

Going Electric

Switching to an Electric Vehicle with the Help of a Mobile Application

Axel Friberg

DEPARTMENT OF DESIGN SCIENCES
FACULTY OF ENGINEERING LTH | LUND UNIVERSITY
2017

MASTER THESIS



Going Electric

Switching to an Electric Vehicle with
the Help of a Mobile Application

Axel Friberg

Computer Science Student



LUND
UNIVERSITY

Going Electric

Switching to an Electric Vehicle with the Help of a Mobile Application

Copyright © 2017 Axel Friberg

Published by

Department of Design Sciences
Faculty of Engineering LTH, Lund University
P.O. Box 118, SE-221 00 Lund, Sweden

Subject: Interaction Design (MAMM01)
Division: Certec, Division of Rehabilitation Engineering Research
Supervisor: Kirsten Rasmus-Gröhn
Co-supervisor: Héctor Caltenco
Examiner: Johanna Persson

Abstract

Global warming is one of the biggest threats to our planet and humanity today. Electric vehicles (EV) can prove to be a great help in combating this threat. However, the adoption rate of EVs is still quite slow. The main goal of this thesis is to design a smartphone application using a human-centred design (HCD) process that aims to help people with switching to an EV.

The project followed a classic HCD approach with the end user being included throughout the entire design process. Methods such as interviews, surveys, prototyping, user tests etc. were used to include them. The creation of the prototypes took into consideration tried and true design principles such as the Seven Fundamental Design Principles by Don Norman.

The result was a hi-fi prototype implemented in code for the Android operating system. The app can:

Record a journey to see if the user exceeds the range of EVs. Show how much less CO₂ would be released and how much money would be saved by switching to an EV. Show a map of charging stations. Show a list of EVs, allowing the user to find one that fits their needs. Show a list of facts about EVs the user might not know.

User feedback indicated that an app like this could be valuable in their decision on switching to an EV. Further research on the topic with a longer project time could be helpful in making sure you are meeting the user's needs.

Keywords: electric vehicle, human centred design, interaction design, smartphone app, UX design

Sammanfattning

Den globala uppvärmningen är ett av de största hot mot vår planet och mänsklighet idag. Elektriska fordon (EF) kan visa sig vara en stor hjälp för att bekämpa detta hot. Antagningsgraden av elektriska och elektroniska komponenter är dock fortfarande ganska långsam. Huvudmålet med denna avhandling är att designa en smartphoneapplikation med en användarcentrerad designprocess (ACD) som syftar till att hjälpa människor att byta till ett EF.

Projektet följde en klassisk ACD-strategi där slutanvändaren inkluderades i hela designprocessen. Metoder som intervjuer, undersökningar, prototyper, användartest etc. användes för att inkludera dem. Skapandet av prototyperna använde sig av beprövade och välanvända designprinciper, såsom de sju grundläggande principerna för design av Don Norman.

Resultatet blev en hi-fi-prototyp som implementerades i kod för Android-operativsystemet. Appen kan:

Registrera en resa för att se om användaren överstiger EF-räckvidden. Visa hur mycket mindre CO₂ skulle släppas ut och hur mycket pengar som skulle sparas genom att byta till ett EF. Visa en karta över laddstationer. Visa en lista med EF, så att användaren kan hitta ett som passar deras behov. Visa en lista med fakta om EF som användaren kanske inte vet.

Användarens återkoppling visade att en app som denna kan vara värdefull i deras beslut att byta till ett EF. Ytterligare forskning om ämnet med längre projekttid kan vara till hjälp för att se till att du möter användarens behov.

Nyckelord: elektriskt fordon, användarcentrerad design, interaktionsdesign, smartphone app, UX design

Preface

I've always had an interest in environmental questions and had the desire to make use of my technical knowledge to help mankind in one way or another. Which is why it has been a pleasure to work on this thesis. Global warming is one of humanities biggest threats and electric vehicles can be a big step in the right direction in the fight against global warming. Which is why we need to help people with the switch to electric vehicles, to make the switch happen faster.

I would like to thank Thomas Koch at Sirgomez Engineering AB for requesting this thesis and for his work in making an affordable electric car that could help with eliminating many of the unnecessary short trips made by fossil fuel vehicles every day. Many thanks to Kirsten Rasmus-Gröhn and Héctor Caltenco for being supervisors. To Johanna Persson for being the examiner. And to Sofia Felding for opposing the thesis.

Lund, September 2017

Axel Friberg

Table of contents

1 Introduction	9
1.1 Background for The Project	9
1.2 Thesis Goals	9
1.3 Thesis Statement	10
1.4 Delimitations	10
2 Theoretical Background	11
2.1 Human-Centred Design	11
2.2 Interviews	12
2.3 The Seven Stages of Action: Seven Fundamental Design Principles	13
2.4 Intention to Switch to Electric Cars	15
2.5 Information Visualization	15
2.5.1 Continuum of Understanding	15
2.5.2 Why Present Data as Diagrams?	16
2.5.3 How to Make Good Visualizations	16
2.5.4 Eight Rules of Thumb	17
3 Methodology	19
3.1 Interviews	19
3.2 Questionnaires	20
3.3 Affinity Diagramming	20
3.4 Scenarios and Storyboards	21
3.5 Prototype Driven Development	22
3.5.1 Mid-Fi Prototype	22
3.5.2 Hi-Fi Prototype	23
3.6 Evaluation	23
4 Results	24

4.1 Interviews	24
4.2 Questionnaires	27
4.3 Storyboard	28
4.4 Mid-fi Prototype	28
4.5 Hi-fi Prototype	32
4.6 Evaluation	35
5 Discussion	37
5.1 Interviews	37
5.2 Questionnaires	37
5.3 Affinity Diagram	38
5.4 Storyboard	38
5.5 Mid-fi Prototype	39
5.6 Hi-fi Prototype	40
5.7 Evaluation	41
6 Conclusion	42
References	43
Appendix A Interview Questions	44
Appendix B Questionnaire	46
Appendix C Mid-fi Prototype Test Scenarios	52
Appendix D Hi-fi Prototype Survey	53

1 Introduction

This chapter provides the background for the project and states thesis goals, statement and delimitations.

1.1 Background for The Project

The one-man company Sirgomez Engineering AB is currently developing a project called Ecoist. The goal of the project is to develop and build two prototypes of a three-wheeled vehicle powered by electricity. The goal is that the vehicle will carry one person and around 10-20kg of baggage (such as a grocery bag, laptop, lunch box) to and from work and other shorter trips. The range is intended to be 50-80 km on one charge. The vehicle aims at keeping a top speed of 90 km/h, be MC classified and weigh under 300kg. It will have pedals, a chair, belt and steering wheel to make the transition for car drivers smoother.

For the car owner to decide if it is possible to change to Ecoist or another electric vehicle it is important for them to get information about their driving behaviour. The thesis proposed by the company was to develop a smart phone application to gather data about the users driving behaviour and then present this graphically. Some initial ideas from the company about what could be gathered was time, GPS-coordinates, mileage, speed etc.

The initial version of the app should be developed as a general tool for people to decide if they can switch to an electric vehicle and not specifically Ecoist.

1.2 Thesis Goals

- Investigate what the main obstacles are for people to get an electric vehicle.
- Design a smart phone application that has high usability using a human-centred design (HCD) process that can help a user overcome these obstacles and determine if an electric vehicle suits their needs.

1.3 Thesis Statement

Using a smartphone app, it is possible to help vehicle owners to become convinced they can switch to an electric vehicle.

1.4 Delimitations

The thesis will consist of 20 weeks of full time work (40-hour weeks). In that time, a smartphone app for the Android operating system will be developed. The design methods chosen will primarily be the ones deemed to fit the time frame and that works well with one-person projects. The users chosen for user tests will be middle aged, middle class people with a full-time work that currently owns one or more vehicles. This is because these are the ones that are deemed to be the target group of the finished app. The target group was decided upon with the help of the company that gave the thesis assignment.

2 Theoretical Background

This chapter gives an overview of the theories used in the project. It covers design principles as well as methods to investigate the userbase.

A *literature review* is the corner stone in any form of academic paper, and it lies as the basis for this theoretical section. It can also prove to be quite useful in design projects. The goal is to give your project a foundation to stand on. A foundation that is based on previous research. The main goal in selecting literature is that it should be relevant to the project [1]. Having this goal in mind literature was chosen from a few topics deemed relevant to the design process. These areas were:

- People's willingness to switch from a FV to an EV.
- Interaction Design.
- HCD.
- Information visualization.

The books and papers used for the literature review can be found in the References section.

2.1 Human-Centred Design

Human-centred Design (HCD) is an approach to design that puts the human needs, capabilities, and behaviours first and then designs to meet those needs, capabilities, and behaviours [2]. The main reason for conducting a HCD process is that it is when the actual user uses the product out in the real world is when the value is created. If you do not design with the end user in mind, there is a risk that the user might not ever use your product and all that money and time is wasted. ISO 9241-210 defines HCD as an iterative process where the user is always in focus [3]. The iterations are constantly evaluated by users to see that the designs meet their needs and desires. They are a part of the entire design process.

In his book on user experience design (UX) Mattias Arvola [4] splits the design process into three phases. The *conceptual design phase*, where you explore what the desires are of the stakeholders in the project. This lays the foundation for the project. You conduct observations, field studies, information collection etc. All of this should be analysed and evaluated with the help of concept sketches. When the team knows what needs to be done they need to figure out how the product is supposed

to be shaped. This brings us to the *processing phase*. In the processing phase the designers work out an operative image of the product through sketching. When the overall concept is done, the project moves into the *detail phase*. Here the details of how the product will work is figured out with the help of prototypes, detail plans and specifications.

2.2 Interviews

When doing HCD a good way to start is to conduct *interviews*. This will give you an insight into the minds of the people that will be using your product in the end. What their hopes, dreams and fears might be. The main difficulty in doing interviews the right way is to formulate your questions properly. People perceive things in different ways based on several factors such as age, education, country of residence etc. It is therefore very important to do your best to formulate questions that are perceived in the same way by as many different people as possible. Worst case scenario is that you cannot use your data from the interviews because the interviewees answered different questions so to speak [5].

The administrative agency Statistics Sweden have written some guidelines [5] for formulating good interview questions. They have chosen to point out what *not* to do when writing questions. This approach is easier since how you *should* formulate your questions entirely depends on what you want to get out of the interview. Some of the guidelines I followed in this project were the following (taken from Statistics Sweden [5]):

1. **Time and space (when and where)**
 - If you are asking someone about a task they are doing in their daily lives but do not specify a time then the person might respond differently than they would otherwise. Do you go jogging two days a week? Instead of: Do you jog?
2. **Unclear questions and answers**
 - How often did you go jogging last year? Never, sparsely, sometimes, all the time. Answers like “sometimes” can mean very different things for different people. It could mean once a week or once a month.
3. **You do not have the same experiences as the person answering**
 - Have you gone on any long jogging trips the past week? For a person who do not normally run a long run might be 3 kilometres. For a marathon runner, it might be 20 kilometres.
4. **Multiple questions in one**
 - If you have a question that assumes the person has done A and asks about B as a follow up to that, separate the questions in two questions to check if the person has done A. So, the right persons answer the question about B.

5. **Yes/No questions on attitudes and values**
 - Having these simple answers on complex matters such as values you might miss out on valuable information. People might also think it is easier to just agree with the question posed than go against it.
6. **Leading questions and strong words**
 - Having questions that lead the person to answer in a certain way. You might also affect the person in the same way by having strong words in the question.

To give the reader an idea of how I formulated my questions they are attached as an appendix (the questions are in Swedish), see Appendix A .

There are three different ways in how you can structure an interview, namely having it *structured*, *semi structured* or *unstructured* [6].

In a structured interview, the researcher has very strong control over how the interviewed is carried out. It is quite like a questionnaire in a way since the researcher uses a set of predetermined questions and the interviewee is given a set number of options when answering. This makes it very standardized and is useful in large scale projects.

When conducting a semi structured interview, the researcher still has a predetermined set of questions and topics. However, in this format the researcher is more flexible when it comes to the order of the questions and gives open questions that allow the interviewee to develop their thoughts and ideas.

The unstructured interview takes this a step further and the roll of the interviewer is simply to get the conversation going by introducing a topic or theme but then take a bit more of backseat roll. This allows the interviewees to develop their own thoughts and opinions rather than letting the discussion be shaped by a pre-determined set of questions.

When it comes to semi structured and unstructured interviews the interviewer is free to change the questions in between different interviews in order to, for example, investigate a new research track.

2.3 The Seven Stages of Action: Seven Fundamental Design Principles

In the classical design book “The Design of Everyday Things” Don Norman explains the seven stages of action. This in turn gives us *seven fundamental design principles* [2]. The seven stages provide a basic checklist of questions for the person using the product to ask:

1. What do I want to accomplish?

2. What are the alternative action sequences?
3. What action can I do now?
4. How do I do it?
5. What happened?
6. What does it mean?
7. Is this okay? Have I accomplished my goal?

According to Norman anyone using a product should be able to determine the answers to all seven questions. This means that the design must make a product that provides all the necessary information to answer the questions at each stage of the action. To accomplish this providing *feedback* and *feedforward* is very important [2]. Feedback is providing information on what happened when you have performed an action. Feedforward is showing the user what is possible to do, what the next execution might be. This brings us to the seven fundamentals of design (taken from Normans book [2]):

1. **Discoverability**
- You can determine what the possible actions are and what the current state of the product is.
2. **Feedback**
- You provide information on what happened after an action carried out by the user and what the new state is.
3. **Conceptual Model**
- The design gives the user the ability to form a conceptual model on how the system works. It does not need to be connected to real inner workings of the system.
4. **Affordances**
- The system has clear affordances, which define what actions are possible. Is more relevant when it comes to physical objects.
5. **Signifiers**
- Signifiers communicate where the action should take place. The system has signifiers that ensures discoverability and provides clear feedback. Very important when it comes to virtual systems.
6. **Mappings**
- Making the relationship between controls and actions follow good mapping.
7. **Constraints**
- Providing different constraints to guide the actions of the user.

An important distinction to make between affordances and signifiers is that affordances define what actions are possible such as a chair provides support and there for the chair affords sitting on. While a sign on the chair might indicate where to sit, this is a signifier [2].

2.4 Intention to Switch to Electric Cars

Previous studies [7, 8] that has been done on people's hesitance on switching to electric vehicles (EV) found the following factors that hinder people from switching:

1. The initial cost of buying an EV is much more expensive than buying a fossil-fuelled vehicle (FV).
2. The consumers are unsure about what the second-hand value of the vehicle would be.
3. Fear of the range not being enough.
4. There not being enough quick-charging stations along the roads.
5. On a lot of the current EVs there is not an option to have a tow hitch.
6. There is a lack of knowledge among consumers about EVs.
7. There is a concern about the environment aspect since the environmental impact from the production of an EV is usually much greater than that of an FV.

There also seems to be a difference in how the consumers are that purchase EV vs FV. EV owners proved to be more open to change, less conservative, showed a higher problem awareness, self-efficacy, and a stronger personal norm [8].

2.5 Information Visualization

The term *information visualization* was coined by the researchers of Xerox PARC at the end of the 1980's to distinguish a new discipline concerned with the creation of visual artefacts aimed at amplifying cognition [9]. When creating visualizations of data, it is important to go to great lengths of making the data easy to understand so the stakeholders can take part of the knowledge given. This is project focuses on displaying information to the user about their driving behaviour, so they can make an informed decision about if they can switch to an EV. Therefore, an understanding about information visualization is important in order to present data in a way that is easy for the user to understand.

2.5.1 Continuum of Understanding

In Ricardo Mazza's book on information visualization he mentions Nathan Shedroff's process called the "continuum of understanding" [9] and it is described as the path of generating information from data. He describes it a four-step process consisting of:

1. Data

2. Information
3. Knowledge
4. Wisdom

Let us take a closer look at these individual parts and how they are defined in Mazza's book [9]:

Data are entities that don't have any meaning on their own. They allow us to build information. It can for example be the age of everyone working at a company. By itself it does not really mean anything.

To make data mean something it needs to be turned into *information*. This is done by processing, organizing and presenting the data in a suitable way. Communicating the context around it. If you take the data of the ages in the company and place it in a table and sort that table, you get information.

Given information and experience you can get *knowledge*. In the previous table, you can find out who the youngest person in the company is at a glance.

Wisdom is the highest level of comprehension. Wisdom is gained when you achieve such a high level of knowledge that you can make qualified judgement on data.

2.5.2 Why Present Data as Diagrams?

Diagrams are important for this project since showing statistics to the user about their driving behaviour is one of the main features of the application. There are three main qualities mentioned by Mazza [9] when it comes to representing data as diagrams instead of text that makes them often superior (see [9]):

- *Locality*. Since every data point has its own position in the space of the diagram they become easier to compare.
- *Minimizing labelling*. Humans are quite adapt at understanding visual information without the need of descriptive text to accompany the visualization.
- *Perceptual enhancement*. We can process a large number of perceptual inference via visual representations and then find relationships and dependencies in the information.

2.5.3 How to Make Good Visualizations

Mazza mentions four criteria for making good visualizations [9]:

- *Graphical excellence*. The representation should provide the beholder with the most ideas, in the shortest amount of time, using the least

amount of ink, in the smallest space. They should not just be a decorative tool.

- *Graphical integrity*. The visualization should in no way misrepresent or distort the data.
- *Maximize the Data-ink ratio*. The ink used in creating the representation should be as much as possible focused on the data and nothing else. Eliminate as much unnecessary elements as you can.
- *Aesthetics*. The complexity of the data should match the simplicity of the design. Complex details should be accessible and used to display data.

When it comes to interactions in information visualization Mazza brings up Ben Shneiderman's [9] mantra that goes as follows

“First, **overview**,
then, **zoom** and **filtering**,
finally, **details on demand**.”

This mantra gives an indication on how the system can support the user's search for information. First giving an overview gives context. Zoom and filter allows you to focus on specific parts. Lastly the details should be accessible if the user needs them [9].

2.5.4 Eight Rules of Thumb

In the book “Visualization analysis and design” by Tamara Munzner she explains eight rules of thumb for designing visual representations in the following way [10]:

No Unjustified 3D

Moving from 2D to 3D is something that requires justification. There are several costs related with having a view in 3D. Some of these are: The plane is quite powerful in comparing data and intuitive for most people, this is partly lost when it comes to 3D. Humans are very adept at perceiving distances in length but not as adept at perceiving depth. In 3D, you can get occlusion that hides information. Distant objects can appear smaller than they are as well as change their planar position. Tilted text becomes illegible.

The main benefit of 3D comes when it is fundamental to the task at hand to understand a three-dimensional shape or structure.

No Unjustified 2D

Similarly, to how you must justify 3D, 2D also needs to be justified. There is no point in using 2D if a simple 1D list is enough. Lists have several

benefits such as being able to show a great deal of information in a small space and being great at lookup tasks.

Eyes Beat Memory

Using our eyes to compare information that is side by side requires a much lower cognitive load than consulting our memory.

Resolution over Immersion

If you need to make a trade-off between resolution (the number of pixels on a screen) and immersion (the feeling of presence in virtual reality, resolution is almost always more important.

Overview First, Zoom and Filter, Details on Demand

Follow the Shneiderman mantra of Overview First, Zoom and Filter, Details on demand. See section 2.5.3.

Responsiveness Is Required

The system needs to be responsive to be useful.

Get It Right in Black and White

A guideline for effective use of colour, the most critical parts of the representation should be understandable even if it is printed in black and white.

Function First, Form Next

Given an ugly but effective design it is most likely possible to refine it to make it more appealing to look at. However, having a pretty but inefficient design you will probably need to toss it out and start over.

3 Methodology

In this section, an overview of the methods used for the project is given along with an explanation of how they were carried out. The methods were carried out in the following order:

1. *Interviews*
2. *Questionnaires*
3. *Storyboard*
4. *Mid-fi prototype*
5. *Hi-fi prototype*

3.1 Interviews

Five interviews were carried out in total and they were aimed at being no more than 15 minutes in length. The interviews were structured in a semi-structured way and were conducted as one on one interviews between me and the interviewee. The only restriction in the selection of interviewees were that they needed to have at least one car in the household. The interviewee was told that the interview was about their driving habits, but not specifically about their views on electric cars. If the interviewee agreed to have the interview recorded the interview was recorded using a Dictaphone. The primary reason for this was so I could focus on listening to the interviewee and not having to focus on writing down notes. The recordings were played back and not fully transcribed, but the most important bits of information were written down and later used in an affinity diagram.

Some examples of what questions that were asked during the interview and why they were asked:

What has stopped you from getting an electric vehicle?

- To find out the biggest hurdles to overcome in the decision on getting an electric vehicle. Helped determine the focus of the app.

Can you tell me about your driving habits (such as how often you drive, common destinations etc.)?

- This was to find out the most common use cases for people's vehicles. It is useful to know their current uses for a vehicle when trying to help motivate a switch to an electric one.

Interviews are often used a supplement to other data gathering methods, to humanize the data [1]. For this project, I also choose to do a quantitative data collection in the form of a questionnaire (see section 3.2). This was done to check the results from the various methods against each other to see if they lined up. If multiple methods lead to the same results you can be more confident in the results you have received.

3.2 Questionnaires

Questionnaires are a form of survey instrument [1] used for collecting self-reporting information from people about their views, thoughts, attitudes, etc. I choose to do mine using the online form tool provided for free by Google [11]. In forming the questions, I followed the guidelines in section 2.2. The questionnaires were distributed in two different ways; through email and the Ecoist Facebook page. Since the questionnaires were made publicly available there was no way to check that the people that answered filled some sort of criteria. It was however written at the beginning of the form that the person answering should have a vehicle.

Two questionnaires were created, one in Swedish and one in English. The reason for this is that when I had already sent out the Swedish survey the company behind the thesis requested that I sent out an English version. Since the Swedish one had already received responses I did not want to remove that one. Hence there are two versions. They both contained the same questions. The Swedish one had 36 responses and the English one 69 so a total of 105 responses.

The English survey have been attached as Appendix B.

3.3 Affinity Diagramming

Affinity diagramming is a way to process qualitative data to categorize and thematise the data collected from e.g. interviews [4]. The idea is to bring order to unstructured data and give clarity about the users and stakeholders, about their will and desires. The team writes down all their observations on sticky notes and then posts them all on a wall. All the team members then proceed to move the notes around and placing notes they find to fit the same category together. When everyone is satisfied with the categorization a name is given to each category [1].

Since this thesis was performed by me alone I alone wrote down key observations from the interviews on post-it notes and put them up on a whiteboard. The notes were then clustered according to how I deemed them belong together and finally the clusters were given a named category.

3.4 Scenarios and Storyboards

Personas are a way of putting a face to the data you have collected [1, 4]. You gather up the data and make a description of a fictive person out of it. Complete with a name and a picture. This humanizes the potential users and gives the team a common ground of who to develop for. It helps to expand the design empathy. If you do not make a persona the end user might be too abstract and the team members all have their own idea of who the user is. It is common practice to make 3-5 personas for a project since the user base usually consists of multiple different users. This ensures that the focus is not too narrow. A persona was created but later discarded due to low quality and lack of use.

If you want to bring personas to life even more you can use *scenarios*. They are a form of story that take place in a day in the user's life. They can either be entirely in text or in the form of pictures. If pictures are used it is called a *storyboard* [4]. They should always have the perspective of a persona [1].

Scenarios can be used in two different ways, either to describe the current situation of the user or the future where the user is using the intended product [1, 4]. Scenarios and storyboards are good at making sure the team can empathetically envision the future of how the intended product will be used [1].

When creating a storyboard there are five design practices common to storytelling that can be used (see [1]):

1. **Degree of artistic or photo-realistic detail:** The storyboard should be realistic enough to get the message across but not so filled with details so it distracts from what is important.
2. **Text-based narration or explanations:** You should use text to complement the images when something would take too much effort or simply be impossible to illustrate using images.
3. **Emphasis on people, products, or both:** To get an emotional response from the audience the focus should be on the people involved. If the storyboard is used in a more technical context it should focus more on the product.
4. **The right number of storyboard panels:** Three to six panels should be enough to get the idea across. They should be focused on one concept. If more than one concept need to be conveyed, consider using multiple storyboards.

5. **Depicting the passage of time:** To convey large passages of time in the story, this should be made clear using things like clocks, calendars, movement of the sun etc.

My storyboard was created using pen and paper. The drawing was scanned and text was later added with the help of a computer. The storyboard focused on the intended future use case of the application.

In the creation of the storyboard the five design practices explained in section 3.4 were followed. Stick figures were chosen to put the focus on the functionality of the app and not so much the artistic details (but also since I cannot draw any better). It still gets the message across. Text was used in certain spots to help with the storytelling. Three to six panels are recommended to have in a storyboard to get the message across but not be overwhelming, therefore four was deemed to fit the story. The passage of time of a few days was portrayed with a textbox.

3.5 Prototype Driven Development

Prototyping is the act of creating tangible artefacts in order to develop and test different design ideas without having to make the finished product first [1]. The reason to work with prototypes is because it is nearly impossible at the start of the project know exactly what demands there might be on the product. New demands might arise when users get to interact and try out the product. Different design choices might affect the user differently [4]. Broadly you can divide prototypes into two different types; *Low-fidelity* (lo-fi) and *High-Fidelity* (hi-fi) prototypes. The lo-fi prototypes are usually done using paper and cardboard and are used for testing early design ideas and rapid iteration. Hi-fi prototypes are more refined and closer to what a finished product might look like [1]. They can for example be done with a digital prototyping tool to almost look and feel like a finished product without doing any actual implementation of features. In my case an in-between prototype, what I'm calling mid-fi prototype, was created instead of a lo-fi prototype.

3.5.1 Mid-Fi Prototype

The intended lo-fi prototype for this project turned into more of a mid-fi prototype so to say. What I mean by a mid-fi prototype is that it is partly made using pen and paper but presented on a smartphone with the help of a prototyping tool. I decided against making a lo-fi prototype using paper and directly made static views of the app in Adobe Illustrator, a vector graphics editor. The vector screens sometimes included hand drawn images to save time. The screens were then used in a prototyping tool called Marvel to give the user the ability to navigate through the prototype.

In the user tests the users were given a couple scenarios to perform, in order to find out areas of confusion and get feedback on the interaction and usability of the app. The scenarios are attached as Appendix C. The user tests were not videotaped or audio recorded.

The users selected for the tests were the same people that were interviewed.

3.5.2 Hi-Fi Prototype

I am a computer science student with some experience with app development. The goal was to have a somewhat finished app to give to the client that gave the master thesis assignment, therefore the hi-fi prototype was coded as a fully functioning Android app. With some of the functionality containing place holder data. A pretty big chunk of the time spent on the thesis was used for the coding of the app (about eight weeks). The prototype incorporated the user input from the questionnaires, interviews as well as the feedback from the mid-fi prototype. Because of time constraints the features in the app were somewhat limited in their capabilities.

3.6 Evaluation

A questionnaire was written to conduct a final user test. This is attached as Appendix D. The main idea behind the questionnaire was to find out sources of confusion in the app and where it had low or high usability. Not to focus too much on the features functionality. The app was published as an alpha test on the Play Store for users to download and give feedback. A link to the questionnaire was placed in the store page description. Requests for feedback was distributed in the same way as the questionnaires, via email and the Ecoist Facebook page. Unfortunately, no answers were received in time for when I had to gather up the results and finish the report.

4 Results

Here the results from the methods used in the project are gathered.

4.1 Interviews

Five interviews were conducted in total. The results from the interviews can be seen as the affinity diagram, seen below.



Figure 1 Affinity diagram based on interviews. The different coloured notes have no special meaning. The diagram is in Swedish.

When the grouping of notes was done (see Figure 1) the groups were given names or categories depending on what was written on the notes. Twelve different categories were constructed.

The environment (miljön) – EVs being better for the environment seems to be a key factor in people’s desire to switch to an EV.

Moves locally (rör sig lokalt) – Four out of five drivers only drive locally (around their home and to and from work). This means that most of their trips are less than

50km in total on a day to day basis. From time to time some longer trips are taken with the cars but this is done quite irregularly.

Cost (kostnad) – High initial cost is one of the reasons commonly cited for not getting an EV. However, the drivers also said that cheaper operating cost in terms of fuel is one of the main reasons to get an EV.

Driving pleasure/Tesla – Two drivers mentioned that they want “driving pleasure” and a car that is fun to drive with a lot of acceleration. A sporty car. There has been a lack of cars like this in the EV sector. Three drivers mentioned Tesla at some point during the interview as being a cool car that they would like to have but that it was too expensive.

Range (räckvidd) – The fear of the range of electric cars not being enough is a concern.

Data per trip (data per resa) – When asked what they want to know about their driving habits most said they already get the information about fuel consumption and how long of a distance they have driven from the car’s dashboard. However, three out of five people also said they would be interested in having the ability in seeing a log of individual trips. Since this is not possible in the car. Data could be how long they have driven and how much CO₂ they released.

Multiple cars (flera bilar) – Four out of five interviewees had two or more cars in the household.

Charging/batteries (laddning/batterier) – There is concern related to the charging of the EVs. The worry is in that there might not be enough charging stations and that the charging takes a long time. One desire was to have the batteries swappable so you do not have to charge them yourself.

Knowledge (kunskap) – Among the interviewees there was a lack of knowledge about EVs. The knowledge levels varied, some knowing a lot and some having next to no knowledge. The trend was, however, that there was a lack of knowledge in comparison with the knowledge of FV. Most of them had never tried an EV.

Storage (förvaring) – EVs are deemed to lack storage space.

Quiet (tysta) – The EVs are totally quiet.

Second hand market (andrahandsmarknad) – Interviewees wanted to buy they cars used, and there is a lack of EVs to buy second hand. There is also a worry of how the quality of the battery will be if you buy it used.

4.2 Questionnaires

105 responses (the Swedish one had 36 responses and the English one 69) to the surveys were received. The full results from the questionnaires are not included, but the most important facts and numbers are gathered here. The reason for the divide between the Swedish and English results are that the answers came in two separate tables in Google Forms. This makes it quite hard and cumbersome to merge the results. Different parts from the two surveys were interesting to point out, which is why the results don't have the same number of points below.

Swedish version:

- A majority has one car in the household.
- A majority drives every day of the week.
- 70% drives less than 50 km on an average day.
- 35% say they have little or no knowledge about electric cars.
- 6% has an electric car.
- The top three obstacles people see for getting an electric car are 1. High initial cost (80%) 2. Afraid the range will not be enough (44%) 3. Lack of charging stations (24%)
- 50% see the main reason for getting an electric car is that it is better for the environment.
- 50% have driven an electric car.
- 67% could see themselves having an electric car as an extra car.

English version:

- A majority has two cars in the household.
- A majority drives every day of the week.
- 72% drives less than 50 km on an average day.
- 25% say they have little or no knowledge about electric cars.
- 10% has an electric car.
- The top three obstacles people see for getting an electric car are 1. High initial cost (72%) 2. Afraid the range will not be enough (44%) 3. Lack of charging stations (41%)
- 64% see the main reason for getting an electric car is that it is better for the environment.
- 40% have driven an electric car.
- 63% can see themselves having an electric car as an extra car.
- There is concern about whether the electric cars are better for the environment since they can have a big impact during production.
- There is concern where the electricity comes from, if it is from a renewable source or not.

4.3 Storyboard

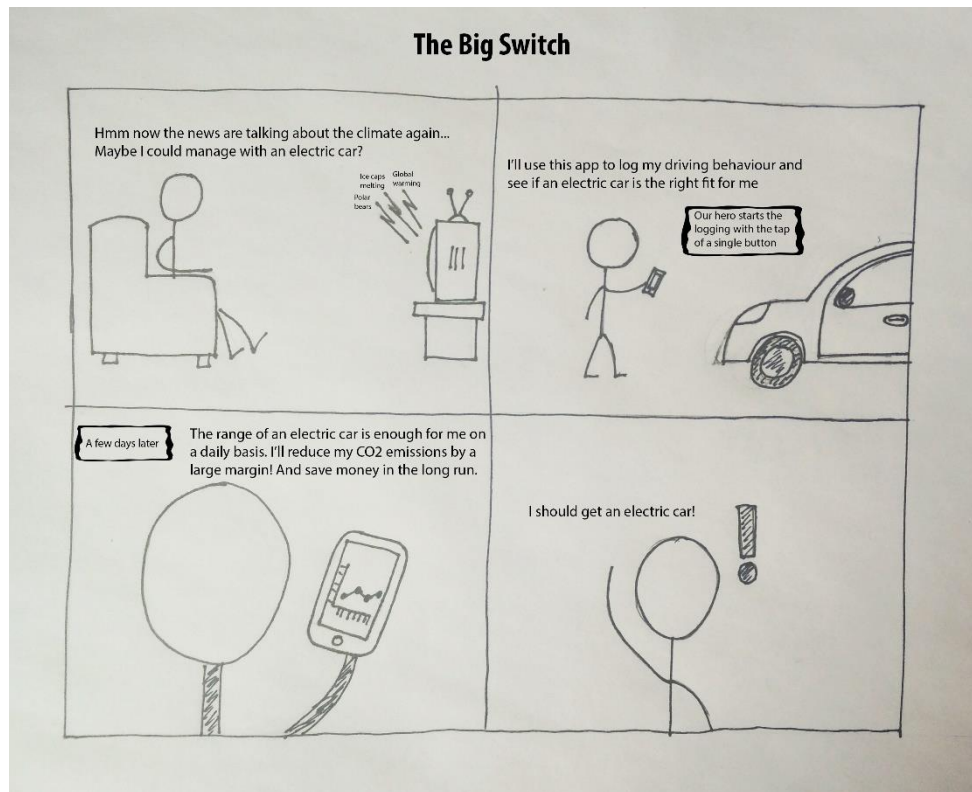
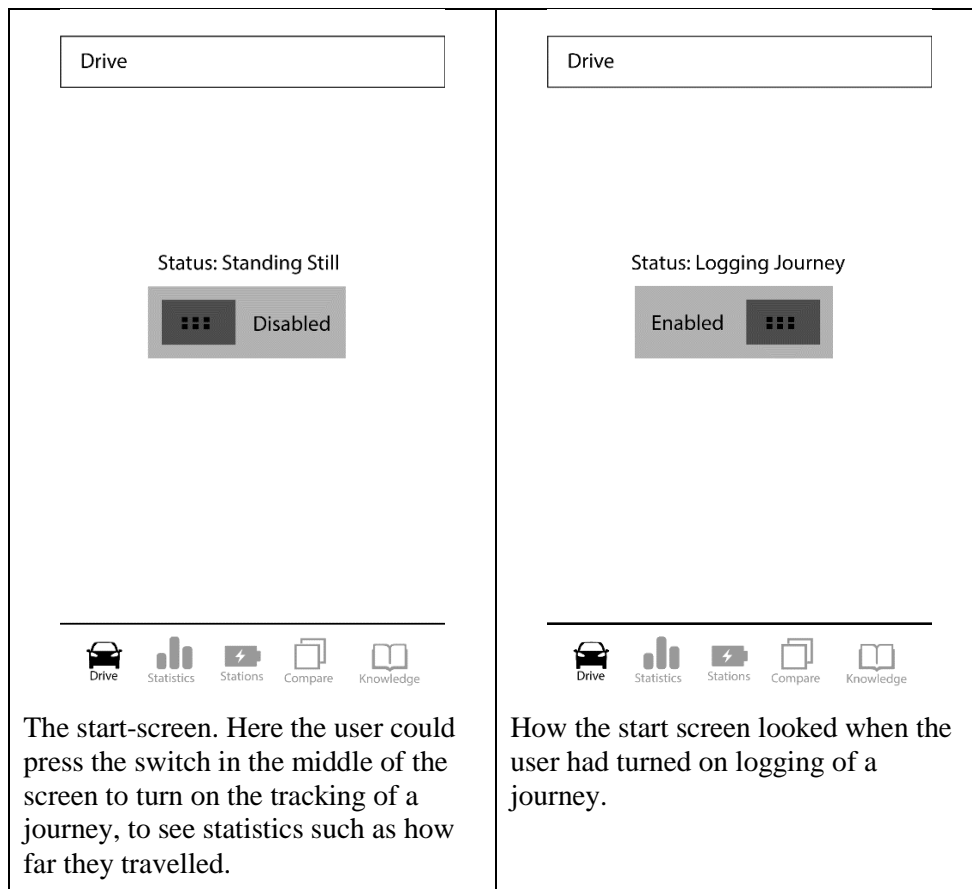


Figure 2. Storyboard explaining how the app might be used.

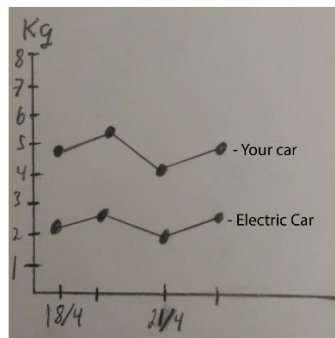
4.4 Mid-fi Prototype

The prototype tried to combat the problems with getting an electric vehicle that users reported in the different user surveys and interviews. The overarching goal was to give the user information about their current driving behaviour as well as inform them about electric vehicles and with the help of that they can determine if an electric vehicle is right for them. And hopefully convince them to make the switch.

Below you will find the screens that were created for the mid-fi prototype as well as a description of what each screen was for.

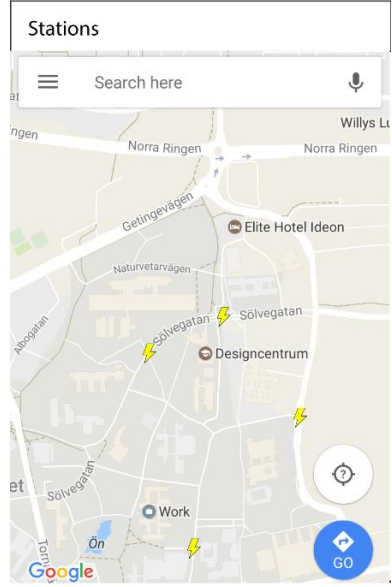


Statistics Emission ▼



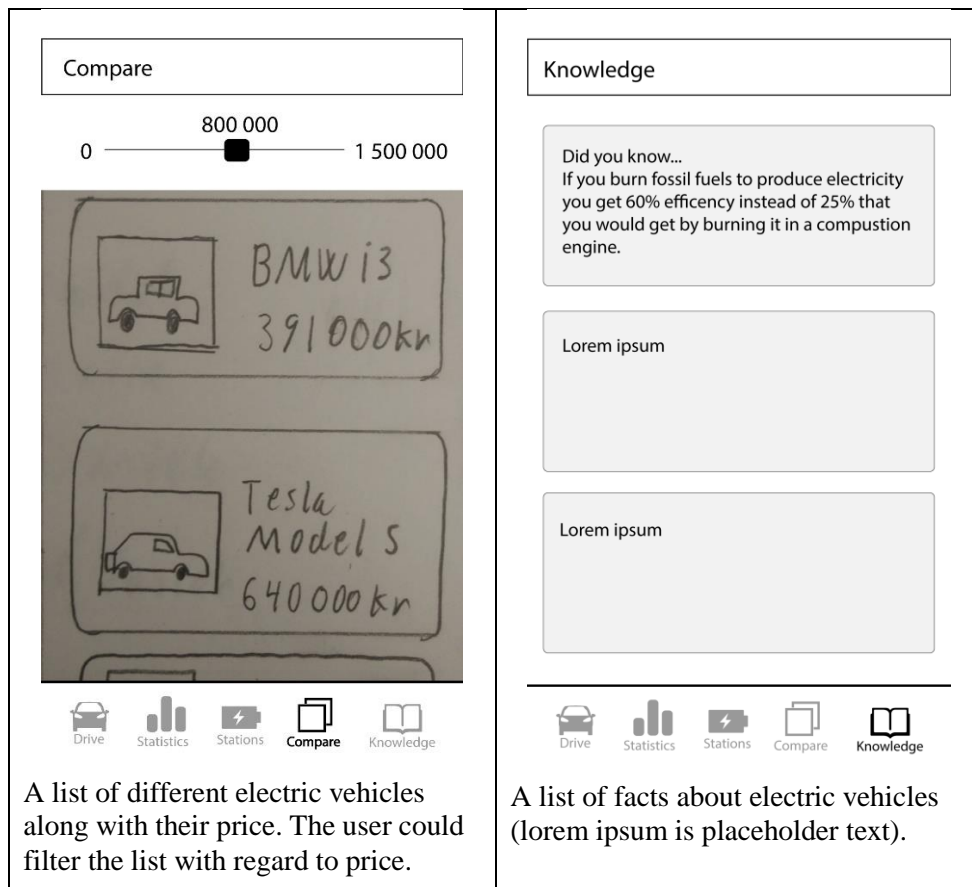
Drive Statistics Stations Compare Knowledge

The user could switch between different graphs to show different information. Could see how far you had driven in past trips. But also, how much lower the emission would have been if you had an electric car instead of a fossil fuelled one.



Drive Statistics Stations Compare Knowledge

A map showing the location of different charging stations.



Four user tests of the mid-fi prototype were conducted in total.

During the user tests, there were two main areas that were a source of confusion. Enabling the log/tracking of a trip and finding a car that costs under a certain price. A few users had trouble finding the emissions statistics.

The users found the “Drive” navigation menu item to be not entirely clear what it meant. It was not clear that this is where you started the tracking. The toggle to start the log also caused some confusion how it was to be used. The fact that it said “disabled” when the log was turned off made some people unsure how to interact with it. I assume that at least some of the confusion arose from that fact that it was just an image I made in illustrator and not a real coded toggle.

In one scenario, the users were tasked with finding a car for less than 300 000kr. Some users found it confusing that this feature was located under “Compare”. Since they did not really feel like they were comparing anything. They felt more like they were finding out information.

Some users suggested features or changes they would like to see added:

- Could use some more feedback when the log has started, such as a number going up of how many kilometres you have driven.
- Would like to see a comparison of the costs of having a fossil fuel vehicle in comparison to having an electric one.
- See how many stations there are along a planned route.
- See what type of charger there is at a station.

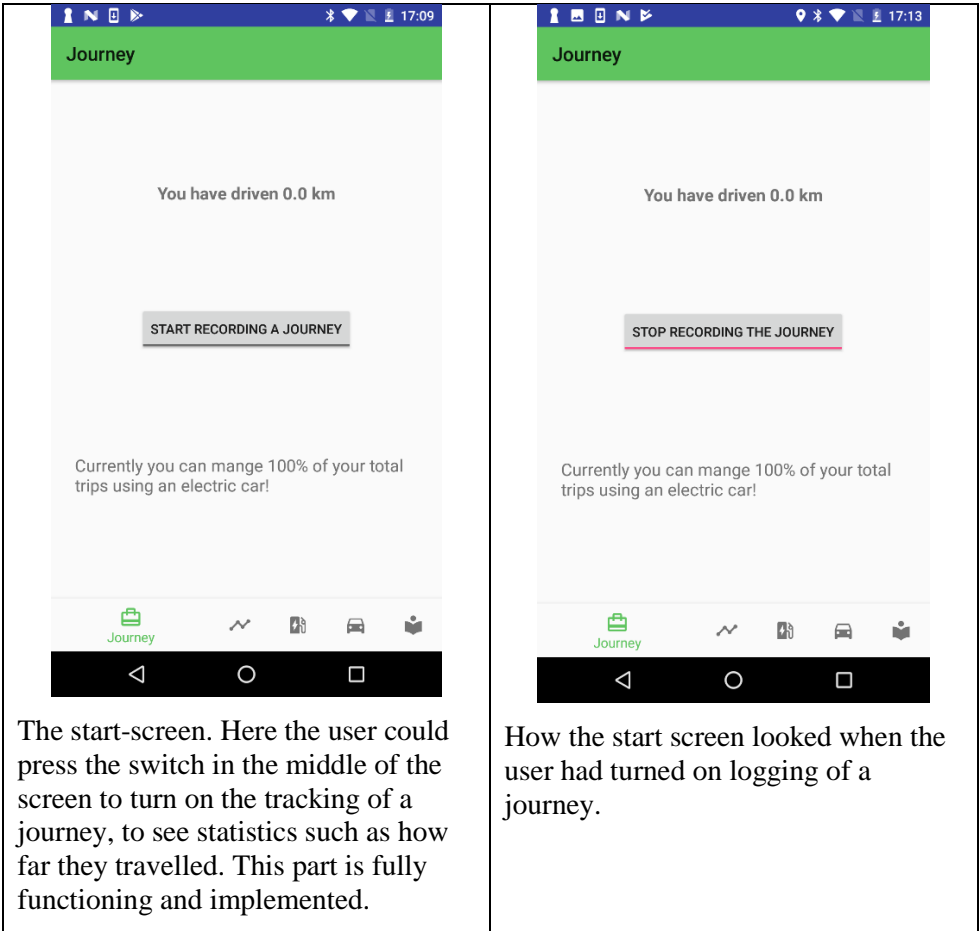
4.5 Hi-fi Prototype

In this iteration of the design process feedback from the previous user tests were incorporated. Renamed the start screen to “Journey” and change the menu item icon. Simplified how to start recording of a journey and made it more user friendly. Now updates in real-time with how far you’ve driven. Added a chart that compares fuel costs. Made the switching of charts more apparent. Renamed the “Compare” section to “Vehicles” and simplified the filtering to make it so you could sort on different features as well as search for a name. Added the option to click markers on the map to show information about specific charging stations (only showed place holder text in this prototype).

The entire design tries to think about Norman’s seven stages of action, see section 2.3. It does so by always trying to provide the user with enough feedback and making sure it is easy to see what actions are possible. In one way it does this is that all parts of the app are always accessible with the bottom navigation bar. It also tries to make sure all the functions are easy to find.

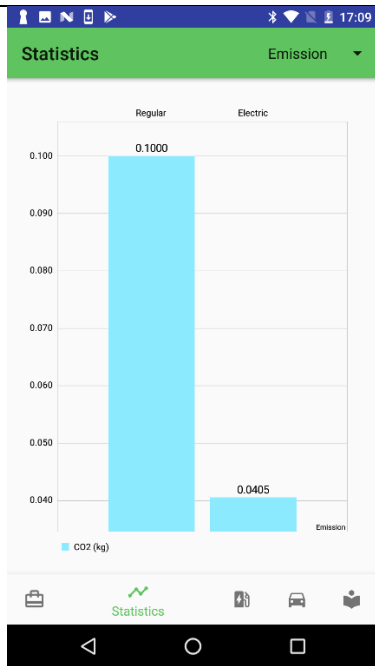
Below are screenshots of the hi-fi prototype. The hi-fi prototype is a fully functioning app, with some placeholder data, and can be downloaded for Android smartphones here:

<https://play.google.com/store/apps/details?id=com.axelfriberg.decider>



The start-screen. Here the user could press the switch in the middle of the screen to turn on the tracking of a journey, to see statistics such as how far they travelled. This part is fully functioning and implemented.

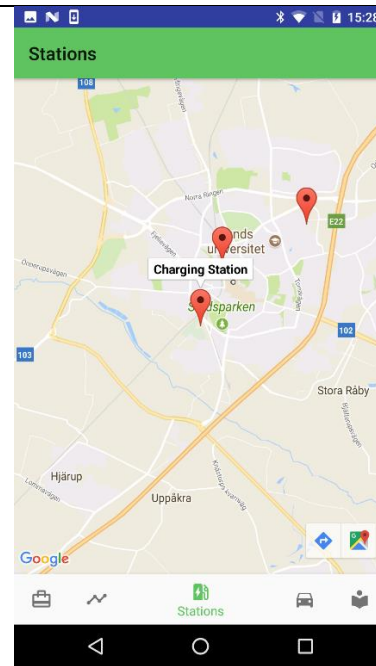
How the start screen looked when the user had turned on logging of a journey.



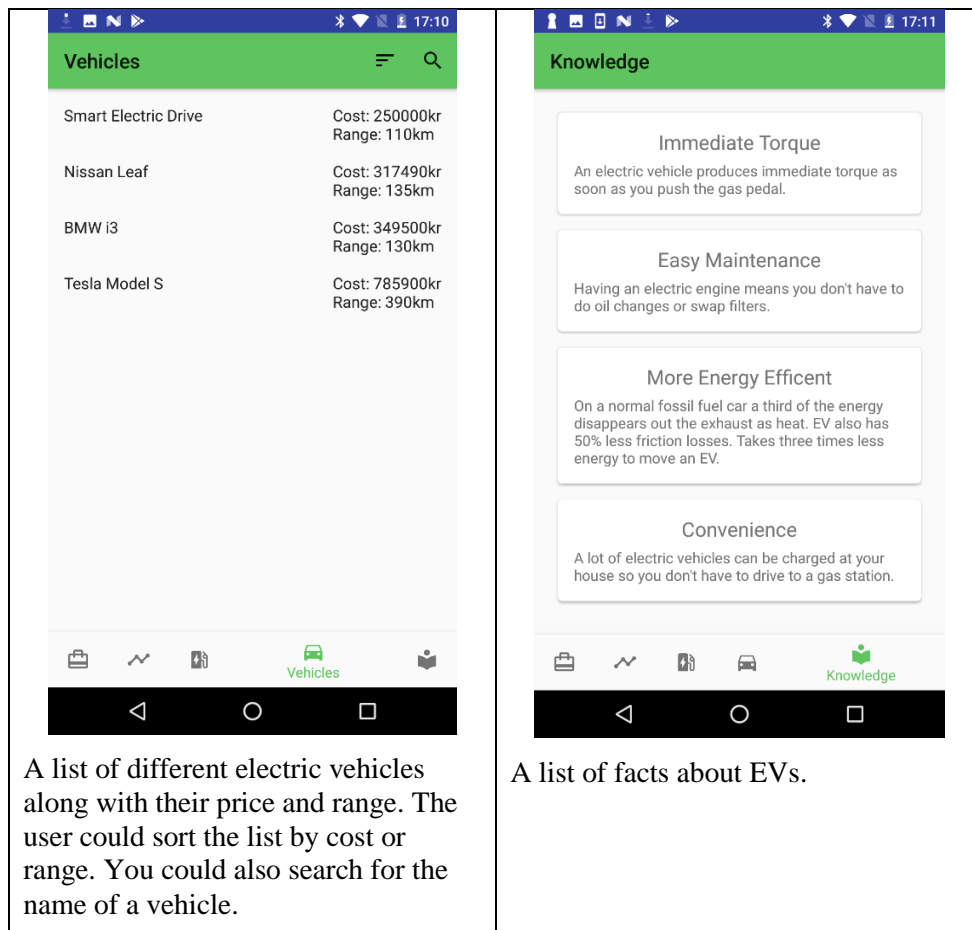
The user could switch between different graphs to show different information. Could see how far you had driven in past trips. How much lower the emission would have been if you had an electric car instead of a fossil fuelled one. How the fuel costs compared between an FV and EV. The values used for calculating costs and emissions are just placeholder values and cannot be changed by the user.

Here we turn the data into information and in turn into knowledge for the user.

The graphs also follow Shneiderman's mantra (section 2.5.3) by first giving an overview. Then the user can pinch-to-zoom. And finally click the bars and points to receive a little bit more information.



A map showing the location of different charging stations. The markers could be pressed to show information about the charging station (placeholder text is show in the image). The locations shown on the map are just placeholder and do not represent real charging stations.



4.6 Evaluation

No responses were received on the final user test of the prototype. However, some feedback was given by my thesis supervisor after she had used the app a couple of times. Her feedback was:

- The text on the start-screen is a bit small and hard to read if you have the phone in a stand in your car.
- Could be even more apparent that you have started the logging of a trip.
- The graphs are a bit hard to read. The text could be bigger and the lines and bars could have a different colour to stand out more from the white background.
- Didn't find the button up at the top to switch between graphs.

- Would be nice to have info on how far you drove when you stop the logging. Right now, it just resets the counter when you press “stop” and you have to go to statistics to get that information.

5 Discussion

In this chapter, a discussion of the methods and results is given.

5.1 Interviews

The two factors that stood out and seemed most important to the users during the interviews were the environment and the economics. This aligned rather well with my preconceived notions.

The semi-structured nature of the interviews allowed for the interviews to be a bit less formal and less strict which allowed for the user to open up more and say what they felt was important to share, and not just what I decided to ask them. Since only five people were interviewed it was quite a small set of interviews, which is why I did not feel the need for a structured interview. I did however want to be able to compare and contrast the interviews which is why I deemed the unstructured interview to not be fitting for my needs.

I did get some varying input from the different interviews but one concern is that the people selected for the interviewees all had similar background. All were of similar age, academic background, working at Lund University. These were of course selected partly due to lack of time, but also since they were deemed to be in the target group for the finished product. It would have been interesting to interview people from some more different backgrounds and see if the answers would have differed more.

The interviews were quite short since I had a clear goal of what I wanted to get out of the interviews. This was also decided upon since I thought I would get more interviews if they were said to be short. They would probably had been more qualitative if they were longer and more data could have been collected.

5.2 Questionnaires

The reason for choosing Google Forms as a tool is that I find it easy to make forms that are clear and easy to understand for the person answering using that tool. And

when it comes to getting a good response rate the appearance, clarity, instructions, arrangement, design and layout of questionnaires are very important [1]. The main benefit of doing a questionnaire is that it is quite easy to get a great number of responses. This is also made even easier by doing it online since you can then send it through email or post it on social media. The responses are also more convenient to go through since they are automatically collected in a digital table.

The survey proved to be a good tool for getting an overview of the opinions of the users and primarily gave an idea of what the main concerns are for getting an electric car. This gave me an idea of where the focus of the app will be. The main reason, by a large margin, is that the initial cost is too high. This might be hard to combat with the app but I tried to include the best solution I could think of. The range not being enough is the second biggest concern. This was chosen to be the focus of the app (put on the start screen) since this is something that can be easily tracked with an app. People see the main benefit of getting an electric car is that they are environmental friendly. The third biggest obstacle for getting an electric car was the lack of charging stations.

Sending it out digitally was a good option in the sense that I got a lot of replies. The downside of course being I had absolutely no control over who answered and what their background might be. But for this project the volume of replies was more important than checking the background of the potential users. The only real criteria were that they were supposed to have a car, and if they did not have a car it's not the end of the world since their answers might be valuable anyway.

The three main hurdles for people not getting an electric car that was mentioned in the survey responses matched what I found in the previous research done on the topic.

5.3 Affinity Diagram

This method was a good way of gathering up the data gathered in the interviews and turning it into information. Though it would have been better suited when you are a team of two or more people since I had no one to discuss the categorization with.

5.4 Storyboard

A story board is supposed to be based on a persona. I skipped doing personas for this project since I deemed it to not be fitting for a one-man project. The main reason for doing a persona is to humanize the user and get everyone in the team on the same page on who you are designing for. When you are just one person it did not make

much sense to put time into creating personas. Since I can just keep my idea of the end user in my head and don't need to convey it to anyone else. Which is why I skipped directly to making a storyboard and not a persona first to base the storyboard around.

Not sure how much value I got from creating the story board this specific project, especially since a story board is supposed to be based on a persona, but it was a fun exercise and good to try out.

5.5 Mid-fi Prototype

There were a few reasons for deciding to make a digital prototype instead of one on paper. The primary one was that it would be easier to conduct the user test. Since I am just one person it is nice to be able to have the user conduct the test on his/her own, allowing me to observe and take notes. If a paper prototype would have been made this would mean I would have to conduct the test and move pieces of paper around and simulate the interaction, making it hard to be observing as well.

A benefit of making a paper prototype would be that it would be easier to simulate advanced interactions that are not possible to simulate when using static images on a smartphone. Another potential benefit would have been that people might be more open to criticizing a paper version since it feels less finished. One thing that came up during the user test was also that since the app prototype almost looked like a finished, working app, some users got frustrated when they could not perform certain actions they expected to be able to, since the prototype was just static images. This was not immediately apparent to the user. To get back to the benefits of making a digital prototype I also deemed it to be faster to make, since I required quite a lot of images and a lot of work could just be copied in Illustrator. Making it on paper would require a lot of repeated work. Making it digitally also means changes are easier to make if you are unhappy with some part of the UI. For example, I decided to change the look of the menu part way through the process, which was easy to change in Illustrator but would be quite time consuming if made on paper. Since the app looks almost like the real thing you get more of a sense of how the user would experience the real app, more so than if made on paper.

Designing the prototype, I chose to include features that tried to help with the three biggest hurdles that people saw with getting an electric car. So, some of the features included were:

- Being able to track how far you drive each day, to help combat range anxiety.
- Showing a map of charging stations to determine if there are enough near the user.

- Showing a list of electric cars along with their price and other features such as range so the user can find one that matches their budget and desires.

As mentioned previously the user tests were not videotaped. There are advantages of videotaping, you can then go back and check if you missed anything in the user's actions. I decided against this since most people (myself included) get uncomfortable being videotaped and I wanted the tests to feel relaxed. Since users could perform the tests by themselves I could also take notes which lowered the need for filming. The tests were also quite short so it was not too hard to keep track of the observations and write them down.

For the next part of the design process the considerations were how to clear up the areas of confusion and think about the possibility of adding the requested features.

5.6 Hi-fi Prototype

Since the resulting hi-fi prototype is a fully functioning app (with some placeholder data) it might be a bit of an understatement to just call it a prototype. Especially since a lot of effort was put in to making the app stable enough for daily use (avoid random crashes etc) and took eight weeks of coding to make. But due to a lack of a better term hi-fi prototype will have to do.

There may be a problem going directly from a lo-fi/mid-fi prototype to implementing a hi-fi prototype in code. All software development takes a lot of time and energy and since I skipped the step of doing a more polished non-code based prototype based on the feedback from the mid-fi prototype it might turn out that I need to discard a lot of the code written depending on user input. In this case though I will not know if that is the case since it did not receive a single response to the final user test. I think the main reason for this is that I did not make the feedback form accessible enough and maybe choose the wrong approach to do the final user test. Maybe it could have been better to do the user tests in person, to make sure the responses were received.

Designing the hi-fi prototype, I took into consideration the feedback I got from the mid-fi prototype and tried to change the app accordingly. One example of this is that I tried to make the process of starting the recording of a journey easier to understand how to do.

Since I did not want to reinvent the wheel an already existing library was used to display the charts of the app. I made sure to check that the charts produced by the library matched the guidelines set out in the theoretical background, section 2.5.

As far as the code goes I choose to focus on clean, self-documenting code. I also tried to follow the UNIX principle of DOTADIW, or "Do One Thing and Do It Well." when writing the code and constructing the architecture.

5.7 Evaluation

As mentioned in the results section I did not receive any responses on the survey for the final test. Since it worked well with sending out the survey at the beginning of the project, which received over a hundred replies, I figured that this could be a good approach for the final user test as well since it would be nice to get a large amount of data. I also thought that it would be good to let the user try the app in peace and quiet on its own time. And not having me staring over their shoulder. Unfortunately, this didn't quite pan out as I had hoped. I choose to distribute the app prototype through Google Play to make it as easy as possible for the testers to download and try the app. The problem I think was that I put the link to the feedback form in the store page description, and here the user must click "read more" to see the actual description that I've written that included the link to the feedback form. So, it might be the case that users have tried the app but then not found how to give feedback, even though I requested that they read the store page description. So, for future design projects, when you really need user feedback it might be better to do it in person to make sure you get the feedback you desire instead of just hoping for the best.

The feedback from my thesis supervisor I don't have too much to say about, except for the fact that I agree and these changes would be beneficial. They also align with what I thought people would complain about. Especially the graph I agree that they are hard to read. I used an already made library for the graphs and I didn't have too much time to customize them and make them easier to use. Also, in a sense this part of the app fails in regard to the seven design principles (discoverability) since my supervisor found it hard to find how to switch between graphs. And it should always be apparent to the user what can be done. So this switch could have been made a bit more apparent.

6 Conclusion

This chapter concludes the report with some closing thoughts.

The goals of the thesis were to investigate the obstacles that hinders people from getting an electric vehicle and designing a smartphone app to help the user overcome those obstacles. All while following a HCD process. In that regard, I'd say the project was successful. The user interviews and surveys gave a great deal of insight into what stops people for getting an electric vehicle. A functioning prototype was developed that addressed a lot of these. However, not all problems are easily addressed with a smartphone app. Primarily the problem that the electric vehicles have too high initial cost. This could be an area of future research, how to help users switch to an electric car with the help from something other than an app. A final thing to note is that part of the goal was the app should have high usability, and it is hard to determine how successful the final version of the app was in that regard due to lack of user feedback in the final test, but that could be obtained at a later time if the time and resources are available.

References

1. Hanington B, Martin B. Universal methods of design: 100 ways to research complex problems, develop innovative ideas, and design effective solutions. Beverly, MA: Rockport Publishers; 2012.
2. Norman D. The design of everyday things -Revised and expanded edition. New York: Basic Books; 2013.
3. Technical Committee ISO/TC 159 E, Subcommittee SC 4, Ergonomics of human-system interaction. ISO 9241-210:2010 Ergonomics of human-system interaction -- Part 210: Human-centered design for interactive systems.
4. Arvola M. Interaktionsdesign och UX: om att skapa en god användarupplevelse: Studentlitteratur; 2014.
5. Frågeteknik: Statistiska Centralbyrån; [cited 2017 15/03]. Available from: http://www.scb.se/sv_/Dokumentation/Statistikguiden/Undersokning-och-urval/Frageteknik/.
6. Denscombe M. Forskningshandboken - för småskaliga forskningsprojekt inom samhällsvetenskaperna. Lund: Studentlitteratur; 2014.
7. Kindstrand D. Barriärer för elbilsintroduktionen i Sverige Attityder, ekonomi och teknik: Lund University; 2015.
8. Nordlund A, Jansson, J., & Westin, K. New Transportation Technology Norm Activation Processes and the Intention to Switch to an Electric/Hybrid Vehicle. Transportation Research Procedia 2016. p. 2527-36.
9. Mazza R. Introduction to Information Visualization. London: Springer-Verlag; 2009.
10. Munzner T. Visualization Analysis and Design. Boca Raton: CRC Press.
11. Google Forms [Available from: <https://docs.google.com/forms/>].

Appendix A Interview Questions

Hur många bilar har ni i ert hushåll?

Svar:

Vilka typer av drivmedel har bilarna i ert hushåll?

Svar:

Varför har ni valt att ha bilar med just de drivmedlen?

Svar:

Kan du berätta om dina körvanor (hur ofta du kör, vanliga destinationer etc.)?

Svar:

Under en genomsnittsdag då du använder bil, hur många kilometer uppskattar du att du kör totalt?

Svar:

Vad skulle du tycka det är intressant att få information om angående dina körvanor/bil (exempelvis hur långt man kör) med hjälp av en mobil-app?

Svar:

Frågor specifika för personer som har fossilbil

Har du några uppfattningar om elbil? Och i så fall vilka?

Svar:

Vad baseras din kunskap på?

Svar:

Har du någonsin använt en elbil?

Svar:

Om du har använt en elbil, förändrades din attityd till dem på något sätt?

Svar:

Har du funderat på att skaffa en elbil?

Svar:

Vad har hindrat dig från att skaffa en?

Svar:

Vad upplever du det finns för positiva aspekter med elbilar?

Svar:

Frågor specifika för personer som har elbil

Varför skaffade du en elbil?

Svar:

Vad har du för uppfattning om elbilar nu när du äger en själv?

Svar:

Förändrades din attityd till elbilar på något sätt sedan du skaffade en?

Svar:

I så fall på vilket sätt?

Svar:

Avslutningsvis

Skulle du vara intresserad av att ställa upp på tester av prototyper?

Svar:

Appendix B Questionnaire

Attitude survey regarding electric cars

I am currently doing my master thesis in computer science/interaction design and I will develop an app to help a driver to determine if it is possible to switch to an electric car. The purpose of this survey is to investigate what people's current attitude is towards electric cars are and what they feel the obstacles are for buying one. I also want to find out what reasons current owners of electric cars had for buying one. The survey is primarily aimed at people who have one or more cars in the household. The survey is completely voluntary to answer and if you want to you can stop at any time. All the answers are anonymous and will be handled confidentially. The survey should take a maximum of 5 minutes to answer. If you have any questions or concerns you can contact me at dat12afr@student.lu.se

Thanks in advance!
//Axel Friberg

* Required

1. Which country are you from?

*2. Which mobile operating system/systems do you have in your phone/phones?
Choose all that applies.*

Android

iOS

Windows Mobile

I do not own a smartphone

Other:

3. How many cars do you have in the household?

4. Which type of fuel is used in the cars you own? Choose all that applies.

Gasoline

Diesel

Electricity

Alternative fuels (biodiesel, nature gas or ethanol)

Other:

5. How many days per week do you drive on average?

6. During an average day when you drive, how many kilometres do you assume you drive?

7. Is there any information about your car or driving habits that your car is currently not showing you that you would like to know? In that case what?

*8. Do you have an electric car? **

*Need to ask this again because of how Google forms works.
Mark only one oval.*

Yes Skip to question 17.

No Skip to question 9.

For drivers who do not own an electric car

9. How much knowledge do you have about electric cars?

None 1 2 3 4 5 A great deal

10. Which are the biggest obstacles you find with getting an electric car? Choose at most three options.

High initial cost

Lack of knowledge

Lack of charging stations

Afraid of the range not being enough

There is a small selection on the second-hand market

It takes time to charge the car

Often a lack of storage space in the cars

Want a sporty car

Unsure if a repairman can fix an electric car

Other:

11. Which is the biggest positive effect you see with electric cars? Mark only one oval.

Better for the environment

Cheaper fuel

No noise from the engine

Other:

12. Here you can leave a more thorough response about your opinions on electric cars if you so wish.

13. Have you ever driven an electric car?
Mark only one oval.

Yes

No

14. If you answered yes to the previous questions, has your opinion on electric cars changed in any way since you tried one?

15. Would you be open to having an electric car as an extra car?
Mark only one oval.

Yes

No

Maybe

16. Any final comments or remarks?

Stop filling out this form.

For drivers who owns an electric car

17. Which was the primary reason you got an electric car?
Mark only one oval.

Better for the environment

Cheaper fuel

No noise from the engine

Other:

*18. Which are the problems you see with having or purchasing an electric car?
Choose at most three option.*

Check all that apply.

High initial cost

A lack of charging stations

The range is not enough

There is a small selection of electric cars on the second-hand market

Takes time to charge the car

Often a lack of storage space

Lacking acceleration

Many repair shops cannot fix an electric car

Other:

19. Here you can leave a more thorough response about your opinions on electric cars if you so wish.

*20. Did your opinion on electric cars change once you got one yourself?
Mark only one oval.*

Yes

No

21. If you answered yes to the previous question, in that case how?

22. *Any final comments or remarks?*

Appendix C Mid-fi Prototype Test Scenarios

Scenario 1

Enable and then disable the logging of driving trips.

Scenario 2

Find out how much emissions your car had on the 18/4.

Scenario 3

Find out how many charging stations there are next too IKDC.

Scenario 4

Find the name of an electric car that costs less than 300 000kr.

Scenario 5

Learn a fact about electric cars.

Appendix D Hi-fi Prototype Survey

Q1 Likert scale 1-7: How would you deem the overall usability of the application?

Q2 yes/no: Was there a particular feature or functionality of the app (e.g. recording a trip, using the stations map) that you found hard to use?

Q3: If you answered yes on the previous questions, what feature/functionality did you find hard to use?

Q4: If you answered the previous question, why did you find that feature/functionality hard to use?

Q5 yes/no: Was there a particular feature or functionality of the app (e.g. recording a trip, using the stations map) that you found easy to use?

Q6: If you answered yes on the previous questions, what feature/functionality did you find easy to use?

Q7: If you answered the previous question, why did you find that feature/functionality easy to use?

Q8: What part of app did you find the most useful?

Q9: Why did you find that part useful?

Q10: Would an app like this prototype help you in deciding if you could switch to an electric vehicle?

Q11: Is there any feature you are missing that you would need to decide if you could switch to an electric vehicle?

Q12: Would you use continue to use an app like this if it was a finished product?

Q13: Any other comments?