 worked together). For sunny and windy, they picked nr. 1 because they thought it would be a firm plant. It can also hold water as it some kind of succulent. The first plant was the hardest. All liked to work on the task because they liked logical thinking. Participant 7 said that she

	Decoration	Scenarios
		would want to do more of it.

Table 4: Interesting results why and how discussion (per participant).

Discussion who

	Playing games when sharing a car with strangers	GROW as addition to existing games
1	Would really like it when someone would be in the same car as him. When sharing his car with his wife, they don't say anything to each other.	Likes the feature of caretaking. Thinks Tamagotchi is one of the first examples. Assumes game is suited for people that love gardens or flowers. You could also raise a child in the app. Thinks of the game "farm …" which is really nice for farmer boys. Would like the game to be projected onto a screen. Thinks GROW is unique concept that could already be implemented without the development of self-driving cars. Likes the idea of connecting GROW with sustainable behavior. Thinks of advertising via GROW. Thinks of using GROW for positioning BMW as a sustainable brand.
2	Thinks the game would be useful when having nothing to talk about.	-
3	-	-
4	Would not like to play the game in the car, because she thinks she would become nauseous. Thinks she would not trust a self-driving car.	-
5	Says It can be used to break the ice.	Thinks there is not a lot to do in a self-driving vehicle and would like to play a game. Reminds of getting a book or game during childhood. Compares the social aspect of GROW to building digital cities together with other people.
6	Asks whether we are still talking about digital games. Does like to play games in the car like "I Spy", but that is not really digital. Wouldn't like to play a digital game in the car because she thinks she would become nauseous.	Thinks of connecting GROW to the speed of the car.



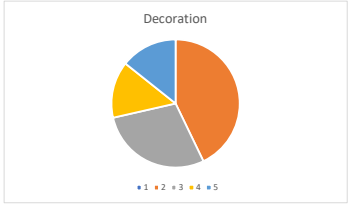


Figure 15: Questionnaire results reasons for playing GROW.

	Playing games when sharing a car with strangers	**GROW as addition to existing games**
	Thinks the game would be attractive to young people.	
7	Also thinks the game would be useful when having nothing to talk about.	Likes the idea of sharing plants and being able to compete.

Table 5: Interesting results who discussion (per participant).

Wrap-up

	Compensation Sustainability
1	Makes a comparison with a Shell example, in which we pay for the energy transition. Questions whether we can combine sustainability with a car that is currently harmful to the environment. Thinks focus on sustainability is a smart marketing tool.
2	-
3	Thinks people pay more to behave sustainably.
4	-
5	-
6	Thinks that in the future, we all drive with electrical vehicles.
7	Thinks that what is marketed as sustainable is often not sustainable.

Table 6: Interesting results wrap-up (per participant).

Tops questionnaire

At the end of the session, the focus group participants received a questionnaire related to the reasons for playing GROW. I quickly analyzed the results (see Figure 24), but one could say that the sample size too small to analyze the results by applying a statistical method. What I did find, was that most participants' opinions differed when it came to the aspects of decoration and feeling motivated to share a car. Finally, most participants were quite positive or neutral when it came to having fun playing the game or gaining new knowledge about plants. The aspect of gaining new knowledge about plants also proved to be valuable during the group discussion.

Question	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
1		1	1	4	1
2	1	3	3	1	
3	1		1	5	
4		3	2	1	1

Table 7: Questionnaire results reasons for playing GROW. The numbers represent the number of participants choosing a certain rating.

4. Implications and Improvements

<u>The concept of GROW</u>

Adding

Smell and sounds were found to be interesting modalities that could be added to the game.

Discarding

People were not as enthusiastic about choosing plants based on weather conditions, so I considered leaving this out.

Confirming

Gaining knowledge about new plants was confirmed to be a valuable aspect. Competition, social aspects, and plant sharing were also found to be valuable.
GROW was found to be connected to sustainable behavior.

Miscellaneous

People had different interpretations of the "carsharing". Some people thought it was about giving your car away, others thought it was about being in a car with other people (including their family members). Therefore, a consistent definition needed to be developed.

Some people mentioned they could become nauseous when they would be playing the game, so I considered researching whether this would be the case.

Although not recorded, people liked the interaction styles with the phone and also added other ideas for interaction that could be used as an input. Nevertheless, I decided to have a look at adding extra interactivity to GROW, as this need was mentioned during both the discussion and the indication of tips and tops.

Session

Improvements

- Having two cameras and better lighting conditions.
- Having an online poll at the end for more efficient data analysis.
- Asking open questions followed by closed questions: during the session I asked them in the same question which could have had a slightly forced effect.
- Having clear descriptions of the session's assignments and providing examples that could be found in the session's presentation slides.
- Giving a small session recap before the break and announcing it via presentation slides.
- Giving the incentives at the beginning instead of at the end because otherwise, participants could feel forced to complete the session.

Valuable activities to maintain while presenting

Providing structure by having presentation slides.

- Having a relaxed and hospitable presentation style.
- Organizing a brainwriting session.
- Having extensive discussions.

D. CONSISTENT DESCRIPTION GROW

GROW

With GROW, you can nurture your own collection of digital plants. It's suited for playing inside autonomous vehicles and can be played together with other people.

Why

Playing GROW is not just fun but it is much more:

- Fun: Being able to talk with other people about your plants and having a competitive aspect increases the overall fun players have.
- Car sharing as sustainable behavior: By playing GROW with people you share a car with, you can gain extra coins for growing your plants. This stimulates to share a car with others as a way of sustainable behavior.
- Gaining new knowledge: By playing GROW, you can learn facts about plants and how to take care of them.
- Decoration: Many people take a plant into their homes because they find them beautiful. Having digital plants into your home could therefore also have a decorative effect.

How

Grow can be played by interacting with your phone. With GROW, you can collect plants by sharing your plants with others or by buying them via g-coins. The coins can be earned by joining games with other people you share a car with. These coins are given by "mother nature", as a reward for sustainable behavior. You can also earn them by completing weekly challenges (e.g. play three levels with three different plants) or by successfully leveling up your plants.

In GROW, you can determine what type of level you would like to play. You can have small levels, medium levels, and large levels. The larger the level, the more points you can receive and the larger your plants grow.

After stating the preferred duration of a level, you start playing.

In a level, you have to take care of several things your plant needs:

- Sunlight: can be given by lighting the plant with the light in your phone
- Water: can be given by making a pouring motion with your phone
- Soil: can be given by using a shovel and the corresponding motion
- Extra nutrition (calcium, chlorine, potassium, etc.): can be given by using a sprayer and the corresponding motion.
- Temperature: can be given by shaking your phone.
- You can retrieve these things by buying them with g-coins or by receiving them from other players.

Where

GROW can be played inside an autonomous or semi-autonomous vehicle (level 3 of automation or higher). With your mobile phone, you can initiate a game. After the initialization of the game, the actual plants will be displayed on the windshield of your car. The plants will be located close to the dashboard and will, therefore, block your view as little as possible. They are located on the windshield, for they stay in close connection to the outside environment. In case you would like to take over the car, your plants would automatically disappear to provide you with a full view of the road ahead.

Who

GROW is made for adults that would like to have fun on the road while also interacting with people that they might share a car with. Even though the game is targeted at adults, it could also be possible to play it together with your family. However, one should take into account that young children might find the game hard to understand and it is therefore not recommended to have them playing it without the guidance of a parent.

When

GROW is ideally played together with people when sharing a car, but can also be played when driving alone. The game should always be played when the car drives fully autonomous, as it would otherwise not be safe to play.

E. Prototype

Figure 16: Heads-up display.

Figure 17: Different tools to play GROW with.

Video link:
https://www.youtube.com/watch?v=BOzgSJY-Cjs

F. MEETING CONCEPT ARTIST

Feasibility 3-D gaming

During our meeting, we looked at the feasibility of using 3D-models. More specifically, we looked at loading models in Unity. This software can, amongst others, be used to create a 3-D game with a HoloLens, or to create a Virtual Reality game. It appeared that loading models in Unity itself would be quite doable, but that creating interactions requires a lot of practice and experience. Therefore, Robin recommended me to either design a 2D game or a low-poly game. Examples of low-poly games he mentioned included SuperHot [65] and Mario Odyssey [47]. The latter was mentioned because its aesthetics contain a lot of different colors which may appeal to a larger audience. Superhot illustrates how simple aesthetics with little details can still be part of a successful 3-D game.

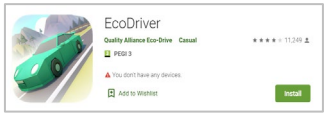


Figure 18: Ecodriver app [18].

Figure 19: ECOdrive Connected [17].

Figure 20: DRIVEC Ecodriving [16].

Figure 21: Ambiance Interior [72].

Concept

After I explained GROW's concept and showed GROW's first interface, Robin told me he expected it to become a typical smartphone game. I then told him the plants should stay connected to the environment outside of the car. I also told him the game should be connected to the car instead of the smartphone. If the game could just be played with a smartphone, the game could be played in any car and would not be typically BMW. Therefore, we both thought of a game that could be projected into the car. Moreover, we thought of a game that would be displayed on an already-existing screen.

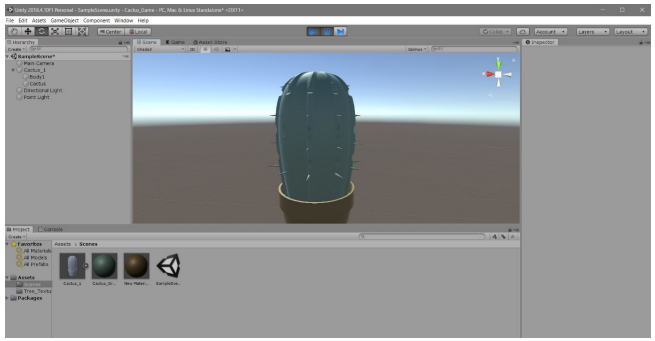


Figure 22: Loading a 3-D model in Unity.

5. Business Proposal

A. SECONDARY RESEARCH: LOOK AT ALREADY EXISTING PRODUCTS AND COMPANIES

Eco-driving

1. App EcoDriver [19]

EcoDriver is a smartphone game and application. Its main target customers are mostly independent drivers (not driving for an employer) that already see the importance of eco-driving and that would like to become better at fuel-efficient driving. It is also targeted at people that already have eco-driving skills and that like the game's competitive aspect. EcoDriver could be a competitor of GROW as it also aims at testing eco-driving abilities in a more playful way.

2. ECOdrive Connected [17]

In comparison to the App EcoDriver, ECOdrive Connected is a behavior stimulator which is connected to a real (instead of a virtual) car. According to its designers, ECOdrive Connected "enables you to control your power, ensuring that more power is only supplied at times when this is needed" [18]. ECOdrive Connected itself is targeted at employers as decisionmakers and employees as end-users [71]. ECOdrive Connected's core value includes the analysis of fuel consumption and personal driving behavior.

3. DRIVEC Ecodriving

DRIVEC offers "a clear in-vehicle display with self-learning driver support" [16]. The product is again targeted at employers as decisionmakers and employees as end-users [71]. One of its competitive advantages entails its computational performance, for it helps to calculate overconsumption. It also helps to set measurable goals in order to improve your eco-driving performances and to diminish overconsumption.

Decoration

1. Ambiance Interior

Ambiance Interior is part of a future concept developed by Volvo. It lets you "indulge in exclusive Swedish luxury from the comfort of your Volvo" [72]. It is

Figure 23: AI:ME concept [58]

Figure 24: The Botanist [29].

Figure 25: Garden Answers [30].

mainly targeted at people who can afford luxury cars. It is a major competitor of GROW as it also uses smell, sound, and visuals as a means to set the driver's mood.

2. AI:ME concept vehicle
The AI:ME concept vehicle by Audi embodies the idea of cars becoming more like living rooms. In the car, they used real plants to improve the air quality inside the car and to add nature to a city environment [58]. Audi's intended customers most likely include independent drivers living in the city, that care about peaceful interiors. The AI:ME concept is a competitor of GROW as it also achieves a decorative effect but then by having real plants.

New knowledge and fun

1. The Botanist [29]
The Botanist is a virtual game that lets you grow and sell your own portfolio of plants from inside your living room. The game is available for pc or can be accessed via streaming. Its main aim is to let players have fun by selling and nurturing plants. There is also a competitive aspect involved as you can level up by selling more plants. Apart from that, playing the game also teaches you interesting facts about various plants.

2. Garden Answers [30]
Garden Answers is an app that helps customers to take care of their plants. The app is targeted at people that own plants, which are not necessarily located in their garden. It does so by providing features such as the identification of plants, pests and diseases, and the provision of expert advice.

B. DEFINE THE DESIGN REQUIREMENTS WITH THE MOSCOW PRINCIPLE [12]

Must have

- A system keeping track of sustainable behavior.
- Visual output representing sustainable behavior.
- A digital plant that can be nurtured.
- A phone to interact with the game itself.
- Being able to share plants with other players.

Should have

- Other output modalities than visuals: sound and smell.
- Having multiple plants that can be nurtured in one level.
- Providing knowledge about different plants.
- Having different interaction styles for nurturing your plants.

Could have

- Being able to hunt for plants outside of the car (e.g. scanning a plant with your phone).
- Connecting the plants in the car with plants that are in the driver's garden.
- Being able to nurture other things than just a plant (e.g. animals).

Won't have

- Real plants or tools to nurture your plants with.

- Face or voice recognition to indicate who is in the car.
- Merely having a touch-screen based interaction.
- Taking care of plants outside of your car.

C. BUSINESS MODELS TWO MAIN COMPETITORS.

1. App EcoDriver [18]

The app EcoDriver is one of the biggest competitors of GROW as it also rewards being a skilled eco-driver in a virtual game. As one could not find any other competitors using the same approach, it would be valuable to look at the business model of EcoDriver. Finally, EcoDriver also targets individual drivers instead of employers, which were targeted by the other competitors in the eco-driving category.

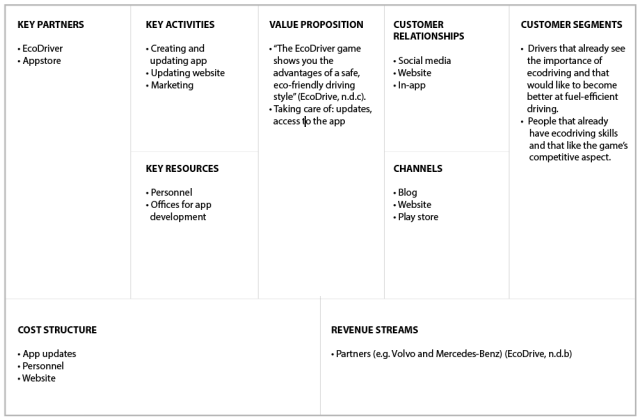


Figure 26: Business model EcoDriver.

Business model

By looking at the presentation of EcoDriver on both its website and in the Appstore, the business model below was filled out. Furthermore, the website of the organization behind EcoDriver, called EcoDrive, was examined. As expected, these websites do not present the exact information needed to fill out the entire canvas. Nevertheless, an attempt was made by making some likely assumptions. One example of such an assumption might be that EcoDriver mainly acquires its revenue through key partners of the EcoDrive organization. This is likely as the EcoDriver app itself does not display any advertisements or in-app purchases.

In general, one could say that the business model of EcoDriver is quite simple, which may also be partly caused by the fact that it is hard to find the required information. One thing that is however interesting about it is that the app has become quite successful with over 500.000 downloads) by involving a rather small amount of key partners, channels and resources.

2. Ambiance Interior by Volvo [72]

As mentioned before, Ambiance Interior is a major competitor of GROW as it also uses smell, sound, and visuals as a means to set the driver's mood. GROW also offers ambiance but does this in a slightly different way: it provides a game-specific ambiance people need to take care of. Although GROW takes a different approach to creating an ambiance, it would be valuable to look at the business model of Ambiance Interior to become inspired and to find things GROW could do differently.

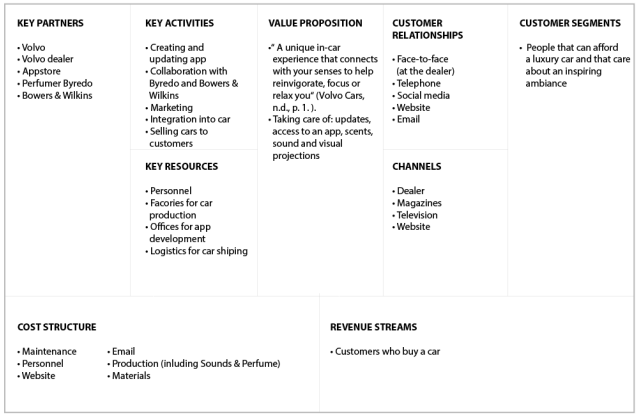


Figure 27: Business model Ambiance Interior.

Business model

For filling out the business model of Ambiance Interior, I mainly looked at the website page of Volvo which presents it. What is interesting about this business model is that Volvo most likely uses its key partners, the perfumer Byredo and Bowers & Wilkins, to position their product as being luxurious. This approach could serve as an inspiration when designing a business model for GROW. One reason is that GROW is part of the product portfolio of BMW, which also positions itself as a luxury brand.

Finally, it is evident that Volvo would have quite a lot of key activities when bringing Ambiance Interior to the market. They would, for instance, take care of creating and updating an app, but they would also have to look at cooperation with their key partners. These various activities should also be taken into account when designing a business model for GROW.

D. Business model GROW

The value of GROW is already partly described by GROW's vision statement. In their book Foundations of Marketing, John Fahy and David Jobber describe the concept of product levels: these consist of the actual, core and augmented product [26, p. 265]. These levels can be used to determine how a product distinguishes itself from those of competitors.

Core product

First of all, GROW is distinctive from competitors' products as its core benefit is not just to help people to drive sustainable, but also to do so in a fun way. The value of fun is stimulated by aspects of competition and gaining new plant knowledge. Similarly, the value of supporting sustainable driving can be divided into supporting eco-driving and carsharing. Finally, there is the value of having an inspiring ambiance.

Actual product

Although GROW mainly distinguishes itself on a core level, it should also meet competitors' standards on the second level. In terms of quality or styling, it would be hard to surpass Volvo Ambiance, as this is also a highly luxurious concept. However, the styling of GROW should at least be better than that of competitive products such as the app EcoDriver or DRIVEC Ecodriving. This is due to the fact that BMW positions itself as a high-quality brand with aesthetic value, whereas the others do not.

Augmented product

On the augmented level, is hard to differentiate by having distinctive installation, guarantees, and delivery. This is due to the fact that GROW gets implemented in cars, which means that installation, guarantees, and

delivery of the physical product have been taken care of before the actual purchase of GROW. Likewise, the app can be found in the App Store, via which installation takes place. Taking these things into account, it is likely that customers will not consider installation, guarantees, and delivery as product benefits.

One thing that could differentiate GROW from competitor's offerings could be brand values. As GROW is a product of BMW, it is already associated with BMW's brand values. Additionally, GROW adds to the brand value of sustainability, which value is not yet promoted by for instance Volvo Ambiance. The products that do have this value (e.g. EcoDriver) are again not associated with luxury or high quality.

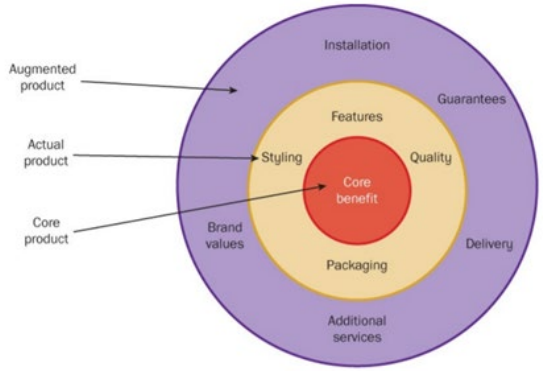


Figure 28: Actual, core and augmented product [26, p. 265].

Customer value

Apart from the three product levels, one can also think of four types of customer value: price, performance, emotional and relational value [26]. GROW should mostly offer performance and emotional value. Price is less relevant in this case, as GROW's price is already included in the car's price. Relational value (or delivering customer service) is always important but is not the core reason for buying GROW.

GROW should mostly offer performance value as GROW's target group highly values quality and functionality. This can be linked to BMW's image as a high-quality brand. Emotional value is also important as the motivation to use GROW is an intrinsic willingness to reduce one's ecological footprint. GROW rewards efforts by providing an inspiring ambiance and fun, that again is assumed to have a positive emotional impact.

Key partners

1. BMW Dealers: One would obviously mention (franchise) BMW dealerships as key partners, for they sell the actual cars in which GROW would be integrated.
2. Appstore: Another key partner includes the Appstore, as the interaction with GROW is established via a smartphone app that indirectly detects hand movements.
3. External Game Developers: BMW could partner with external game developers as the company's core business is about car creation instead of game design. One important aspect that they should take into account is linking the visual style of GROW to the luxurious image of BMW. This luxurious element could also be enhanced by mentioning artists that have worked creating the visual style.
4. Miscellaneous: Apart from the partners that were mentioned above, there are several others that could be involved: master perfumers and the creators of premium sound systems. During the

analysis of the business model of Volvo Ambiance, partnering with these kinds of premium brands was also found to possibly suit the luxurious image BMW is known for.

Key activities

The first key activity BMW could be involved with is marketing. John Fahy and David Jobber state that the modern marketing concept can be expressed as 'the achievement of corporate goals through meeting and exceeding customer needs better than the competition' [26, p.39]. Amongst others, one goal of BMW would be to create awareness about the brand GROW and eventually sell GROW as a part of an automated vehicle.

A second activity includes collaboration with key partners. Lastly, activities could include the integration of GROW into new cars, selling cars and maintaining customer satisfaction.

Key resources [22]

1. Human resources: BMW would have to hire personnel for maintaining customer satisfaction, collaboration with key partners and the integration of GROW. They would not need to hire personnel for selling their cars as this is managed by franchise dealerships.
2. Physical resources: They include factories (as well as machines) that are necessary for producing devices for projecting GROW and for producing the cars itself. Furthermore, proper logistics should be established in order to transport assembly parts to factories and again, to transport cars themselves. Finally, required physical sources would be materials for the actual production of GROW. First of all, they would have to be sustainable, fitting the overall aim of eco-driving and carsharing. Of course, these materials would also need to be appropriate for the set production methods and the products' functionality.
3. Intellectual resources: Some of the intellectual resources that need to be taken into account are the BMW and GROW brand, patents, partnerships and finally customer databases.
4. Financial resources: The main financial resource includes the cash that is needed to acquire the aforementioned resources and to realize key activities.

Cost structure

The total costs could be calculated by adding up key activities, partners and resources [21]. Firstly, there are costs involved for maintaining partnerships with for instance the app store, dealerships, and game developers. Secondly, there are marketing costs and lastly, costs for hiring personnel and the rent or purchase of factories (including machines).

Customer segments

For creating customer segments, one could look at the created personas. Commonalities between them are that they care about luxury, that they are environmentally aware and that they work fulltime. One thing that is however missing, is their overall income. Therefore, this was added and set at an average of $124,800 per year or €112.064 a year [33].

Customer relationships

To find customers for GROW, one could look at the already existing customer base of BMW. Furthermore, new customers could be attracted that currently buy other cars in the luxury segment or that have just decided to do so. One way to attract these customers would be by providing more functionality than competitors while charging comparable prices.

To maintain customer relationships, one could think of doing this via the following channels:

1. Face-to-face: Customers could ask questions about GROW to employees from the nearest BMW dealer to receive expert-feedback and personal treatment.
2. Website: Customers could ask questions about GROW via the website of BMW or a sperate page dedicated to the idea of GROW.
3. Social media: Nowadays, more customers see social media as one of the easiest channels for asking questions about a product [60].
4. Email and phone: These are traditional channels of communication many people are familiarized with.

Marketing channels

There are several marketing channels that could be appropriate for promoting GROW:

1. Dealerships: When people would be looking for a car, dealerships could tell about the implementation and value of GROW.
2. Email: This could be used for reaching customers that already subscribed to receive emails from BMW.
3. Magazines: Customers could be reached via advertisements.
4. Website: Obviously, GROW could be found via the official BMW website.
5. Television: According to Jim Nail, "linear TV still is more reliable in delivering reach than any other medium, and its strength lies in effective, emotional storytelling" [45].
6. Social media: Nowadays, social media
7. Word of mouth: People can become motivated to share a car as they receive extra GROW tools by doing so. When wanting to play with others, people could talk about the game and therefore promote its use.
8. Billboards: Having billboards can be valuable as people can also see them from inside their cars as they are often played near highways and thoroughfares [14]. While driving they can link GROW to the activity they partake in and can, therefore, sooner be able to evaluate the concept.
9. PPC (pay per click advertising): This type of advertising could be used to direct potential customers to the website of BMW or to a page dedicated to GROW.
10. Content Marketing: From the focus group, it appeared that people were interested in gaining knowledge about plants. One could regularly send new facts about plants to keep users engaged.

Revenue streams

The main source of revenue will come from customers who buy a car with GROW as an integrated functionality. Preferably, customers do not have to pay for having premium access to special updates or functionality. This is due to the fact that BMW itself is a premium brand and that people already expect a high level of luxury when they pay a lot of money for their car.

E. Price Setting

Limitations

When considering pricing strategies, it is important to mention that this is not a simple task. This is mainly due to the fact that the launch of GROW is part of a Blue Ocean Strategy: meaning that it is launched in uncontested market space, which is untainted by competition [74]. Therefore, it is hard to compare GROW's price to that of competitors. As mentioned earlier, there are of course some competitive products that compete in relation to individual values.

Nevertheless, GROW offers a distinct combination of values, being a product that has no direct substitutes.

Choosing a pricing strategy

Value-based and cost-informed pricing

There exist many pricing strategies, of which the following are the most common: cost-plus pricing, competitive pricing, value-based pricing, price skimming and penetration pricing [3]. For picking a suitable strategy, one could rely on the work by Ingenbleek, Frambach, and Verhalle. They emphasize that product pricing is often over-simplified and found a new approach that looks at more complex pricing scenarios. They then describe that managers, before launching a new product, should first "determine their explicit pricing objective, either stressing market performance or a higher price level"[36, p.560].

For GROW the first objective is to enhance market performance, as it is a new product that needs to acquire a customer base. According to Ingenbleek et al, one should, in this case, rely on value-based pricing [36]. This is because one first needs to gain an understanding of customers' willingness to pay, which prevents one from setting a price that is too high. In the case of unstable markets (fitting Blue Oceans), one could also focus on cost-informed pricing. One should however not use competitive pricing, as information about competitors can quickly become obsolete [36,p.569].

Optimal pricing for green products

The study by Ingenbleek et al. focused on finding pricing strategies for launching new products in general. However, they did not look at the difference in strategies for green products and non-green products. In 2007, Nimse et al. described green products as follows [46]:

"Green products may be defined as products that contain recycled materials, reduce waste, conserve energy or water, use less packaging, and reduce the amount of toxics disposed or consumed. These products are less harmful on humans and their environment compared with the traditional products in use, and are more socially, economically, and environmentally viable in the long run."

According to this definition, GROW could be considered to be a green product as it supports people in sustainable driving behavior which is less harmful to the environment.

When considering a difference in pricing strategies for green and non-green products, it is beneficial to look at a study by Shen, Liu, Zhang and Choi which is about finding optimal advertising and pricing for new green products in a circular economy [62]. They examined the differences between the effects of simultaneous pricing and sequential pricing on market performance and environmental sustainability. It appeared that it would be best to determine the price of a green product after that of a similar non-green product is determined (in line with sequential pricing).

GROW could be seen as a green substitute for the product "Ambiance Interior" by Volvo and setting its price after the price of this product would, therefore, be a suitable approach. However "Ambiance Interior" has not yet entered the market, which currently makes it

impossible to set the price later that Ambiance Interior's price. Nevertheless, one could take this approach into account when it gets launched or when another non-green substitute enters the market.

Executing Strategies

To sum, the current suitable pricing strategies that can already be validated are value-based pricing and cost-based pricing. Value-based pricing refers to what customers are actually willing to pay for your product. For measuring willingness to pay, one could refer to "A Quick Guide to Value-Based Pricing" by Dholakia [15]. According to this guide, there are four steps that could be taken into account in order to achieve value-based pricing:

1. Focus on a single segment: in the case of GROW, this segment aligns with the built personas or to make things easier with Dutch people that care about luxury, are environmentally aware and work fulltime. One could also include the fact that they earn €112.064 a year but it is hard to validate as potential participants are most likely not willing to share their earnings.
2. Compare with the next big alternative: Currently, the biggest competitor of GROW would be "Ambiance Interior".
3. Understand differentiated worth: This was already mentioned in GROW's vision statement:
4. It does not merely present people statistics but also rewards eco-driving and carsharing with an appealing ambiance and tools for playing a game.
5. Place a dollar amount on the differentiation: People often use conjoint analysis to determine the actual price people are willing to pay for a product's components. This analysis can be conducted by having a survey, asking people to rank certain product alternatives.

Conjoint analysis

One could conduct a conjoint analysis by having customers rate different product alternatives with different attributes. GROW could, for instance, have the attributes price, sound, smell and visual style. By varying the attributes of different levels, one can create different product options. One option could, for instance, be to have GROW with a price of €1000, music from Deezer, smells from Bonneton (a perfumer) and a low-poly style. A second option could be having GROW with a price from €1500, music from Deezer, smells from Kurjian and a high-poly style. By having customers pick between several options can help to determine which attributes customers value the most and which levels they prefer. As executing a conjoint analysis can take a lot of time, it will be executed in case there is time left after tasks with a higher priority. One of these tasks is the development of a high-fi prototype, which could also be used to illustrate the different product options.

Variable name (attributes)	Value label (attribute levels)
Price	€1000, €1500
Sound	Youtube Music, Deezer
Smell	Bonneton, Kurdjian
Visual Style	Low-poly, High-poly

Table 8: Example of variables and corresponding attributes that can be used to create different product options.

Cost-based pricing

Before conducting a conjoint analysis, cost-based pricing should be applied in order to determine the minimum price which should be set. Based on this price, different prices can be set which can be used as

different levels for the conjoint analysis' price attribute. When applying cost-based pricing, one can make a distinction between variable costs and fixed costs (see Table 9). However, most fixed costs can also be viewed as semi-variable costs, which is actually a mix of variable and fixed costs. It means that "costs are fixed for a set level of production or consumption and become variable after this production level is exceeded"

One example of semi-variable costs is that of maintaining a partnership with game developers. This is due to the fact that one may need to ask them for extra services when GROW becomes more successful. In this situation, new updates would require new software developments, which in return cost more money. For convenience purposes, all of the semi-variable costs were however considered to be fixed costs by solely looking at the first year of launch.

Physical product

For estimating unit-costs, one can use the following formula:

$$\text{Minimal unit cost*} = \text{Variable costs} + \frac{Fixed\ costs}{Maximum\ unit\ sales}$$

$$= \text{€}355{,}00 + \frac{\text{€}308786{,}90}{17205} = \text{€}355 + \text{€}17{,}95 = \text{€}372{,}95.$$

From this calculation, we find the estimated minimal unit cost of GROW. The values used for this calculation are however partly based on assumptions and could, therefore, be validated in order to make a better estimation. Moreover, the fixed costs do not include costs for logistics, maintaining partner dealerships and factory rent as they cannot be determined without detailed knowledge of BMW's production practices.

Variable	Value	Explanation
Components Variable Cost		
Materials projection device.	€90,00	The price for the projection device's materials was based on the price of an existing small projection device of the brand Dieux [7], which costs €54,95. However, the price of GROW's projection device has been set higher as its made out of sustainable materials, that often have a higher price than regular ones.
Materials sound system (arranged by key partner).	€150,00	The set price was based on a professional speaker system's price of €129,00 by the brand MB Quart [9], which is suited for placing inside a BMW car.
Materials smell dispenser (arranged by key partner).	€115,00	The price was again based on the price of an existing product. In this case, it was based on the

		price of a smart home dispenser by the brand Moodo, costing €108,98 [8].
Total Variable Costs	€355,00	
Fixed costs		
Maintaining partnership app store	Apple Store: €89.34/year Google Play: €22.56/year	Both the Apple Store and Google Play charge different prices for launching an app. The Apple store charges $99/year, whereas Google Play charges a onetime fee of $25 [40]. As the app itself will be free, there are no extra costs involved (e.g. stores taking a percentage of the app income).
Maintaining partnership game developers	Apple: €36.145,00 Android: €40050,00	For the price of app development, we consider the GROW app to be launched in both the Apple Store and Google Play. For estimating the costs of launching the app, one can use the Estimate My App feature from OOZOU [56]. For two medium apps, an estimation* was made (see Figure 38). *For the estimation, we assumed the following app characteristics: Medium-sized, polished UI, Email Signup, User Profiles, App Icon Design, Cloud Syncing, Device Sensor Data, Social Sharing, Forums or Commenting, Push Notifications, User Analytics, Two Factor Authentication, and Connection to one or more third-party services.
Maintaining partnership dealership	Unknown	Unknown
Marketing costs	€97480	It is hard to estimate marketing costs, as it is still unclear which marketing channels will actually be used and what they all will costs. However, one could try to make a rough estimation by using the following rule of thumb:

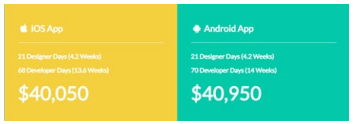


Figure 29: Price estimation app development.

		Total Revenue x 10% = Marketing budget required to grow and gain market share [34]. In 2018, BMW's estimated total revenue included € 97.480.000.000,00 [6]. We, for now, assume that 0,001% of their marketing budget is used for advertising GROW. $\frac{€97.480.000.000,00}{100000}$ x 0,10= €97480
Hiring personnel	€135000,00/year	One could assume BMW hires three full-time employees all being responsible for one of these three aspects: maintaining customer satisfaction, collaboration with key partners and the integration of GROW. One could also assume that they have a salary of €3770/month or €45.000/year [39]. This was based on the average salary of German employees working fulltime.
Rent/purchase factories (including machines)	Unknown	Unknown
Logistics	Unknown	Unknown

Table 9: Calculation cost-based pricing.

6. Defining and Ideating

A. FEEDBACK DESIGN PROFESSIONALS BMW

- Instead of a plant, you could also take care of a pet or a dog. It could like a modern Tamagotchi.
- You could not just apply your idea to green driving, but also to have real plants in your car.
- Your idea fits the personalization of a car's interior. This is especially important when sharing a car.
- You could also create your own perfect world inside your car and you could also use VR to achieve this.
- You can also have a personal assistant you need to take care of.
- What are the long aspects of playing the game? In the long term, you might actually change your driving style.

7. PROTOTYPING

A. MEASUREMENTS 3D-MODEL

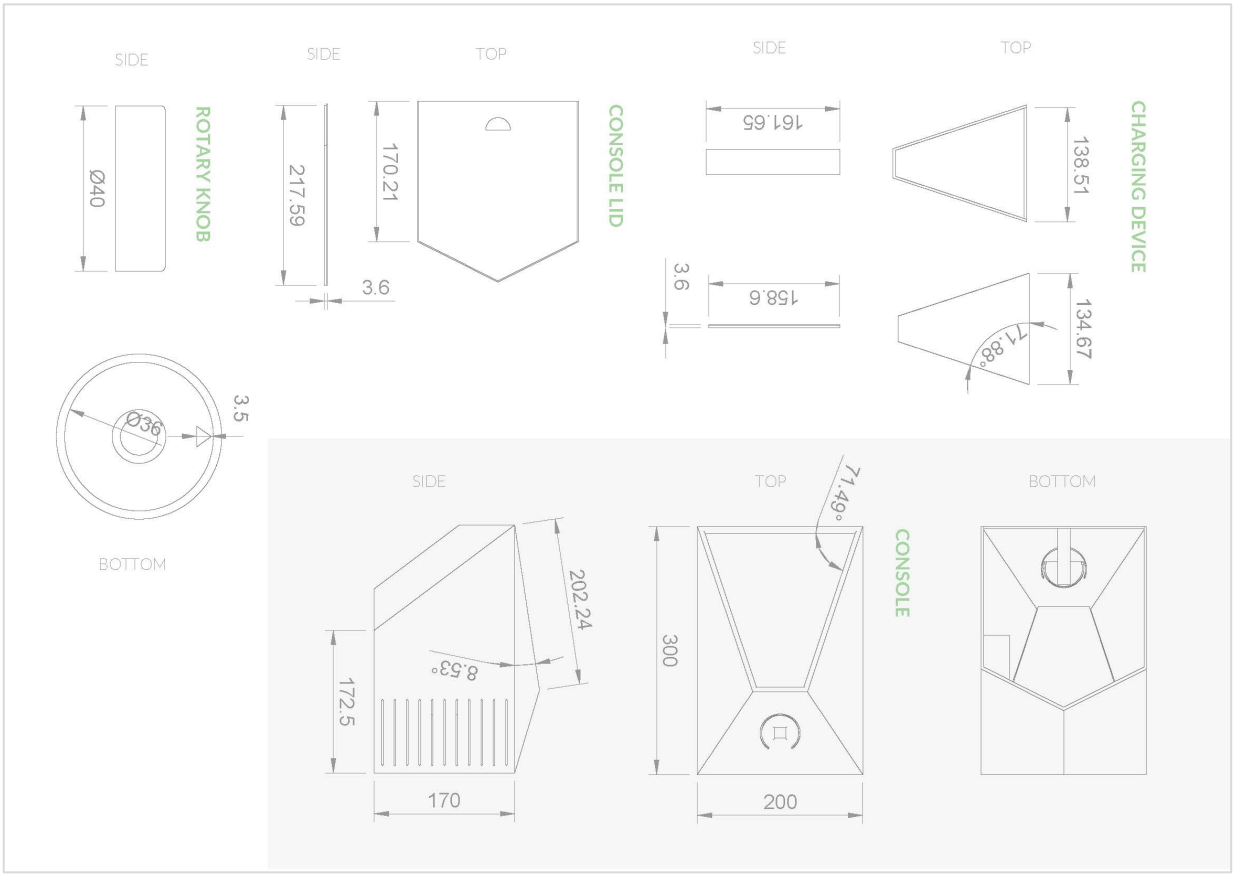


Figure 30: Measurements 3D-Model GROW (in mm).

B. ELECTRONICS

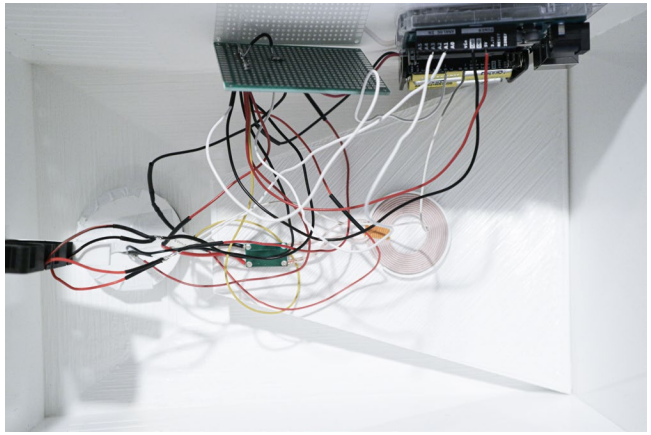


Figure 31: Placement of electronics inside console.

Circuit Calculations

1. LED ring, Coil (Transmitter) and Potentiometer

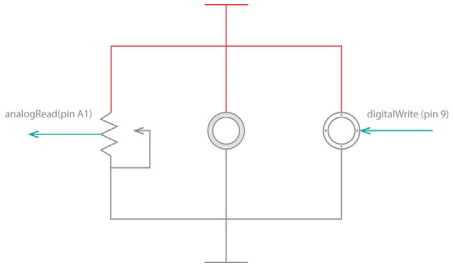


Figure 32: From left to right: circuit potentiometer, coil and LED ring.

1. Potentiometer (Model Alps RK09K1130C17)

R_{max} = 10 kΩ (given)
U = U_{source} = 5V (parallel)
I_{max} = U/R = 5V/10^3 Ω = 5*10^{-3} A

2. LED ring (SK6812 Digital 5050 RGB LED)

I = 12*10^{-6} A (given)
U = U_{source} = 5V
R = U/I = 5V/(12*10^{-6}) A = 42* 10^4 Ω

3. Coil

I = 1 A (given)
U = U_{source} = 5V
R = U/I = 5V/1 A = 5 Ω

4. Source

I = I_{pot} + I_{LED} + I_{coil} = 5*10^{-3} A + 12*10^{-6} A + 1 A = 1 A
U = 5V
$R_{total\ circuit}$ = U/I = 5V/(5*10^{-3}) A = 10^3 Ω

2. Coils

Figure 33: From left to right: Transmitter coil and receiver coil.

1. Resistor

I = I_{LED} = 20*10^{-3} A

R = 330 Ω
U = U_{source} - U_{LED} = 5V- 1,6V = 3,4V

2. Blue LED

I = $20*10^{-3}$ A (given)
U = 1,6 V
R = U/I = 1,6V/($20*10^{-3}$) A

Calculation U

R = (U_{source} - U_{LED})/I_{LED}
330 = (5V - U_{LED})/ $20*10^{-3}$ A
330($20*10^{-3}$) = 5-U_{LED}
6,6 = 5 - U_{LED}

3. Fans

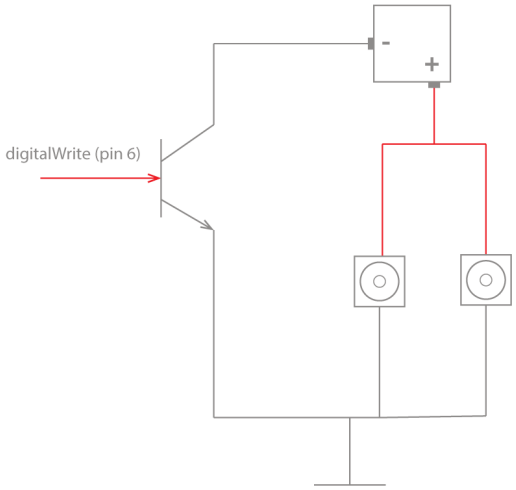


Figure 33: From top to bottom: Battery (4,5V) and fans.

1. Fans (Model RPIFAN3X3)

I = 0,2 A (given)U = U_{source} = 4,5 V
R = U/I = 4,5V/0,2A = 2,3*10 Ω

2. Source

U = 4,5 VR = R_{fans} /2 = 1,2*10 Ω
I = 2* I_{fan} = 0,4 Ω (given)

C. CODE
After personal requests, GROW's code can be accessed via GitHub: https://github.com/

8. User testing

A. QUESTIONS

Game-specific Rewards

- If you were to design GROW, what incentive would you then add to promote ride-sharing?
- What appeals most to you: being able to share plants with each other as a reward for ride-sharing or the social aspect of talking about your (good) sustainable behavior?
- If you were to talk about your plants in relation to sustainable behavior, how would you then talk about these plants?

Route choice

- If you were to design GROW, what incentive would you then add to promote picking a sustainable route?
- Which one of GROW's incentives do you prefer: bees or bonus plants?

General electricity usage

- If you were to design GROW, what incentive would you then add to promote using less electricity?
- Do you think that there exists a logical connection between GROW's reward (extra pruning power and raindrops) and a driver's effort of using less electricity?

Decorative aspects

- The current visualization of plants is rather static, what kind of movements or visual elements would you add to make it more rewarding and interesting to look at?
- What do you like and dislike about the current representation of plants?

Miscellaneous

- In what categories would updates be most valuable to you? Think of rewards, plants, targets, and aesthetics.
- Do you envision GROW to be a short-term learning tool or a game that you would play over longer periods of time?

Wrap-up

- Is there anything that you would still like to mention?
- What did you like and dislike about this user test?

B. PLANNING

Time	**Activity**	**Probes**
xx:00 – xx:05	Introduction	Presentation indicating the interview's outline. Consent forms.
xx:05 – xx:15	Explanation GROW	GROW's prototype
xx:15 – xx:20	Game specific rewards: Ride sharing	Scenario of sharing plants with each other. Different plant visualizations matching different choices.
xx:20 - xx:25	Game specific rewards: Route choice	Scenario of having to pick between routes and giving them bonus plants and bees in return.
xx:25- xx:30	Game specific rewards: General electricity usage	Pruning game and representation raindrops.

xx:30 – xx:35	Decorative aspects	Visualization plants on windshield in driving context. Papers they can draw onto.
xx:35 – xx:40	Miscellaneous	-
xx:40 – xx:45	Wrap-up	-
Time	*Activity*	*Probes*
xx:00 – xx:05	Introduction	Presentation indicating the interview's outline. Consent forms.
xx:05 – xx:15	Explanation GROW	GROW's prototype
xx:15 – xx:20	Game specific rewards: Ride sharing	Scenario of sharing plants with each other. Different plant visualizations matching different choices.
xx:20 - xx:25	Game specific rewards: Route choice	Scenario of having to pick between routes and giving them bonus plants and bees in return.

Table 10: Planning user test.

C. INFORMED CONSENT

Gaming in Zelfrijdende Auto's: GROW

Vink alstublieft de juiste vakjes aan.

Deelname interview
Ik ben voldoende geïnformeerd over deze gebruikerstest (met als datum (xx/xx/2019) en ik begrijp wat deze test inhoudt. Ik ben in de gelegenheid gesteld vragen over deze test te stellen en mijn vragen zijn naar behoren beantwoord.

Ja	**Nee**

Ik geef mijn vrijwillige toestemming om aan deze gebruikerstest deel te nemen en ik begrijp dat ik kan weigeren vragen te beantwoorden of op verzoeken in te gaan. Ook begrijp ik dat ik me op elk moment zonder reden te geven uit de test terug kan terugtrekken.

Ja	**Nee**

Ik begrijp dat deelname aan de focus groep sessie het volgende inhoudt:

- Opnames: De sessie zal worden geanalyseerd met behulp van video opnames. Het onderzoek zelf zal worden gebruikt voor een designproject met als focus gaming in zelfrijdende auto's. Het project wordt uitgevoerd als onderdeel van de bachelor Industrial Design van de TU/e en heeft als opdrachtgever het automerk BMW.

- Sessie: Tijdens de sessie zullen deelnemers tijdens een gebruikerstest geïnterviewd worden en opdrachten krijgen die gerelateerd zijn aan een ontwikkeld design concept met de naam GROW. De sessie zal ongeveer 45 min. in beslag nemen. Aan deelname aan de sessie zijn geen directe risico's verbonden.
- Beloning: Als beloning voor deelname aan de sessie zal voor het ingaan van de sessie een kleine verassing aangeboden worden die te maken heeft met het gepresenteerde design concept.

Ja	Nee

Informatieverwerking

Ik begrijp dat de informatie die ik verstrek gebruikt zal worden voor een designproject en dat het doel van deze studie het valideren van een concept gerelateerd aan duurzaam gedrag en gaming m.b.t. zelfrijdende auto's inhoudt.

Ja	Nee

Ik begrijp dat de persoonlijke informatie die over mij verzameld kan worden en iets zegt over mijn identiteit (zoals mijn naam of woonplaats), niet gedeeld zal worden met derden buiten mijzelf. Het is wel mogelijk dat overige data (zoals vergregen via de uitgeschreven audio opnames) geanonimiseerd gedeeld worden indien het onderzoek in aanmerking komt voor publicatie.

Ja	Nee

Toekomstig gebruik en hergebruik van informatie door anderen

Ik geef toestemming de informatie die tijdens de sessie verzameld worden en die ik verstrek om gearchiveerd te worden in de beveiligde ICT infrastructuur van de TU/e.

Ja	Nee

Naam deelnemer

_____

Handtekening

_____

Datum

Ik heb de informatie over deze sessie voorgelezen aan de potentiele deelnemer en heb zo goed als mogelijk vastgesteld dat de deelnemer begrijpt waar deze zich vrijwillig voor aanmeldt.

Naam deelnemer

_____

Handtekening

_____

Datum

Contact gegevens voor verdere informatie over het onderzoek:

Designer: ----------

Supervisor: ----------

D. CODES

Participant 1

Lines	Code	Theme
4-5	Likes to unlock more plants	Updates
8-9	Prefers to get new plants and minigames	
15-16	Wants to talk about sustainable behavior	Overall concept - Sustainability
15-16	Likes GROW's competitive aspects	Overall concept
24-31	Likes growing plant as representation of sustainable choices.	
48-52	Thinks bees are good reward for picking the most sustainable route	Rewards – Route choice
57-58	Thinks route with most bees is most attractive if	
	difference between routes is 5 min	
61-65	Thinks people would always avoid the traffic jams even if the route is faster	
73	Thinks there is a logical connection between more time and raindrops as a reward for using less electricity	Rewards – Using less electricity
75-76	Doubts whether people will keep playing it	Long-term vs Short-term
76-78	Thinks of having extra puzzles as playing motivation	
87-88	Thinks updating goals is most important to keep playing	
92-94	Thinks GROW could be played multiple years if it would be more elaborate	
98-100	Likes to find a way to visit other people's "gardens"	Aesthetics - Miscellaneous
102-103	Wants to be able to pick new pots	Personalization pots
117-118	Likes to have soft sounds and small extra animations	Animations
123-124	Doesn't mind the moving road behind the plants	

127-128	Likes GROW's modern aesthetic	Modern Aesthetic

Table 11: Codes Participant 1.

Participant 2

Lines	Code	Theme
139-140	Likes the idea of sharing plants	Rewards - Car sharing
140-141	Thinks GROW can create awareness	
141-142	Thinks awareness is already some kind of reward	
142-143	Is unable to come up with new rewards for sharing a car	
149-150	Does not think bragging about sustainable behavior outweighs sharing plants	
157-161	Hopes others like the plants as well when telling about them	
163-166	Would be likely to ask for help if her plants would not look great	
172-174	Would usually be competitive and pick the route with the most bees	
175-176	Would pick the fastest route when in a hurry	
186	Prefers getting bees over bonus plants as a reward for picking a sustainable route	
191	Thinks extra time and raindrops are logical rewards for using less electricity	
193-195	Thinks 4 min. is too long for completing the pruning game	
198-201	Believes the games simplicity might also be its strength	
206	Thinks the game's aesthetic is pretty	
2017-208	Would want to add achievements	
209-210	Would like to attract different insects	
211-212	Would like the game to become more difficult over time	
217-223	Thinks GROW as a tool for awareness is short-term	
225	Thinks GROW as entertainment could be long-term	
230	Does not mind that the plants are static	
231-232	Likes to personalize the pots	
233-234	Likes it to stay minimalistic	
240-243	Wants to name the plants to feel more connected	Miscellaneous

250-251	Thinks that car usage is hard to avoid and therefore wants to do it as sustainable as possible	
254-255	Thinks GROW could motivate many people to make changes	
257-258	Thinks the phone interaction could be improved	

Table 12: Codes Participant 2.

Participant 3

Lines	Code	Theme
263-264	Is unable to come up with new rewards for car sharing	
267-268	Thinks sharing plants also leads to talking about the game	
276-277	Would show her plants to explain the sustainable choices she made	
288	Would pick the route with most bees if the difference is fifteen min.	
289	Would pick the shortest routes if the difference is one hour.	
293-294	Thinks bees are a more important route award than extra plants	
303-304	Thinks rewards for using less electricity are logical	
310	Would not add anything to the current plant visualization	
310 + 315-317	Thinks the current plant visualization is clear	
322-323	Would like to have extra minigames when out of motivation	
329-330	Envisions GROW to be a long-term game if there would be more minigames	
333-335	Thinks it mandatory play would be fine to create more awareness	

Table 13: Codes Participant 3.

Participant 4

Lines	Code	Theme
363-364	Cannot think of another reward for carsharing	
368-369	Thinks bragging about plants would motivate people to play the game	
384-387	Would like to see the plant's progress over time	
401-404	Thinks route choice depends on how motivated you are to play	
401-404	Thinks about how to determine the route's sustainability score	
411	Believes bees are a more important reward than bonus plants.	

411-415	Believes multiple rewards for the same thing might be unclear.	
422	Thinks the rewards for using less electricity are logical	
422	Questions how using the air-conditioning gets rewarded	
436-437	Thinks adding more visuals or animation would make it too crowded	
444-445	Thinks of having a different representation than plants	
463-470	Thinks GROW is more of a short-term learning goal	

Table 14: Codes Participant 4.

Participant 5

Lines	Code	Theme
483	Is not able to come up with a new reward for carsharing	
368-369	Thinks bragging about plants would motivate people to play the game	
486	Thinks talking about sustainable behavior is interesting	
492-494	Would give plants as evidence of sustainable choices	
499-500	Would always pick the fastest route, regardless of bees	
508-509	Would like to have other rewards than just bees to make picking the most sustainable route more attractive	
517	Prefers bonus plants over bees because of variation	
523	Thinks the rewards for using less electricity are logical	
529-530 + 532	Mentions air-conditioning is necessary when having car sickness	
541-544	Would not want extra animations and visuals if it would use more electricity	
548-550	Likes plants to move with the car's speed	
553-555	Likes to have projections on every window	
561	Would like to personalize own pots	
568-569	Likes to have special plants matching the season	
575-577	Would add more minigames that become harder over time	
582	Thinks GROW could be a long-term game if it would be more elaborate	
588	Thinks the overall concept is very cool	
593	Thinks the app's font is too small	

Table 13: Codes Participant 5.

Participant 6

Lines	Code	Theme
599-602	Would like to have a reward other than sharing plants when being with the same people	
617-620	Would use game's terminology when talking about sustainability	
622-623	Would talk about plants' changed aesthetics when talking about sustainable choices	
630-634	Would usually pick fastest route	
637-639	Does not think driving fifteen min. extra is worth the amount of bees	
642-648	Would like to have an overview of saved money and energy to become more motivated	
655	Prefers bees over bonus plants as a reward for picking a sustainable route.	
660-663	Doubts whether raindrops is a logical reward for charging less devices.	
667	Would like the plants to move in the wind	
668-669	Would like to see how other players play the game.	
684	Likes the current representation of plants.	
703-704	Is not able to say whether the game is long-term or short-term	

Table 14: Codes Participant 6.

E. CONCLUSIONS

Long-term vs Short-term

Motivation to play

Route choice

Bees are the most preferable reward (over receiving extra plants) and are perceived as logical.

Supported by 5 codes from 5 participants.

The fastest route may still be preferred, especially when in a hurry.

Supported by 2 codes from 2 participants.

General electricity usage

The rewards for using less electricity are perceived to be logical, maybe raindrops can be more linked to charging devices.

Supported by 4 codes from 4 participants.

Car sharing

The rewards for car-sharing are fine, maybe one could still think of the scenario in which people always share the car with the same ones.

Supported by 3 codes from 2 participants.

Updates

Participants liked the idea of extra minigames that get more difficult over time.

Supported by 5 codes from 3 participants.

Aesthetics

Personalizing pots was found to be a valuable extra feature.

Supported by 3 codes from 3 participants.

Participants liked GROW's minimalistic approach: they found it modern and clear

Supported by 6 codes from 6 participants.

Many participants did not prefer many added visuals, sounds and animations.

Supported by 6 codes from 6 participants.

Overall concept

Participants can talk about plants as a metaphor for sustainable behavior.

Supported by 6 codes from 6 participants.

The overall concept appeals.

Supported by 3 codes from 3 participants.

Considerations

All considerations were supported by one code but were nevertheless important to keep in mind.

- Size of the app font might be too small
- New animations might use more electricity
- There might need to be extra statistics, showing a player's progress over time.
- Routes: an overview of actual saved energy and money
- Improvement phone interaction