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Gamified Mobile Application to Raise Awareness and Support Energy Efficient Behavior

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Abstract

Climate change is a fact, and our human activities are part of the cause of it happening. CO_2-emissions from our daily activities, like transportation and heating, are a big part of the problem, and change is needed to meet UN's temperature goal. However, not many people know how their everyday choices and activities affect the environment.

This master thesis seeks to explore the possibilities of using gamification and behavior change models together, to design a mobile application that aims to raise awareness and change peoples behavior to be more sustainable.

The master thesis is part of a European research project called DESENT. The project partners were active in the requirements and design phase by attending a workshop and completing a survey that helped to co-design the specifics of the game mechanics in the application.

This master thesis starts by presenting the research strategy chosen together with the research questions that are the focus for the research. The background study done on the relevant topics for the work, namely gamification, behavior change models, co-creation, data privacy and evaluation of applications are presented next. Furthermore, the process of defining the requirements where a survey and a workshop were conducted, are presented. After the requirements are defined, design choices and technology choices are described and justified along with a presentation of the architecture and how the new features of the app were implemented. Finally, a user evaluation was conducted, and this is described together with the results and analysis from this.

Findings from the user evaluations suggest that the game mechanics elicited in the co-creation session with the stakeholders worked well in the app. It also confirmed that ease of use is essential to create an intention to use the app. It also showed that amusement and ease of use are not enough in all cases to make people use the app, as some people may also need to have a certain interest in the topic to want to use it. Although the feedback from the evaluation was positive for some aspects of the app, there are still some improvements with the concept and the user interface that must be done before the app is ready to be put into use.

Sammendrag

Klimaendringene er et faktum, og det er våre menneskelige aktiviteter som er årsaken til at de skjer. CO_2-utslipp fra våre daglige aktiviteter, som transport og oppvarming er en stor del av problemet, og endring er nødvendig for å nå FNs temperaturmål. Mange er ikke klar over hvordan deres daglige valg og aktiviteter påvirker miljøet.

Denne masteroppgaven forsøker å undersøke mulighetene ved å kombinere adferdsmodeller og gamification sammen, for å designe en mobilapplikasjon som tar sikte på å øke bevisstheten og forandre folks adferd til å være mer bærekraftig.

Masteroppgaven er en del av et forskningsprosjekt som heter DESENT. Prosjektpartnerne var aktive i kravspesifikasjon og designdelen ved at de deltok på en workshop og svarte på en spørreundersøkelse som skulle hjelpe til å designe spillets spesifikasjoner i applikasjonen.

Masteroppgaven starter med å presentere den valgte forskningsstrategien og forskningsspørsmålene som er fokuset for forskningen. Bakgrunnsstudiet gjort av de aktuelle emnene for arbeidet, nemlig gamification, adferdsmodeller, co-creation, personvern og evaluering av applikasjoner er så presentert. Videre blir kravspesifiseringsprosessen beskrevet der en spørreundersøkelse og en workshop ble utført. Etter at kravene er definert, blir designvalg og teknologivalg beskrevet og begrunnet sammen med en presentasjon av systemarkitekturen og hvordan de nye funksjonene i appen ble implementert. Til slutt ble det gjennomført en brukerevaluering, og dette er beskrevet sammen med resultatene og analysen fra dette.

Resultatene fra brukerevalueringene tyder på at spillmekanikkene, som ble valgt av deltakerne i workshopen, fungerte bra i appen. Resultatene bekrefter også at brukervennlighet er viktig for å skape en intensjon om å ville bruke appen. En annen ting resultatene var at fornøyelse og god brukervennlighet ikke er nok for å folk til å bruke appen i alle tilfeller da man også må ha en viss interesse for temaet. Selv om tilbakemeldingene fra evalueringen var positive for noen aspekter ved appen, er det fortsatt endel forbedringer med konseptet og brukergrensesnittet som må gjøres før appen er klar for å bli tatt i bruk.

Preface

This master thesis was conducted during the spring semester of 2018. This is the last semester of my Master of Science in Computer Science at the Department of Computer and Information Science (IDI) at the Norwegian University of Science and Technology (NTNU).

Project links related to this master thesis is listed in Appendix L.

Acknowledgements

This master thesis would not have been completed without help and support from the following people:

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- my co-supervisor, Peter Ahcin, for supporting me in the development process and for answering questions related to energy and emissions
- SINTEF Energy, for lending me an Android phone to use in the development and testing of the application
- all the people that have participated in the user evaluations
- fellow students, friends and family for supporting me through my years of study

Thank you!

Ragnhild Larsen 7.6.2018

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Listings

List of Acronyms

APK Application Package Kit.

DESENT Smart Decision Support System for Urban Energy and Transportation.

FR Functional Requirement.

GDPR General Data Protection Regulation.

GPS Global Positioning System.

N-FR Non-Functional Requirement.

SINTEF Stiftelsen for Industriell og Teknisk Forskning.

SUS System Usability Scale.

TAM Technology Acceptance Model.

TTM Transtheoretical Model.

Chapter 1

Introduction

This introductory chapter will present the scope and definition of the problem addressed in this master thesis, as well as the motivation for studying this topic. After that, the contributions from this master thesis will be stated, and at the end of this chapter, the structure of the remaining chapters will be described.

1.1 Background Motivation

Every day we make decisions that affect our surroundings. The decisions can involve everything from what we have for dinner, or how we choose to get to the grocery store. Do we take the bus, the car, walk or cycle? Often these choices are made based on convenience and what brings us the least stress. However, it is hard to know how these choices affect the environment. By intuition, we may know that taking the bike to the store is more environmentally friendly than driving a car, but exactly how much this choice affects the environment is hard to know precisely.

The term *carbon footprint* has been increasingly discussed in the media over the years, but is still something that is difficult to understand. It is also hard to know what a personal carbon footprint is and what it means. In the Paris Agreement adopted at the COP21 (Conference of the Parties) held in Paris on December 12. 2015, the countries agreed to limit the rise of the global temperature to be below 2 degree Celsius [1]. The carbon footprint of each country has to be drastically reduced to meet this goal. This also means that our personal carbon footprint has to be reduced, and that means less traveling, less driving, less heating, less meat in the diet and much more. Carbon dioxide emissions related to housing and transportation are a significant contributor to the personal carbon footprint, but these can be reduced by, e.g., switching energy source to solar panels, drive less and buy electric vehicles [2]. However, deciding to make these changes can be hard when you are not aware of how your activities affect the environment.

This master thesis aims to design an application to raise awareness and motivate people to take greener choices with regards to means of transportation and energy sources for heating and cooling at home. The theories about game mechanics and behavioral models of change were studied to find out how these could be used to accomplish this. Behavioral models of change, such as the Transtheoretical Model (TTM), describes the different stages of change and the processes that helps a person progress from one stage to another [3]. Making people change their habits and behavior is difficult, but the behavior models have been found useful to structure and understand how to facilitate making lasting changes [4]. Gamification can make everyday tasks more fun by adding elements from games. Helping people to lower their carbon footprint can seem tedious and much work, but turning it into a game and giving out rewards and acknowledgment for good work can support them to reach the goal set.

1.2 Problem Definition

This master thesis, which is written during spring 2018, is a continuation of the specialization project (TDT4501) that was conducted during fall 2017. Since the thesis is a continuation of that work, the main description of the problem will be the same for both;

Climate change is a fact, and our human activities are part of the cause for it [5]. CO_2-emissions from our daily activities, like transportation and heating, are a big part of the problem, and change is needed to meet UN's temperature goal [1]. However, not many people know how their everyday choices affect the environment, and few know how much the short car ride to work every day affects the environment regarding kg$C0_2$, or carbon footprint.

The problem of this master thesis is focused on exploring how to design an app that can raise awareness and motivate people to change their behavior to reduce their emissions from energy and transportation and save the environment. What is needed for an app to be perceived easy and fun to use, and how can it be designed for this. By using the theory of behavior models of change and gamification, the master thesis will try to answer how an app should be designed to fulfill its purpose.

1.2.1 Vision

The vision will be achieved by designing an application that should make people more aware of how their everyday choices related to transportation and housing affects the environment. By raising awareness of the individual's carbon footprint and including game mechanics, the goal of the master thesis is to design an app that motivates the user to change behavior to be more sustainable.

1.2.2 Issue Statement

This master thesis is a part of a research project that is called DESENT that is an abbreviation for Smart Decision Support System for Urban Energy and Transportation. The project is a collaboration between two municipalities (Weiz in Austria, Helmond in the Netherlands), a university (TU/e in the Netherlands), and research and engineering companies from three European countries (Austria, Netherlands, Norway). It is SINTEF Energy and NTE that represents Norway in the project, and the co-supervisor of this master thesis (Peter Ahcin) works at SINTEF Energy. The DESENT project aims to streamline the energy use of buildings and transportation [6]. The DESENT project will be further described in Chapter 3. Figure 1.1 shows the elements of which creates the foundation of the master thesis. The DESENT project is the first element in this foundation.

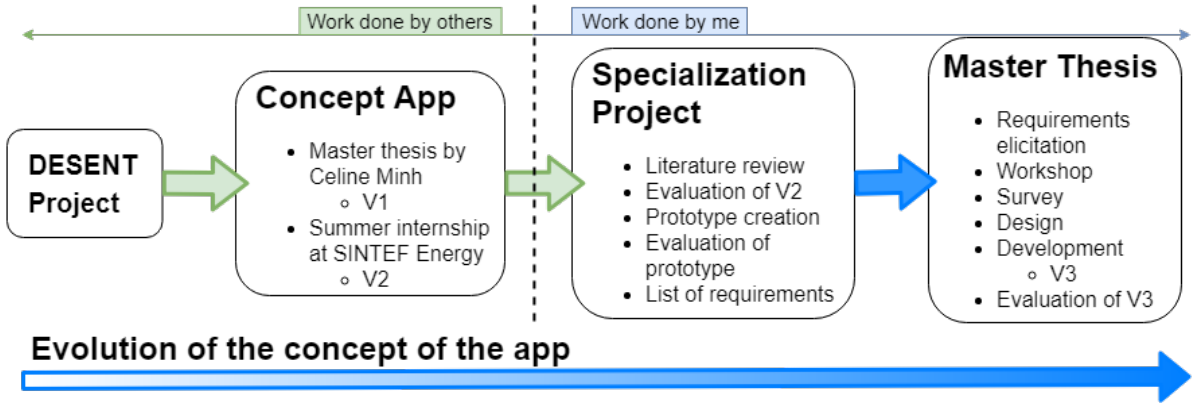


Figure 1.1: Issue statement

The second element in the foundation for the master thesis is the master thesis written by Celine Minh during spring 2017 [7]. What my thesis will build upon is the application that was created in her thesis (referred to as V1) and further developed during a summer internship at SINTEF Energy during the summer of 2017 (referred to as V2). The application (referred to as *the app*, *the application* or *Smiling Earth*) is a good foundation for achieving the vision. However, the status of the app is that it has some usability issues and lacks functionality that makes the app fun to use. This was stated in a final evaluation of the app that was presented in Minh's master thesis [7].

During the summer internship, changes were mostly done in the back-end of the app, but it was also made some changes in the user interface as well. These changes were not evaluated by any users. This was the starting point for the specialization project that was conducted during Fall 2017.

In the specialization project, user evaluations of *Smiling Earth* V2 were conducted [8]. The results of the evaluations made it possible to compare how the design changes done in the summer

internship had impacted the usability of the app. Based on the results of these evaluations, a digital prototype (referred to as *the prototype* or *the digital prototype*) was created (screenshots presented in Appendix D). The aim when creating the prototype was to improve the usability and to include some game mechanics to see how the users perceived these. User evaluations of the prototype were also done, and the results were compared to the previous results of V1 and V2 to see if there had been any improvements in usability or if it had become worse. The results showed that the prototype had solved some of the issues with the usability, but there were still some things left to improve. The game mechanics were perceived as fun and worth pursuing to make the app more fun to use.

To not fall into the most common trap when working with gamification, that is just adding traditional game mechanics to the application, a gamification workshop was conducted in the master thesis. The workshop was a co-creation session with the stakeholders that are the project members of the DESENT project. By doing this, and by including the feedback from the evaluation of the prototype created in the specialization project, and the theory studied on the topic, the implemented game mechanics would hopefully contribute to motivate people to change their behavior and help lower their carbon footprint. This will be incorporated in *Smiling Earth* V3 that is designed and developed during the master thesis (referred to as V3).

1.3 Contribution

The contribution of this master thesis is a gamified mobile application with game mechanics found in literary studies, and during evaluation with users, workshop and a survey filled out by the workshop participants. The application will be evaluated by users that have used the application for a short period, and a review of the proof of concept will be provided.

1.4 Document Structure

The rest of the thesis will have the following structure:

Chapter 2 Materials and Method: This chapter presents the research questions and the different stages of the research project. The methods used in the various stages are presented and reasoned.

Chapter 3 Background The background chapter gives an introduction to the topics that are relevant to the work done in the master thesis. This includes the background study done in the

specialization project. Since the application is part of the work in the DESENT Project, the project is also introduced, and the context of the work done in this master thesis is given.

Chapter 4 Requirement Elicitation To have a clear plan of what is required by the stakeholders, users, and theory, this chapter describes how the requirements elicitation was conducted and the processes done during this stage of the project.

Chapter 5 Workshop As a part of the requirement elicitation and the process of designing the game in the application, a workshop was conducted with the stakeholders at the DESENT Project meeting. This chapter presents the objectives of the workshop, the planning, execution, and the results.

Chapter 6 Design The design chapter gives reasoning for the different design choices made in the development of the app. This chapter ensures that the design support the behavioral model used. It also presents the game mechanics that was decided to be implemented.

Chapter 7 Software Architecture This chapter will present the software architecture of *Smiling Earth*. It will also give the main structure of the code, and give a presentation of the technologies used to develop the app.

Chapter 8 Implementation Chapter 8 presents how the app was implemented and how the development was conducted.

Chapter 9 User Evaluation User evaluations were conducted after the implementation was finished. This chapter will present how the evaluations were planned, conducted and the results from this.

Chapter 10 Discussion The discussion chapter will discuss the results and findings found in the different stages of the master thesis. In addition to discussing the results, a retrospective on lessons learned during the master thesis will be given as well as tips for future work based on the results and the unfinished tasks from the implementation.

Chapter 11 Conclusion This chapter will sum up the major findings and conclude the master thesis.

Appendix The appendix contains twelve chapters with various elements that were not fitted to be included in the main part of the master thesis:

- **Appendix A Survey:** the survey used at DESENT Project meeting 25.1.2018 and the response retrieved
- **Appendix B Workshop Participants:** a list of the participants in the gamification workshop conducted at DESENT Project meeting 25.1.2018
- **Appendix C Backlog and Sprints:** Screenshot of the backlog created at `www.trello.com`
- **Appendix D Digital Prototype:** Images of the digital prototype created with `https://proto.io/` in the specialization project
- **Appendix E Flow Diagrams:** Activity Flow Diagram and Fragment Flow Diagram that visualize the connection between the Android Activities and Android Fragments in the code for *Smiling Earth*.
- **Appendix F Calculations Retrieved from [7]:** the documentation for the calculations that are used in the app
- **Appendix G Code:** Code snippets from the Android Studio Project
- **Appendix H Screenshots from the app:** Images from *Smiling Earth* V3
- **Appendix I Pre-Intervention Questionnaire:** the questionnaire and responses from the user evaluations of *Smiling Earth* V3 that was given to the participants before the test period.
- **Appendix J Post-Intervention Questionnaire:** the questionnaire and responses from the user evaluations of *Smiling Earth* V3 that was given to the participants after the test period. The appendix also contains a comparison of average results from the four evaluations conducted of V1, V2, the digital prototype and V3.
- **Appendix K Unfulfilled Requirements:** Tables with unfulfilled requirements will be shown in this appendix.
- **Appendix L Project Links:** links to project files such as GitHub repository and digital prototype.

Chapter 2

Materials and Method

This chapter will first present the research questions that the research in the master thesis is focused around. After that, an overview of the research project with all its stages will be given. The research methods used in each stage of the research project will be presented and reasoned for after that.

2.1 Research Questions

The research questions for this master thesis will be related to the research questions proposed in the specialization project since this project builds upon that work [8]. The main research question for this research project is:

Can gamification increase motivation to use an application and change behavior and if so, how?

The following sub-questions will support the main research question above:

RQ1: How is the user's motivation affected by the app?
This research question is important because it will answer if the app has successfully managed to implement the game mechanics and the theory behind the behavioral change models. It will also show if the proof of concept is successful and if it should be further developed. Will also try to explore how the user is motivated, and what created this motivation.

RQ2: Which game mechanics seems to be the most effective form of motivation?
This research question will answer which game mechanics are found most useful and maybe reveal which game mechanics that are unnecessary to pursue further. The research question will also give support to RQ1.

RQ3: How do we design an app that is easy to use?

It is essential for the app to be easy to use or else it may not be used, hence not get the possibility to motivate and create awareness. This question is thus essential to explore how the users perceive the app.

RQ4: Is the concept of the app understood?
Understanding the concept of the app is vital to get the users to understand the goal of the app, and to create engagement.

RQ5: How is the user's enjoyment affected by the app?
It is not only important that the app is easy to use, but also that it is fun to use. This question will give a pointer on whether or not the game mechanics and the concept is engaging and fun. If so, this may have an impact on the user's motivation to change their behavior.

RQ6: Is the user's engagement affected by the app?
Personal engagement is also vital to create usage of the app and to encourage friends and others to use the app.

RQ7: How does the app contribute to behavioral change?
This question will examine how many stages of the transtheoretical model of behavioral change the app supports, and considers what is needed to move further to the next stages.

2.2 Overall Research Process

This section will present the overall research process and methods used in the different stages of the research project, namely literature study, requirement elicitation, workshop, design, use case creation, prototyping, development and user evaluation. The overall research process can be viewed in Figure 2.1. The figure is an overview of the research process and its components and is retrieved from the book *Researching Information Systems and Computing* [9]. This figure was chosen to be used to describe the research process as it was introduced in the course *Fordypningsemne* TDT39, that was taken during fall 2017 together with the specialization project. The figure seemed like a good way to structure the research process and to support the choice of methods to be used in the research project. The elements that are found most relevant to this research process are marked with red boxes around them.

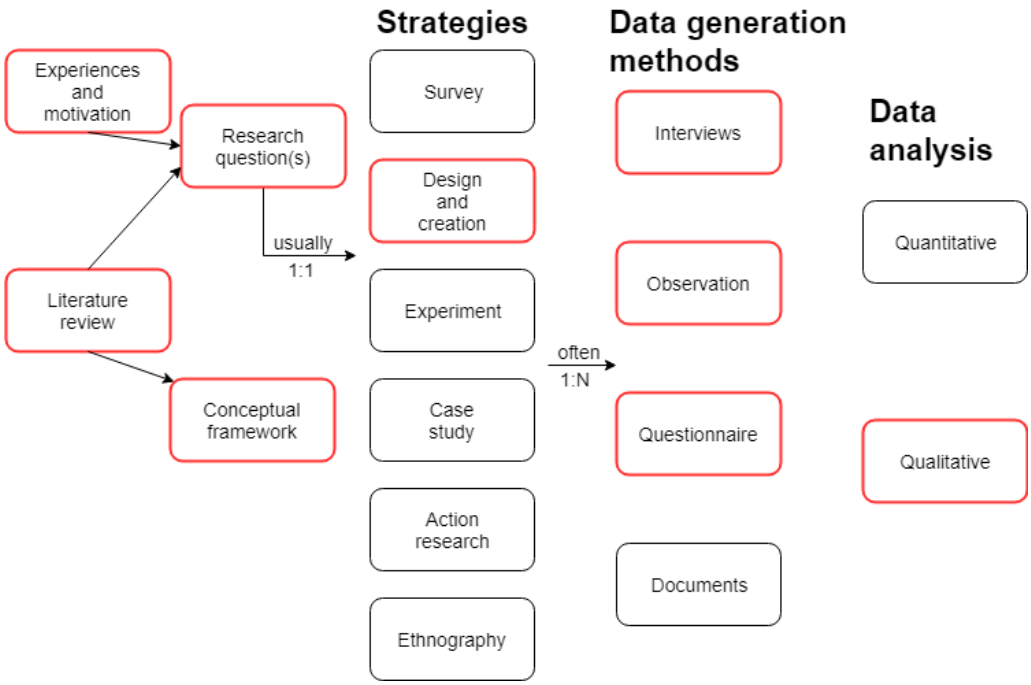


Figure 2.1: Overall research process retrieved from [9]

As the figure above is a general figure, it has been adapted to fit the actual research process that is used in this master thesis. The adapted figure can be viewed below in Figure 2.2.

Experiences, motivation, and literature review were necessary for specifying the research questions. The research questions were mainly determined from the needs of the DESENT project, and the goal of the application to motivate and change behavior habits. The literature review provided a conceptual framework for the research project and specified the methodology that consisted of the strategy and the data generation methods chosen to be able to answer the research questions [9].

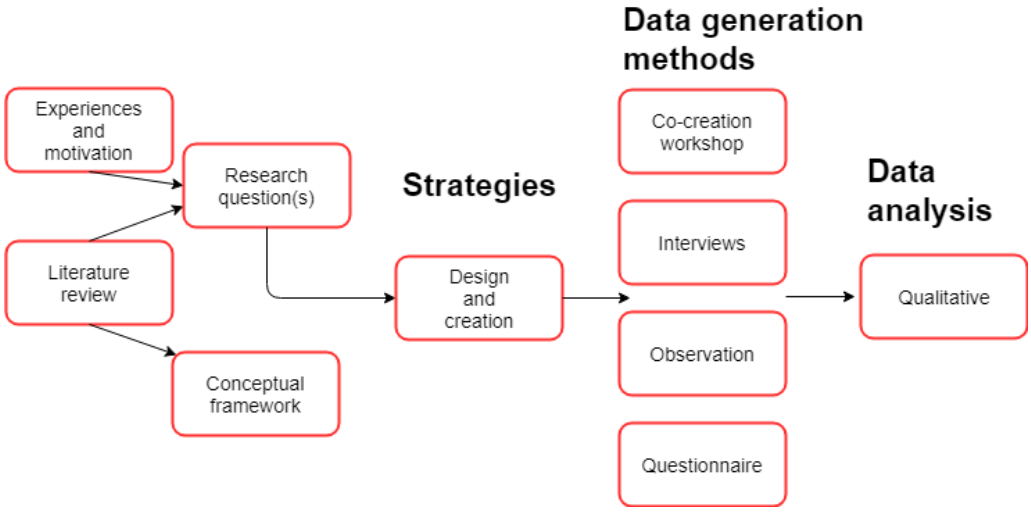


Figure 2.2: Overall research process adapted from figure retrieved from [9]

This master thesis is a research project that uses Design and Creation as a research strategy. It uses this strategy because the primary focus of the research project is to develop an IT product, that is a mobile application [9]. This strategy also includes prototyping and other methods related to developing IT applications. The goal of the research project is to have a working mobile app that can demonstrate that the gamification theory together with behavior change models can be used in a computer-based system and affect the users in a motivating and engaging way. The contribution to knowledge will be a mobile application as a proof of concept and a set of suitable game mechanics found in the background study and during a workshop.

The research activities used within this strategy are evaluation, analysis, and prototyping [9]. These activities are not shown in Figure 2.3 below, but described in the book written by Oates [9]. Figure 2.3 is relevant to show which data generation methods that are suitable within this research strategy. The data generation methods for the strategy that is *Design and Creation* are a combination of co-creation workshop, questionnaires, observation, and interviews. The data generation will be done by the survey, workshop and user evaluations of the application. Participants for the survey and workshop are recruited on the DESENT project meeting. Observations will be done during the workshop, and questions relevant to the situation will be asked.

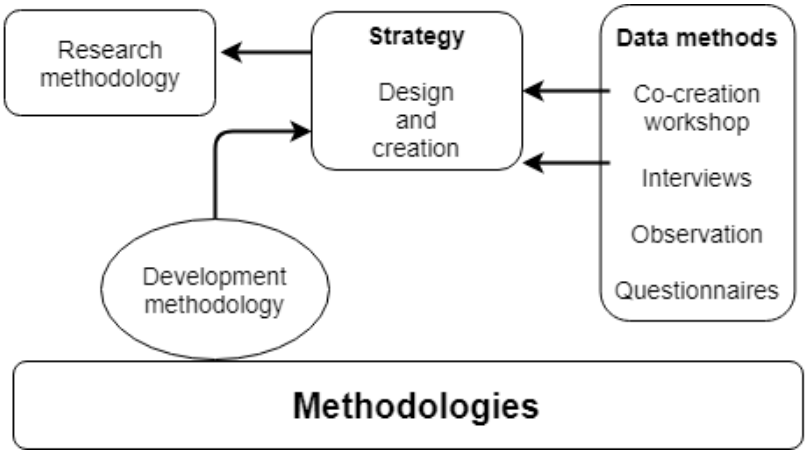


Figure 2.3: Research methodology for the design and creation strategy adapted from [9]

When it comes to the user evaluations, a pre-intervention questionnaire will be given before the evaluation period, and a post-intervention questionnaire will be given after the period. Both the questionnaires are made with Google Forms. Participants in the user evaluation must be recruited, and this will be done by contacting people I know with different backgrounds that owns an Android device, and that are willing to use the application for approximately a week. Both people with technological knowledge and people from other study areas and professions will be contacted for the user evaluation. During the period, the participants can make contact if questions arise or something wrong happens with the app.

The data analysis will be mainly qualitative and based on the results of the questionnaires,

workshop, interviews, and observation. The data processing consists of gathering all the data in a spreadsheet to get an overview of the answers and notes taken. The answers that are connected to values in the five-point Likert scale used in the questionnaire, are taken the average of and compared to the average of the previous evaluation, to see if there have been improvement or deterioration in the results. The data from these generation methods are both quantitative, regarding comparing values, but also qualitative from the observation and interviews. The results of the evaluations will be used to discuss the proof of concept, and to identify improvements that need to be done in future work.

The game mechanics that will be found must be critically judged and tested to check if they are suitable for the mobile application. The mobile application that will be developed will be the primary focus of the research as the focus is on developing the design of the app, the game mechanics, and their specifics, and finally evaluating if the app motivates the users to change their habits. The aim is to find out the relevance and utility of using the game design theory and behavior change model theory to demonstrate that they could be incorporated into a mobile application. The primary focus of the research is to find out how this affects the users when it is included. Do they get motivated or does it not have any effect on them.

A figure describing the overall research process related to the work done in the master thesis is shown in Figure 2.4 below. The subsections following the figure describe in detail the different steps of the research process.

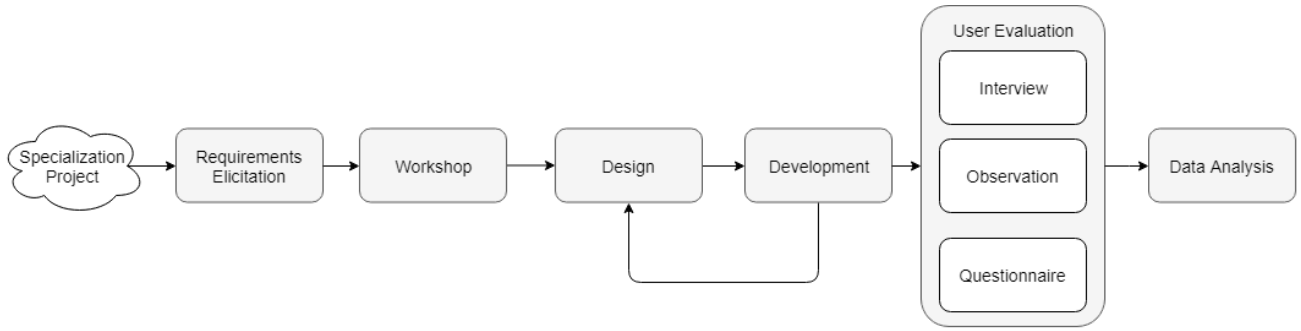


Figure 2.4: Overall research process

2.2.1 Specialization Project and Literature Review

Together with the background study done in the specialization project, literature about game mechanics, transtheoretical behavioral models, co-design, and MyG methodology to mention a few, were studied during this stage. The literature reviewed were recommended books and articles suggested by my supervisor. After studying these, search engines such as Oria (from NTNU) and Google Scholar were used to find peer-reviewed articles and books on the sub-

ject. Search words used during this stage were words like ”game mechanics”, ”transtheoretical model”, ”co-creation”, ”co-design”. It was attempted to find articles or books that were relevant regarding developing mobile applications when looking through the results of the search. The articles that had the most citations were looked at when selecting what to read. The background study conducted in the specialization project was the basis for the literature further studied in work for the master thesis. The knowledge gained was used to elicit requirements, design the application and find relevant game mechanics.

2.2.2 Requirement Elicitation

This stage consisted of three different phases. Each phase has different data generation methods that will be described below.

Specialization Project

Requirements elicitation is an essential phase of the project to find the requirements to implement and focus on when developing the app. Several methods were used for this stage, and the phase started in the specialization project with studying the revealed requirements in the work done by the former master student [7]. After the two rounds of user evaluations of the app and the prototype, conducted in the specialization project, requirements were revealed during testing with users and documented so they could be fulfilled. Together these were gathered in a list of requirements shown in Chapter 4.

Survey

The next method used to find further requirements was a survey that was handed out to the project members at the DESENT Project meeting held at SINTEF Energy. This survey was created to reveal what the project members thought were most important to prioritize in the work and find out which requirements should have the highest priority.

Workshop

The last method to finalize the list of requirements was the workshop held at the same project meeting mentioned above. The workshop was a co-creation session that used a gamification methodology called MyG methodology that will be further described in Chapter 3 and 5. The result of the workshop was a set of game mechanics the participants thought should be used in the app, and it also gave a lot of feedback and ideas they had for the app. The results from the

workshop were found to be useful input for requirements elicitation. The workshop stage will be further described below as it is categorized as an own stage in the research.

2.2.3 Workshop

As mentioned in the previous paragraph, a workshop was conducted that was based on the MyG methodology. The methodology is a co-creation methodology that is developed primarily for gamifying processes to support the operation of brainstorming how to best gamify the processes. For data collection during this stage, a template was used to structure the process and to gather data. Pictures were also taken to document the workshop and to save the results. The methodology is described in Chapter 3 and the process and the results are described in Chapter 5. MyG was suggested by my supervisor that is the co-creator of the methodology. MyG proved to be a relevant methodology to use for running the workshop since it had been used in similar situations before. Since the workshop was to be conducted at the beginning of the semester, it was beneficial to use a methodology that was familiar.

2.2.4 Design

The focus of the design stage was to gather the information from the previous stages and design how the app should look like and how the game aspect of the app should be designed. The design stage included both defining the specifics for the game mechanics, and outlining how the game mechanics should be incorporated into the app.

At this stage, the literature study was a valuable aid to facilitate the design, and especially the behavior change models, like TTM, was used to ensure that the stages in the model were incorporated in the design.

Use cases were created to design how the user should interact with the application. These were created by going through the different features and functionality in the app, and creating use cases wherever it felt necessary.

2.2.5 Development

The development stage is divided into three different phases; prototyping, backlog creation and sprint planning, and implementation.

Prototype

The digital prototype (referred to as *the prototype* or *the digital prototype*) was mainly created in the specialization project last semester, with only small adjustments made after receiving feedback from the user evaluation of the digital prototype that was conducted at the end of the specialization project (see Figure 1.1 for the context of when the prototype was created). It was the front-end of the application that was the focus for the digital prototype.

Since the digital prototype was created in the specialization project, most of the work with the prototype was already done. However, because some new game mechanics were included, that had been found during the workshop, these needed to be prototyped as well. Paper prototyping was used to save time and to quickly sketch how these features should look.

The prototypes (both paper and digital) were very useful in the implementation phase as the design was already planned for and this removed a lot of uncertainty around how the app should look, and it was possible to incorporate the new changes effectively. Some elements from the digital prototype were discarded when planning what to implement as they had been showed not to be as engaging to the workshop participants, as initially thought.

Backlog Creation and Sprint Planning

An agile methodology approach similar to Scrum method was used in the implementation phase. Started by creating a backlog of the planned tasks obtained from the elicited requirements. The first draft of the backlog was created in a word document as a list and later formed in a Trello board[1]. The board had the following categories:

- *Backlog:* all the tasks in the backlog,
- *Current Sprint:* all the relevant tasks for the given sprint,
- *In Progress:* the tasks in the current sprint that is currently being worked on,
- *Test:* the tasks that are almost finished but have to be tested,
- *Done:* the tasks that are finished testing.

Since it is only one developer, that is me, the methodology was not followed entirely, and aspects such as daily scrum meetings and strict sprint lengths were not practiced.

When planning for the sprints, the time available was considered, and the plan was to have sprints with duration of 1-2 weeks with different focus areas. The focus on each sprint was obtained from the feedback received from the survey (see Chapter 4.2) and the workshop held, so the prioritization for the sprints was the following:

[1] `https://trello.com/`

1. Usability
2. Gamification
3. Social aspect and the remaining tasks from the previous sprints

Implementation

During the implementation phase, tasks from the *Current Sprint* were moved to *In Progress* as they had been started. After each sprint, the backlog was reviewed and the Scrum board was prepared for the next sprint with the next focus area. As obstacles were met during development, alternative solutions had to be made that were not the ones planned in the design phase. Figure 2.4 shows the overall research process, and an arrow back from the development stage to the design stage was added to show that this was an iterative process that changed the design and how the app was implemented.

2.2.6 User Evaluation

A user evaluation was planned and conducted to test how *Smiling Earth* had managed to achieve the goal of creating awareness, motivate for behavior change and how the new functionality was working out. The evaluation was planned based on the research questions, that will be described closer in Chapter 9. Data generation methods in this stage of the research mainly consisted of results from questionnaire and notes from unstructured interview and observations described below. Due to the small number of participants in the evaluation, this will only give a proof of concept since a statistical analysis is not feasible [9]. The participants consisted of acquaintances with Android devices that were recruited by convenience.

Questionnaire

Two questionnaires were used in the user evaluation. A pre-intervention questionnaire before the test period, and the second, a post-intervention questionnaire after the test period. The first questionnaire contained seven questions that were asked to create a picture of who the participant is, how environmentally friendly he/she perceives him/herself before using the app. The post-intervention questionnaire is longer and examines several things like perceived usability and usefulness of the app, gamification, behavior change model, general concept, bugs detected and tips for further development. The questionnaires can be found in Appendix I and J, and the evaluation method is further described in Chapter 9.

Observation

Observations were done during the installation phase of the evaluation, and also consists of the additional feedback received from the participants during the test period.

Interview

Together with the questionnaire and observation, an unstructured interview was done by asking follow-up questions when needed. These questions were asked to reveal factors that may have had an impact on the results. No questions were planned, and they varied from participant to participant. These informal interviews were conducted during both the installation and pre-intervention questionnaire, and after the evaluation period was over, and the post-intervention questionnaire was finished.

Chapter 3

Background

This chapter will present the background information and theory that is useful for the master thesis. The literature reviewed in the work for the master thesis includes both the review done in the specialization project and the new studies done for the master thesis.

Section 3.1, and some of the subsections from Section 3.2 are obtained from the specialization project which is the basis for the master thesis and is thus relevant to provide the necessary background info for the project and to set the context [8].

3.1 Project Context

The master thesis is part of a research project that is called DESENT. The DESENT project is a European collaborative research project between Norway, Austria, and The Netherlands, and is an abbreviation for *Smart Decision Support System for Urban Energy and Transportation* [10]. The project aims to provide a smart decision support tool to be used for smart grid and city planners, and the goal is to develop a smart energy control concept of household/vehicle energy use through the implementation of advanced ICT technology [6].

One of the primary objectives of the DESENT project is
"To develop an integrated energy information management system for consumers to monitor, control and manage their energy consumption at home and with respect to their vehicles." [6]
In other words it is a goal to use the citizens' energy and transportation data to motivate them to change their transportation and energy habits.

The primary objective of the DESENT project fits well with the goal of the app called *Smiling Earth*, that is to motivate the user to have a behavior that reduces their costs and impact they have on the environment [7]. This is done by showing the effect that their lifestyle has on the environment, based on visualization of carbon dioxide emissions related to the user's energy

consumption and transportation [7].

3.1.1 About Smiling Earth

The following information about the app called *Smiling Earth* is based on my exploration and use of the app during the specialization project, and information provided in Celine Minh's master thesis that is the foundation for this research project [7].

The goal of the app is to create awareness and motivate the user to lower their carbon footprint. This is done by showing the user what their daily carbon footprint is, and how the type of heating and daily driving distance affect the carbon footprint. The app also tries to motivate the user to consider investing in solar panels and an electric car. This is currently done in the *estimation functionality* that shows how much money you can save by switching to either solar panels or electric vehicle. The last factor that should motivate the user to drive less is the calorie tracker that counts calories if you walk or cycle. This should trigger the user to walk or cycle instead of driving to gain health benefits as well as saving money.

The daily target that is set by the app is not to have a higher carbon footprint than 4.0 $kgC0_2$. If the user exceeds that daily limit, the Earth, that is happy and healthy from the beginning of the day, will get sadder, sicker and eventually die, see Figure 3.1. This is a metaphor that should show the user how the Earth is affected by a high carbon footprint and global warming.

Figure 3.1: Earth metaphor retrieved from [7]

(a) (b) (c) (d) (e)

The carbon footprint and the expenses are calculated from many things:

- The heating type and the outside temperature (calculates how much energy it takes to heat up a house based on the outside temperature)
  - How much does this amount energy cost? (NOK)
  - How much $kgC0_2$ does it takes to produce this amount of energy?
- The type of car and how much the user drives based on GPS tracking
  - How much does it cost to have this car (registration fee, road fee, etc.) and how much does the use of the car cost? (NOK)

- How much kg$C0_2$ does the car produce when driving x km?

The app uses the GPS of the device, and an API from Google called *Google Awareness API* [1] to track what type of transportation the user is utilizing. Based on the speed of the movement, the app classifies the transportation as either walking, cycling or driving (car). The API currently cannot separate between different transportation means regarding driving, so it is assumed that it is a car that is driven when the app detects this. The reason for this is that the car aspect is supported in the app when the user registers details about his/her car. Calories are calculated if the transportation is classified as cycling or walking.

The calculation algorithms are created by SINTEF Energy and were treated as a black box during the development because this is outside the study area for this master thesis. The documentation for the calculations can be viewed in Appendix F. This document is retrieved from Celine Minh's master thesis because it is the only documentation that exists of it [7].

Application Interface

The interface of *Smiling Earth* consists of some elements that should be presented since a lot is focused around them. The app is mainly focused on showing the user's carbon footprint and the distribution of emissions between transportation and energy. Figure 3.2 shows the circular indicators that visualize this distribution. Green is used to symbolize transportation and blue is used for energy. The figure also shows how the Earth metaphor presented is displayed in the app.

Figure 3.2: Circular indicators and Earth metaphor

The colors mentioned above are also used in the historical graphs that give a visual presentation of the last seven days of historical data about carbon footprint ($kgCO_2$), transportation (km) and

[1] https://developers.google.com/awareness/

energy consumption (kWh). An example of how the graph looks like is shown in Figure 3.3.

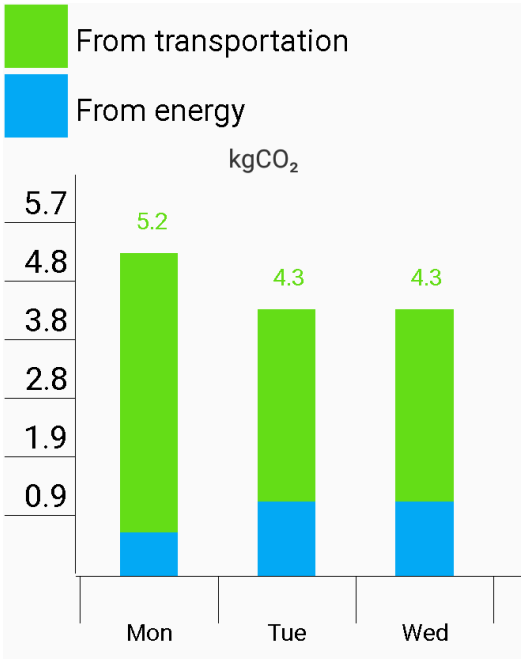


Figure 3.3: Stacked bar chart for historical data

The images shown in Figure 3.2 and 3.3 are retrieved from the *Smiling Earth* V3 to show how the essential elements look when they are discussed later in the thesis.

3.2 Literature Review

This chapter will give a presentation of the literature that is the background for the research conducted in this master thesis. The study is a combination of five main topics that will be presented in the following order: evaluating applications, motivation and behavioral models, gamification and game mechanics, pervasive applications and privacy of data.

3.2.1 Evaluating Applications

One of the main focus areas when evaluating an application is usability. The International Organization for Standardization (ISO) 9241, defines usability the following way:

"Usability is the extent to which a product can be used with effectiveness, efficiency, and satisfaction in a specified context of use." [11]

The following sections are useful when evaluating the usability of the application, and they can be applied when creating questionnaires for the user evaluations.

Ten Usability Heuristics for User Interface Design

Jakob Nielsen formed ten ”rules of thumb” for developing interfaces with good usability [12]. The following heuristics are included in the ten heuristics for user interface design:

1. Visibility of system status
2. Match between system and the real world
3. User control and freedom
4. Consistency and standards
5. Error prevention
6. Recognition rather than recall
7. Flexibility and efficiency of use
8. Aesthetic and minimalistic design
9. Help users recognize, diagnose, and recover from errors
10. Help and documentation

The ”rules of thumb” can be us as guidelines when developing the user interface of *Smiling Earth*, as well as in a heuristic evaluation, which is characterized as informal [13]. According to Nielsen, heuristic evaluation is done by user evaluations looking at the interface and giving their opinion about what is positive and negative about the design. The ”rules of thumb” are beneficial for the user evaluations that are conducted in this master thesis as they are both informal and will ask the participants to give their opinion about the interface.

System Usability Scale (SUS)

SUS is a tool for measuring the usability of a system or application [14]. It uses a five-point Likert scale, that spans from *Strongly Agree* to *Strongly Disagree*. The positive thing about the System Usability Scale is that it works well on small sample sizes, which fits well with the evaluations that will be conducted in this research project. The following items are included in the System Usability Scale:

1. I think that I would like to use this system frequently.
2. I found the system unnecessarily complex.
3. I thought the system was easy to use.
4. I think that I would need the support of a technical person to be able to use this system.

5. I found the various functions in this system were well integrated.
6. I thought there was too much inconsistency in this system.
7. I would imagine that most people would learn to use this system very quickly.
8. I found the system cumbersome to use.
9. I felt very confident using the system.
10. I needed to learn a lot of things before I could get going with this system.

Technology Acceptance Model

A Technology Acceptance Model (TAM) can be used to study the acceptance of an application [15]. This model states that perceived ease of use leads to perceived usefulness and intention to use the application as shown in the Figure 3.4 below.

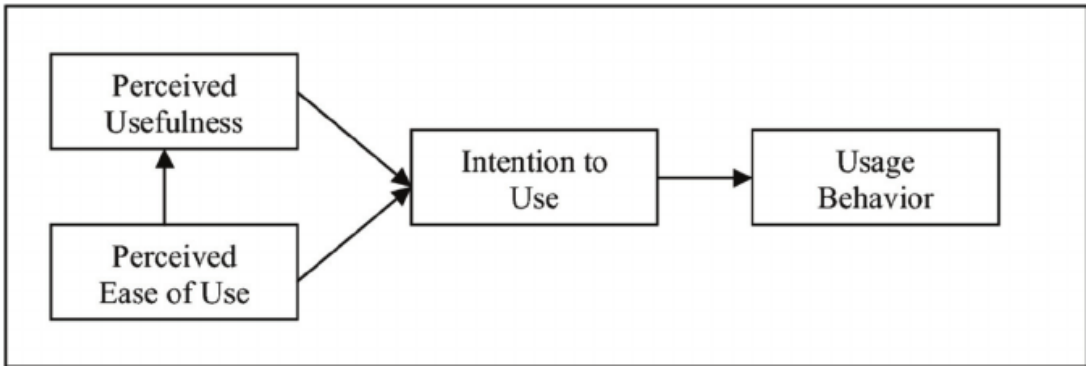


Figure 3.4: Technology Acceptance Model [16]

3.2.2 Motivation and Behavioral Models

Motivational factors and how to motivate players in a game are essential aspects of the application. The app aims to encourage behavioral change, and the following paragraphs will present different theories that are relevant for this aim.

Motivation

There are two types of motivation, external and internal [17]. Those who have internal motivation are usually more genuinely motivated than those who are only driven by external motivation [18]. External motivation in the application can, e.g., be that the points received in the app give physical rewards such as free bus tickets or a discount on solar panels or electric cars. Internal motivation is wanting to reduce their carbon footprint to help save the Earth

because they know how a high carbon footprint affects the climate. Richard M. Ryan's self-determination theory is focused on the internal motivation to achieve personal development and self-regulation [18]. It should be a goal for the application to try to inspire the user to get an internal motivation for reducing their carbon footprint.

Player Motivations

Since one of the goals with the application is to include game mechanics and create a game around lowering the players' carbon footprint, it is necessary to look at what motivate players in a game. Barbaros Bostan, claims that gaming motivation is derived from the human's basic needs, that is [19]:

- **Materialism:** associated with inanimate objects
- **Power:** represent the will to arouse strong emotions in other people, to be in charge, and to be noticed
- **Affiliation:** represent the motive to establish, maintain, or restore positive social relationships with others
- **Achievement:** the desire to achieve success and to overcome obstacles
- **Information:** the instinct to gather and analyze information
- **Sensual needs:** the tendency towards exciting or gratifying experiences that satisfy or are attractive to the senses

Another focus area when developing a game is to maximize player enjoyment [19]. Enjoyment is important to keep the player from getting tired of playing the game, and enjoyment contains the three dimensions physiological, affective and cognitive.

Challenges in the app cannot be too hard so that they feel impossible to complete, but at the same time, they cannot be to easy as this would lead to boredom [20]. A right balance between this will increase the enjoyment of the user. Reaching this balance is called *Flow* and the theory behind this is stated by Mihaly Csikszentmihalyi [20]. The design of *Smiling Earth* should hence try to be exciting and challenging enough, but not too challenging as this could lose users if the app is too hard and the goals feel impossible to reach.

Personal and environmental factors trigger a goal-directed behavior [19]. In an app like *Smiling Earth*, it should be the focus to trigger goal-directed behavior. Goal-directed behavior is explained by continuous interactions between individuals and their environments. The long-term goal of the application is to lower the users' carbon footprint, and this can be achieved by achieving short-term goals.

The Transtheoretical Model

The Transtheoretical Model of behavior change (TTM) is a behavioral change model that consists of five stages of change (see Figure 3.5) [21]. It is called ”Transtheoretical” because it integrates different processes and principles of change from various theories. TTM is essential for the application because the app aims to change peoples behavior, and the model can be used as guidance on how to help people through the stages and reach lasting behavior change.

Figure 3.5: The Transtheoretical Model of behavioral change [3]

The process of behavioral change can be linear, as shown in the figure above, but it is also common that the process is non-linear and cyclical [3]. Following is a description of the five stages that are presented in Figure 3.5 above:

- **Precontemplation** *(Not Ready)*: Not planning to take any action within the next six months.
  - This stage involves people that have not started to use *Smiling Earth*. They are uninformed about the consequences of climate change and a high carbon footprint.
- **Contemplation** *(Getting Ready)*: Planning to take action within the next six months.
  - This stages involves people that have started to use *Smiling Earth*, and are getting more aware of how their habits affect the environment. They also start to see the pros for making the change, like receiving health benefits from walking to work, but they are also aware of the cons, like using 45 minutes to get to work instead of 10 minutes by car.
- **Preparation** *(Ready)*: All set to take action within 30 days.

  - Typically for people in this stage is that they have made some changes the last year, and have a plan for how they can change, like buying an electric bike that can be used instead of the car.

- **Action:** Have made changes in everyday behavior in the last six months.
  - People at this stage have, e.g., started to cycle to work, but they have to strain themselves not to fall back into old habits like driving to work when it is raining outside.

- **Maintenance:** Have done the new behavior for over six months.
  - People in this stage have made changes in their lifestyle, like replacing their petrol car with an electric car, but they still have to prevent relapses in some situations.

Applications of TTM

When searching for literature, TTM is shown to be used mostly for health-related behavior changes such as losing weight and quit smoking. One of the applications found was a project to increase exercise in a workplace [22]. The good thing about TTM is that it incorporates the fact that not everyone starts at the same stage. Some may not make any changes to help the environment, while some are taking action and have already started to make small changes in their habits. These people are in different stages and have different needs to motivate them to move to the next stages.

The stages of TTM were presented in the previous section, and the ten processes that help them move from stage to stage are presented in the list and the Figure 3.6. The book called *The Transtheoretical Model* have described the processes in the following way [3]:

- **Consciousness raising:** finding and learning new facts, ideas, and tips that support the healthy behavior change
- **Dramatic relief:** experiencing the negative emotions (fear, anxiety, worry) that go along with unhealthy behavioral risks
- **Self-reevaluation:** realizing that the behavior change is an important part of one´s identity as a person
- **Environmental reevaluation:** realizing the negative impact of the unhealthy behavior or the positive impact of the healthy behavior on one´s proximal social and physical environment
- **Self-liberation:** making a firm commitment to change
- **Helping relationships:** seeking and using social support for the healthy behavior change

- **Counterconditioning:** substitution of healthier alternative behaviors and cognitions for the unhealthy behavior
- **Reinforcement management:** increasing the rewards for the positive behavioral change and decreasing the rewards of the unhealthy behavior
- **Stimulus control:** removing reminders or cues to engage in the unhealthy behavior and adding cues or reminders to engage in the healthy behavior
- **Social liberation:** realizing that the social norms are changing in the direction of supporting the healthy behavior change

Participants in change will always weigh the pros and cons against each other. The advantages will be the benefit of changing, and the disadvantages will be the costs of changing [3]. The pros must weigh more than the cons to a person that is supposed to make a change. This is because the change must not feel like a sacrifice that costs too much. Figure 3.6 shows that as a person progress towards higher stages of change (towards *Maintenance*), the pros of changing increases and the cons decreases.

There is also the aspect of self-efficacy, i.e., the belief the person has in themselves to manage to do the change [3]. Self-efficacy has two dimensions, and increases as a person progress towards taking action (see Figure 3.6). The two dimensions are:

- **Confidence:** Confidence that one can engage in the healthy behavior across different challenging situations.
- **Temptation:** Temptation to engage in the unhealthy behavior across different challenging situations.

Figure 3.6 shows the stages and the processes together. The illustration is created on the basis of [3] and [22]. The figure visualize which processes that are most common between the stages and is used to structure the TTM in Chapter 4, 6 and 10.

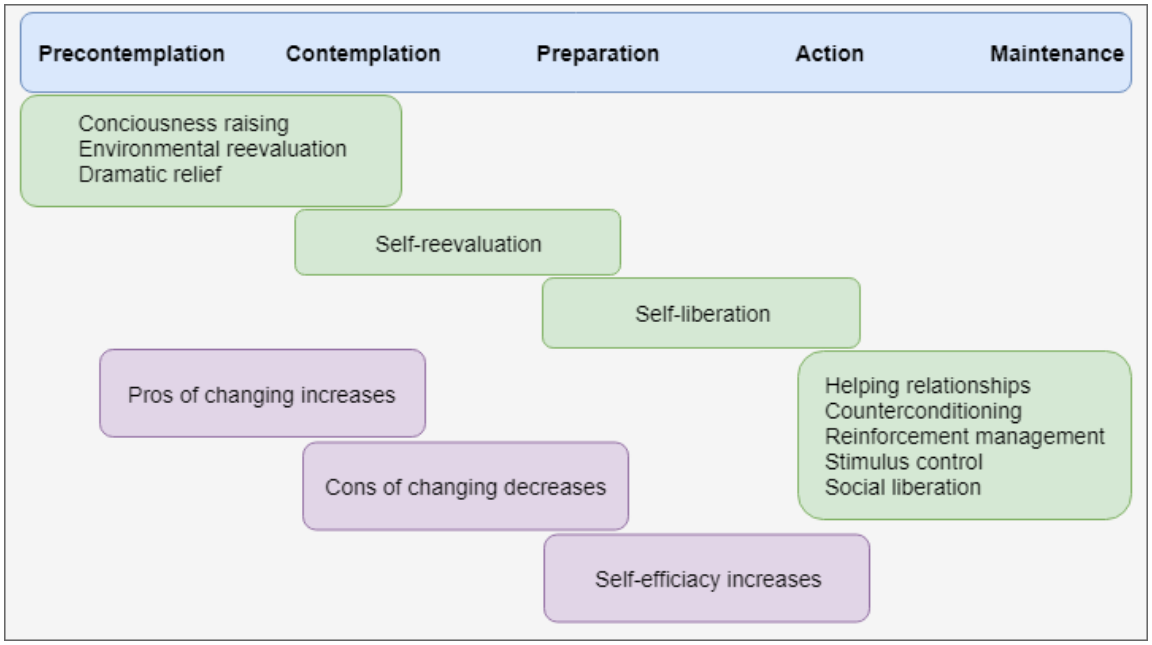


Figure 3.6: The stages and processes in TTM created on the basis of [3, 22]

3.2.3 Gamification and Game Mechanics

Incorporating game mechanics in the application could be a method to increase the user's motivation. The following paragraph will present the concept of *gamification* and a methodology that helps gamifying processes.

Gamification

In Karl M. Kapp's book about gamification, he defines gamification the following way:

> *"Gamification is using game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning, and solve problems."* [17]

Sebastian Deterding has proposed a different definition of gamification, that is:

> *"..the use of game design elements in non-game contexts."* [23]

The definitions of gamification fit well with the aim of the application because the goal is to motivate, teach and engage people in solving the problem of climate change and too high carbon footprints per person. However, Kapp points out that the trick is to integrate game mechanics in such a way that it is not excessive noise in the application [17]. Kapp also states that gamification is not just about adding badges, points and rewards [17].

MyG Methodology

As mentioned in the last paragraph, gamification involves using game mechanics. Game mechanics are important building blocks to be used during the gamification process [17]. To help the process of deciding which game mechanics that could be useful to include in an app to achieve successful gamification, a gamification methodology named MyG, has been created [24]. This methodology involves 52 playing cards that incorporate six different aspects of gamification. The cards are a fun and helpful tool in workshops. The following six types of cards exist:

- **User archetype:** identifying target users of the game
- **User experience:** the experience of the user when playing the game
- **Goal:** goals that can be achieved in the game
- **Motivation:** intrinsic motivation the user can have
- **Game mechanic:** components of gamification
- **Social game mechanic:** social components that influence the user's behavior

This alternative method for gamestorming/brainstorming ideas was created to generate ideas for how to best gamify the app, and supports co-creation activities [24]. Co-creation is an excellent method for including the stakeholders in the process and making sure the process and final results meet their requirements [24]. The methodology was developed in 2013 by Sobah Abbas Petersen (my supervisor), Manuel Oliveira and Anandasivakumar Ekambaram. The objective of creating the methodology was to help the process of deciding which game mechanics that could be most useful to include to successfully gamify a process [24].

MyG involves playing with cards and deciding which cards would be most important to include to achieve successful gamification. By using the cards, it becomes easier to brainstorm and concrete the process. The methodology can be viewed in Figure 3.7 below, and it consists of three main parts, namely *Setting the context*, the *MyG process* and *Crowning a solution* [24].

Figure 3.7: Co-design method [24]

The cards that were mentioned above are used in the *MyG process*. The cards are created based on carefully studying games and literature, and finding the elements that are most often used, and the cards systematically show their purpose in most games [24]. Figure 3.8 below shows a general description of how the game cards look and of which elements it consists.

Figure 3.8: Gamification cards [24]

The papers written about the MyG Methodology were used to prepare and plan the workshop, as well as discussing with my supervisor that is the co-creator of the methodology [24]. The paper presents the literature the methodology is based on, how it is tested and what the results of testing and pilot studies were. It also presents the methodology and the cards used in a thorough way [24].

Co-Creation

The MyG methodology facilitated running a workshop with the stakeholders of the DESENT project in a co-creation session. Sanders and Stappers have defined co-creation as

"any act of collective creativity, i.e., creativity that is shared by two or more people." [25]

There are several different applications of co-creation, ranging from physical to metaphysical, and from material to the spiritual. The co-creation process will include participants with different levels, based on their experience on the topic. The researcher or the leader of the co-creation process must adjust the support giving based on the skill level of the participants.

Conceptualization

Coming up with ideas for the game, or conceptualization, is essential for successfully gamifying the application [26]. Co-creation is a suitable method for conceptualization, as brainstorming with other people will typically generate more ideas and inspiration during discussions. Previously, brainstorming for game mechanics were done alone, but the MyG methodology presented have shown that getting other peoples' opinion and structuring the processes can be essential to productive brainstorming [24]. It can be useful to focus on formal elements such as player's goal, who the target audience of the game is and so forth. This will help the game take form and to outline where the game is headed. Kevin Keeker claims that focus groups are more useful for generating ideas, and not for evaluating games [26].

Game Mechanics

Choosing which game mechanics to implement in the application is part of the goal of the MyG gamification workshop. There exists a lot of different game mechanics that could be included in the app, but the following paragraphs will describe the game mechanics that are found most relevant to use in the app, *Smiling Earth*.

Progression To be able to see the progression towards a goal can be motivating. This can both be because a user can see that their actions help them progress towards a goal, as well as visualizing how little is missing when approaching the goal [24]. Progression can be shown in different ways, e.g., linear progress bar, circular progress bar, and figures that change according to progression [27].

Figure 3.9 shows screenshots from two applications that use many game mechanics. Progression is a very common game mechanic that is used in various applications, like Fitbit (circular progression bar)[2], Hold (circular progression bar)[3].

[2]https://www.fitbit.com/ Activity tracker with a mobile app that you sync the tracker to view the data.
[3]https://www.holdstudent.com/ App to prevent you from using the phone at school.

(a) Fitbit [28] (b) Hold App [29]

Figure 3.9: Related apps with progression bars

Time The game mechanic time could be a motivator for player activity and action. By having a countdown in the game could raise the player's stress level and motivate them to take action [17]. Another consequence of having time as a game mechanic is that the player could become more focused on finishing the tasks needed to accomplish the goal with the time limit.

Time is used in the Hold app in Figure 3.9 (b) above, where a timer is counting, and you get points every 20 minutes. This means that if you are close to finishing the 20 minutes, then you will wait until the timer is completed before using the phone.

Another example using the Fitbit, that was displayed in the figure above, is that it is a short-term goal to walk at least 250 steps per hour to reduce inactivity. You get a reminder on the watch ten minutes before the hour is up, in which you then have ten minutes to walk the remaining step. This gives the user a time limit and motivates them to take action within the time available.

Virtual Currency Having virtual currency as a reward system in the application implies that it can be used to "buy" something in the app. This could, for example, be coupons or new features. This can motivate the player by trying to gain more currency to afford to purchase something they want [24].

The Hold app, that was used as an example for the game mechanics progression and time (Figure 3.9 (b)), also includes virtual currency. The points you gather when not using the

phone can be used in the ”store” in the app, see Figure 3.10 below.

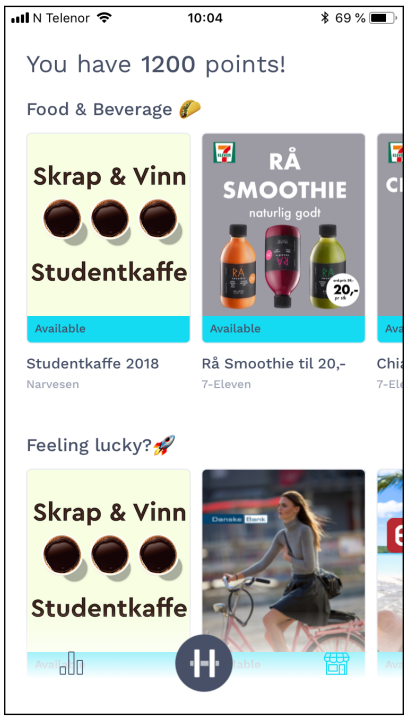


Figure 3.10: The store in the Hold app [29]

Social Game Mechanics

The game mechanics described above are mainly directed towards motivating a single player towards a goal. To have a shared purpose can be a motivation for a lot of people [17]. It can be hard to do things only for ourselves, but if someone else is working towards the same goal, it can put things in a higher perspective and make people do things not only for themselves. Player's can either compete against each other or cooperate towards a common goal [30].

An idea for *Smiling Earth* is to include the community aspect by connecting with friends in the app and be able to see how the people in the neighborhood are doing compared to you. This can be implemented by, e.g., having a **leaderboard** in the app. To have this, we must define rules for scoring points, a user profile that the user creates, and recognizing and rewarding outstanding users.

Another way to create a community feeling is to encourage player-to-player interactions [26]. Social interaction between players can make the game more addictive and fun because it adds another level to the game other than just playing alone. Interactions between players could also have other positive effects, such as finding people to carpool to work to save emissions on transportation. The following paragraphs present some social game mechanics that is suitable for the application.

Call To Arms This is a social game mechanic that aims to engage people in a common cause. A concrete example is a demonstration, where people are encouraged to show up to support a specific cause [24]. The game mechanic can also be used in games to help players do an activity achieve something. Examples of this could be to encourage players to invite as many friends as possible to use the app within a specific period. This could be rewarded by giving them, e.g., virtual currency.

Leaderboard A leaderboard is a ranking of how the player is doing compared to the other players [31]. The leaderboard is a very common game mechanic, and it is well established and easily understood by most users. Leaderboards create competition and can motivate players to do better to get past their friends and be the top player [32]. However, it can also have a demotivating effect if the way to the top seems unachievable. The two apps mentioned above, Hold and Fitbit, both contain leaderboards.

Gifting Gifting means that a player can give a gift to another player. The gift could, e.g., be an amount of the virtual currency in the application. The gift is provided without any expectations of getting something in return, but will often create the wish to repay the gift [24]. This game mechanic is useful for both creating social interaction between the players and creating more usage of the app [26]. Zichermann and Cunningham highlight that the most important thing is that the gifting is fun and easy [31]. They also propose three key mechanics to support gifting:

- easily transferable virtual items
- gift reminders and recommendations
- karma points

Defining Rules

In Salen and Zimmerman's Rules of Play, they define that

"rules are the deep structure of a game from which all real-world instances of the game's play are derived" [30].

Defining rules for the game in the app is thus fundamental for the players to know what to do in the game.

3.2.4 Pervasive Applications

Smiling Earth is based on sensing and tracking of movement of the user without having to register data manually. The vision of pervasive computing is to seamlessly blend into the

life of everyday users and provide services and information anywhere and anytime [33]. The application could give the user real-time information based on where it is, about, e.g., public transportation available nearby.

An example of a related research project that has done a similar thing a few years back, is *UbiGreen* [34]. The goal of this app was to encourage users to use green transportation, and it did this by monitoring transportation habits to create awareness. *UbiGreen* was developed and tested in 2009, and since then a lot has happened with the technology [34]. *UbiGreen* was pervasive by using an extra tracker that had to be brought. *Smiling Earth* does not need an additional device to track movements, as all devices have built-in GPS nowadays and everyone is carrying their devices around all the time.

3.2.5 Privacy of Data

Since the application is a pervasive app that continuously tracks the user with the GPS on their device, it is vital to think about the privacy of the data. The app must obtain consent from the users to be allowed to store their data. The new EU directive, which is called General Data Protection Regulation (GDPR), ensures this [35]. This directive took effect in May 2018, and a fine of 20 million dollars can be received if not followed. GDPR comprises of the following five main points, were especially four of them is relevant to the app [35]:

- **Right to be forgotten:** if the user no longer wants to use the app, their data have to be deleted and erased from both active services and backup systems. The app should also not store data that is no longer necessary to be stored.
- **Explicit consent:** must request consent to collect, use and move data up front. This consent must describe what data you are collecting, why you are collecting it, how it will be processed, how you will protect it, how it is moved and how long it will be stored for
- **Mandatory data breach notifications:** the authorities and users must be notified of data leaks within 72 hours
- **Privacy by design:** privacy and data protection is a key consideration at the start and throughout a project life cycle. Data privacy and protection need to be focused on during the development of an app.
- **Data protection officer:** this requirement is more relevant for large enterprises. The requirement is that they need to employ someone that main task is to manage data protection. This point is not that relevant to this project since it is a smaller project.

Chapter 4

Requirements Elicitation

Requirements were elicited during various stages of both the specialization project conducted last semester and the research phases during the work for the master thesis. To have a clear plan of what is required by the stakeholders, users, and theory, this chapter will describe how the requirements elicitation was conducted and the processes done during this stage of the project. It consists of three main parts: findings from the **background studies**, **survey**, and **workshop**.

4.1 Background Study

As mentioned in the chapter description, the requirements elicitation phase began in the specialization project. User evaluations were conducted, and requirements were elicited from this. The first subsection will present this requirements list. After that, the requirements found in literature will be described.

4.1.1 Requirements from Specialization Project

Table 4.1 shows the list of requirements to be used in the work for the master thesis. The priority labels decide what is most important to implement. The requirements in the table below are retrieved from observations made during user evaluations of the app and the prototype, and from comparing results of the two evaluations conducted in the specialization project Fall 2017 [8]. The ID's of the requirements indicates if they are a *Functional Requirement (FR), Non-Functional Requirement (N-FR)* or a *Constraint (C)*.

Table 4.1: List of requirements

ID	Requirement	Priority
	Goal setting and feedback	
FR1	The app shall provide personalized goals	Medium
FR2	The app should provide daily challenges to lower the user's gas emissions	Low
FR3	The app should provide a physical reward	Low
FR4	The app shall provide personalized feedback on how the user is doing, and how that affects the environment	High
FR5	The app shall provide practical examples of related things that the carbon footprint represent	High
FR6	The app shall have defined rules for when to receive points and badges	High
	Data visualization	
FR7	The app shall display information regarding the user's behavior on a daily basis	
FR7-1	The app should explain the cause of the possible deviation from the user's habits	Medium
FR8	The app shall raise the user's awareness about the effect of gas emission	High
	Community and social media	
FR9	The app shall provide a comparison of the user's data with the community	Low
FR10	The user shall be able to compare his/her results with his/her friends	Low
FR11	The user shall be able to compete with other users	Low
FR12	The user should be able to join collaborative challenges	Low
FR13	The app should allow the user to share his/her results in external social media	Low
	Settings	
FR14	The user shall be able to correct the details of transportation used during a journey	Medium
	Backend calculations	

Table continues on next page

Table 4.1: List of requirements

ID	Requirement	Priority
FR15	The app shall distinguish different means of transportation used during a travel	
FR15-1	The app shall detect the use of public transportation	Medium
FR16	The app should estimate the gas emission during a travel	
FR16-1	Depending on the number of people sharing a car	Medium
FR17	The calculations of calories shall be realistic	High
FR18	The app shall explain how numbers are calculated	High
	Data storage	
FR19	The data generated by the app shall be stored anonymously	High
	Usability	
N-FR1	The app shall have enough explanations, so the users understand what to do in the app	High
N-FR2	It shall be easy to navigate back to previous screen or dashboard from every screen	High
N-FR3	The buttons in the app shall look clickable, or everything that looks clickable shall be clickable	High
N-FR4	The app shall scale items to fit every screen size	High
N-FR5	It shall be easier to switch between categories at the history graph	High
N-FR6	The app shall give an introduction on how to use the app	High
N-FR7	The app should contain information about the app with contact info to report bugs or other feedback	Medium
N-FR8	The app should show the title of the screen in the toolbar	High
	Constraints	
C1	The user shall be able to navigate offline, between each synchronization with the server	

4.1.2 Requirements from Transtheoretical Model

The different stages of the Transtheoretical Model (TTM) must be connected to the application to ensure that the app supports the user through the various stages. The five stages that TTM consists of (*Precontemplation, Contemplation, Preparation, Action, and Maintenance*) are related to ten processes that can move the user to a higher stage in the model [22]. Behavioral

change is often constructed as a discrete event [22]. For the context of the application, such a discrete event could be lowering the user's carbon footprint to be less than 4 $kgCO_2$ every day. The process of change will take time and unfold itself over the mentioned five stages, which may not be in a linear manner [3]. Following is a description of the ten process (in **bold**) that mediates progression between the stages (in *italic*) of change, that is applied to the context of the application. Table 4.2 will summarize the requirements elicited from the ten processes.

- *Precontemplation*
  - **Consciousness raising:** The app must raise awareness about how the user's daily activities affect the environment, and the consequences this have.
  - **Dramatic relief:** The app should show that by reducing driving distance or similar, this can help save the environment.
  - **Environmental reevaluation:** Show the impact the user has on the environment, and how the environment could improve if emissions are reduced.
- *Contemplation*
  - **Self-reevaluation:** Give the user an image of what kind of person they are and how that type of person affects the environment, and show the type of person that it should strive to become.
- *Preparation*
  - **Self-Liberation:** Show the user alternatives to transportation that can reduce the emissions. The app could, e.g., show availability of city cycles or public transportations nearby, or support the possibility to arrange to carpool with acquaintances.
- *Action*
  - **Counterconditioning:** The app should focus on the benefits of walking or cycling instead of driving, such as health benefits, saving money, and how the environment benefits from it.
  - **Helping relationships:** The app could have functionality for social support from other users. It should be possible to give (and receive) encouragement to other users, as well as make the user feel not alone in the behavior change.
  - **Reinforcement management (Contingency management):** Show the user that green behavior is the right behavior, by giving prizes when a positive behavior has been done. This will reward the users and teach them what is correct behavior. Could also punish the user if it has a high carbon footprint, but this could have an opposite effect than what is desired.

- **Stimulus control:** Support the user to not fall back to old (not environmentally friendly) habits such as driving everywhere instead of cycling. Show examples of how the reduction in emissions has made a difference in the environment.
- **Social liberation:** Show the user that it is not alone in making a change, and proving that it is a new social norm to change towards supporting the environment.

• *Maintenance*

ID	Requirement	Priority
FR20	The app shall visualize the effect the user's activities have on the environment, and the concrete consequences this impact have	Medium
FR21	The app should provide concrete feedback that shows the user what reducing emissions would contribute to	High
FR22	The app should have levels that places the user based on his/hers emissions	Medium
FR23	The app should provide suggestions for alternative transportation for distances often travelled:	
FR23-1	- Public transportation available	Medium
FR23-2	- Walking/Cycling distance with benefits	High
FR23-3	- Car sharing opportunities with users living close by and are travelling the same way	Medium
FR23-4	- City cycles available	Medium
FR24	The app shall highlight the positive effects of walking/cycling instead of driving:	
FR24-1	- Health benefits	High
FR24-2	- Expenses saved	High
FR24-3	- Benefits for the environment	High
FR25	The app shall provide functionality for social interaction between the users so they can encourage each other on the way of reducing their carbon footprint	High
FR26	The app shall provide the user with prizes to reward positive green behavior	High
FR27	The app shall provide feedback when negative trends in the behavior are detected	Medium
FR28	The app shall provide the functionality to look back on the user's evolution and give feedback on how much this has helped the environment	Low
FR29	The app shall provide the user with news from the media related to how the society is changing and what is the social norm	Medium

Table 4.2: TTM requirements

4.1.3 Pervasive

For *Smiling Earth* to be a pervasive app, it must fulfill the expectations of pervasive applications that is to seamlessly blend into the everyday life [33]. This means that the application must automatically sense when the user is on the move, and track this as accurate as possible, so the user does not feel the need to report information manually. The aspect of receiving prizes for green behavior should also meet the expectations of pervasiveness, and it is crucial that the user does not feel it has been cheated for any awards.

ID	Requirement	Priority
FR30	The app shall automatically track the user's movement to calculate the carbon footprint based on transportation means and energy consumption	High
FR31	The app should track as accurate as possible so the user does not feel the need to manually report	Medium
FR32	The app shall give the user prizes seamlessly during the day when green behavior is detected	High

Table 4.3: Pervasive requirements

4.1.4 Privacy

Privacy of data is vital to make the user's data safe and make the app reliable and trustworthy so that the user feels safe when using the app. GDPR is a directive that must be met not to receive a fine [35].

ID	Requirement	Priority
FR33	The app shall be in compliance with the GDPR	
FR33-1	Right to be forgotten	High
FR33-2	Explicit consent	High
FR33-3	Mandatory data breach notification	Medium
FR33-4	Privacy by design	Medium

Table 4.4: Privacy requirements

4.1.5 Gamification

Game mechanics must not be excessive but well integrated into the app [17]. Rules of play must be well defined as described in the app, so the user knows how to receive prizes and why things happen in the game [30].

ID	Requirement	Priority
N-FR9	The app design shall be minimalist and not get overloaded with game mechanics	High
N-FR10	The app shall have clearly define rules of play that is easy accessible for the user	High

Table 4.5: Gamification requirements

4.2 Survey

This section will present the survey handed out at the DESENT project meeting held at SINTEF Energy in Trondheim January 25. 2018. The objectives of handing out the survey will be presented first, and the process of creating the survey will be described after that. How the response was retrieved from the participants is presented in Section 4.2.3 and the results follow afterward.

4.2.1 Objectives

The primary objectives of handing out a short survey were to find out what the stakeholders thought was most important to focus on during the development of the app. Another significant objective was to get some input on which direction to take concerning pursuing a focus on the individual user or a community focus.

4.2.2 Survey Creation

The complete survey can be viewed in Appendix A. The first question of the survey asked the respondents to prioritize the four functions/features for implementation explained below, by giving a rank of importance from 1 to 4:

- **User profile:** create a user profile for the user that can show their achieved score and rewards, set their personal goal and see their progress, change personal information, see their friends.
- **Gamification:** focus on gamifying the app and make it fun to use and motivate the user to change their behavior.
- **Connect with friends:** implement functionality to connect with other users and to be able to compete and encourage them.
- **Visualization of historical data:** focus on presenting the user's data in a good way that is correct and easy to read.

The second question was created to find out which characteristics of the app were most important for the stakeholders. The following characteristics were asked to be ranked:

- **The app should be easy to use:** Is usability of the app important? This statement is mostly focused on the functionality and the fact that it should be easy to navigate and use the app.
- **The values presented in the app should be easy to read and understand:** numbers are easy to read, graphs are easy to interpret and easy to find.
- **The app should show correct values when tracking:** the correctness of the data showed in the app is important.
- **The app should be fun to use:** game mechanics should be implemented to make the app fun to use.

The third question was asked to find out which direction to pursue concerning gamification directed towards motivating the individual users, or a community of users. The question was formulated in a way that asked what the respondent thought would excite them the most.

The next questions were open for longer answers, and it was asked for their perceived intention to use the app together with an explanation of their answer. If they had any ideas on how the app could be improved or had other comments, the next two questions supported this.

The last question in the survey was created to see if the respondents had any suggestions for a new name for the app. The app is currently named *Smiling Earth*.

4.2.3 Execution

There were eight respondents with different background and interests in the project. Their backgrounds are listed in Appendix B, and their positions were ICT professors, employees from an innovation company, employees from the municipality, scientist, and engineer. The survey was printed out on two-paged papers and handed out. There was no time limit on completing the survey, and they were told to return it when they were finished completing the survey. The participants had to base their answers on a short presentation that was given of the prototype and the aims for the master thesis. They did not get the opportunity to test the prototype.

4.2.4 Results

The survey had eight respondents, but one misunderstood the first two questions and just crossed off instead of ranking the items with numbers. This should probably have been explained better, but luckily the seven other participants understood what to do. The items that

were crossed received the rank of 1 and the ones that did not receive a cross, got a 2. To see which feature/functionality that received the highest ranking, the average of the rankings for the four features were calculated. The feature with the lowest average is the one that should be of highest priority. The results were quite even between first and second place (see Table 4.6). An example of how the average is calculated is shown below:

$$(\mathbf{4} * 4 + \mathbf{3} * 3 + \mathbf{2} * 1 + \mathbf{1} * 2)/8(\textit{respondents}) = 2.9$$

Which feature/functionality do you think is the most important to prioritize?

	Respondents								Priority ranking				
	R1	R2	R3	R4	R5	R6	R7	R8	4	3	2	1	**Avg.**
User profile	4	4	4	1	4	1	3	2	4	1	1	2	**2.9**
Gamification	3	1	1	2	3	2	1	3	0	3	2	3	**2.0**
Connect with friends	2	3	3	2	2	3	2	4	1	3	4	0	**2.6**
Visualization of historic data	1	2	2	2	1	4	4	1	2	0	3	3	**2.1**

Table 4.6: Results of question nr. 1 in the survey

It looks like Gamification received the highest ranking, and should thus be of highest priority. Visualization of historical data received almost the same score and should also be of high prioritization. Connection with friends and creation of a user profile will be of lowest priority. The final prioritized list looks like this:

1. Gamification
2. Visualization of historical data
3. Connect with friends
4. User profile

The same method for calculation was also used in the second question. The results were more spread in this question as can be viewed below in Table 4.7. Ease of use had the lowest average, and thus it will be of highest priority. The highest average and thus the lowest priority went to *"The values represented in the app should be easy to read and understand"*. This shows the fact that the app is not first of all an accurate measuring instrument, but it is an app that should create awareness and motivate users to lower their carbon footprint. That the app should be fun to use reflects the result in the previous question, and it is ranked as the second most important thing for the app.

What do you think is most important for this app?

	Respondents								Priority ranking				
	R1	R2	R3	R4	R5	R6	R7	R8	4	3	2	1	**Avg.**
The app should be easy to use	3	1	2	1	2	1	2	3	0	1	2	3	**1.3**
The values presented in the app should be easy to read and understand	2	4	1	1	4	3	3	2	2	2	2	2	**2.5**
The app should show correct values when tracking	1	3	4	2	3	4	4	1	3	2	1	2	**2.8**
The app should be fun to use	4	2	3	1	1	2	1	4	2	1	2	3	**2.3**

Table 4.7: Results of question nr. 2 in the survey

The final prioritized list looks like this:

1. The app should be easy to use
2. The app should be fun to use
3. The values presented in the app should be easy to read and understand
4. The app should show correct values when tracking

Six out of eight respondents answered that they thought both focus areas would be motivating for them, namely both personal actions and individual goals and community actions and collective goals. This indicates that it should not only be a focus on one of the two, rather a focus on finding game mechanics that will embrace both aspects. The distribution of the answers is shown in Figure 4.1 below.

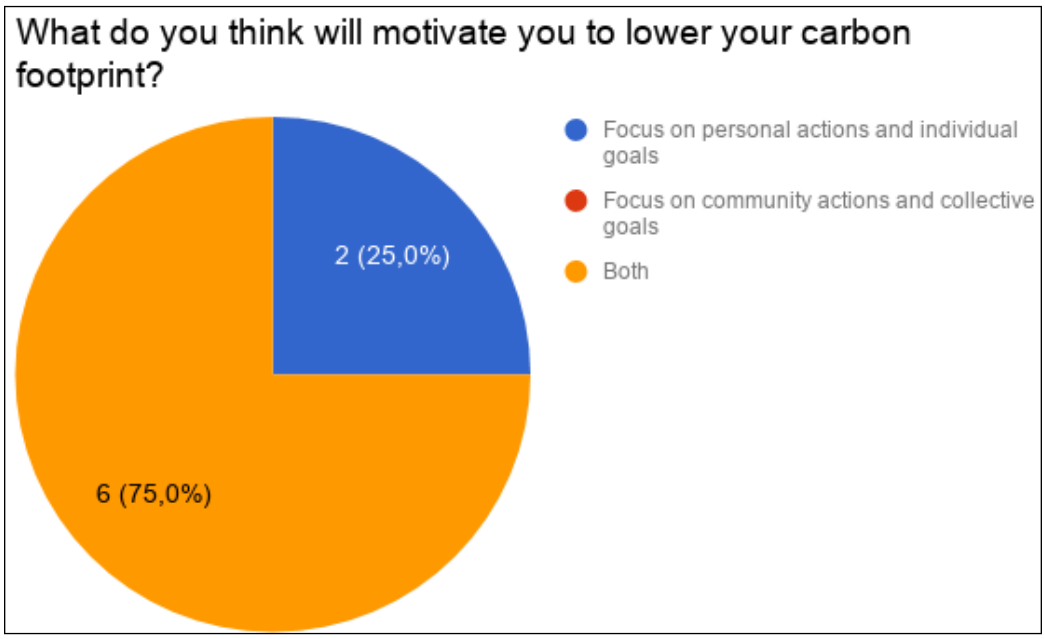


Figure 4.1: Pie chart: Focus on individual or social

When it was asked to suggest other things that will motivate, the following answers were received:

- Money, micro-rewards, ranking, ”leveling-system”
- Competition, incentives
- Connection with friends, ”goodies” from the municipality for reached goals
- Household budget

A third of the respondents said they would like to use this app in the future, and the rest except one said they would maybe want to use the app (see distribution in Figure 4.2 below). One answered that he/she would not like to use the app as he/she did not usually use apps at all. The explanations from the people that responded *”maybe”* were mainly that the app must be perceived useful for them to start using it. The answers are listed below Figure 4.2.

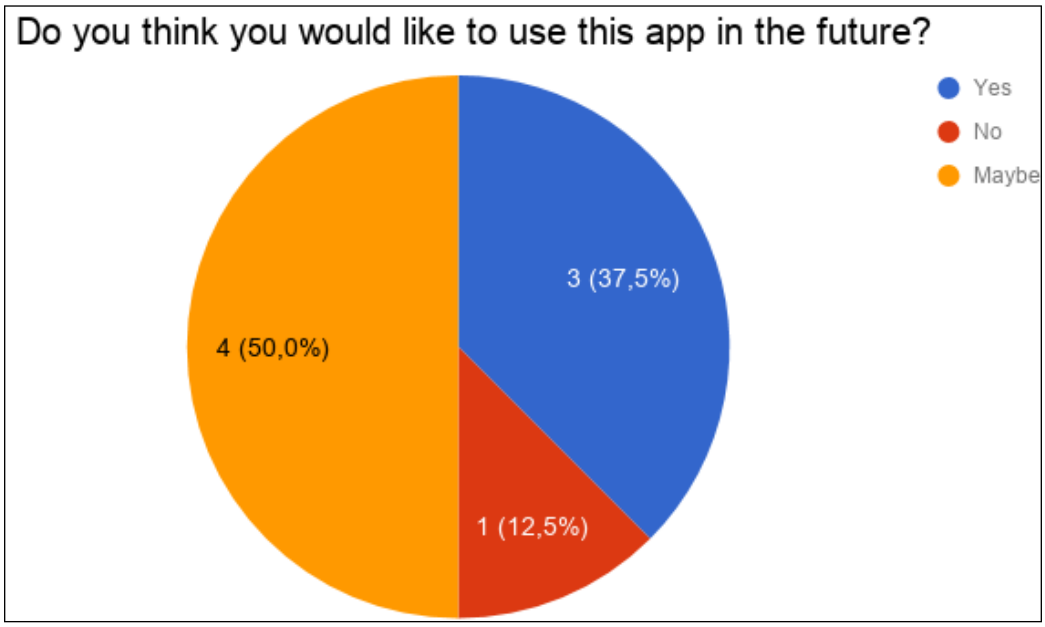


Figure 4.2: Pie chart: Intention to use app

Explanation of their answers:

- Yes, I‘m interested in my savings and carbon footprint
- Yes, interested in the environment
- Yes, it’s very interesting to see your carbon footprint. Can change the behavior.
- Maybe, will try for a certain period and find out how useful/fun it is
- Maybe, have to try it first
- Maybe, to use the bike more, to save CO_2, to do more for my health

- Maybe, if the app would help me to achieve the goal
- No, I don't use apps

Following are the answers received on the question about how the app could be improved. These are all good feedback to keep in mind when choosing what to implement, as they show that some of the things that received a lower rank in the first two questions are in fact things that could help improve the app.
How do you think the app could be improved?

- More accurate information, maybe more transportation modes, include time allocation for activities
- More attractive for younger people, more interesting
- Connection with friends, family, connection to real life, connection to other city citizens
- Information accuracy

The last two questions in the survey gave the following feedback:
Do you have any other comments or feedback about the app?

- The app should focus on not too many things, but rather some aspects to not confuse the user too much
- The design is easy to understand and use - I like it

Do you have a suggestion for a new name for the app?

- "This is you - CO_2"
- No, Smiling Earth
- I like Smiling Earth

All the answers from the survey can be viewed in Appendix A.2.

4.2.5 Conclusion Survey

From the survey it was found that the most important functionality to prioritize when implementing the changes in the app were:

1. Gamification
2. Visualization of historical data
3. Connect with friends
4. User profile

This means that the results of the gamification workshop are valuable for the work to be done since the stakeholders highly prioritized it. It also shows that the choice of focusing on gamification in the research appealed to the stakeholders and that they believed the app could be improved by including game mechanics.

The stakeholders also found these aspects most important for the application:

1. The app should be easy to use
2. The app should be fun to use
3. The values presented in the app should be easy to read and understand
4. The app should show correct values when tracking

An important focus area in the specialization project was to make the app easier to use. The results of the survey show that the stakeholders also think this is an essential aspect of the app. This confirms the prioritization of the focus done in the specialization project and the implementation phase.

4.3 Gamification Workshop

The gamification workshop provided support for choosing which game mechanics to include in the app and will be further described in the next Chapter 5.

Chapter 5

Gamification Workshop

This chapter will present the gamification workshop conducted at the DESENT project meeting. The objectives of the workshop, and how it was planned, are first introduced. How it was executed, and the results are described after that.

5.1 Objectives

The primary objectives of conducting a gamification workshop were to get some ideas from all types of stakeholders of how to best gamify the app, and to engage users and co-create design ideas for the app. To be more specific, the aim was to get a list of game mechanics and define specifics for the gamification that could be used to successfully gamify the process of changing people's habits to emit less CO_2 in everyday life. Another primary objective was to get input on which direction to pursue regarding focusing on the individual user or a community of users.

5.2 Planning the Workshop

To ensure that the workshop would meet the objectives and provide useful insights and results, it had to be well prepared and planned. A meeting with Sobah (supervisor) and Peter (co-supervisor) was held before the project meeting to plan how long time we had available for the workshop and to decide which methodology to be used and how it should be adapted. The *MyG methodology* was suggested to be used as workshop method by my supervisor that is also the co-creator of the methodology [24]. The methodology has been successfully tried with similar types of stakeholders on similar kinds of problem areas. MyG proved to be a relevant methodology to use for running the workshop since it had been used in similar situations before. Since the workshop had to be held at the start of the semester in the project meeting, it was

beneficial to use a methodology that was familiar. This would make it easier to get some useful insights from the workshop as the time to prepare for it was short. The preparation for the workshop consisted of familiarizing with the methodology, adapting it to the workshop and fitting it to the concept of the application.

5.2.1 MyG Methodology

The preparation phase first started in the specialization project during the fall semester 2017, when Sobah first introduced the idea of running a gamification workshop and using the MyG methodology. She provided documentation/papers about the methodology and the gamification cards so these could be studied. The papers written about the workshop were used to prepare and plan the workshop. The papers present the literature that the methodology is based on, how it is tested and the results of the pilot studies. The papers also described the methodology and the cards thoroughly. It was also a lot of help to get explanations from Sobah that is the co-creator of the methodology, when there were any uncertainties. The MyG methodology is presented in Section 3.2.3 in the Background chapter.

Figure 3.7 in Section 3.2.3 shows the MyG methodology and the elements in the process. During the planning meeting with the supervisors, it was decided due to the time constraints in the workshop, that *Setting the Context* would include a short presentation of the work done in the specialization project with evaluating the application, the prototype made and the plans for the master thesis. Then *Setting the Context* would continue with Sobah giving a short introduction of gamification and the MyG methodology.

5.2.2 Adaptions of the MyG Methodology

The MyG methodology and the MyG Process (see Figure 3.7) that was presented in the Background Chapter 3 had to be adapted to ensure that the time spent on the workshop was efficiently used and that the data collection and the knowledge available was captured in a structured way.

Creation of Template

The main process of the methodology was followed, but it was adapted in two ways. The first adaption was to create a template that the participants should use during the workshop. This template was created to streamline and guide the participants as an aid in the gamification process [26]. The template was also created for ensuring the data generation and capturing the results of the workshop. In the documentation for the MyG methodology, it was shown that during their pilot studies they had used templates in some of the workshops [24]. Based on the

results from the pilot studies, the template was created with the aim to fit the objectives and capture the data that was needed. The template created can be viewed in the Figure 5.1 below.

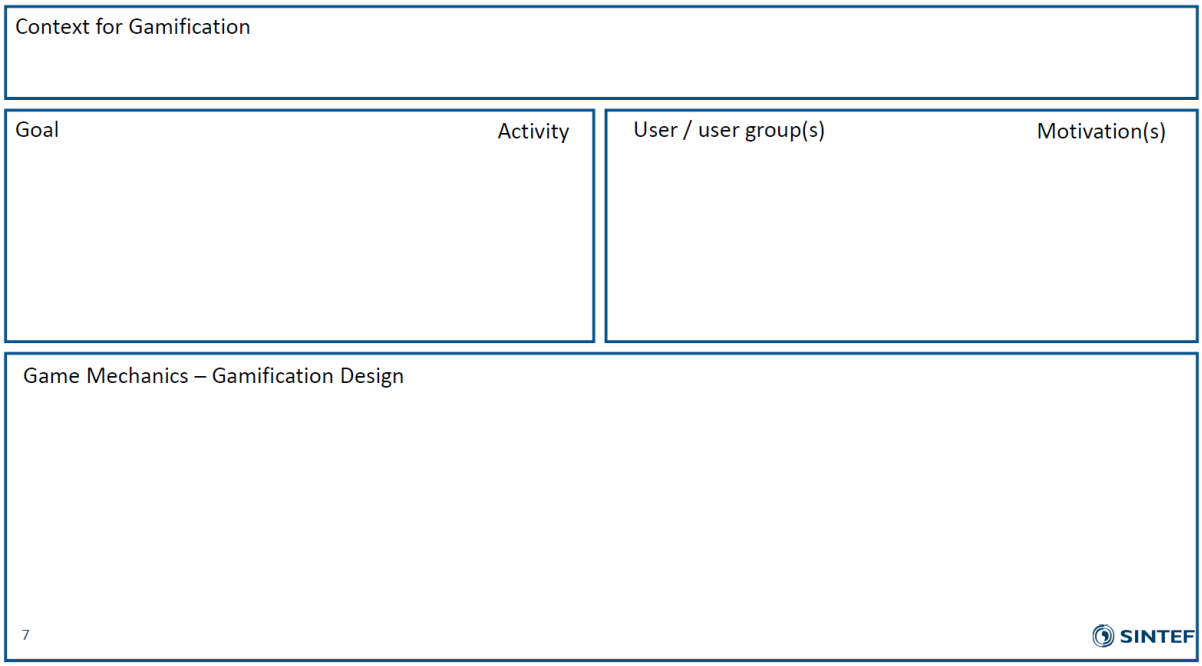


Figure 5.1: Template

Selection of Card Categories

The second adaption of the methodology, to better fit the time and resources available at the project meeting, was not to use all the card categories that the MyG methodology initially contains. The original deck of cards includes 52 cards distributed into six categories that were presented in the Background Chapter 3. Two of the card categories, *User archetype* and *User experience*, were not included in the workshop. This was decided because they would require more experience and knowledge to understand how to be used appropriately, and probably confuse the process for some of the participants that are new to game design theory and gamification. The card categories were also not that important to create a gamified process as the remaining card categories would sufficiently support that.

5.2.3 Goal Cards

The cards in the goal category were reviewed and applied to the concept of the app in preparation for the workshop. The idea behind this was to be able to assist the participants in the workshop by giving them examples of the meaning of some of the goal cards if they were uncertain. The following list shows all the goal cards in the deck together with the explanation

found on the card, and an example of an application to the concept of *Smiling Earth* [24]. All the goal cards were given to the participants in the workshop to be used to create the scenario boards.

- **Share:** The goal is to encourage a situation where users need to share. To consider: Is the aim to share an object? A place? Responsibility?
  - The goal of the app is to get users to lower their carbon footprint by encouraging, e.g., car sharing
- **Build:** The goal is to build something that may be tangible (e.g., a house) or intangible (e.g., trust). To consider: How does a user collate the necessary resources? Is it necessary to have a team to do the building? Are there multiple roles in the building activity? Is the motivation different for those involved in the building?
  - The goal of the app is to build better habits (intangible) that is good for the environment, e.g., cycle/walk to work or the grocery store instead of driving.
  - Could also support building mutual relationships (intangible) between the players where they give each other rewards to help each other reach a goal, e.g., ”gift” the virtual currency in the app to another player so it eventually can afford to buy a solar panel.
- **Make it real:** The goal is to create an activity that leads users to go from the digital to reality. To consider: How to capture what happens in the real world (e.g., use of QR codes, redemption of issued vouchers)? Are there privacy and trust concerns?
  - The application could help the user to choose greener transportation means by showing different alternatives to where the user is usually driving, and by doing this, the user could be convinced to, e.g., cycle instead of driving.
- **Overcome:** The goal is to overcome an obstacle towards meeting a challenge. To consider: Is the obstacle tangible? Or intangible? How is the obstacle related to the challenge? Overcoming the obstacle results in meeting the challenge?
  - The obstacle to overcome could be the habit (intangible) of taking the car wherever you go. This obstacle is directly related to the challenge, and overcoming this obstacle would help a lot with meeting the challenge of the application.
- **Social re-engagement:** The goal is to design a loop starting with a motivating emotion, promoting user re-engagement that leads to a social call to action, with visible progress and reward. To consider: What emotion to elicit from the users? What will be the desired social call for action? What will bring users back? What feedback/rewards to provide?
  - A loop can be created by giving the users the possibility to give each other rewards

to help each other reach a goal, e.g., ”gift” the virtual currency in the app to another player so he/she eventually could afford to buy a solar panel. This will increase the usage of the app because the user that has received a gift from another user would want to repay that gift.

- **Bring a friend:** The goal is to encourage a friend to follow or engage in an activity. To consider: How to capture that the activity was carried out due to the encouragement? How to avoid that users exploit the mechanism for self-benefit?
  - The overall aim here could be to engage more users, increase usage of the app and participation.
  - The users are encouraged to invite other friends to start using the app. This could, e.g., be done by sending them an e-mail invite to the app. If the friend starts using the app, the user that invited will receive a reward.

5.3 Running the Workshop

At the DESENT project meeting held at SINTEF Energy January 15. 2018, there were a total of nine people that could participate in the gamification workshop. Since another student would run another workshop in parallel, we shared the group into two and switched groups after approximately 30 minutes. The first group consisted of four participants, and the second group consisted of five participants. The participants had different background and nationality and consisted of

Figure 5.2: Participants in action

- Two ICT professors from Eindhoven University of Technology located in the Netherlands
- Two municipal employees from the municipality of Weiz in Austria
- One scientist from *4ward Energy Research GmbH* located in Austria
- Two engineers from *Reiterer & Scherling GmbH* in Austria
- Two employees from *W.E.I.Z. (Weizer Energie- Innovations- Zentrum) GmbH* in Austria

(see full list of participant in Appendix B)

The workshop started by setting the context and briefly introducing the prototype and possible directions to take when moving on with the project. To further establish the context for the gamification workshop, a brief introduction to gamification, the gamification cards and the process to be conducted, were given.

When the context was established, the MyG process started. This is the step that supports the co-creation process. The methodology was created to facilitate for co-creation for the gamification process. Co-creation is a useful method for including the stakeholders in the process and making sure the process and final results meet their requirements [25].

The participants needed some guidance in the beginning, and they also had to spend some time on reading the descriptive texts on gamification cards. With some help from the template, they first started to think of which goal the app should support. After deciding a goal and a context, they tried to identify the target users for this goal, and how these users could be motivated to reach the goal that was set. Then they tried to find game mechanics and social game mechanics that they thought applied to the target users and that could contribute to reaching the goal. If the participants seemed stuck in the process, questions were asked to the participants to guide them further in the process. When a template was filled with cards in each category, they were asked to try to fill out a new template with a different goal card or target group.

5.4 Results from the Workshop

The results from the workshop were captured by the participants writing on the templates that were printed out on A3 paper, and blank A3 papers when there were no more templates left (we call these scenario boards or boards). A picture was taken from each scenario board after it was completed. Notes were taken during the discussion among the participants. To make it easier to see what is written on each board, the boards are reconstructed as digital boards. The notes taken during their discussion are tentatively included in the scenario boards. The names of the boards are an abbreviation that describes which group has created it and the order it was created (e.g., G1-B1-R means Group 1, Board 1 Reconstructed). Following are the results from the two groups that participated in the workshop.

5.4.1 Group One

The first group that participated the workshop consisted of four participants. These four all had different backgrounds. More specifically, the group consisted of one ICT professor, one employee from an innovation company, one employee from the municipality and one engineer (see Appendix B). The group got approximately 30 minutes before the new group came, and during that period the introduction was given, and they managed to create two boards.

After the introduction, the participants needed some time to discuss in their mother tongue what they had understood from what they were supposed to do. Gamification and the way of thinking in the methodology seemed new to all the participants, and with some language differences, it was necessary to use the time to ensure that everyone had understood what they were supposed to do. Although it was a new way of thinking, they said it was fun and a good idea to do the process like a game.

First board

The first scenario board that group one created (see Figure 5.3 below or reconstructed board in Figure 5.4), focused on that the goal of the app should be to encourage people to walk or cycle more, and use their car less. They identified the goal card *Overcome* that has the description *"The goal is to overcome an obstacle towards meeting a challenge"*. The obstacle here would be the convenience of taking the car instead of walking or cycling.

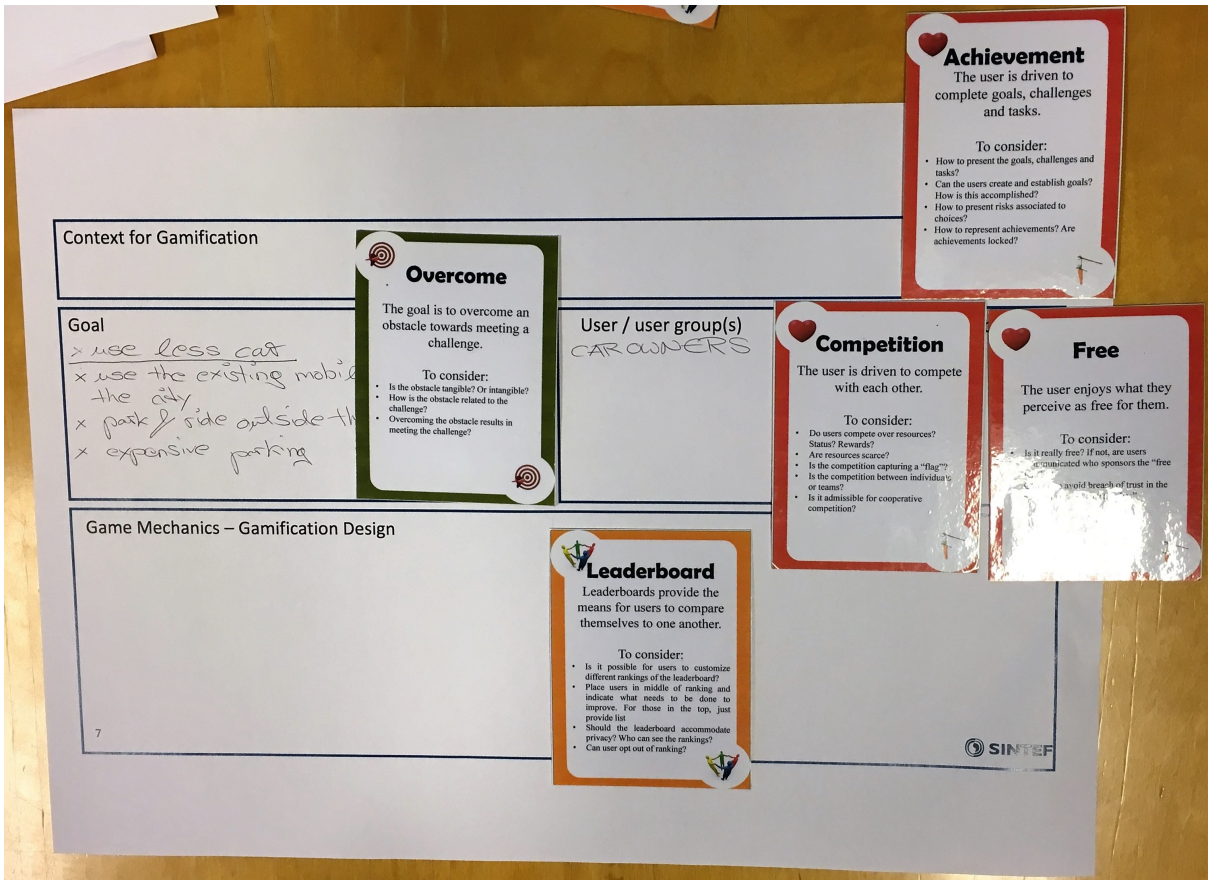


Figure 5.3: G1-B1: First board created by group one

When they were asked to identify the target users group for this goal, they identified car owners as the main target group. They thought the motivational factors *Achievement, Competition* and

Free would motivate this target group. These motivational factors were probably chosen based on themselves, because the participants were all car owners, and they thought of what would motivate them.

They did not identify more than one game mechanic and one social game mechanic. They thought it would be a good idea to reward good behavior by giving points, and encourage competition among the players by using a leaderboard. They suggested having a leaderboard within a physical area or municipality so you could compete with other users within that area. However, they thought that it would be more motivating to compete with people they know. This also makes it less official than it would be with a competition within a municipality. They also suggested that it would be possible to win prizes from the community such as gift cards or something similar that could be used in shops within the municipality.

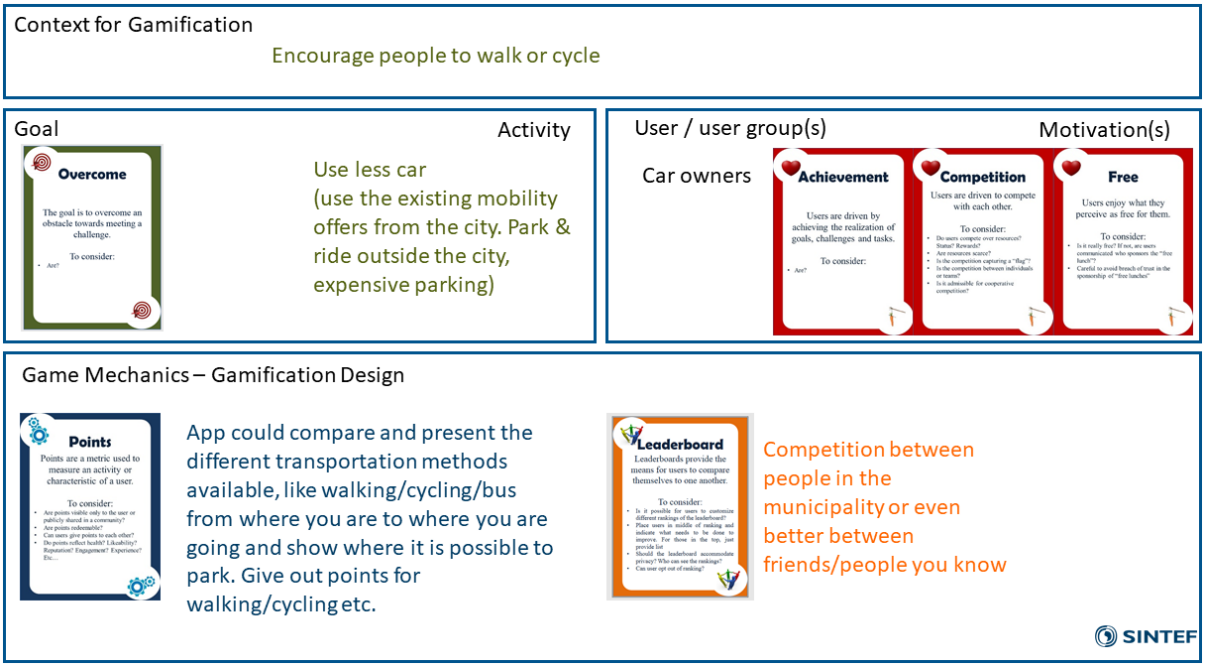


Figure 5.4: G1-B1-R: Board one reconstructed

Second board

The same group created a second board (see Figure 5.5 or reconstructed board in Figure 5.6) where the focus was to get people to start using the app, and keep them using it. They identified the goal card *Bring a friend* with the description *"The goal is to encourage a friend to follow or engage in an activity"*, and the target user group identified were the individual citizens.

The motivational factors identified for this target group were *Belonging, Competition* and *Loyalty*. *Competition* was also chosen as a motivational factor for the previous board as well which shows that this is an essential factor for both car owners and individual citizens.

Game mechanics they identified to meet the goal and the target group were *Points, Currency* and *Virtual Goods*. And a social game mechanic identified was *Call to Arms* which is described as *"Rally the users within a community around a cause"*.

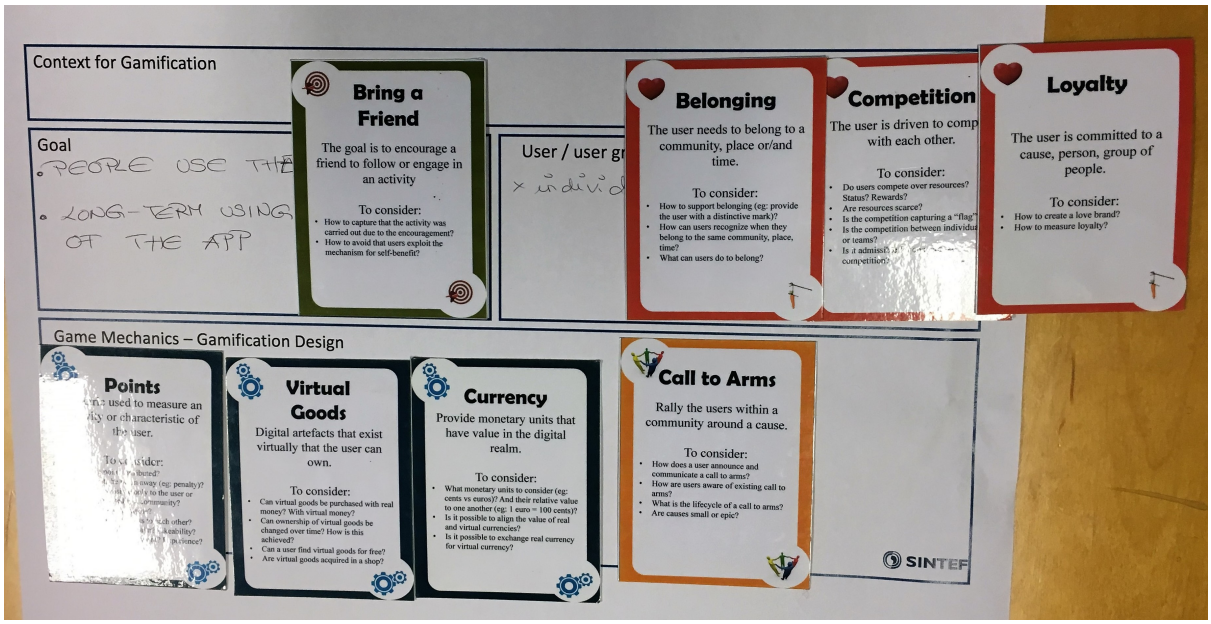


Figure 5.5: G1-B2: Second board created by group one

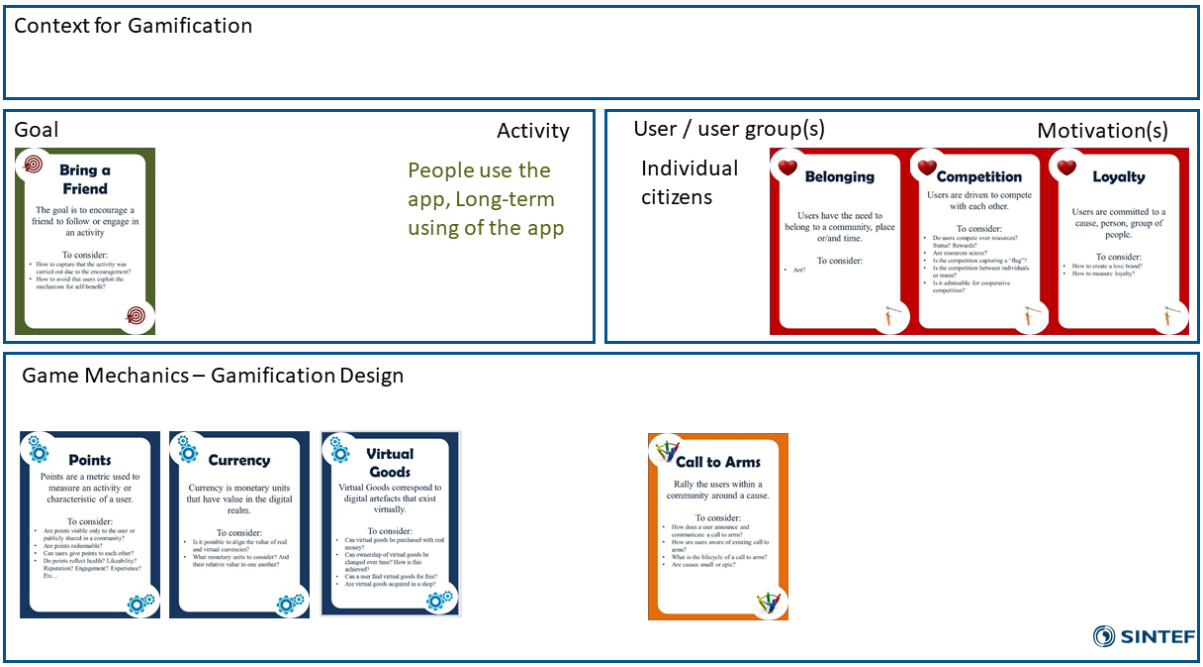


Figure 5.6: G1-B2-R: Second board reconstructed

5.4.2 Group Two

The second group consisted of five participants. These five also had different backgrounds. More specifically it was one ICT professor, one employee from an innovation company, one employee from the municipality, one scientist, and one engineer (see Appendix B). Similar to the first group, this group also had approximately 30 minutes before the time allocated for the workshop was spent. During that period the introduction was given, and they managed to create three boards. Some of the participants in this group seemed to have some experience with both gamification and games in general, and this probably helped the group being more productive than the first group. During the workshop with group two, the number of blank templates went out, so blank A3 sheets and post-it notes were used to create the boards.

First board

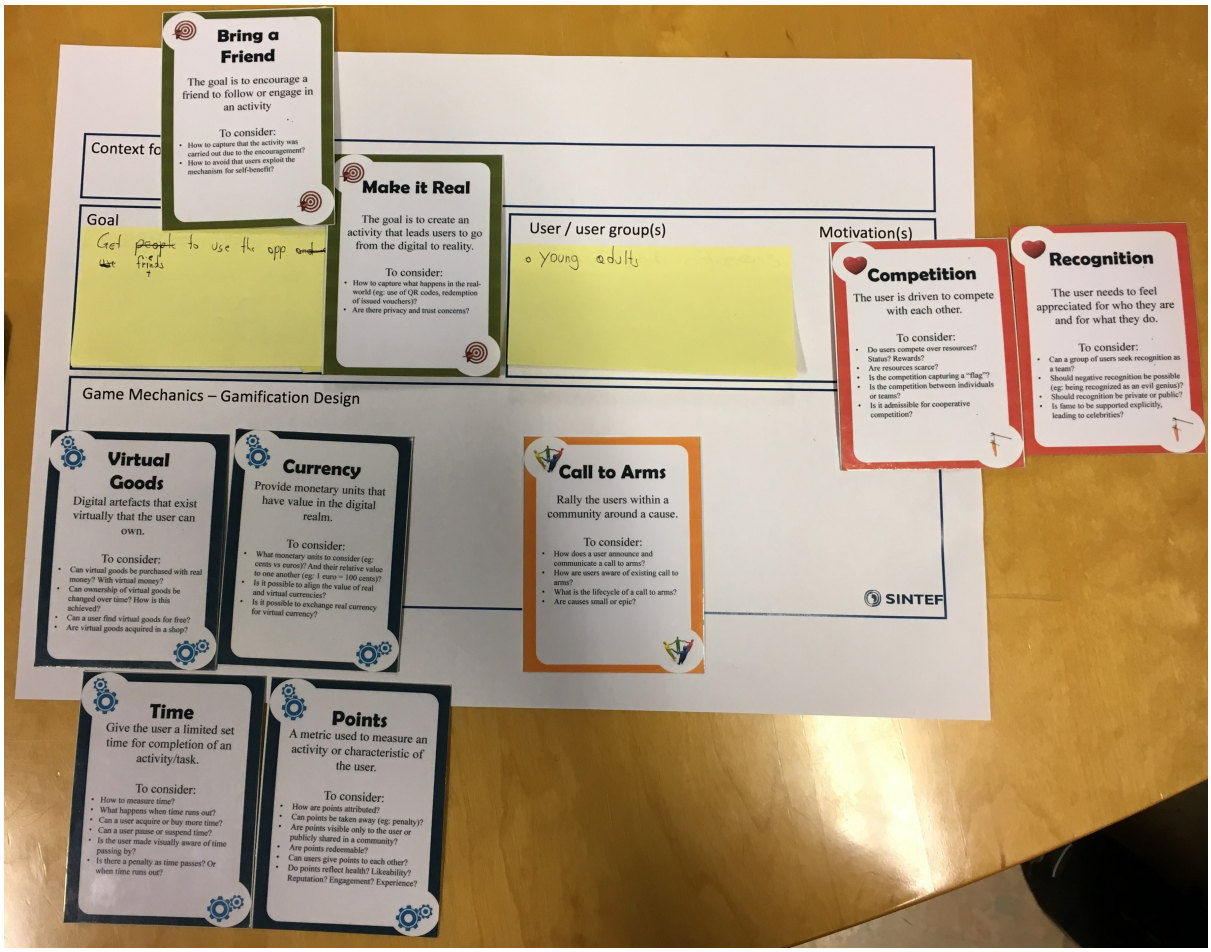


Figure 5.7: G2-B1: First board created by group two

The focus for the first scenario board was to get friends to use the app, and hence the goal cards *Bring a friend* and *Make it real* were chosen (see Figure 5.7 above or reconstructed board in

Figure 5.8). The first group also used *Bring a friend* (so the description is given above), and the description for *Make it real* is *"The goal is to create an activity that leads users to go from the digital to reality"*. The last card was chosen because they argued that it would be good to see the progression in the real world as well as in the app. Young adults were identified as the target group for this goal, and *Recognition* and *Competition* motivates this group.

Four game mechanics were chosen, and one social game mechanic. Mostly the same as the previous group, namely *Points, Time, Currency* and *Virtual Goods*. As an example of *Virtual goods* they proposed to insert a crown or a fun frame around the user's picture to give them a virtual "present" when they had achieved something. The social mechanism was fitting to the goal of getting friends to use the app, namely *Call to arms* which was described in the previous section.

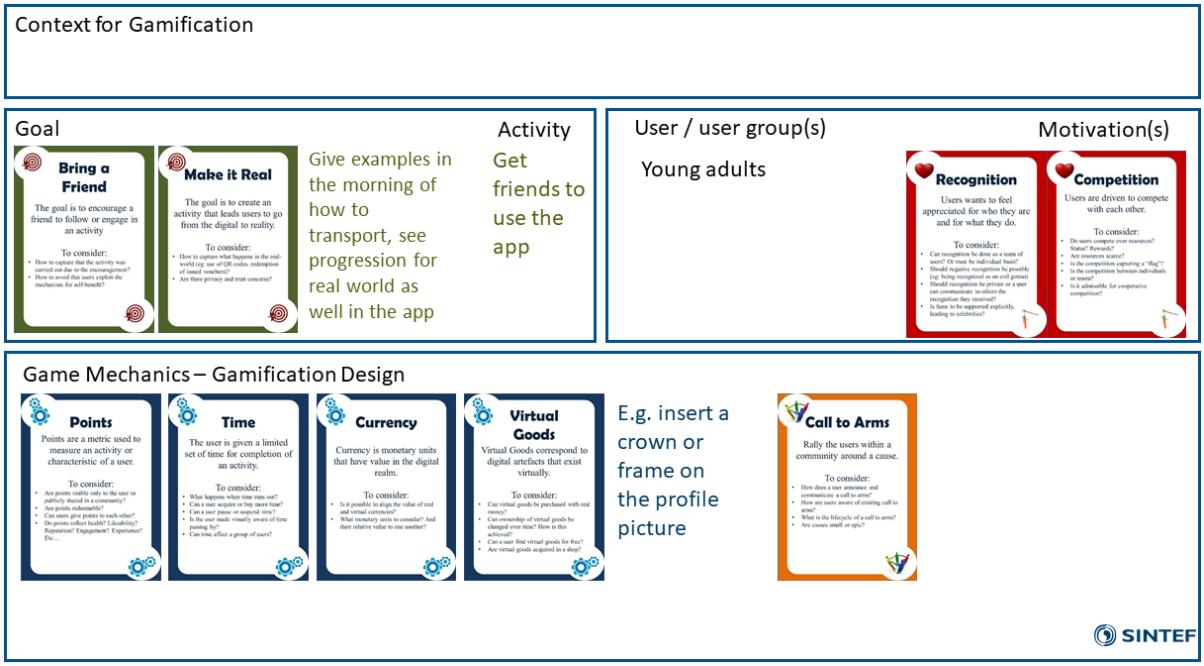


Figure 5.8: G2-B1-R: First board reconstructed

Second board

The participants decided that the focus for the second board was to get users to continue using the app over time. They initially started with one board but detected that it would be better to split the board in two, for the target groups *young users* and *old users*. This was decided because they believed that different motivational factors and game mechanics would motivate the two user groups. They did not find a particular goal card they found suitable for the context, so they skipped this. Following is the presentation of the two boards.

Young users Following is the board created for the target group young users (see Figure 5.9 below or reconstructed board in Figure 5.10). The motivational cards identified for this user group were *Belonging* and *Curiosity*.

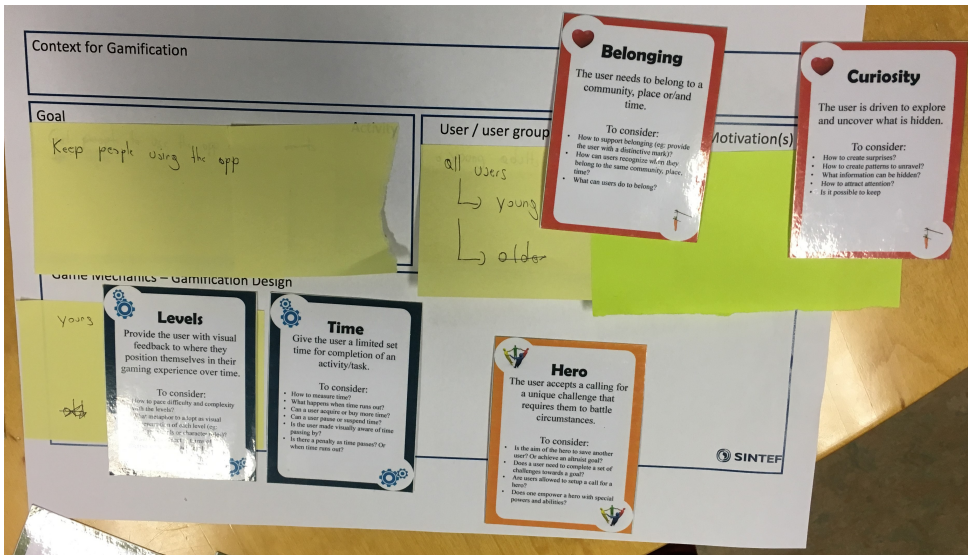


Figure 5.9: G2-B2-P1: Second board part 1 created by group two

The game mechanics identified were *Levels* and *Time*. Their idea for *Time* was that within a certain period, it could be a challenge to, e.g., invite as many people as possible and increase the usage of the app. Another idea from the participants was that you could somehow get a notification if a friend starts using the app, which will make you want to use the app because your friends are using it. The social game mechanic chosen was *Hero*, which has the description: *"The user accepts a calling for a unique challenge that requires them to battle circumstances"*.

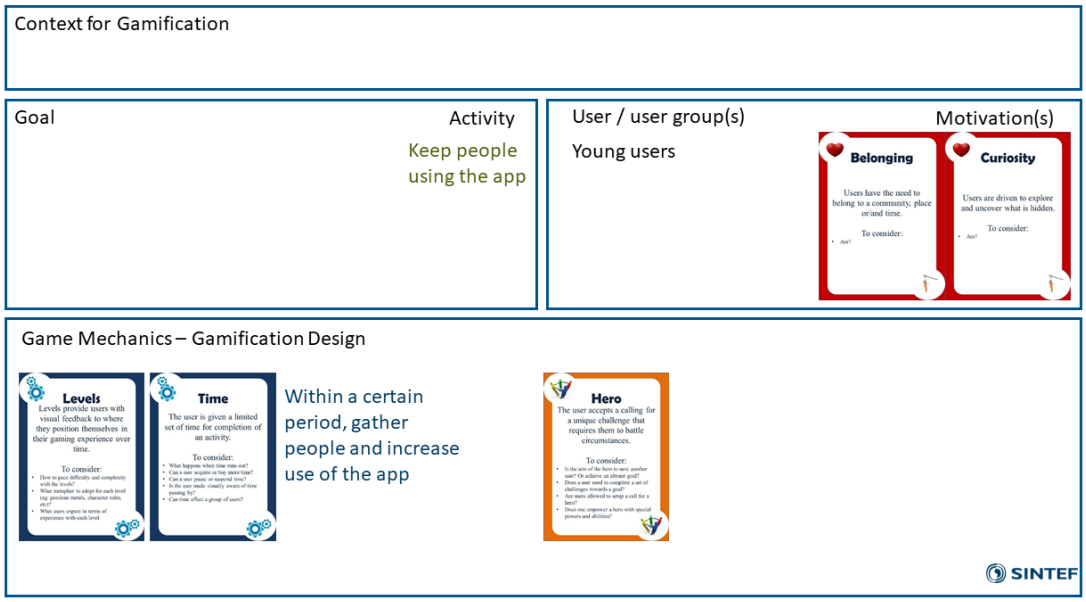


Figure 5.10: G2-B2-P1-R: Second board part 1 reconstructed

Older users The board directed towards the older users (see Figure 5.11 below or reconstructed board in Figure 5.12) had some of the same aspects as the one directed towards the younger users. However, as motivation, they selected *Achievement* instead of *Curiosity* as they thought that older users would be more motivated if they received an achievement for their actions. *Belonging* was a common motivational factor for both user groups.

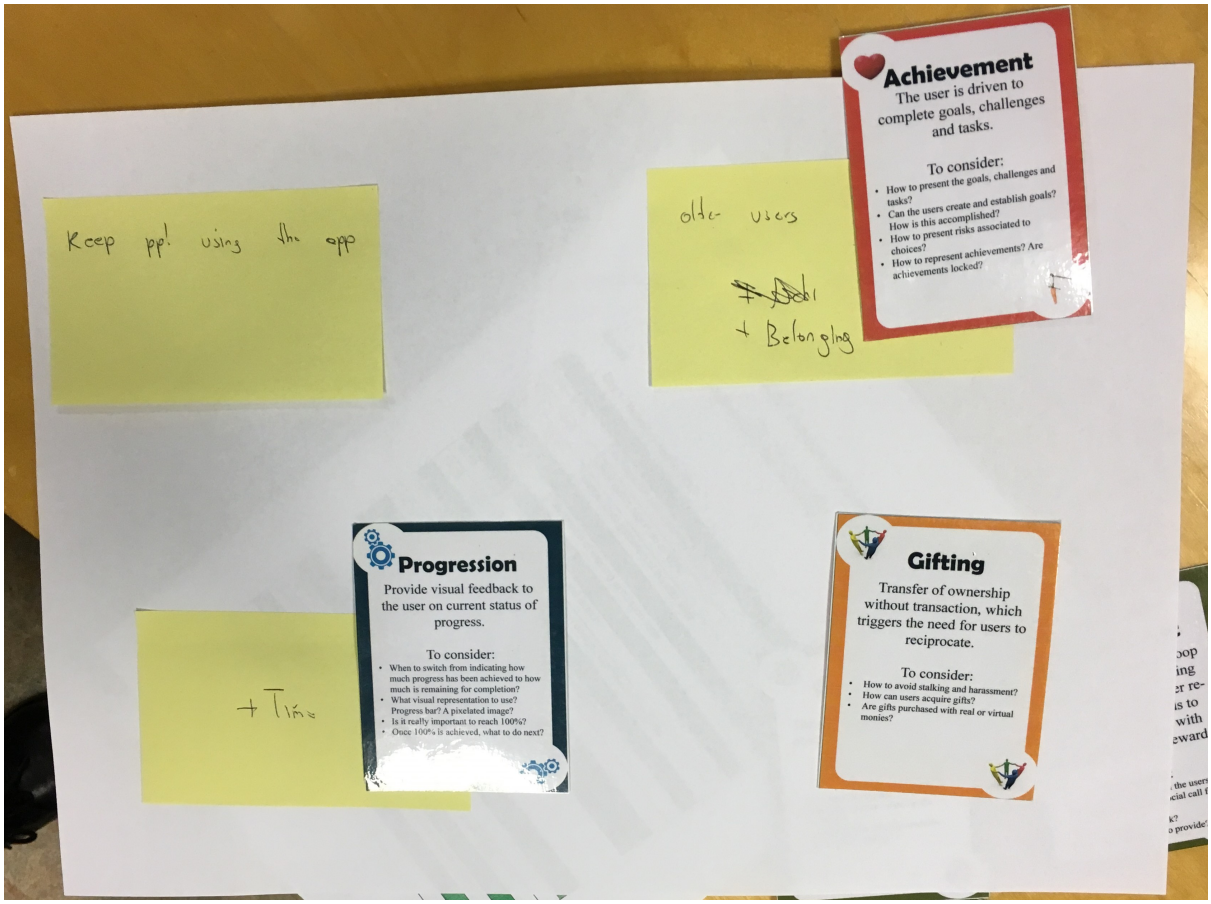


Figure 5.11: G2-B2-P2: Second board part 2 created by group two

As for game mechanics, they kept *Time* and added the game mechanic *Progression*. For the social game mechanic, they selected *Gifting* which is described as *"Transfer of ownership without transaction, which triggers the need for users to reciprocate"*. The idea here was that if the goal is to, e.g., walk 5 km per day, and one day you would walk 10 km. Then you do not "need" all the 10 km and thus "gift"/give away 5 km to a friend that you see has not reached the goal. The user that receives the gift would probably feel grateful for the gift and feel like it has to repay it. This will, in turn, create more usage of the app, as the user will try to achieve rewards to repay the other user.

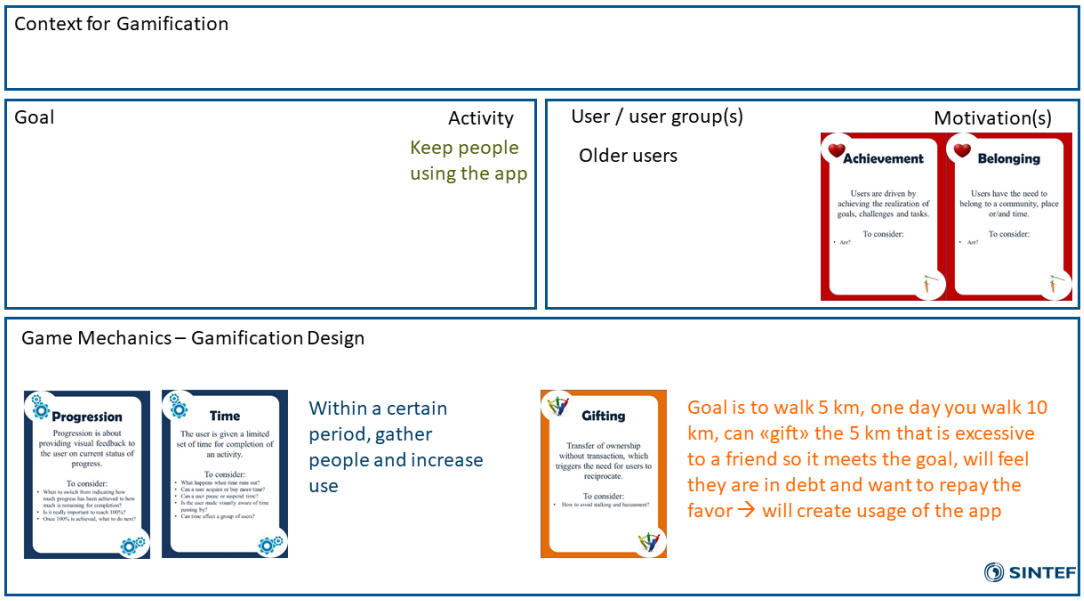


Figure 5.12: G2-B2-P2-R: Second board part 2 reconstructed

Third board

The last scenario board created by this group was focused on the activity to stop using private cars, and the goal card that was used for this was *Make it real* (see Figure 5.13 below or reconstructed board in Figure 5.14).

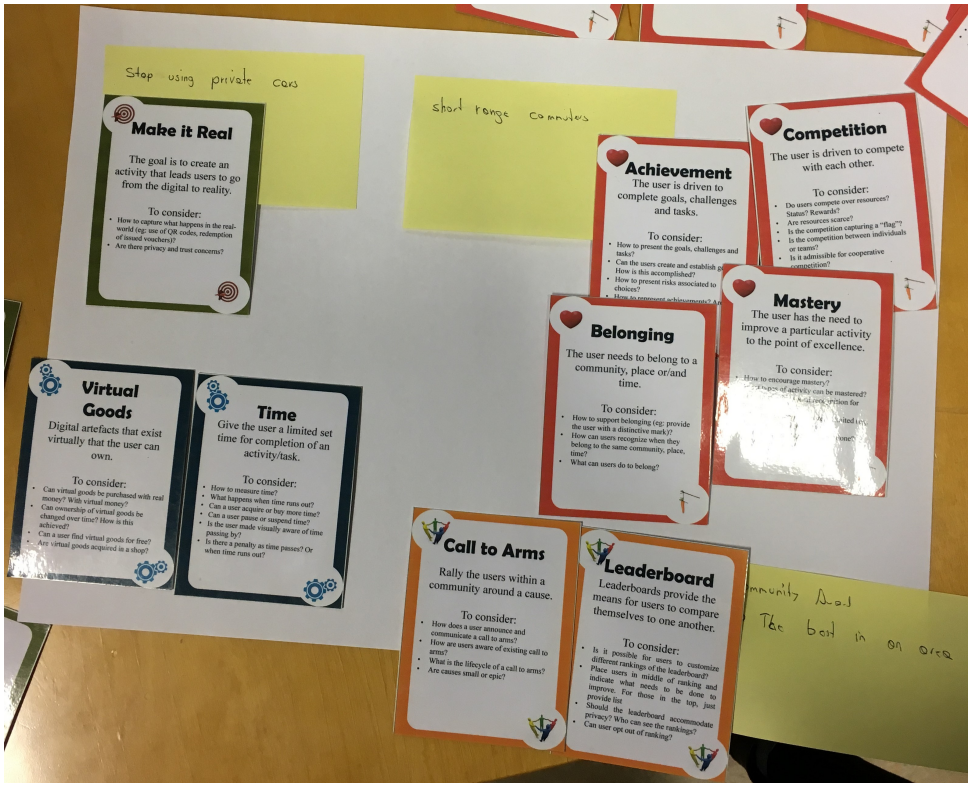


Figure 5.13: G2-B3: Third board created by group two

The target group identified for this context were short-range commuters. These are most likely to be the one with the possibility to change their habits when they commute. This was revealed during the DESENT Project meeting 25. 1. 2018, where the results of a survey conducted with the citizens of Weiz, Austria was presented. It was revealed that most of the people lived within 5 km of their work so this is a large group of users. Motivational factors for this group were *Achievement, Competition, Belonging* and *Mastery*.

The game mechanics chosen were *Virtual Goods* and *Time*. Social game mechanics chosen were *Call to arms* and *Leaderboard*, where they suggested to embrace the community aspect by having a competition of being the best in the area, and the winner will receive a prize.

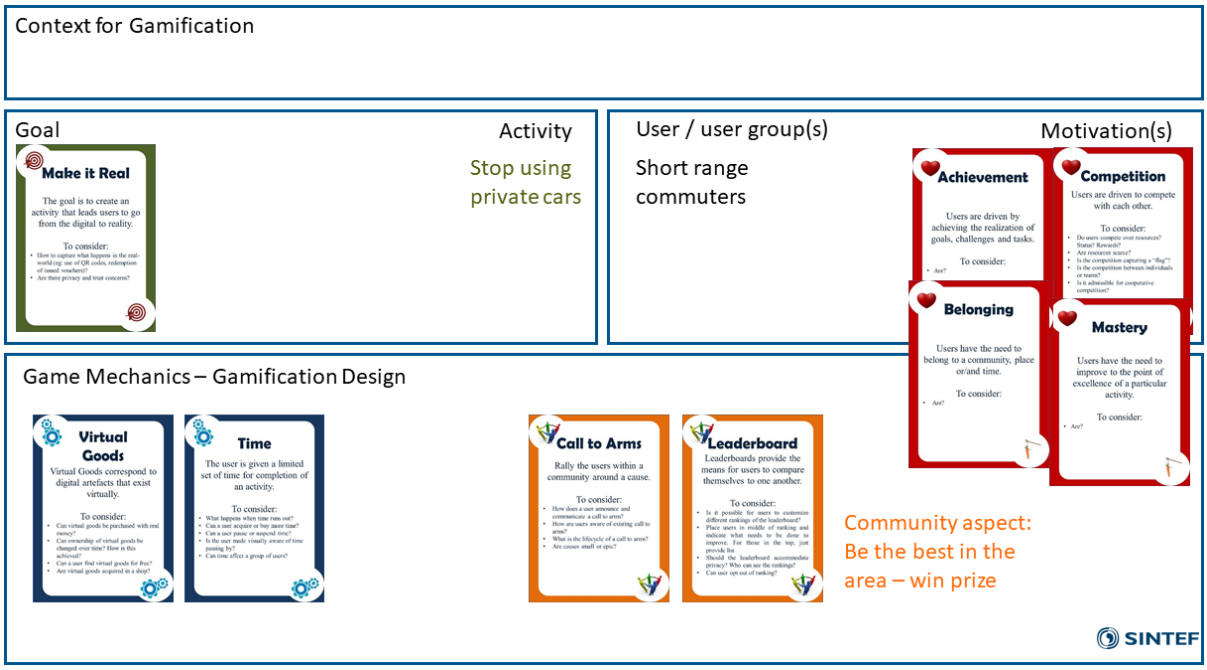


Figure 5.14: G2-B3-R: Third board reconstructed

5.5 Conclusion Workshop

The gamification workshop was a useful exercise that gave a lot of ideas and feedback on the concept and the app. It was helpful to get the others' thoughts and new ideas on a topic that have been studied for a while.

Chapter 6 Design, will discuss in detail which game mechanics that should be implemented. The participants in the workshop chose some of the game mechanics that were already included in the prototype that was created in the specialization project. This confirms that those game mechanics would probably be valuable to add in the app as they came up in the co-creation session.

The template and the number of card categories seemed to be suitable for the workshop participants. The template helped them to know which cards to find next. The goal cards were probably the card category that was the most difficult of the remaining categories. Perhaps particular goal cards could have been selected for them to make the process even smoother.

Chapter 6

Design

This chapter will present the design phase. The design of the application will be supported by the theory and results of the survey and workshop shown in the earlier Chapters 4.2 and 5 respectively. The first section will describe the application and the concept. The game mechanics that are used in the app are presented after that, and the connection to the behavior models are shown in Section 6.3.

6.1 Description of the Application

The application, *Smiling Earth* that was first developed by Celine Minh in her master thesis from 2017 is a pervasive app, and by adding game mechanics, it can be categorized as a pervasive social app [7, 36]. Pervasive application means that the user only needs to have the application downloaded on their device, and carry the device with the application running in the background. Manually reporting is not necessary for a pervasive app, as the app senses and tracks automatically. There is a need for giving the user a reason to want to check the app once in a while, and here the game mechanics come into play. Gamifying the application makes it more fun to use and motivates the user to open the application and check if any rewards have been awarded or if something else has changed.

The app is designed to create awareness and motivate behavioral change regarding lowering the carbon footprint and save the Earth from global warming. For *Smiling Earth* to reach this goal of changing behavior and creating awareness, and not lose its purpose, it is crucial that the game aspect of the app does not get too messy so that the aim of the app is drowned by all the noise created by the game mechanics. As described in the Transtheoretical Model of behavioral change, different processes are needed to help move towards a lasting change. The game mechanics could support these processes, and it needs to be enough to keep the user interested but not too much so that the user finds the app annoying.

The advantage of *Smiling Earth* compared to similar applications, is that it does not rely on extra devices such as *UbiGreen* does [34]. *UbiGreen* was presented in the Background Chapter 3, and is a pervasive app that relies on the user to bring an additional device around with them. This device was a tracker to track the journeys. The users of *UbiGreen* also had to answer a survey after each trip traveled, which gives the user more work when using the application. *Smiling Earth* will track the travels automatically, and calculate the emissions and costs from this, which makes the app easier to use without any hassle with additional devices.

6.2 Game Design

The results of the gamification workshop gave a set of game mechanics, and user scenarios that the participants believed would fit in the application. It also resulted in insight into what and how they thought citizens would be motivated to change their behavior through the app. In the following section the results from both the survey and the workshop are gathered, and in the last subsection, a final list of the game mechanics that will be implemented is shown. The mechanics that are not included from the workshop were discarded because of both that they were found unsuitable, or too complicated to implement. Suggestions for future work in Chapter 10 will include game mechanics that could be successfully applied in the app in the future.

After selecting the game mechanics, some specifics for the gamification were necessary to declare. The users have to know how they can gain points/virtual currency, and such. This requires a set of defined rules, that can also be used to guide the implementation of the game aspect in the application. The specifics that are defined for the game mechanics are shown in Section 6.2.3.

6.2.1 Game Mechanics - Results from the Workshop

As previously mentioned, there are two possible directions to take regarding pursuing individual or social game mechanics. Some game mechanics are suitable for engaging the individual user, and others can motivate the user by creating a social competition with friends and other users.

In the tables below which show the results of the workshop, it should be noted that the workshop participants have found suitable social game mechanics for all the scenario boards in addition to the individual game mechanics. This indicates that the participants found the social aspect relevant, even though this aspect was ranked third in the survey.

The main objective of having a gamification workshop was to co-design how the app should

be gamified. When looking at the six different scenario boards created during the workshop together, as in the Table 6.1 below, it may be easier to see which game mechanics that should be included in the app by looking at the repeating mechanics and the connection between for example, goal, user group, and so forth.

ID	**Activity**	**Goal**	**User Group**	**Motivation**	**Game Mechanic**	**Social Game Mechanic**
G1-B1	Use less car	Overcome	Car owners	Achievement Competition Free	Points	Leaderboard
G1-B2	People use the app	Bring a friend	Individual citizens	Belonging Competition Loyalty	Points Currency Virtual goods	Call to arms
G2-B1	Get friends to use the app	Bring a friend	Young adults	Recognition Competition	Points Time Currency Virtual goods	Call to arms
G2-B2-P1	Keep people using the app	-	Young users	Belonging Curiosity	Levels Time	Hero
G2-B2-P2	Keep people using the app	-	Older users	Belonging Achievement	Progression Time	Gifting
G2-B3	Stop using private cars	Make it real	Short range commuters	Achievement Competition Mastery Belonging	Virtual goods Time	Call to arms Leaderboard

Table 6.1: All the boards created in the workshop

The six boards that were created can be categorized and divided into two Tables 6.2 and 6.3, depending on which direction is selected (individual or social focus). The common factor in the first table of boards (Tables 6.2) is that the target groups are car owners or short range commuters. Different goal cards are chosen for these groups, but they could probably be combined to both be *Overcome*, and *Make it real* as goals for the game. Two common motivational factors are identified, namely *Achievement* and *Competition*. Other potential motivational factors are *Free, Mastery* and *Belonging*. As for game mechanics, *Points, Virtual goods* and *Time* could probably be combined. Both have mentioned *Leaderboard* as a social game mechanics, and *Call to arms* is a second. *Leaderboard* is a ranking of the participant and is very relevant to create competition between users, and *Call to arms* can be used to engage friends or people in the community to decrease car usage.

Nr.	Activity	Goal	User Group	Motivation	Game Mechanic	Social Game Mechanic
G1-B1	Use less car	Overcome	Car owners	Achievement Competition Free	Points	Leaderboard
G2-B3	Stop using private cares	Make it real	Short range commuters	Achievement Competition Mastery Belonging	Virtual goods Time	Call to arms Leaderboard

Table 6.2: Common factor: target group car owners/short range commuters

The next Table 6.3 shows the scenario boards that focused on getting people to use the app and to keep them continuing to use it. These are two critical objectives because first, the app has to be engaging enough so that users would like to use it, and secondly, the app must continue to engage to be able to change the user's behavior. These objectives are essential to think of during the design phase because if the app does not engage the user immediately, they would probably not like to use it at all.

The boards are focused on three separate user groups, namely individual citizens in general, young users, and older users. The workshop participants have identified *Belonging* as a common motivation for almost all the user groups. Only one goal has been identified, that is *Bring a friend* which is relevant to get new people to use the app. Other different factors for the user groups that are detected are *Competition, Loyalty, Curiosity, Recognition* and *Achievement*. Various game mechanics are suggested, but all could be applicable to meet the different age groups needs. Also, three different social game mechanics are found, namely *Call to arms, Hero* and *Gifting*.

Nr.	Activity	Goal	User Group	Motivation	Game Mechanic	Social Game Mechanic
G1-B2	People use the app	Bring a friend	Individual citizens	Belonging Competition Loyalty	Points Currency Virtual goods	Call to arms
G2-B1	Get friends to use the app	Bring a friend	Young adults	Recognition Competition	Points Time Currency Virtual goods	Call to arms
G2-B2-P1	Keep people using the app	-	Young users	Belonging Curiosity	Levels Time	Hero
G2-B2-P2	Keep people using the app	-	Older users	Belonging Achievement	Progression Time	Gifting

Table 6.3: Common factor: goal, get people to use app

6.2.2 Deciding Which Game Mechanics to Implement

After studying the results from the workshops, and considering the findings from the specialization project and the literature study, it was decided to focus on initially implementing the game mechanics *Virtual Currency, Progression, Leaderboard, Call To Arms* and *Gifting* to *Smiling Earth*. These are chosen because they have seemed relevant to the people involved in evaluations and workshops, and have been found used in other similar applications where they have contributed positively. A bundle of game mechanics is chosen to limit the number of items to implement because of time restrictions.

A description and justification for each game mechanic that is decided to focus on are following in the next paragraphs.

Virtual Currency

The virtual currency in the game will be called *Earth Coins* and will be the primary reward system in the app. The user receives *Earth Coins* when the app detects green behavior such as walking and cycling. The user can use *Earth Coins* on various things, such as getting a discount on buying a solar panel or an electric car from specific companies, or smaller prizes such as free bus tickets or discount on cinema tickets.

Retrieving *Earth Coins* for positive actions could make the user more motivated to gain even more *Earth Coins* so it can afford to buy something they want [24].

Figure 6.1 shows the *Earth Coin* that is created for *Smiling Earth*. The basis for the coin is the Earth metaphor, and by using an image manipulation program called Gimp [1], it was attempted to make it look like a coin. A text field to show the number of coins earned is also necessary to display together with the image. The digital prototype was created before it was decided to use currency as a game mechanic. Instead of the points viewed in Figure 6.2 below, the *Earth Coins* will be displayed.

Figure 6.1: *Earth Coin* to be used as virtual currency in the application

[1] https://www.gimp.org/

Plan for implementation: Define a set of rules for the distance tracker and similar that will generate coins when, for example, a certain distance has been walked or cycled. The number of coins will be stored in the database at all times and will be shown on the user profile and in the toolbar at the dashboard (see Figure 6.2).

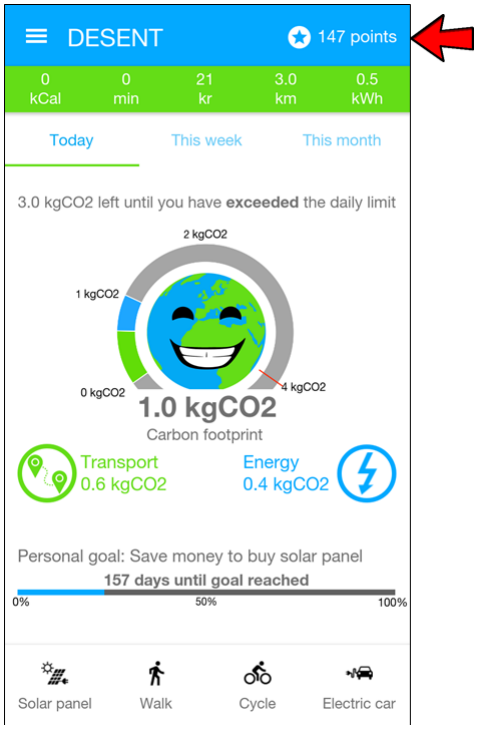


Figure 6.2: Prototype: Earth Coins in toolbar

Progression and Personal Goal

The user can choose a goal that fits the most. The ability to pick a personal goal and have the freedom of choice, could be more motivating and increase the wish to achieve the goal because it is something that is self-chosen and not imposed by anyone else.

A goal can be selected from a drop-down list (see Figure 6.3). Since the items in the drop-down list are predefined, it will be possible to steer the player towards the wanted behavior, but still, make it feel like it is their choice. It is also possible for the player to create a customized goal to meet the needs of all kinds of players.

The goals can be both long-term goals or short-term goals. The long-term goal can be accomplished by achieving the daily targets and the short-term goals. A long-term goal could, for example, be to save for solar panels. Daily targets could be, e.g., keeping the carbon footprint below 4 $kgCO_2$, be active for at least 30 minutes, and so forth. By achieving the daily targets, it helps to get closer to achieving the short-term goal of being active for at least 30 minutes, seven days in a row, and eventually reaching the long-term goal of saving for solar panels.

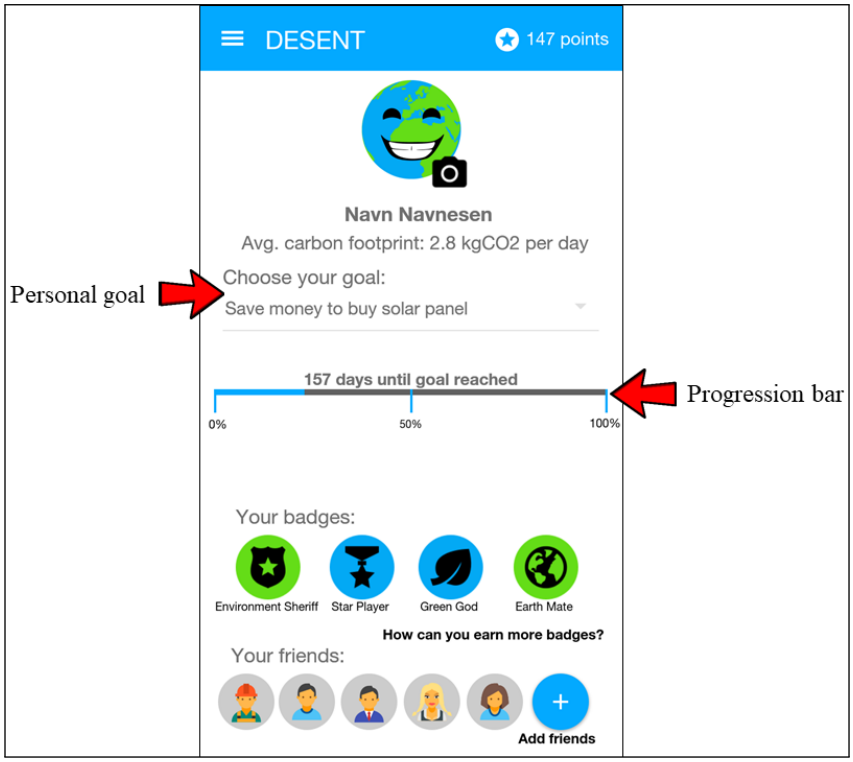


Figure 6.3: Prototype: Personal goal and progress bar

After a personal goal is chosen, a progression bar is used to show how far the player is from reaching their goal. Showing the progression bar could motivate the user to progress towards the goal [24]. The progression bar can be found in the player's user profile and on the dashboard of the app.

Plan for implementation: The progress bar represents how close you are to reaching a goal. This goal could be different things, for example, an amount of money that needs to be saved to afford a solar panel. When the player collects *Earth Coins*, these make the progression bar move towards the goal. The plan is to have some discrete points on the horizontal bar that indicates other rewards you can afford to buy if you reach the point. The player can then choose to use the *Earth Coins* to buy a reward or continue saving for the long-term goal.

Progression bars are also used in other aspects of the application. On the dashboard, the changing face of the Earth symbolizes progression (see Figure 3.1), when the carbon footprint rises, the mood of the Earth gets worse. The circular indicators that show how much is emitted during the day and how far it is left until the daily limit is exceeded, are also progression bars.

Leaderboard

The leaderboard will create a competitive feeling between players, and engage them to achieve better to beat their friends [32]. The plan is to have two different leaderboards, one that shows the ranking of the players with the lowest average carbon footprint, and one that shows the players with the most *Earth Coins* collected.

The prototype created in the specialization project contained a leaderboard (see Figure 6.4). The user evaluations of the prototype showed that the user found the leaderboard motivating and a fun aspect of the app.

(a) Lowest avg. carbon footprint (b) Most Earth Coins

Figure 6.4: Prototype: Leaderboard

Plan for implementation: From the database, the app retrieves the average carbon footprint and the number of *Earth Coins* of the friends that are connected to the player. Then the leaderboard is sorted based on the ranking condition. The player can compare him/herself to other players, and also be motivated to achieve better results and hence act more environmentally friendly.

Call To Arms

Now and then the game administrator could start challenges/call to arms that could, e.g., encourage the players to invite friends to download and start using the app, or not use the car for the weekend/or a week if the air quality is especially poor for a period. This game mechanic could create engagement and more usage of the app [24]. *Call to arms* could be a combination of the game mechanics *Time* and *Challenge*. Time restrictions can be given, and concrete challenges could be formulated to engage the user [17].

It is decided to call this game mechanic *Challenges* in the app, since *Call to Arms* is not that familiar for regular users without a background in game design theory, and *Challenges* is a common word to be used in, e.g., fitness apps like Fitbit and Endomondo. Calling it *Challenges* also opens the possibility for including other types of *Call to arms* as it can be personal challenges or challenges between friends, or call to arms to all the users in an area. Figure 6.5 presents the paper prototype of the game mechanic.

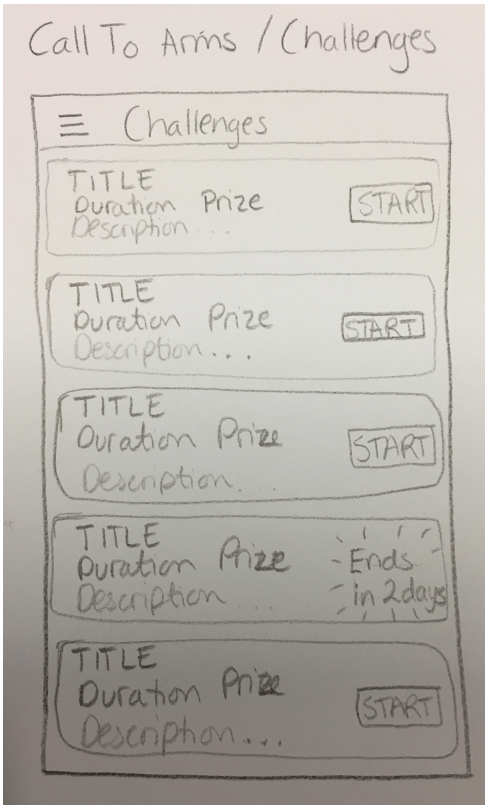


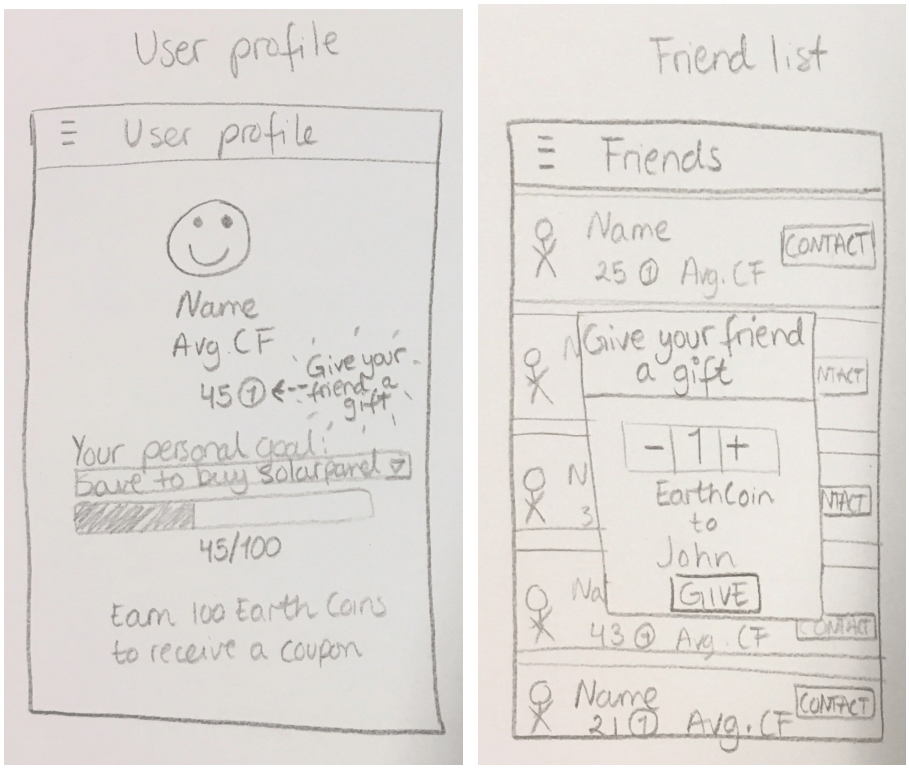
Figure 6.5: Paper prototype: Call to arms

Plan for implementation: The challenges that could be initiated by the municipality or the administrators of the app will appear as card views in a list of challenges in the app, see Figure 6.5 above. The user could be notified with an alert dialog when a new challenge is added to engage the users to join the challenge. When a challenge is started, a progression bar could

replace the button in the card view to visualize how far it is from reaching the goal of the challenge. The user will receive the amount of *Earth Coins* that was advertised in the challenge description when the challenge is finished or the time has elapsed.

Gifting

Gifting means that it would be possible to give *Earth Coins* to other players as a gift. This will create usage of the app and motivate the user that received a gift to return the gift later [26]. A paper prototype of the game mechanic *Gifting* is displayed in Figure 6.6.



(a) User profile (b) Friends

Figure 6.6: Paper prototype: Gifting

Plan for implementation: The card views for each friend has a button that can be pressed to make contact with a friend in several ways, see Figure 6.6 (b). One way of contacting the friend can be to give the friend a gift. This will open a dialog box where the amount of *Earth Coins* is chosen that will be given to the friend. A hint that it is possible to give a friend a gift could also be shown on the user profile where the score is displayed. The friend will get a notification that it has received a gift from a player. The *Earth Coin* balance will then increase accordingly.

6.2.3 Defining the Specifics of Gamification

The specifics will be mostly focused around when to receive *Earth Coins* as a reward for positive actions. The users need to be aware of the way to win awards to be motivated for the correct behavior [30]. A suggestion for a set of rules for *Smiling Earth* is presented below.

The player will receive *Earth Coins* when it

- Reaches the goal of 30 active minutes in a day: 1 Earth Coin
- Cycles:
  - more than 3 km and less than 5 km: 1 Earth Coin
  - more than or equal to 5 km and less than 8 km: 2 Earth Coins
  - more than or equal to 8 km: 3 Earth Coins
- Walks:
  - more than 3 km and less than 5 km: 1 Earth Coin
  - more than or equal to 5 km and less than 7 km: 2 Earth Coins
  - more than or equal to 7 km: 3 Earth Coins
- Stays on top of the leaderboard for a certain period
- Adds a friend
- Call to arms: when doing the action wanted in the calling within the time limit
- Gifting: when giving Earth Coins to another player, receive a bonus of 1 Earth Coin per 10 Earth Coin gifted.
- has a carbon footprint below 4 kgCO_2 during a day

6.3 Behavior Model

The connection between the behavior change model, the game mechanics and the general functionality in the app will be presented in this section. Capturing all aspects of TTM is a big job, so only some of the processes are designed to be connected to the app at the moment. Implementing the other functionality to support all the stages and process in TTM will be described in the Section 10.6 for Future work.

The list below contains the processes that are currently designed for and supported in the app with the new functionality that is planned to be implemented:

- *Precontemplation*
  - **Consciousness raising:** the app shows the carbon footprint during the day, and the distribution of carbon dioxide emissions from transportation and energy consumption, and thus raises awareness about how the daily activities affect the environment
  - **Dramatic relief:** The estimation functionality shows how much can be saved by, e.g., reducing driving distance or switching to solar panels
  - **Environmental reevaluation:** the app shows at some level the impact the user has on the environment, and the estimation functionality can give a pointer on how the emissions could be reduced
- *Contemplation*
  - **Self-reevaluation:** the app gives a certain image by making the users aware of their carbon footprint and comparing them with other users
- *Preparation*
  - **Self-liberation:** this is not integrated into the app at the moment
- *Action*
  - **Counterconditioning:** the app shows the health benefits as well as how much money that can be saved by cycling, and the estimation functionality also shows how much it saves the environment
  - **Helping relationships:** the app is designed to make contact with friends that the user can compete with, interact, give gifts and start challenges with
  - **Reinforcement management (Contingency management):** the app rewards the user with Earth Coins when green behavior is detected
  - **Stimulus control:** this is not integrated into the app at the moment
  - **Social liberation:** the app shows other users that are also trying to reduce their emissions
- *Maintenance*

Chapter 7

Software Architecture

This chapter will first present the technologies used to develop *Smiling Earth*. An overview of the system architecture will then be given together with the structure of the classes and project files of the system. The overview of the project structure in Section 7.3 can both serve as documentation for future developers who will be working on *Smiling Earth*, but it also shows the process that was done to become familiar with the structure of the code before the implementation started.

7.1 Technologies

Before going into detail about how the implementation phase was conducted, the technologies used during the development needs to be presented. The technologies include websites and programs used during prototyping and development.

7.1.1 Prototyping

Proto.io

Prototyping was done both on paper and digitally. The digital prototype was created by using a website called *Proto.io*[1]. The prototype was mainly created during the specialization project and was used as a guideline when implementing the app [8]. My supervisor recommended the website, and it turned out to be an easy tool to get started with. A free 15 days trial was started to see how it worked, and after the trial period ended, a student account was activated where the monthly fee was 14.50 USD. Since it was only used as a guideline when implementing the app this semester, and it was possible to freeze the account and still have access to the preview

[1] `https://proto.io/`

function of the prototype (see Figure 7.2 below), the account was parked. The monthly fee when the account was parked was 2.50 USD.

As can be viewed in Figure 7.1 below, the interface on the website is mostly based on drag and drop, and it is easy to add simple logic to buttons and other things to make the prototype feel like a real app.

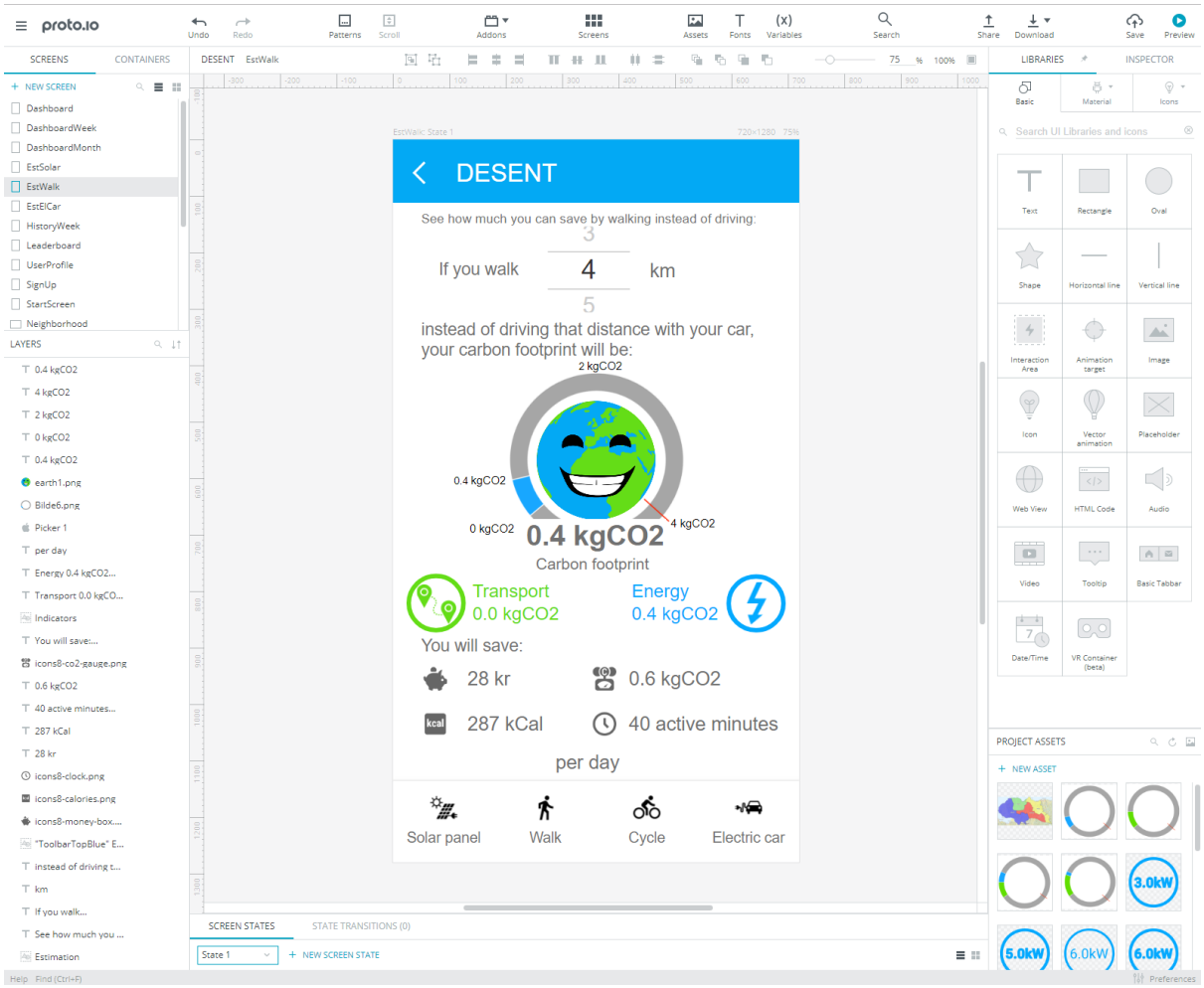


Figure 7.1: Prototype editor in the browser

The prototype can be previewed in the browser (see Figure 7.2). *Proto.io* also has an app that makes it possible to download the prototype to a device (see Figure 7.3). The app is downloaded from Google Play or App Store, and you log in with the *proto.io*-account and then it is possible to access all the projects that are created on *proto.io*. The app makes user evaluation genuine and straightforward. This feature is not available when the account is parked.

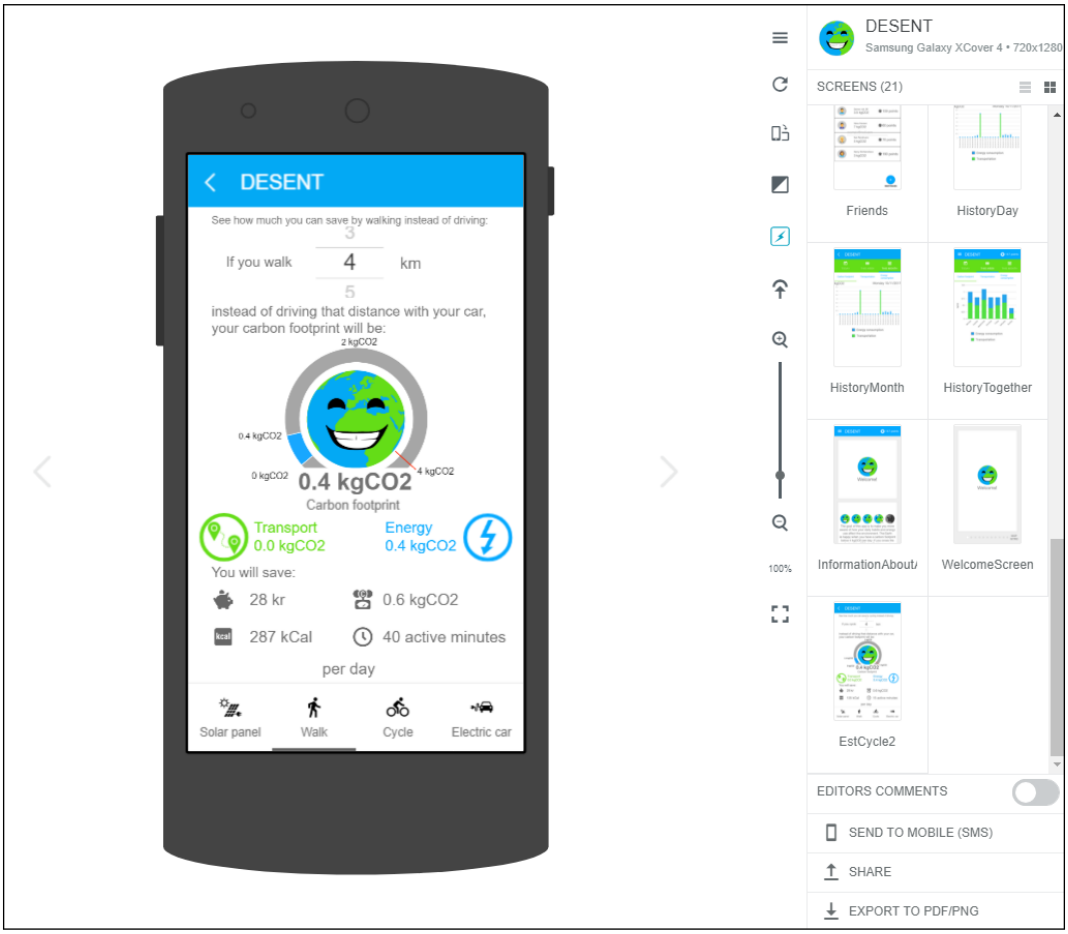


Figure 7.2: Preview mode in the browser

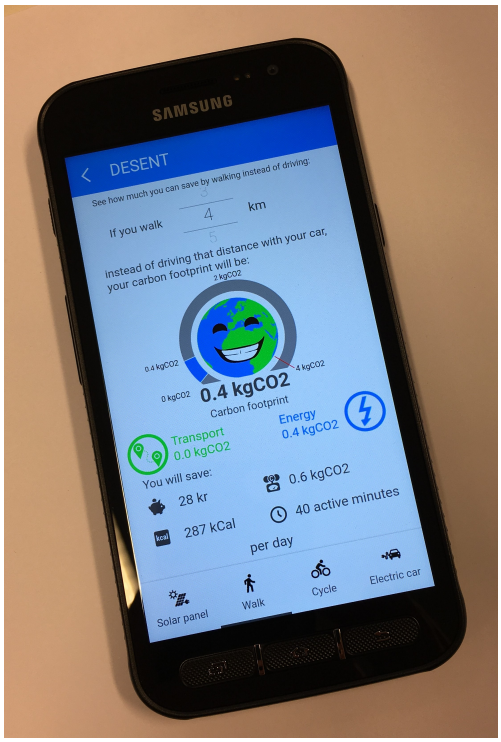


Figure 7.3: Prototype priewed on the device

7.1.2 Developing

The development of the application required a few tools. The technologies used during this phase are presented below.

Trello

The website called *Trello* was used for structuring the backlog and planning the sprints[2]. This website was chosen as it had been used in previous projects. The advantage of using *Trello* is that it is a free and easy way to structure elements into different boards and list. After creating items in the different lists, the item can be dragged and dropped to another list (see Figure C.1 in Appendix C).

GitHub

GitHub is a hosting service for version control that uses Git[3]. Github is web-based and is also a useful way to distribute code and projects with easy access. Since *Smiling Earth* is based on the work done in a previous master thesis, it builds on the work of an already existing app. When starting the further development of the app, it was easy to just *fork* the original project to my GitHub-account. The original project became a new repository on my account, and thus changes could be made on the new repository without affecting the original source code. The project was forked from Celine Minh's GitHub account that was provided in her master thesis with the following link:
`https://github.com/cminh/DesentApp` [7].
The link to the repository that contains the new functionality and user interface can be found in Appendix L. The repositories are public, so in theory, all GitHub users can access these projects.

Figure 7.4: GitHub logo [37]

SourceTree

The most common way to communicate with GitHub and managing version control is to use the terminal or command line to add new files, commit changes and push changes so that the code that is available on GitHub stays

Figure 7.5: SourceTree logo [38]

[2] `https://trello.com/`
[3] `https://github.com`

up to date. Remembering the Git commands to be typed in the terminal can be hard. There exist some substitutions for this, and *SourceTree* is one. *SourceTree* is a free Git GUI (Graphical User Interface) client that can be used to more easily see changes done in the code before it is committed and pushed to GitHub[4] (see Figure 7.6). SourceTree arranges so that it is not necessary to use the terminal, and since I had experience with using *Source Tree* from before, it was decided to use this program for the development phase.

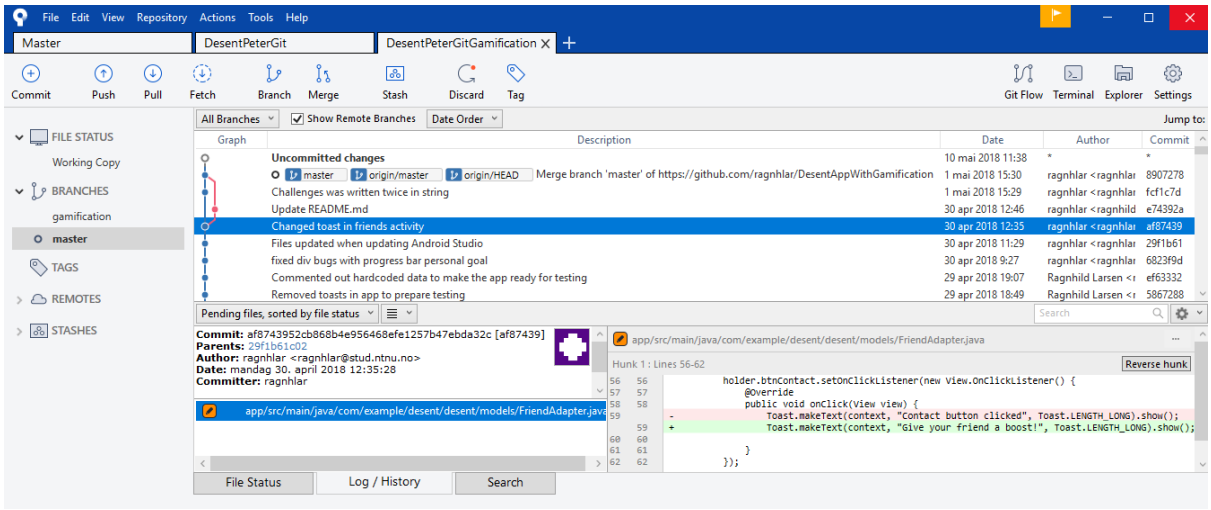


Figure 7.6: Screenshot of SourceTree desktop

Android Studio

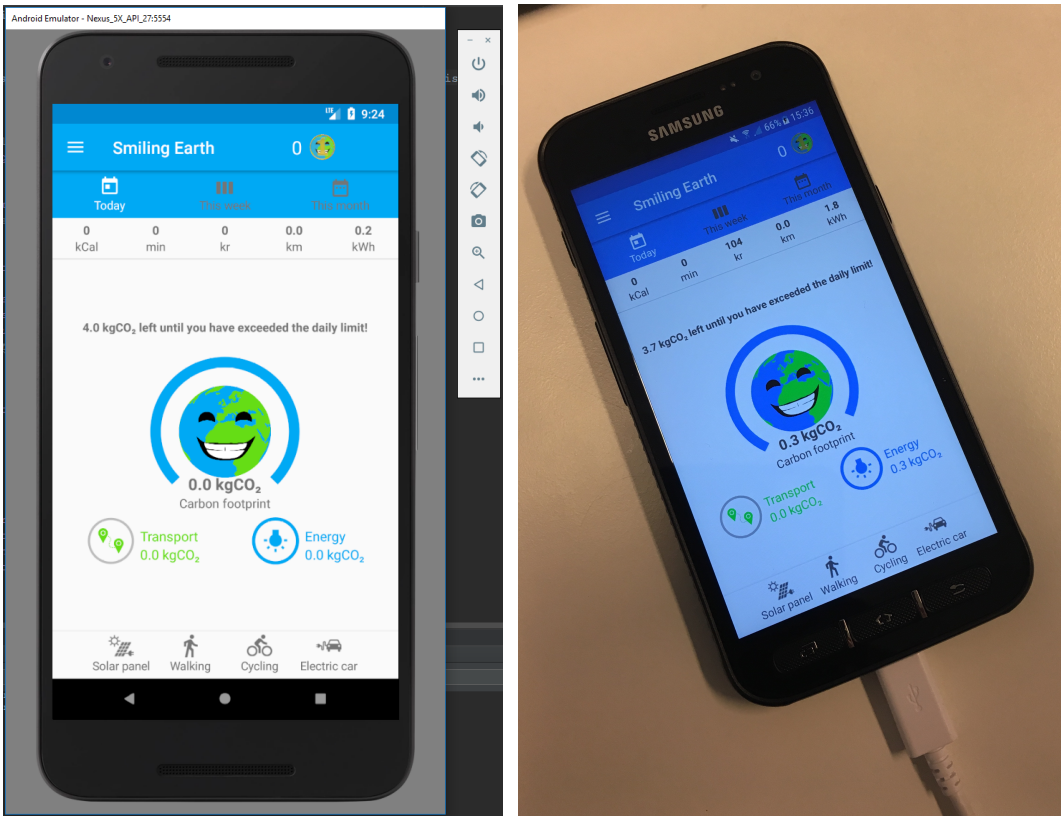
Android Studio is an Integrated Development Environment (IDE) for creating Android applications[5] [40]. Android Studio is based on IntelliJ IDEA and is free to download. After cloning the project from GitHub and adding it to *SourceTree*, the development of *Smiling Earth* was ready to begin. When a project is cloned, all the files that belong to the project is downloaded and stored at the computer, and the project can be opened in Android Studio. Both functionality and interface can be created and edited in Android Studio. The IDE has a preview of the interface that is updated in real time when items are added or edited.

Figure 7.7: Android Studio logo [39]

There are two ways to test and run the app. The first way is to start up an *Emulator* that appear on the screen (see Figure 7.8 (a)). The emulator can be chosen to be almost every Android device and Android version that exist. This makes it possible to test the app on different devices that have different screen sizes and Android versions. This emulator is showing a Nexus phone.

[4] https://www.sourcetreeapp.com/
[5] https://developer.android.com/studio/

In addition to using the emulator, it can be useful to have a physical device for testing as well. A Samsung Galaxy XCover 4 with Android version 7.0 (Nougat) was borrowed from SINTEF Energy to be used for testing the app during development. Figure 7.8 (b) shows the app running on the device connected with a USB cable during development.



(a) Emulator (b) App running on the device

Figure 7.8: Emulator vs. running the app on a device

DB Browser for SQLite

Smiling Earth stores values to an SQLite database that is stored locally on the device the app is installed and run on. The database must be downloaded to view the content. This action is called ”dump”, and is done via the following steps:

Figure 7.9: DB Browser for SQLite logo [41]

1. Open terminal or command line
2. Locate the folder *platform-tools* in terminal
   - It is usually located in Appdata\Local\Android\sdk\platform-tools
3. Run commands in terminal:

- `adb backup -f data.ab com.example.desent.desent`
- `dd if=data.ab bs=24 skip=1 | openssl zlib -d > data.tar`

4. Unzip data.tar file (stored in platform-tools folder)
5. Open ActivityLog.db file in DB browser for SQLite

After taking the database dump and unzipping the .tar file, the database can be viewed in a free program called *DB Browser for SQLite*. This program was found by searching for suitable programs to do this task on *Google*. The program is helpful to check if the application is working correctly.

The screenshot in Figure 7.10 shows the content of the table named *DISTANCETRACKER* that stores the number of km walked, cycle or driven a given day.

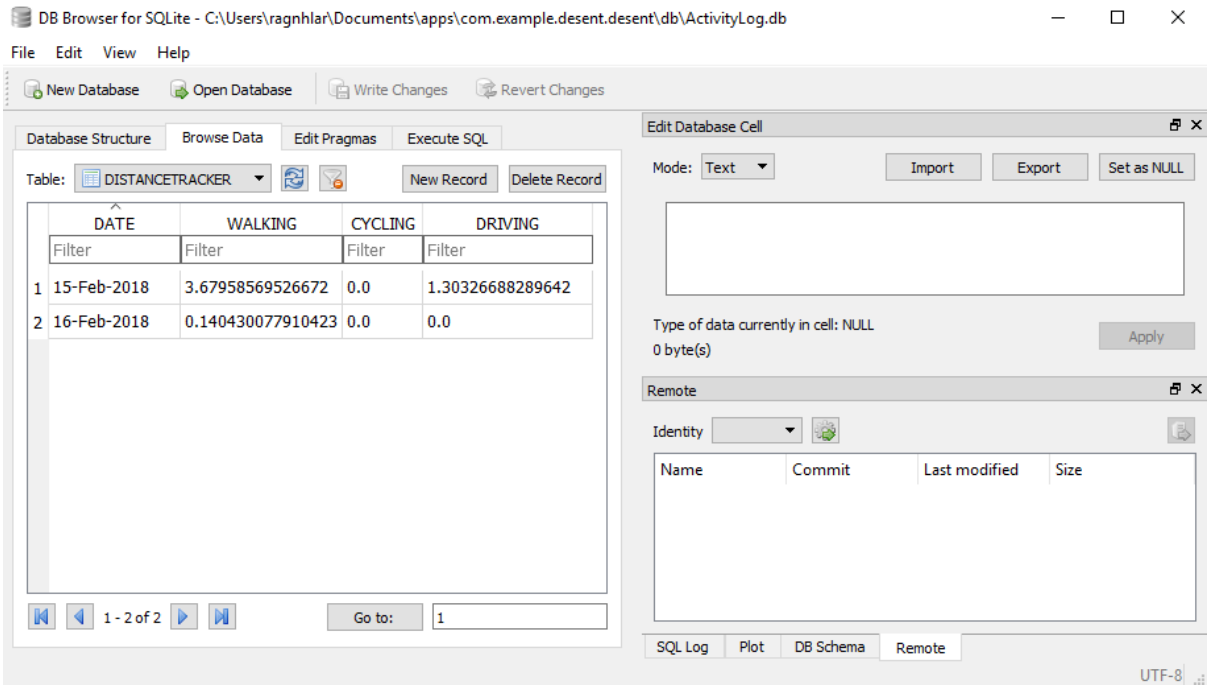


Figure 7.10: Screenshot from DB browser

Gimp

Gimp is a photo editing program, that is free to download[6]. Gimp has some similarities to Adobe Photoshop, but since just a few features were needed it was chosen to use the free alternative in this case. During development, Gimp was used to create the

Figure 7.11: Gimp logo [42]

[6]https://www.gimp.org/

image for the Earth Coin (see Figure 6.1), and for creating transparent backgrounds in images, to mention a few things.

Technologies used when trying to connect to a server

During the development phase, it was considered to set up a server that could support users of the app to connect and compete with each other. It was thus experimented with connecting to a server running on the localhost of the desktop computer. Several technologies and programs were needed to do this. SINTEF Energy, the customer for the project, decided to wait with this, so in the end, the experimenting with connecting with a server was not implemented in *Smiling Earth*, and the local SQLite database was pursued instead. The following technologies and programs were used during the experimentation:

XAMPP Control Panel *XAMPP* is an *Apache* distribution program[7]. This program starts up *Apache* and *MySQL* servers that is needed to be able to access the localhost server (see Figure 7.12).

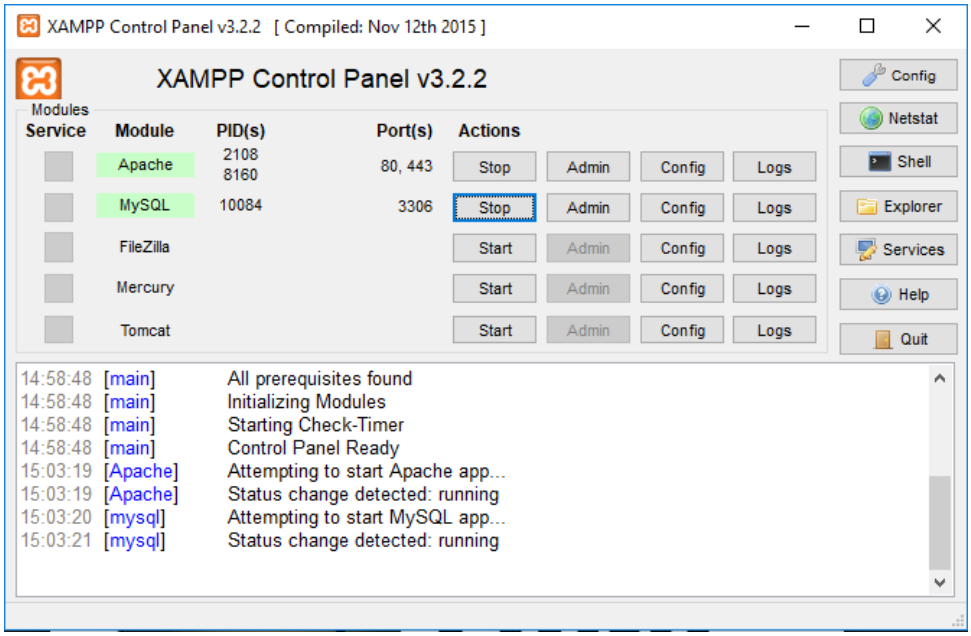


Figure 7.12: XAMPP Control Panel

phpMyAdmin After the servers are started in *XAMPP*, by just writing `localhost/phpmyadmin` in the browser, the dashboard for all the databases on the localhost can be viewed on the dashboard to the left in Figure 7.13. If a server is set up in the future, the localhost part of the address must be replaced with the IP-address of the server.

[7] https://www.apachefriends.org/download.html

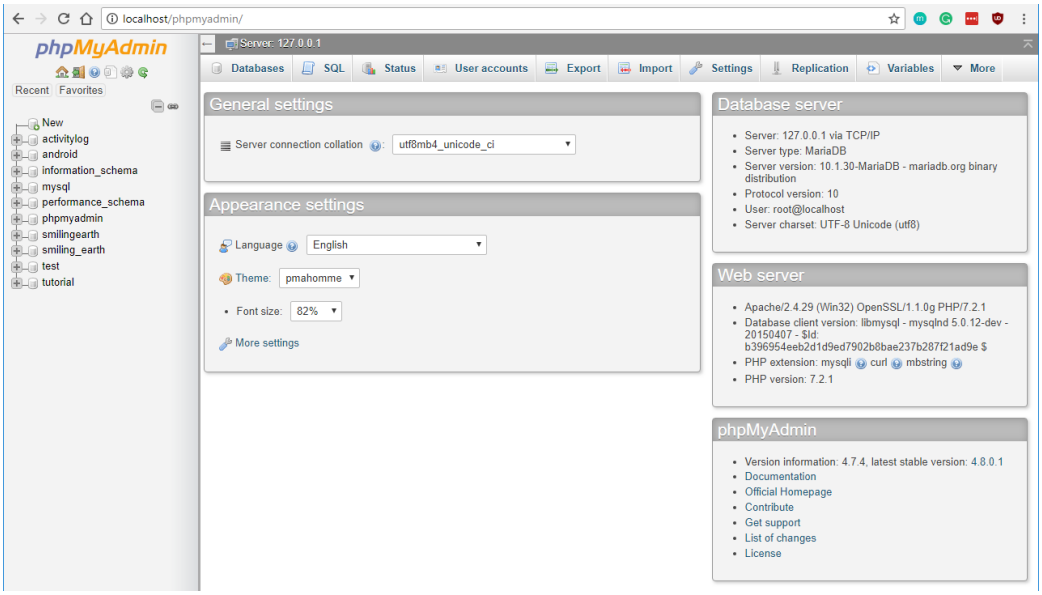


Figure 7.13: phpMyAdmin dashboard

Sublime Text PHP files were generated to connect to the database on the server. The PHP files were created with the free text editor, called *Sublime Text*. The files were stored in a folder in the *xampp* folder in the file directory on the desktop computer.

Figure 7.14: Sublime Text logo [43]

Postman *Postman* is a free API Development Environment (ADE)[8]. This program can be used to check if the PHP-files have any errors, and to test the POST and GET functions to see what the requests retrieve from the database.

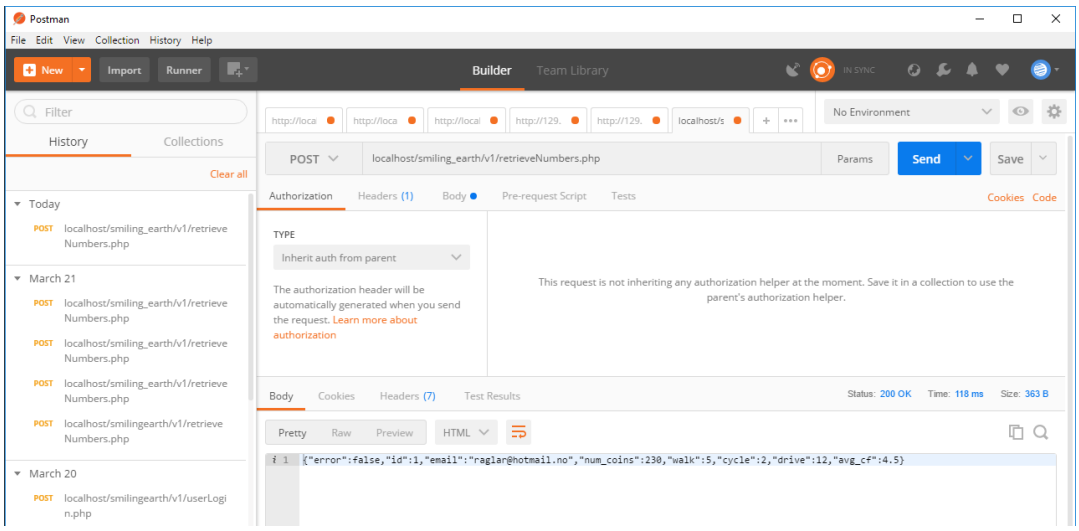


Figure 7.15: Screenshot from Postman

[8]https://www.getpostman.com/

7.2 Architecture Overview

The architecture of *Smiling Earth* is a result of the further development of the app that was first created by Celine Minh, and then further developed by Celine Minh, Magnus Tangen, Peter Ahcin and Idar Petersen during a summer internship at SINTEF Energy. The overview of the architecture shown in Figure 7.16 below, is adapted from Minh's master thesis [7].

The app uses the device's built-in GPS, and the connected API's, such as the *Google Awareness API*, interpret the movement detected by the GPS and decides which activity is being done. This is stored in the local SQLite database that belongs to the application located at the device. The API's also consist of *OpenWeatherMap* that retrieves a weather forecast that is used for the calculations of energy consumption. These data are also stored in the SQLite database. The application retrieves the data from the database and calculates the carbon footprint, expenses, calories, and distance. Other information retrieved from the internet is, e.g., details about the car (only if Norwegian, as *Statens Vegvesen* has an API for this). Other things that are stored in the SQLite database are activity data, user information, distance tracking history and so forth.

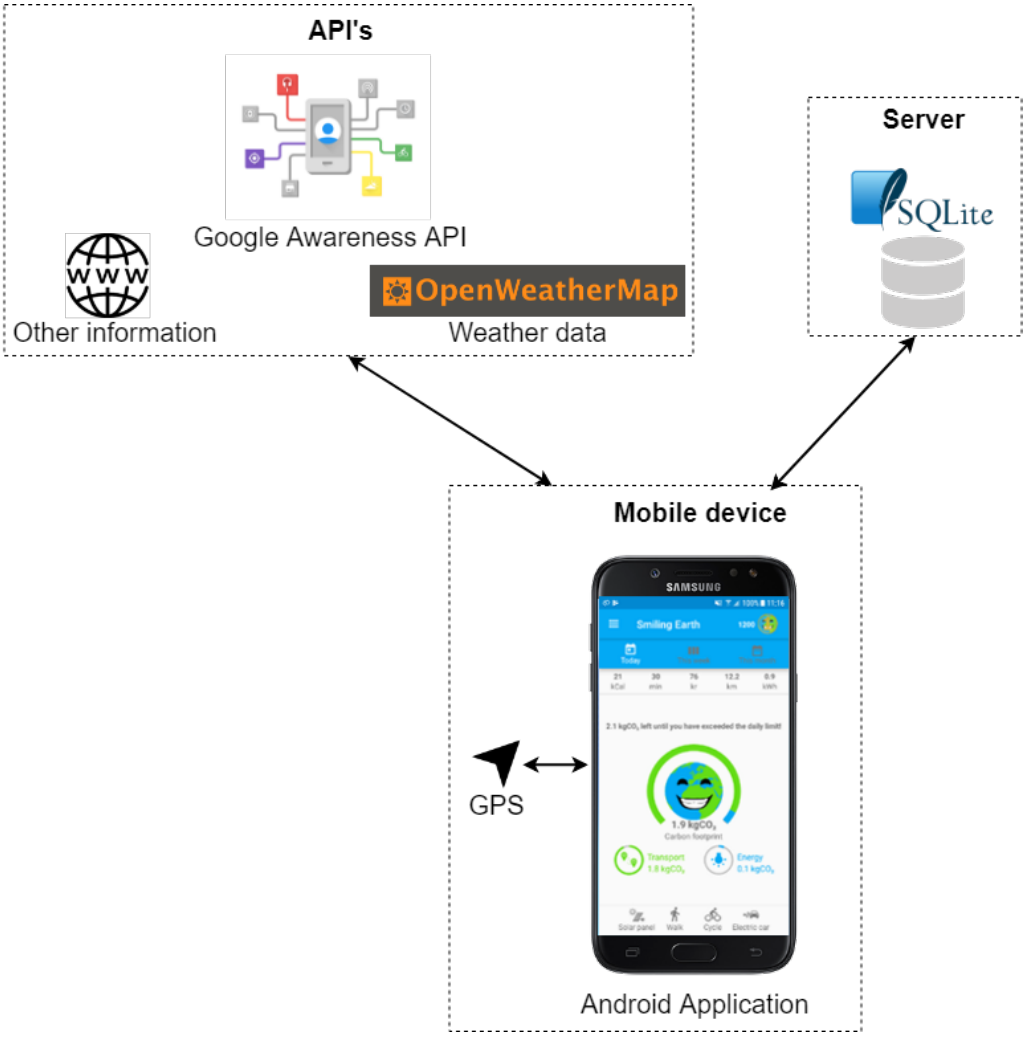
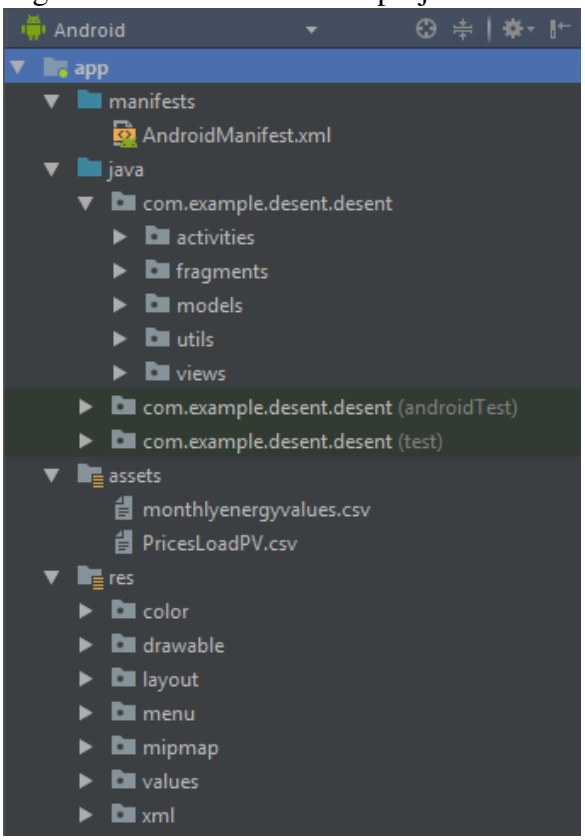


Figure 7.16: System overview

7.3 Project Structure

The Android Studio project structure is displayed in Figure 7.17 to the right. This section will present the various java-class files and the layout files in the project.

Figure 7.17: Android Studio project structure



7.3.1 Class Structure

The Android Studio project consists of the following five different java class-types that can be viewed in the Figure 7.17:

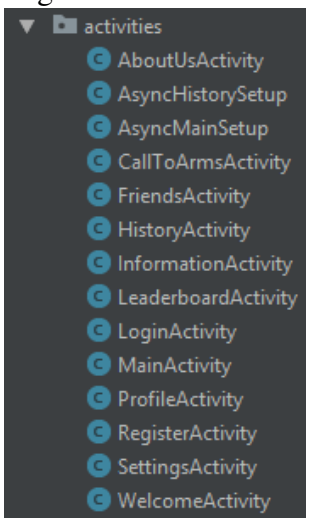
- activities
- fragments
- models
- utils
- views

During the development of the new features, the existing structure was followed when creating new classes and features. The following subsections will go through the different class types that exist in the project.

Activities

Activity is used for displaying views and the item that the user can interact with. The project consists of 14 activities that can be viewed in Figure 7.18 and the flow between them is shown in the activity flow diagram in figure E.1 in Appendix E.

Figure 7.18: Activities



All activities have to be declared in `AndroidManifest.xml`, and they have to implement certain methods like `onCreate()` and `onDestroy()` because it extends/inherits from `AppCompatActivity`. Android activities follow the life cycle displayed in Figure 7.19.

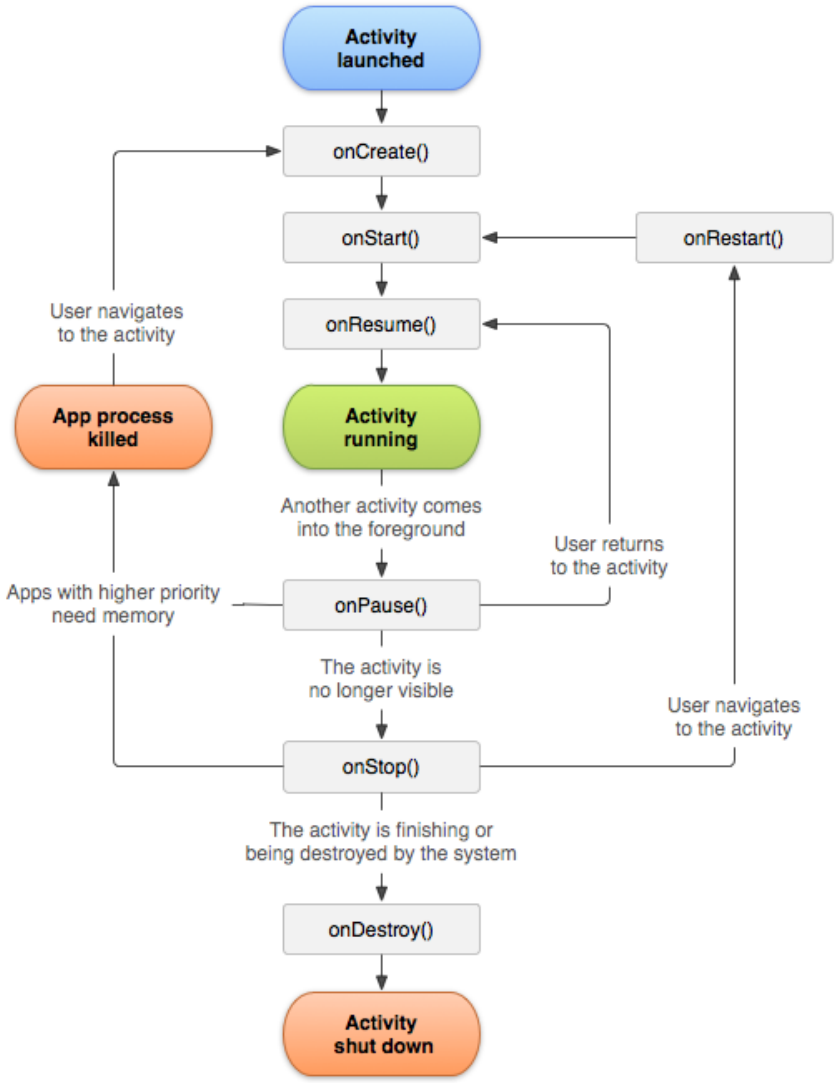


Figure 7.19: The life cycle of an Android activity [44]

Activity Flow Diagram In the activity flow diagram in Appendix E.1, it may look like there is no access between the activities that lead out from `MainActivity`. This is not correct, but to more easily visualize the flow without adding numerous arrows, the diagram was simplified. The app contains a side menu, or a `NavigationDrawer` as it is called. This enables access to all the activities and is accessible from all the activities displayed on the right side of the figure as well as from `MainActivity`.

NavigationDrawer All the activities that have access to the side menu (see Figure H.6) must implement the interface that is called `NavigationView.OnNavigationItemSelectedListener`, and the method `onNavigationItemSelected(MenuItem item)` must be implemented (see code snippet in Listing 7.1). It is this method that declares which activity that opens when a menu item in the side menu is clicked. The method is almost equally implemented in each

activity, but has a different *".this-class"* in the code line
`startActivity(MainActivity.this, HistoryActivity.class).`
The code line `drawer.closeDrawers()` is used for the *".this-class"*.

Listing 7.1: NavigationDrawer in FriendsActivity

```
public class FriendsActivity extends AppCompatActivity
   implements NavigationView.OnNavigationItemSelectedListener{
   DrawerLayout drawer;
   @Override
   protected void onCreate(Bundle savedInstanceState) {
      super.onCreate(savedInstanceState);
      setContentView(R.layout.activity_friends);
      drawer = (DrawerLayout)findViewById(R.id.drawer_layout);
      ActionBarDrawerToggle toggle = new ActionBarDrawerToggle
         (this, drawer, toolbar, R.string.
         navigation_drawer_open, R.string.
         navigation_drawer_close);
      drawer.setDrawerListener(toggle);
      toggle.syncState();
      setUpNavigationView();
   }
   protected void setUpNavigationView() {
      //arrange the navigation header
   }
   @Override
   public boolean onNavigationItemSelected(@NonNull MenuItem
      item) {
      // Handle navigation view item clicks here.
      int id = item.getItemId();
      if (id == R.id.nav_home) {
         startActivity(new Intent(FriendsActivity.this,
            MainActivity.class));
         drawer.closeDrawer(GravityCompat.START);
      } else if (id == R.id.nav_friends) {
         drawer.closeDrawer(GravityCompat.START);
      }
      return true;
   }
}
```

Another consequence of using the `NavigationDrawer` is the structure of the layout files. Each activity must have three layout files (see Listing 7.2):

- activity_leaderboard.xml (that is a DrawerLayout)

- app_bar_leaderboard.xml
- content_leaderboard.xml

Listing 7.2: Layout file structure

```
//activity_friends.xml
<android.support.v4.widget.DrawerLayout xmlns:android="http://
   schemas.android.com/apk/res/android"
   ...>
   <include
      layout="@layout/app_bar_friends"
      android:layout_width="match_parent"
      android:layout_height="match_parent"/>
   <android.support.design.widget.NavigationView
   .../>
</android.support.v4.widget.DrawerLayout>

//app_bar_friends.xml
<android.support.constraint.ConstraintLayout xmlns:android="
   http://schemas.android.com/apk/res/android"
   ...>
   <android.support.design.widget.AppBarLayout
      ...>
      <android.support.v7.widget.Toolbar
         .../>
   </android.support.design.widget.AppBarLayout>
   <include layout="@layout/content_friends"/>
</android.support.constraint.ConstraintLayout>

//content_friends.xml
<RelativeLayout
   ...>
   <android.support.v7.widget.RecyclerView
      ...>
   </android.support.v7.widget.RecyclerView>
</RelativeLayout>
```

Fragments

As can be seen in Figure 7.18, there is no activity for the estimation functionality for solar panels, walking, cycle and electric car that is available from the `MainActivity`. That is because this functionality is created by using fragments.

A FragmentActivity is a subclass of Fragment. Multiple fragments can be displayed at the same time, and they work like activities by it being interacted with. Fragment transaction manages fragments. The advantage of using fragments is that it makes it easy to adjust the user interface on devices with different screen sizes.

Similar to the activity presented above, fragments also have a life cycle that can be viewed in Figure 7.20. A fragment has to be attached in an activity and must implement some methods that are called when a fragment is added.

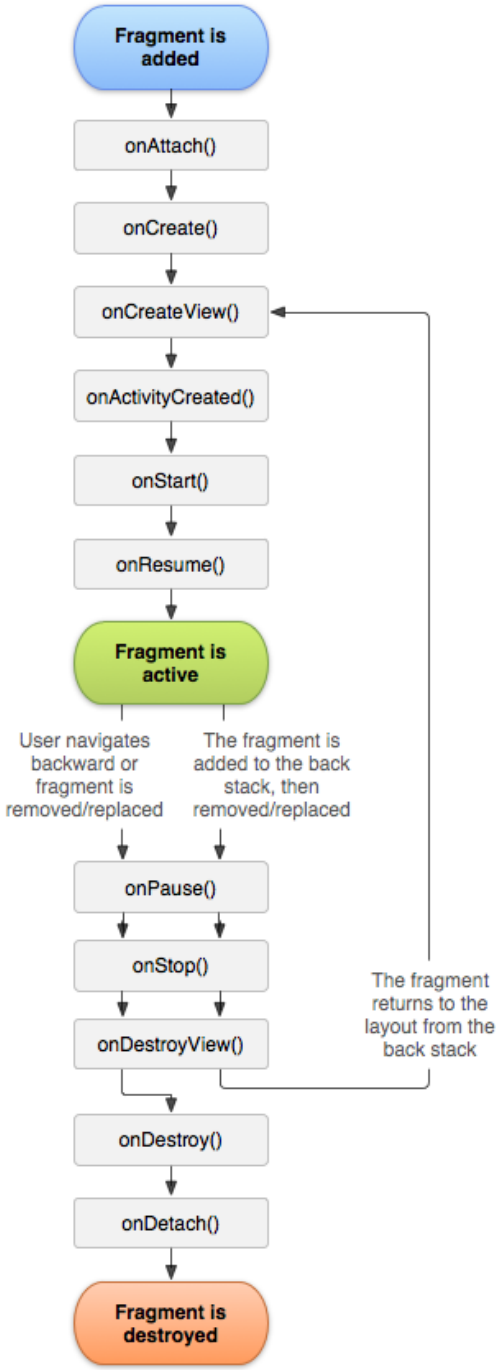


Figure 7.20: The life cycle of an Android fragment [45]

Fragments Flow Diagram *Smiling Earth* contains the fragments shown in Figure 7.21 below. As previously mentioned, a fragment has to be added to an activity. Appendix E.2 shows the activities in the project that add fragments, and which fragments that are added via the activity.

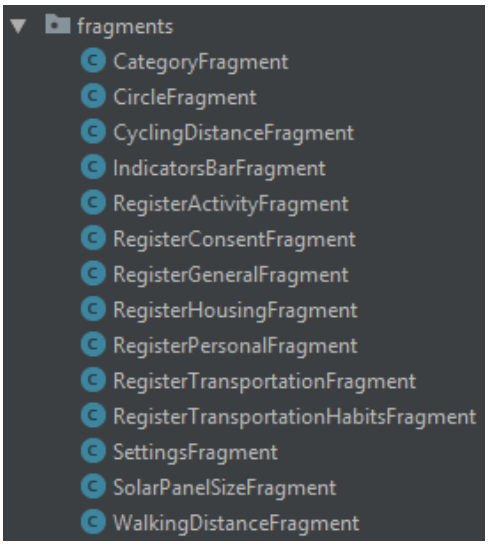


Figure 7.21: Fragments

A fragment is added to an activity by using a Fragment Transaction Manager, see the code snippet in Listing 7.3:

Listing 7.3: Fragment added to activity

```
public class MainActivity extends AppCompatActivity implements
    NavigationView.OnNavigationItemSelectedListener {
   @Override
   protected void onCreate(Bundle savedInstanceState) {
      super.onCreate(savedInstanceState);
      setContentView(R.layout.activity_main);
      //Bottom navigation for Estimation
      bnveEst = (BottomNavigationViewEx) findViewById(R.id.
         bnveEst);
      bnveEst.setOnNavigationItemSelectedListener(
            new BottomNavigationView.
               OnNavigationItemSelectedListener() {
               @Override
               public boolean onNavigationItemSelected(
                  @NonNull MenuItem item) {
                  FragmentTransaction ft = getFragmentManager
                     ().beginTransaction();
                  switch (item.getItemId()) {
                     case R.id.navigation_none:
```

```
                        ft.hide(walkingDistanceFragment);
                        ft.hide(cyclingDistanceFragment);
                        ft.hide(solarPanelSizeFragment);
                        ft.commit();
                        break;
                    case R.id.navigation_solar_installation:
                        ft.hide(walkingDistanceFragment);
                        ft.hide(cyclingDistanceFragment);
                        ft.show(solarPanelSizeFragment);
                        ft.commit();
                        break;
                } return true;
            }
        });
    }
}
```

A typical fragment class is structured as following Listing 7.4 where the layout file is inflated in the onCreateView()-method:

Listing 7.4: Fragment class

```
public class SolarPanelSizeFragment extends Fragment
    implements View.OnClickListener {
    @Override
    public View onCreateView(LayoutInflater inflater, ViewGroup
        container, Bundle savedInstanceState) {
        return inflater.inflate(R.layout.
            fragment_solar_panel_size, container, false);
    }
}
```

Listing 7.5 shows a layout file for an activity that includes a fragment:

Listing 7.5: Fragment included in a layout file for an activity

```
//content_main.xml
<RelativeLayout xmlns:android="http://schemas.android.com/apk/
    res/android"
    ...
    <ScrollView
        ...>
        <LinearLayout
            ...>
            <fragment android:name="com.example.desent.desent.
                fragments.CircleFragment"
```

```
            android:id="@+id/dailyCarbonFootprint"
            android:layout_width="190dp"
            android:layout_height="190dp"
            tools:layout="@layout/fragment_circle">
        </fragment>
    </LinearLayout>
  </ScrollView>
</RelativeLayout>
```

Listing 7.6 shows a typical layout file for a fragment:

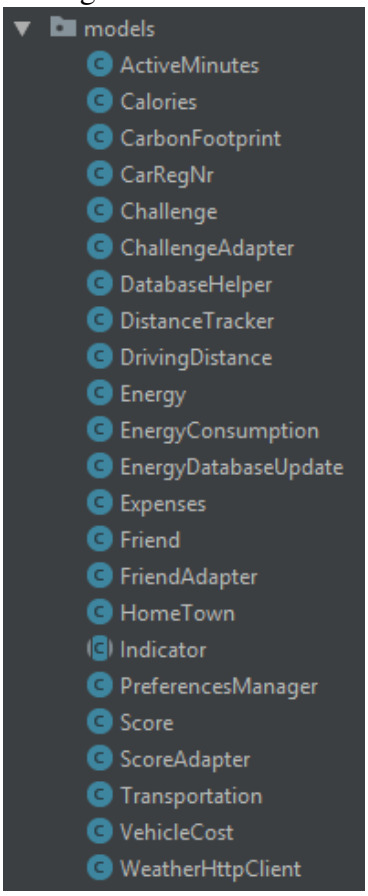
Listing 7.6: Fragment layout file

```
//fragment_solar_panel_size.xml
<LinearLayout xmlns:android="http://schemas.android.com/apk/
  res/android"
  android:orientation="vertical" android:layout_width="
    match_parent"
  android:layout_height="match_parent">
  <TextView
    android:layout_width="match_parent"
    android:layout_height="wrap_content"
    android:textSize="13sp"
    android:gravity="center"
    android:text="Select solar panel size to see how much
      you can save:"
    android:paddingBottom="6dp"/>
  <LinearLayout
    android:id="@+id/solar_panel_button_container"
    android:orientation="horizontal"
    android:layout_width="match_parent"
    android:layout_height="wrap_content"
    android:gravity="center"/>
  <View
    android:layout_width="match_parent"
    android:layout_height="1dp"
    android:background="?android:attr/listDivider"
    android:layout_marginTop="8dp"
    android:layout_marginBottom="8dp"/>
</LinearLayout>
```

Models

Models consist of 23 classes that have various purposes in the project. Some of the classes hold the objects in the app such as:

Figure 7.22: Models



- CarRegNr
- Challenge
- Friend
- HomeTown
- Indicator (Abstract class), following extends this class:
  - ActiveMinutes
  - Calories
  - CarbonFootprint
  - DrivingDistance
  - Energy
  - EnergyConsumption
  - Expenses
- Score
- Transportation
- VehicleCost

Other classes are used to fill the RecyclerView with items with an adapter such as:

- ChallengeAdapter
- FriendAdapter
- ScoreAdapter

The remaining classes have different functionality:

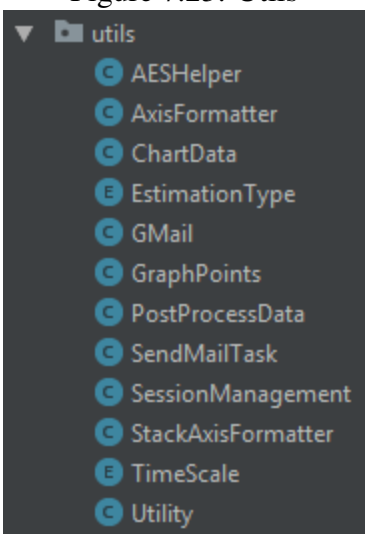
- DatabaseHelper: writes to the SQLite database and defines the tables and fields in the database.
- DistanceTracker: ApiAwareness class that interprets which activity is done.
- EnergyDatabaseUpdate: retrieves weather data and stores to energy table in SQLite database

- PreferenceManager: not used that much since the built-in SharedPreferences is mostly used
- WeatherHttpClient: API that retrieves weather data from an open weather map

Utils

The 12 classes in utils are related to different aspects of the app.

Figure 7.23: Utils



Graph These classes are related to creating the historical graph.

- AxisFormatter
- ChartData
- GraphPoints
- StackAxisFormatter
- TimeScale

Sending CSV-file to DESENT email These classes are related to the functionality to send transportation data like acceleration as a CSV file to a DESENT email account. Magnus Tangen added this functionality during the semester.

- GMail
- PostProcessData
- SendMailTask

AESHelper Class used to encrypt password.

EstimationType Predefined constants (enum) that holds the different estimation types that are available in the app.

SessionManagement Class to manage login and logout in the app. This will be further described in Chapter 8.

Utility The class manages functionality with the profile picture in the app, such as cropping.

Views

Five classes are located in the folder called views and are hence related to managing the views of, e.g., the circular indicator, the indicator bars and the history graph. This includes the classes shown in Figure 7.24.

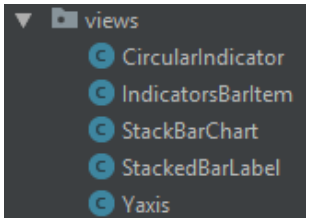


Figure 7.24: Views

7.3.2 Resources

The structure for the resources that the project consists of is shown in Figure 7.25. The resources consists of XML-files and images. The layout file structure was briefly shown in Listing 7.2.

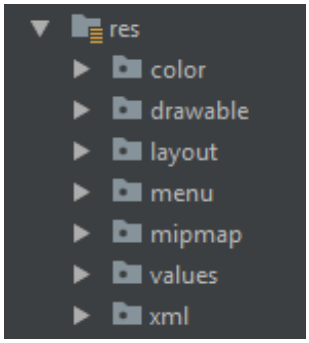


Figure 7.25: Resource structure

color: Consists of XML-files with defined colors for particular items used in the app.

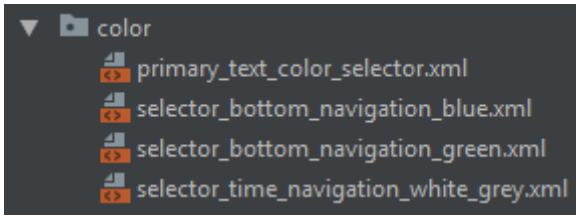


Figure 7.26: Colors

drawable: This folder includes the images and icons that are used in the app.

layout: Consists of all the XML layout files.

menu: Includes the menu items that are used in, e.g., the side menu and other menu items in the app.

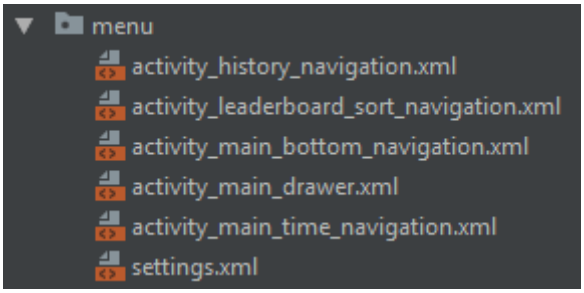


Figure 7.27: Menu

mipmap: Holds the app/launcher icons.

values: Comprise of the following XML-files:

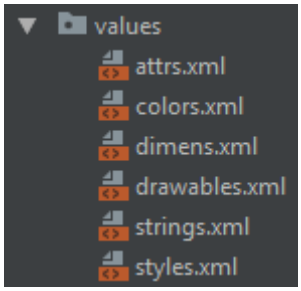


Figure 7.28: Values

- attrs.xml
- colors.xml: holds defined colors
- dimens.xml: defined dimens used in the layout
- drawables.xml
- strings.xml: holds the strings used in the app, can be used to easily manage to switch between language in the app if more string files are created of, e.g., Norwegian strings. The language that is chosen on the device decides which strings that will be used
- styles.xml: self-defined styles of, e.g., spinner items can be defined in this file

xml: Contains `preferences.xml` that hold the preferences used in `SettingsActivity` and works as the layout file for the activity.

Chapter 8

Implementation

Chapter 7 gave an overview of the system and the technologies used. This chapter will provide an insight into how the development phase was conducted and how *Smiling Earth* was implemented. The planning phase, and how the backlog was created and the sprints were planned will first be described. To show what has been implemented, the three sprints that were completed will be reviewed, and the changes done will be presented. How the app was made ready for user evaluation and distribution is presented in Section 8.3.

8.1 Backlog Creation and Sprint Planning

8.1.1 Backlog Creation

A backlog of all the tasks needed to be completed during the development phase was created as the first step in the development phase. The backlog was formed based on the list of requirements, the feedback from the evaluations conducted in the specialization project, and the results of the gamification workshop.

The first draft of the backlog was created in a word document as a list of items, and later they were created as separate tasks in a *Trello* board (see Figure C.1 in Appendix C). *Trello* was used to structure the tasks into sprints and use *Scrum* as a methodology. This gave a clear overview of which tasks were currently being worked on, which were done and which were left to do. It could be debated whether it is necessary to use the scrum methodology when only one person is developing, but it was found useful to keep control of the tasks that were being worked on and what needed to be done.

8.1.2 Sprint Planning

After creating the backlog, the tasks had to be distributed into sprints. The gamification workshop and survey showed that usability and gamification should be the top two prioritized focus areas for the development phase. When planning for the development period, three sprints that lasted 1-2 weeks each could be arranged within the time available. The first sprint would focus on enhancing the usability issues discovered during user evaluations in the specialization project. The second sprint would mainly focus on gamifying the app, and the third sprint would focus on making the app social by being able to connect with friends, and fixing the remaining tasks from the previous sprints.

8.2 Review of the Sprints

Following is a review of the work done in the three sprints conducted in the development phase. Explanations of how things were implemented, what were changed, and why they were changed will be given.

8.2.1 First Sprint

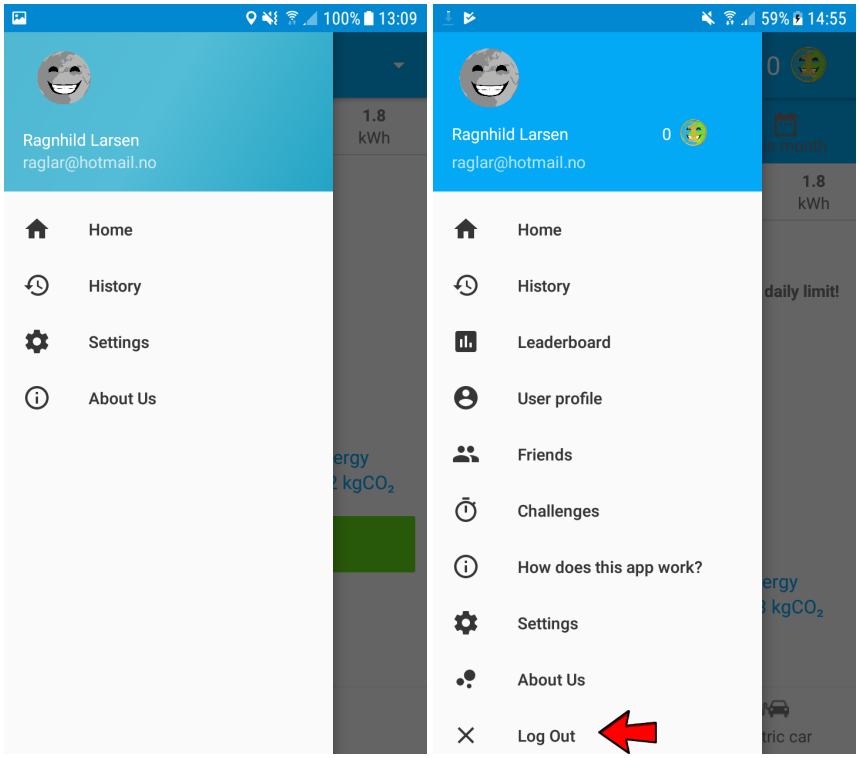
The source code for the project cloned from GitHub had been studied a bit before starting the development phase, but the first sprint was the first real encounter with the code. Hence, this sprint included much time spent on understanding the code and how it is structured and getting familiar with Android functionality. Because of this, the first sprint lasted 2,5 weeks, and still, all the planned tasks were not completed. The code structure is described in the Software Architecture Chapter 7. The main focus for this sprint was to improve the usability of the app. The tasks done in this sprint is presented in Figure C.1 in the Appendix C in the list called *Sprint 1*.

Prevent App from Automatically Logging out

Smiling Earth V2 had the functionality that you got logged out every time the app was closed. During development it was frustrating having to log in every time the app was closed, or when changes were made, and the app had to be rerun. To avoid this, a `SessionManagement` class (see Appendix G.1) was implemented to keep track of whether someone is logged in or not. The class uses Android's Shared Preferences and the SQLite database to store and retrieve the user's email when registering to the app. The methods in the class are used in `MainActivity` to check if someone has logged in before or is already logged in. If no one has ever logged in,

the `WelcomeActivity` starts and is followed by `RegisterActivity` (see Figure 8.2). When a user finishes the registration, the method `createLoginSession()` is called.

A logout button was added to the side menu as this did not exist in the previous versions of the app (see Figure 8.1 below). When the button is clicked, the `logoutUser()`-method is called and the `LoginActivity` starts (see Figure 8.3). When a user has logged out, the app will open the `LoginActivity` the next time the user opens the app, and `createLoginSession()` is called at login (see Figure 8.4).



(a) V2 (b) V3

Figure 8.1: Side menu before and after change

The following sequence diagrams visualize how the `SessionManagement` class works in different scenarios:

New user

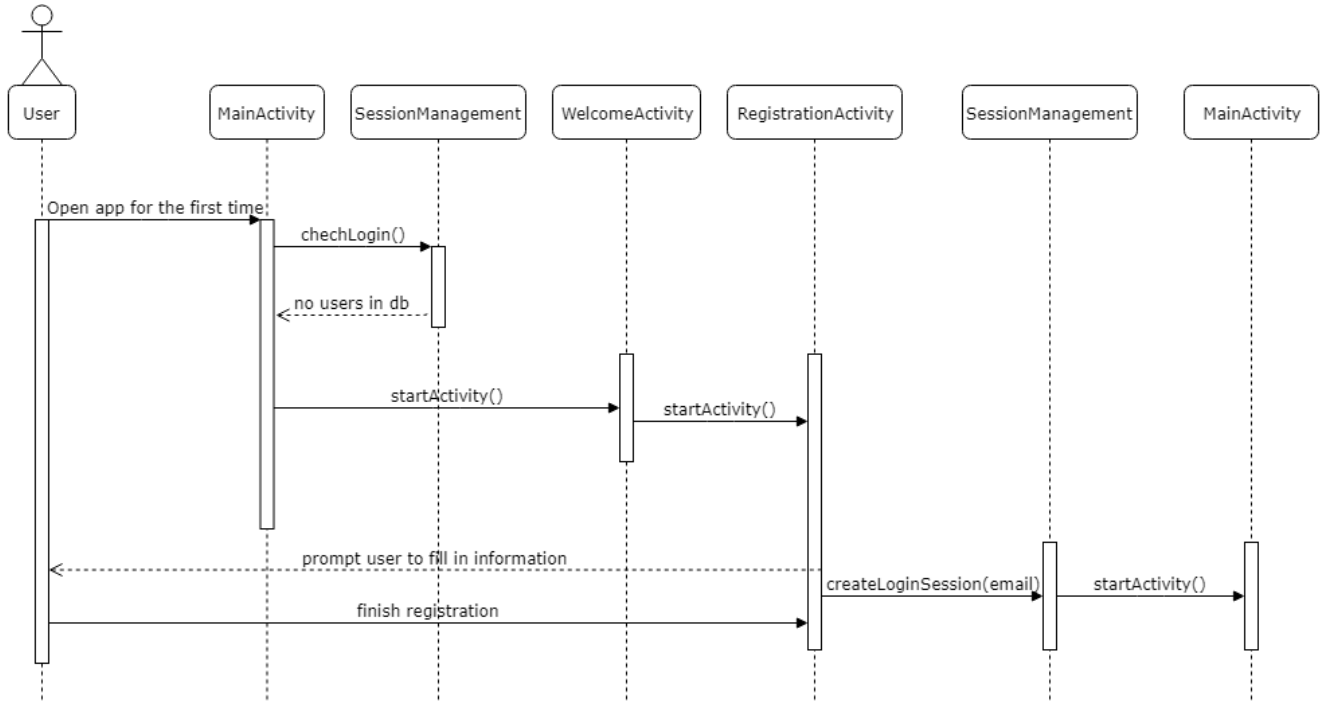


Figure 8.2: New user

Registered user who is logged in, logs out

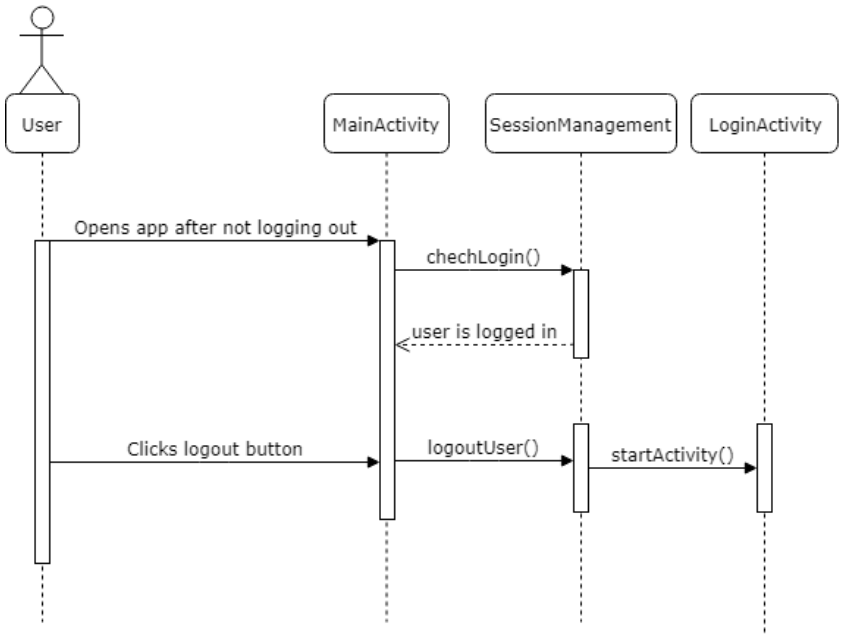


Figure 8.3: User registered and logged in

Registered user logs in

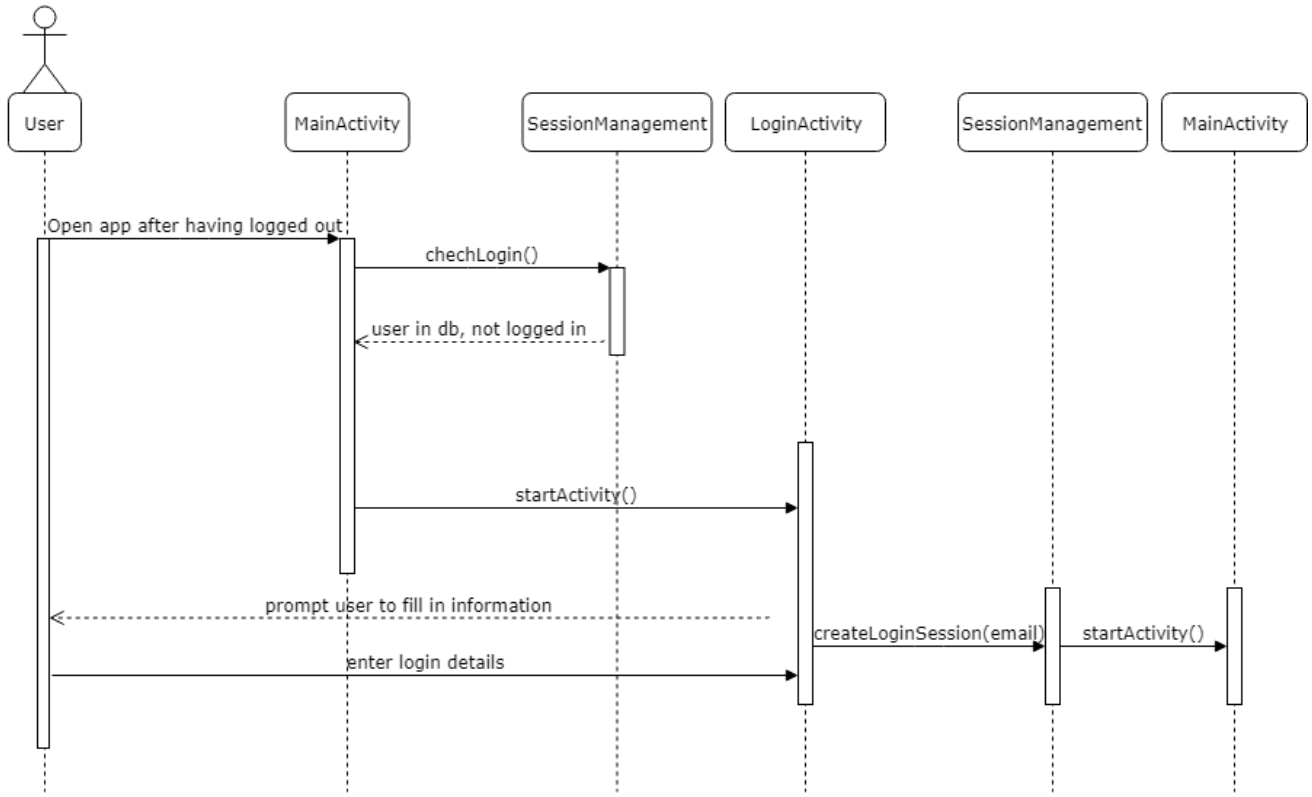


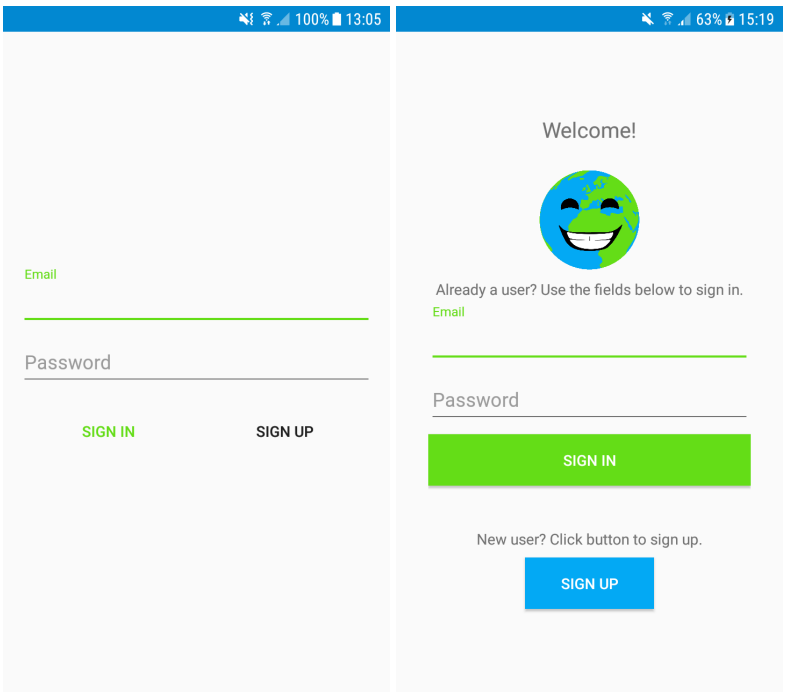
Figure 8.4: User registered and logged out

Login Screen

Observations during evaluations of V2 conducted in the specialization project showed that almost every person started filling in the fields for email and password without clicking on ”SIGN UP” (to register a new user) first as they were supposed to. This indicated that the layout of the login screen was not intuitive. If an unregistered user clicked ”SIGN IN” before having signed up, they would only get an error message that said that either the email or password was typed wrong, and not any message indicating that the user had to register before signing in to the app.

Two things were mainly done to overcome this problem. Firstly, the layout of the screen was changed (see Figure 8.5). The button for ”SIGN IN” and ”SIGN UP” is now clearly separated, and explanatory text will help the user to understand where to click.

Secondly, the flow of the application and the adding of the `SessionManagement` class will prevent new users to come directly to the login screen. This is fixed by taking the user directly from the welcome screen, through the registration process, to the dashboard, and thus preventing new users from trying to log in unregistered (see Figure 8.2).



(a) V2 (b) V3

Figure 8.5: Login screen before and after change

Welcome Slides

Based on the new welcome slides that were added to the prototype, the welcome slides in the app were updated as well. These slides were not enabled in the app when the user evaluation of V2 was conducted, and most participants did not understand the purpose of the app as they were thrown in without any introduction to *Smiling Earth's* concept. The welcome slides in the prototype received positive feedback, so adjustments were made to fit the new functionality and layout in the app. The welcome slides can be viewed in the Appendix H.1.

The welcome slides are only showed the first time a new user is using the app. This is implemented together with the `SessionManagement` class, and the sequence is shown in Figure 8.2.

How To-Slides

During the evaluation of the prototype when the welcome slides were added, it was observed that several participants skipped the slides, or said that they would typically do it. Since it is essential that the user understand the purpose of the app, it was decided to add an `InformationActivity` class that holds the relevant welcome slides. The slides are accessed through the item in the side menu with the description *How does this app work?* (see Figure 8.2.1).

Dashboard

The dashboard, or the main page of the app, was changed in a few ways as can be viewed in Figure 8.6 below. These changes were made on the basis of the feedback received in the user evaluation of V2 conducted in the specialization project. The changes done will be presented below.

(a) Version 2 (b) Version 3

Figure 8.6: Dashboard before and after change

Sizing of items The size of some of the items was changed based on feedback that indicated that the size of some of the items was too small in V2. The Earth and the circular indicator were made larger, as well as the text connected to it. The icons for estimation were also made bigger and text was added below to describe the icons.

Tab Bar In addition to adding text and increasing the size of the buttons for estimation, the `BottomNavigaionView` that was used for the estimation buttons in V2 was replaced with a tab bar called `BottomNavigationViewEx`[1] that was implemented from a library found on GitHub.

The reason for choosing this library was that it was easier to customize compared to the `BottomNavigationView` that was initially used. The library made it possible to have icons and text together in the tab bar, with different animations and colors that show the selected tab.

[1] `https://github.com/ittianyu/BottomNavigationViewEx`

Evaluation of V2 revealed that the buttons for estimation did not look like buttons, so to try to make it clearer, the library was implemented. The digital prototype created in *Proto.io* also contained such tab bar instead of the spinner item and was well received.

The `BottomNavigationViewEx` was also used to replace the spinner item used for switching between views for Today/This week/This month that was located in the toolbar in V2, and the spinner in the `HistoryActivity` (see Figure 8.8). As displayed in Figure 8.6 (b) the spinner is removed, and a tab bar is inserted between the toolbar and the indicators bar. This was done because of the feedback received from the evaluation of V2, where many of the participants struggled with understanding that they had to click on the spinner item to switch between the different screens. The tab bar was added to give the user the opportunity to view all the possible options clickable right away.

The `BottomNavigationViewEx` was implemented by importing the library to the build gradle file with copying the following line into the file:
`compile 'com.github.ittianyu:BottomNavigationViewEx:1.2.4'.`

Active Minutes In the indicators bar that is located below the toolbar in V2 and below the tab bar in V2, the indicator *Active minutes* (min) has been added (see Figure 8.6). This was added because it was discussed with the participants of the evaluations of V2 which one they found most motivating of calories and active minutes. The original idea behind this was proposed in Celine Minh's master thesis [7]. Some users may find calorie counting demotivating and think that active minutes is a healthier measure of daily activity. Active minutes was also added to the digital prototype and was found motivating by the participants in the user evaluation. The initial thought was to remove calories and only have active minutes in the bar, but as it did not look too messy with both, it was decided to keep them both in the app.

The implementation was done by following the code structure of the other indicators that was already there (kcal, kr, km, kWh). More specifically, an `ActvieMinutes` class was created, that can be viewed in Appendix G.4. The indicator was then added to the `ArrayList` of indicators in `AsyncMainSetup`. Listing 8.1 shows a code section that is highly shortened, that shows how the indicator is added to the indicator bar. The daily goal that is set for active minutes is 30 minutes as this is the recommendation from the WHO (Worlds Health Organization)[2].

Listing 8.1: AsyncMainSetup

```
public class AsyncMainSetup extends AsyncTask {
   private ArrayList<Indicator> indicators;
   private ActiveMinutes activeMinutes;
```

[2] `http://www.who.int/dietphysicalactivity/factsheet_adults/en/`

```
   ...
    @Override
    protected void onPostExecute(Object o) {
        activity.setActiveMinutes(activeMinutes);
        ...
    }
    protected void setUp(){
        indicators.add(activeMinutes = new ActiveMinutes(
            activity.getString(R.string.active_minutes_name),
                activity.getString(R.string.active_minutes_unit),
                activity.getString(R.string.
                    active_minutes_explanation),
                transport,
                activity));
        activeMinutes.setDecimalsNumber(0);
        for (Indicator indicator: indicators) {
            indicator.setTimeScale(TimeScale.TODAY);
            indicator.setEstimationType(EstimationType.NONE);
        }
        indicatorsBarFragment.setLength(5);
        indicatorsBarFragment.addIndicator(activeMinutes);
        ...
    }
}
```

Changed wording of how much kgCO_2 left The design and wording of how much kgCO_2 left were changed in V3. The writing *You have X kgCO_2 left!* can be interpreted as an encouragement to use up all the ”allowed” daily limit (see Figure 8.6 (a)). Hence the sentence was changed to *X kgCO_2 left until you have exceeded the daily limit* (see Figure 8.6 (b)). This will hopefully be interpreted in a way that does not encourage the user to use their ”allowed” amount of kgCO_2. The layout and placement of the sentence were also changed. This was done to fit the new size of the circular indicators.

Navigation between Dashboard and Estimation During user evaluation of V2, it was found hard to navigate back to the dashboard after having looked at the estimation screens for solar panel, walk, cycle and electric car. The way it was implemented was that the estimation button that was already activated had to be pressed again to go back to the dashboard. The method most participants of the user evaluation tried to get back to the dashboard from the estimation screens, was to click the back button on the device or to click ”Home” in the side menu. Since this seemed like the most natural solution, this was implemented by using `startActivity`

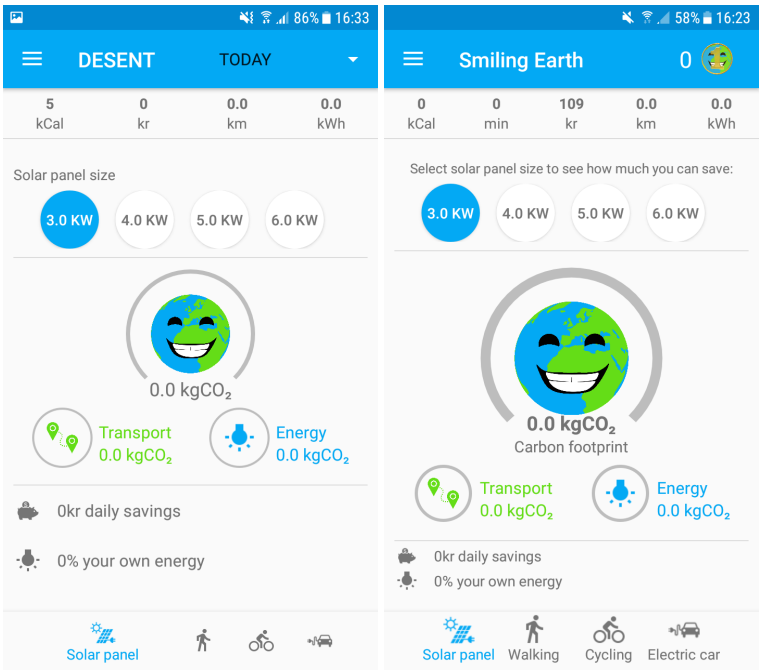
and calling the `MainActivity` to start when the back button or ”Home” is clicked.

In the digital prototype, the side menu icon was replaced with an arrow icon symbolizing ”back” when the estimation screens were activated (see Figure D.6 in Appendix D). This received mixed feedback during the evaluation, so it was decided not to pursue this but instead implement functionality for the back button and ”Home”. The negative feedback dealt with the inconsistency it created using the icon on what might have seemed like random screens for the participants and showing the side menu icon on other screens.

Estimation Functionality

The estimation functionality for solar panels, walking, cycling and the electric car received a lot of negative feedback during the user evaluation of both V2 and the digital prototype. This feedback was tried to be met, and the initial goal was to make the estimation functionality easier and more intuitive.

However, it was found that the functionality was intricate and hard to change due to how it was implemented, so a temporary solution was to add some explanatory text and try to make the layout a bit clearer. This can be viewed in the Appendix H.4. A comparison of the estimation for solar panels is shown in Figure 8.7 below. As can be viewed, there is not much difference, only more description at the top, and less spacing between the values below the circular indicators.



(a) Version 2 (b) Version 3

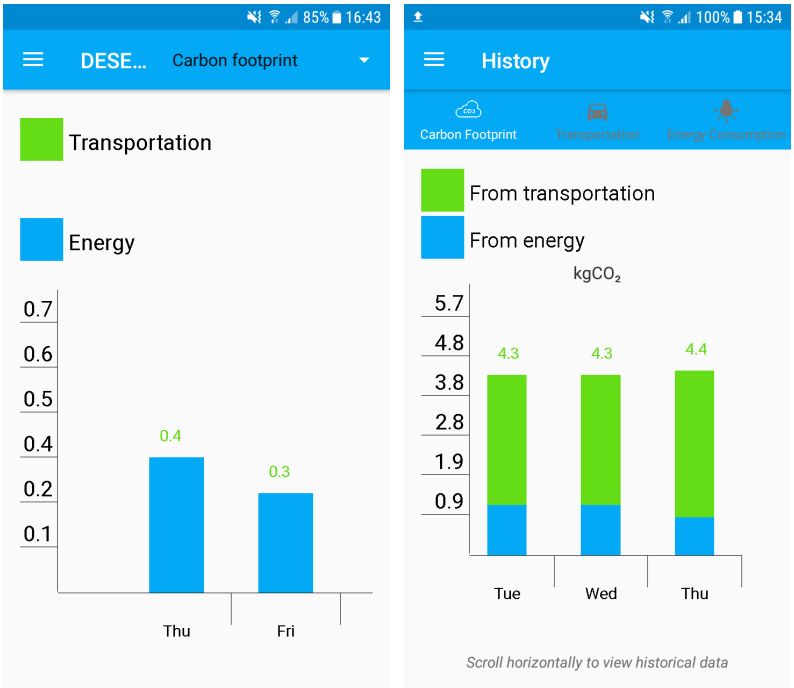
Figure 8.7: Estimation before and after change

Screen Title in Toolbar

In V2 of the app, all the screens in the app had the title ”DESENT” in the toolbar. During the user evaluation of this version, many expressed confusion of which page was which and proposed that the title should be changed after which screen that was active, such as History, Settings, Profile and so forth. This was changed in the Android Manifest by using labels for each activity as shown in Listing 8.2:

Listing 8.2: Android Manifest

```
<?xml version="1.0" encoding="utf-8"?>
<manifest
   xmlns:android="http://schemas.android.com/apk/res/android"
   package="com.example.desent.desent">
   ...
   <application
      ...
      <activity
         android:name=".activities.HistoryActivity"
         android:label="History" />
      ...
   </application>
</manifest>
```



(a) V2 (b) V3

Figure 8.8: History Activity before and after change (Title)

History Graph

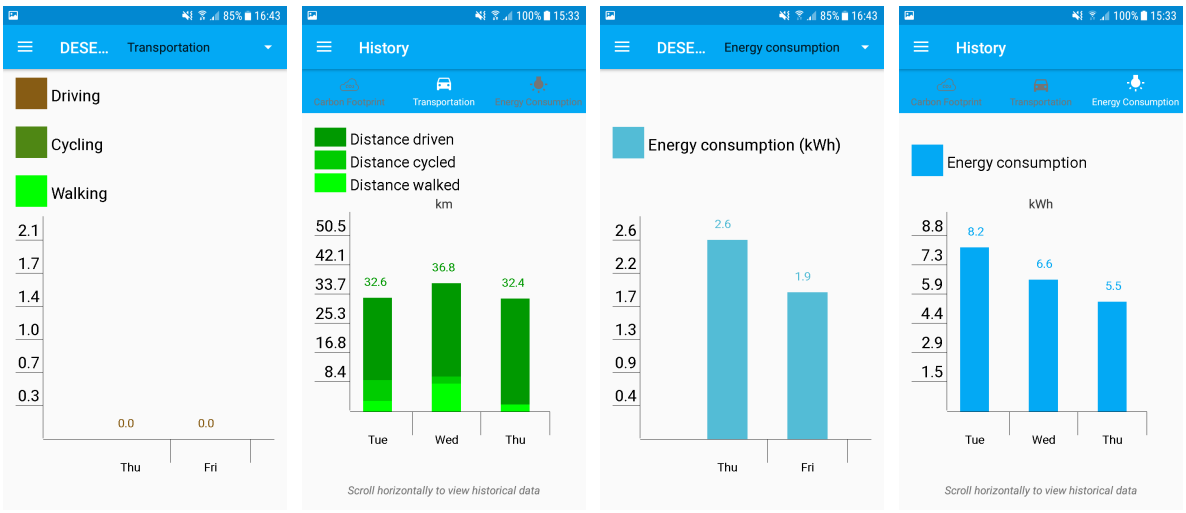
In addition to switching to a tab bar and adding the title to the screen as described above, an attempt was made to change the historical graph to fit the screen as proposed in the digital prototype (see Figure D.8 in Appendix D). Many libraries were tried, but problems were met when the data was going to be imported, so it ended up with keeping the graph as it was but changing the size of the bar and labels.

A hint was added to the screen for the historical graphs, to give the user a hint that scrolling horizontally will reveal the rest of the days in the graph (see Figure 8.8). The central issue with the historical graph, which was revealed during user evaluations of V2, was that you had to scroll to see the different days. The hint was added as a temporary solution because it was not accomplished to change the graph to fit the screen.

Annotations were added to the graph to more clearly show which values the graph displays (that is $kgCO_2$, km, kWh). These changes can be viewed in Figure 8.9 and the rest of the screenshots from the historical graph can be viewed in the Appendix H.7.

It was included in the prototype to have graphs for today (hour by hour), week and month (day by day), but these plans were also deprioritized as it was hard to retrieve the data.

The colors of the labels and stack bars were changed to keep the color code more consistent in the app, as this had been an issue in the previous versions. Transportation now has different shades of green instead of green and brown. Energy consumption graph now has the same color that is used for energy consumption on the dashboard.



(a) V2 (b) V3 (c) V2 (d) V3

Figure 8.9: History Activity before and after change (Colors)

Registration

The stakeholders in the DESENT project requested fields they wanted to include in the registration process of the app to get more data about the user. These were fields for building and renovation year of the building, and transportation habits. The new fields were added to the existing registration slides, and functionality was added to store the data in shared preferences. The registration slides can be viewed in the Appendix H.2.

During the specialization project and throughout the design phase it was discussed that because some people own more than one car, that it should be possible to add details about a second car during the registration. The fields for a second car was thus added to the registration and the settings, but no further functionality was added at this moment. Future work could implement functionality to enable the possibility to choose which car that is driven. A dialog box could appear after a trip where the car that is driven and the number of passengers could be specified. This is also mentioned in the future work Section 10.6 in Chapter 10.

Terms and Conditions

Terms and conditions and user's consent for collecting and storing data about their mobility (GPS, time, profile) were added as the last step in the registration process to comply with the new EU directive, GDPR. This can also be viewed in the Appendix H.2.

Status after finishing the first sprint

After finishing the first sprint, some new experiences had been gained. Some tasks took longer time than expected, and it was difficult to plan the sprint in a way that all the tasks would have been finished within the set time. It was also frustrating to experience that tasks that initially were thought to be easy to fix were much more complicated and difficult to fix. This was partly due to some things being implemented intricately in the previous app versions.

The following tasks were left in the backlog:

- **Estimation:**
  - Solar panel: drop-down list with the size of solar panel (to save space)
  - Walk/Cycle: change the slider to a scroller
  - Electric car: estimation should be based on current daily driving distance, should show the difference between a hybrid, fuel based and electric car
  - Solar panel, walk, cycle, electric car: removed unnecessary values

- **Dashboard:** kr/expenses should show where the expenses come from in the app
- **Registration:** should not be possible to go through the slides without filling out all mandatory fields.

8.2.2 Second Sprint

The focus of the second sprint was gamification and adding game mechanics to the app. The tasks done in this sprint that lasted two weeks are presented in Figure C.1 in Appendix C in the list called *Sprint 2*.

Experimenting with the server

Much time was spent on experimenting with connecting the app to a local server in this sprint. A proposal for a new database structure was also tried made. In the end, it was decided to not set up a server at SINTEF Energy after all.

This resulted in that for LeaderboardActivity and FriendsActivity, ”friends” are hardcoded in to visualize how it would look when a server is connected, and the user has actual real friends (see Figure H.7 and H.9 in Appendix H).

Leaderboard

A leaderboard was implemented by creating a `LeaderboardActivity` and adding an item to the side menu (see Figure H.9 in Appendix H). The implementation is not completed as the server for the data storage was not set up, and the leaderboard implemented in *Smiling Earth* will work as a prototype to show how it works. The other users shown in the leaderboard in Figure H.9 in Appendix H are hardcoded in. The leaderboard has two sorting criteria, that is *Lowest average carbon footprint* and *Most Earth Coins*. The `BottomNavigationViewEx` is reused in LeaderboardActivity to switch between the two criteria, as can be viewed in Figure H.9.

The layout is created with an image of a podium where the top three users will be displayed, and card views below the podium with the ranked users below third place, i.e., fourth place and below. A recycler view is used to reuse the layout for the card views, and to implement this, two classes were needed; `Score` and `ScoreAdapter`, where `ScoreAdapter` is the class that binds the content with the layout in the recycler view.

The `loadScores()`-method is called in the `onCreate()`-method that runs when the activity is started or when the tab bar is switched. The method calls the `updatePodium()`-method

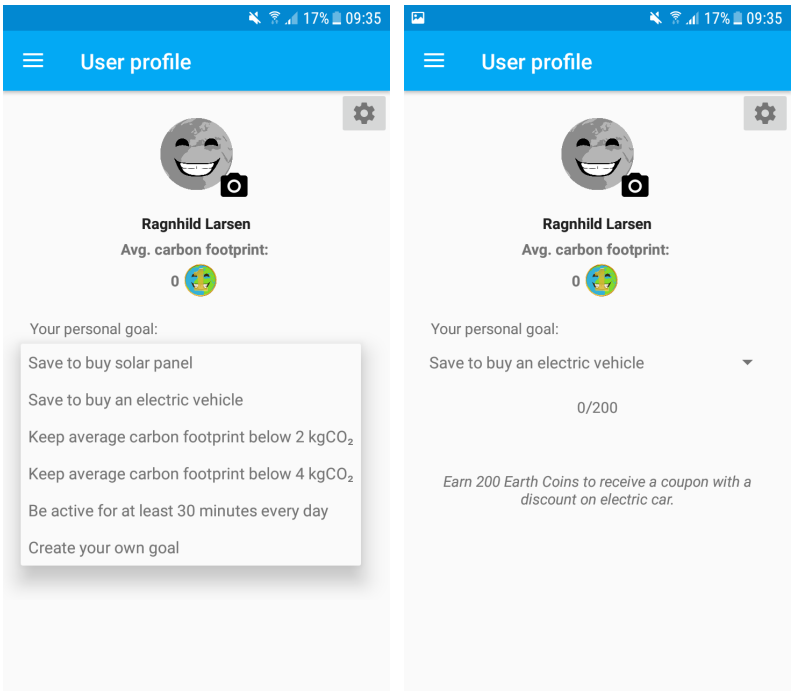
that inserts the users into correct place on the podium, and the others in the card views below. The code for the leaderboard can be found in the Appendix G.2.

User Profile

A user profile was added to the app by creating a `ProfileActivity` where the idea was to show the relevant user info, being able to change profile picture and edit other information about themselves. The user profile would also contain the personal goal and the progress bar for this, as well as showing the score of Earth Coins and the average carbon footprint (see Figure H.11 in Appendix H). The information displayed at the user profile is either retrieved from Shared Preferences or the SQLite database. Code snippets from how the user profile was implemented are shown in Appendix G.5.

Personal Goal and Progression

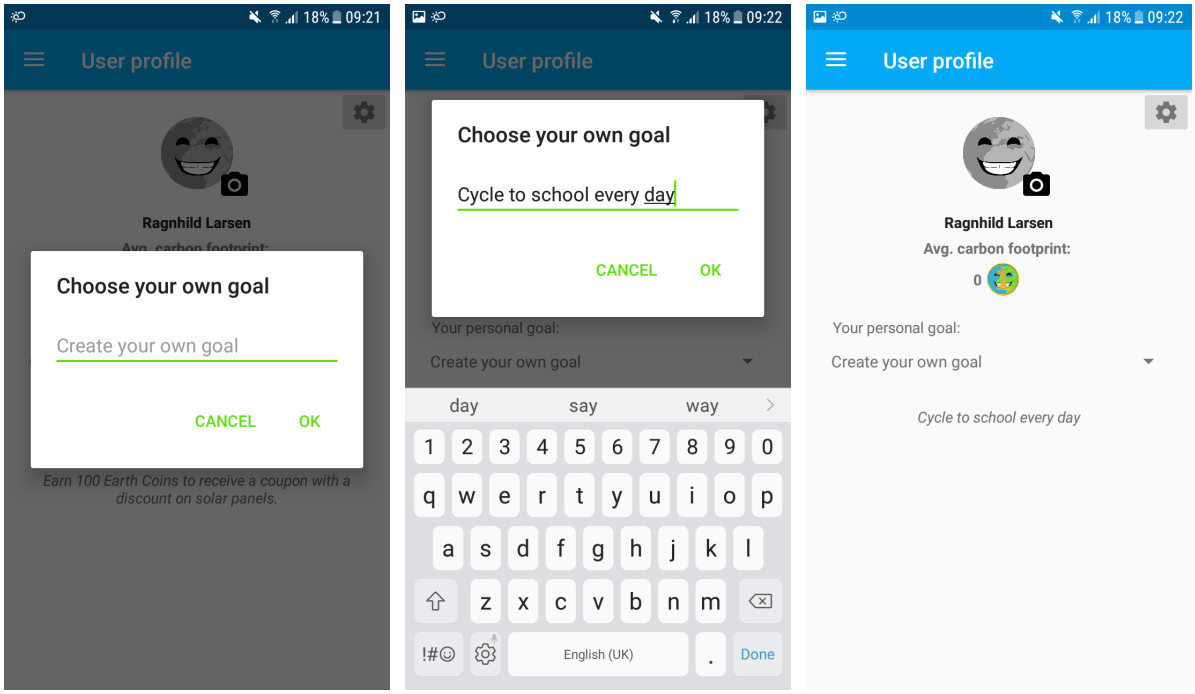
The personal goal and the progression bar were implemented on the user profile (see Figure H.11 in Appendix H). This was implemented by using a spinner menu to create a drop-down list for the goals (see Figure 8.10 (a)). The progression bar changes according to the goal that is chosen, as can be viewed in Figure 8.10 (b). The progression bar increases according to the Earth Coin balance.



(a) (b)

Figure 8.10: Change goal

The item *"Create your own goal"* in the drop-down list will open a dialog box where a goal can be defined, to let the user create a personal goal. Code snippets from how the personal goal and progression bar were implemented are shown in Appendix G.5.



(a) (b) (c)

Figure 8.11: Create personal goal

The plan was initially to have discrete points on the progression bar that would symbolize short-term goals. This proved to be more difficult than anticipated to implement, and since the personal goal was not properly implemented, it was decided not to spend more time on this.

Friends

The idea was that the user could connect with other users in the app. The `FriendsActivity` displays the friend list in card views (see Figure H.7 in Appendix H). The card views were created similarly to the card views used on the leaderboard. The card views contain the user's profile picture, name, Earth Coin balance, and their average carbon footprint.

Gifting

Gifting was not implemented properly because of the server, but the "Contact" button in the card views could be clicked, and a toast is shown to give a view of how the feature could look (see Figure H.7 (b) in Appendix H).

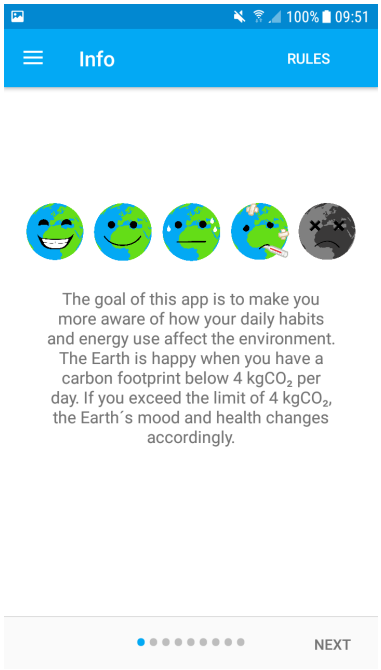
Earth Coins

The photo editor program, Gimp, was used to create the image for the Earth Coin used throughout the app. The balance is currently stored in Shared Preferences and is updated when more coins are gained. This is implemented in a runnable thread that runs in the background of the `MainActivity`. This thread is run every 15 minutes. The code for the runnable thread is shown in Appendix G.3.

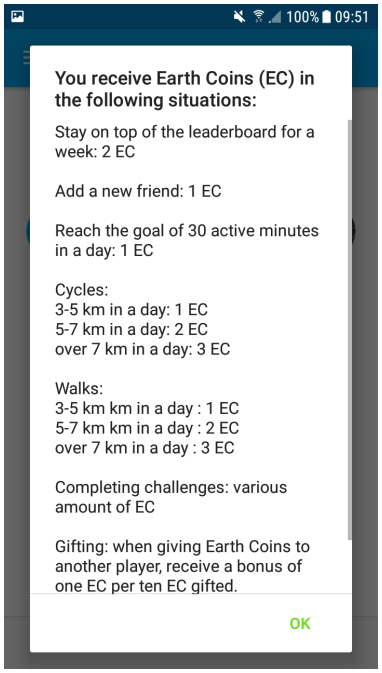
Glimpses of the Earth Coins that have been implemented in the app have already been shown in some of the figures mentioned in this chapter. The Earth Coin is currently added to the following screens:

- Side menu (Figure 8.1)
- Toolbar at the dashboard (Figure 8.6)
- User profile (Figure H.11)
- Leaderboard (Figure H.9)
- Friend list (Figure H.7)

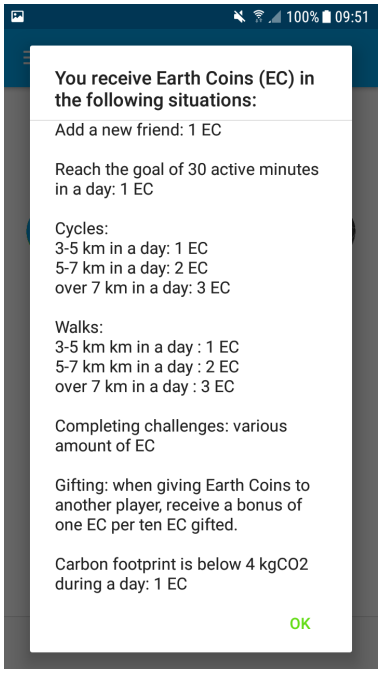
The specifics of the Earth Coins is presented in the How To-Activity where a button for ”Rules” has been added to the toolbar. When the button is pressed, a dialog box with the specifics are shown. All the specifics that are shown in Figure 8.12 are not fully implemented, but they are proposed specifics that can be used for further development.



(a) Rules button in the toolbar



(b) Dialog box with specifics 1



(c) Dialog box with specifics 2

Figure 8.12: How does this app work with game specifics

Status after finishing the second sprint

Even though much time was spent on connecting the app to a server that turned out not to be used, some new functionality was added to the app during the sprint. This was mostly functionality related to gamification, both individual and social game mechanics. The fact that the server was not set up was fatal for how the result of the app turned out. Due to limited functionality for the game mechanics, the app will function more like a functional prototype during the user evaluations.

The following tasks were left in the backlog:

- Call to arms game mechanic
- Designing a proper database and connecting the app to that database
- Providing feedback with concrete examples as notifications in the app (Ex. Your drive emitted as much CO_2 as X plain trips)

8.2.3 Third Sprint

The primary focus for this sprint was to finish the things that were started on in the two first sprints. In addition to this, there was an aim to finish the tasks that were not yet started on in the backlog. The tasks done in this sprint that lasted for 1,5 week is presented in Figure C.1 in the Appendix C in the list called *Sprint 3*.

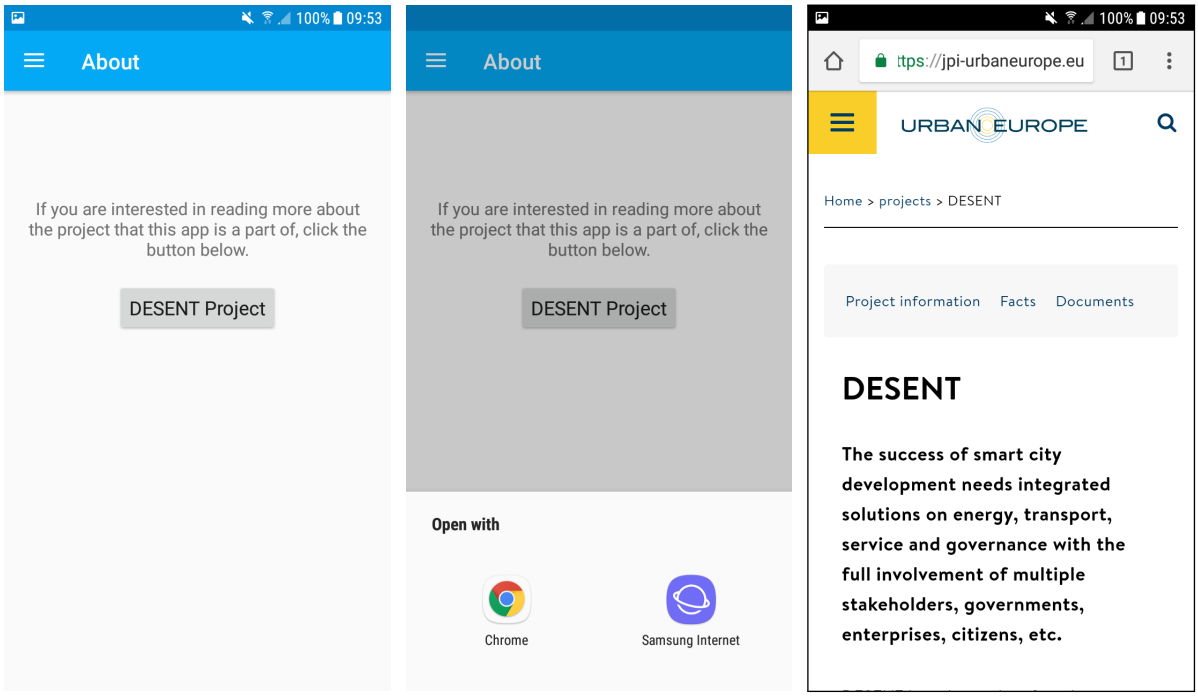
Call to Arms

The social game mechanic *Call to Arms* was left in the backlog after Sprint 2. This was partly implemented in Sprint 3, by reusing the code from the `FriendsActivity`. Because the functionality could not be implemented fully, and since the plan was to have a similar design as the friends' list, it was handy to reuse some code and layout, even though the functionality were to be different. Similarly, as with the friends in the friends' list and leaderboard, the challenges are currently hardcoded into the code, and the only thing that happens when the "Start"-button is pressed is that a toast is displayed (see Figure H.10 in Appendix H).

About Us

In *Smiling Earth* V2, the side menu contained the menu item, *About Us*, that had no functionality connected to it. An `AboutUsActivity` was added to have an activity that could be connected to the menu item.

This is a straightforward activity with a simple layout that only contains a couple of text views and a button as can be viewed in Figure 8.13 (a). When the button is pressed, a website that contains information about the DESENT project is opened in the browser on the device (see Figure 8.13 (b) and (c)).



(a) About us (b) Open in browser (c) Website open in browser

Figure 8.13: AboutUsActivity

Settings

The changes done in *Settings* is not that many, but the new fields that were added to the registration were added to *Settings* to be able to edit them later. Also, the fields for the extra car was added. This was done by just following how the other settings items were implemented and adding the new items.

Clean up in code

During development, a lot of code was tried out and rejected. The code was not removed entirely but just commented out. When merging the changes made with Magnus Tangen's new feature (email function for sending CSV files with data), it was decided to try to go through the code carefully and only move over the code that was necessary for the app, and that was working.

The other thing that was done during the cleaning of the code was to move most of the hard-coded strings to the `strings.xml` file in Resources. This was done because it is good practice and can be helpful if the app is to be translated into other languages and cultures. It is also useful to define a string that is used in several places in one place so that it only needs to be edited once.

Similarly, the `dimens.xml` and `color.xml` should contain all the most used margin sizes and colors to use a standardized dimension and colors that can be edited once if needed.

8.2.4 Backlog after Sprints

After going through three sprints in the development phase, some tasks were deprioritized and left in the backlog to be able to finish the app in time for evaluations. The remaining tasks can be viewed on the Trello board in Figure C.1 in the list named *Backlog*.

8.3 App Distribution

To easily distribute *Smiling Earth* via e.g., email, an *Application Package Kit (APK)* file was generated. An APK file contains all the packages and files of the Android Studio project and is used to distribute and install the app on Android devices. The APK file is created in Android Studio buy selecting *Generate Signed APK's* in the Build folder. Then a Key store path was created that holds a .jks (Java Key Store) file, that is a key store file that stores the passwords and alias for the application. This is most important when an app is to be published on Google Play Store to verify that it is a secure version and that it has not been tampered with. In the next step, the build file is chosen. Here is release and debug the two options, and release was chosen in this case. Later it was found that the SQLite database could not be accessed when the *APK* file is not in debug, so for the user evaluations the APK file should have been a debug build type. After choosing build type and Signature Version (chose V1 Jar Signature), the APK file was created and found in project folder under the folders *app* and *release*.

The APK file was used in the user evaluation by sending it as an attachment in an email together with the pre-intervention questionnaire. The participants had to follow the following steps to install *Smiling Earth* on their device:

1. Click on the attached file *SmilingEarth-app-release.apk* and download it.
2. Follow the steps and install the app by allowing to install apps from unknown sources in settings.

Chapter 9

User Evaluation

After implementing the new functionality in the app and making some changes in the user interface, it was necessary to conduct a user evaluation. This chapter will present the planning and execution of the evaluations conducted, together with the results and an analysis of the results.

9.1 Planning and Execution

The idea for the evaluation of the app was to run an evaluation over a short period, to possibly get some insight if the app contributed to raise awareness and motivate for behavioral change. This insight would not be gained in a brief evaluation of the user interface. The objectives of conducting a user evaluation over a short period were thus to see if the game mechanics elicited from the workshop was found enjoyable for the participants of the evaluation. The desired period for testing the app, was seven days, but the participants were given the option of testing the app ranging from five to eight days, depending on what suited them best.

The test period started and ended with filling out questionnaires. A pre-intervention questionnaire was given before the participants downloaded and started to use *Smiling Earth*. After the test period was over, a post-intervention questionnaire was given to end the evaluation.

The planning phase consisted of recruiting participants for the evaluation, planning what information the participant should receive and creating the pre- and post-intervention questionnaire.

9.1.1 Participants

Participants to the user evaluations were recruited among acquaintances with Android devices. The participants included friends and co-students. Five people participated in this evaluation.

Most of the participants were students that usually do not use a car, but public transportation to get to places. Their carbon footprint will probably not be high, and thus they would probably not be surprised by how much carbon dioxide they emit every day as they are already walking or cycling to get to places. All except one of the participants have a background in IT.

9.1.2 Creation of the Pre-Intervention Questionnaire

To be able to explore if the game mechanics and the application had transformed the participants in any way, a pre-intervention questionnaire with seven questions was created. The questions were mainly about how the participant perceives themselves as an environmentally conscious person, and a self-assessment of the possibility of changing habits in their every day lives. The questions would create a basis for comparison of the status before and after using the app for a week.

The questionnaire had various methods of responding. Some questions had radio buttons where only one option could be selected, while others had checkboxes where more than one answer was acceptable. A five-point Likert scale ranging from *Strongly agree* to *Strongly disagree* were used for some of the statements (see Table 9.1 below). The questions can be found in the list below and in Appendix I.

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
4	3	2	1	0

Table 9.1: Likert scale

The first question was related to age, and the next two questions were related to the participant's information about having access to a car and commuting habits. These questions are asked to be able to see how the fact of having a car and their commuting habits affect how the app is perceived.

Three statements were asked to get a sense of how the participant view him/herself and are aware of how they affect the environment. The statements in the list below used the Likert scale as answering method.

- **Q4.** I am very concerned about the environment.
- **Q5.** I am a very environmentally conscious person.
- **Q6.** I have some habits in my everyday life that could be changed to be more environmentally friendly.
- **Q7.** Name some habits you have that could change to be more environmentally friendly:

The pre-intervention questionnaire was given together with the instructions for installing the app. It took the participant approximately 15 minutes to finish the questionnaire and to install *Smiling Earth* on their device.

9.1.3 Installation and Test Period

Four out of five participants were starting the evaluation with me present. Some information about the app was given orally in addition to the instruction that was sent to them via email. Being present also made it possible to answer questions they immediately had, and these participants might have had an advantage of understanding what to do during the evaluation period, compared to the last participant that only received instructions via email. However, the email and the welcome slides in the app should contain enough information for them to get going, and they were told to make contact if they had any questions.

The app was installed on the participant's device by sending the email with the instructions and the *APK file* (Android Package file) [1]. How the APK file was generated is described in Chapter 8.3.

When the email with the APK file was received, they first completed the questionnaire, and then they downloaded the attached APK file. Before the installation started, the participant had to allow installing apps from *Unknown sources* in *Settings*. *Smiling Earth* was now installed, and the participant could start using the app.

The participants were given instructions that it was desired that they used the app for a five to eight days period. Ideally, a test of behavior change model should be conducted over a more extended period as it could take a long time for a human to change behavior, but due to limited time in the master thesis, one week was all we could do within the time frame [3].

9.1.4 Creation of the Post-Intervention Questionnaire

After the test period had ended, five to eight days after the start date, the participants were asked to complete the post-intervention questionnaire. This questionnaire consisted of 49 questions and statements divided into five sections. The questionnaire can be viewed in Appendix J.

Following is a description of each section in the questionnaire, and the objectives of asking the questions.

[1] https://developer.android.com/google/play/expansion-files

Behavior Change Model

The structure of the questions is done to group the different focus areas of the questions. To get an insight of whether the participant was affected by using *Smiling Earth* regarding wanting to change their behavior to a more sustainable one, seven questions were asked. The questions are listed in Table 9.2, and the answers are given with the five-point Likert scale (see Table 9.1). The statements were asked to get data for the main research question stated in Chapter 2, and more specifically in the sub-questions RQ1, RQ4, and RQ6.

ID	Question/Statement
Q1	During the test period, I chose a different transportation means than I normally use to achieve better results in the app.
Q2	I was surprised by how much my daily activities were affecting the environment
Q3	Viewing the data visualized in the app made me want to make some changes to reduce my emissions
Q4	I would tell people I know about the app so that they also become aware of their impact on the environment
Q5	After using the app, I am considering buying an electric car or solar panels in the future, to reduce my emissions
Q6	The app motivated me to change my behavior to a more sustainable one
Q7	My concern for the environment has increased after using the app

Table 9.2: Behavior change model questionnaire

Gamification

The next group of questions was about evaluating the game mechanics to see if they were successful or not. The seven questions in the category can be viewed in Table 9.3. They were included to evaluate how well the game mechanics, that were chosen and elicited from the gamification workshop, were working in the app, and to give data to answer the main research question, and specifically RQ1, RQ2, RQ5, and RQ6.

ID	Question/Statement
Q8	Choose one game mechanic from the list that motivated you the most: [Earth Coins, Personal goal and progress bar, Leaderboard, Challenges, Giving friends a gift/boost, None of them]
Q9	Which of the game mechanics in the app did you find motivating?
Q10	Which of the game mechanics in the app did you NOT find motivating or fun at all?
Q11	The game mechanics motivated me to check the app
Q12	I was curious to see if I had gained any Earth Coins after a walk or a bike ride
Q13	I find the concept of connecting and competing with friends motivating

Table 9.3: Gamification questionnaire

Concept

The next section in the questionnaire consisted of nine questions about the concept of *Smiling Earth* (see Table 9.4). The questions aimed to answer RQ1, RQ3, RQ4, and get the participants general experience with the app. A high score from the participants on these questions means that they think the concept of the app is promising and have potential to work.

ID	Question/Statement
Q14	I find the concept of the app interesting
Q15	I understand clearly the purpose of the app
Q16	I find the link between energy, carbon footprint, activity, and expenses motivating
Q17	I am more curious about energy and environment after using the app
Q18	Did the app make you more aware of how your daily activities affect the environment?
Q19	I find the earth metaphor engaging
Q20	The earth metaphors teach well the impact of a high carbon footprint
Q21	I find estimation functionality for solar panel, electric car, walk, and bike ride motivating
Q22	I could be willing to share my data about electricity use, transportation and carbon footprint with other users

Table 9.4: Concept questionnaire

Usability and Usefulness

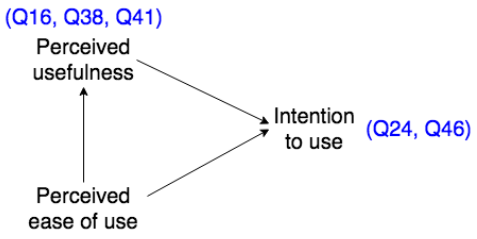
The next section consisted of 20 questions that were aimed at both answering the research questions RQ3, RQ5, and to evaluate the usability of the app and the perceived usefulness of the app. The questions and statements can be viewed in Table 9.5, and in its entirety in Appendix J. The questions are reused from the previous evaluations conducted in the specialization project, and consists of questions retrieved from SUS, TAM and Nielsen's Ten Heuristics described in Chapter 3 [12, 14, 16].

ID	Question/Statement
Q23	I would consider recommending this app to people I know
Q24	I think I would use this app frequently
Q25	I find the app design attractive
Q26	I think the app was easy to use
Q27	I enjoyed using the app
Q28	I felt very confused when I used the app
Q29	I did not have enough knowledge to use the app
Q30	The welcome slides showed the first time I used the app was useful to get to know the app
Q31	I would imagine that most people would learn to use this app very quickly
Q32	I think there is too much inconsistency in the app
Q33	I find the various functions in the app are well integrated
Q34	The following information is easy to find:
Q35	The color code is clear and keep the same meaning in the whole app
Q36	The following screens do not contain too much information:
Q37	The following screens had all the information I needed to understand them:
Q38	I find the visualization of last weeks historical data useful
Q39	I viewed the historical graphs in the app during the test period
Q40	I would like to view detailed historical data for:
Q41	I find it useful to have a defined daily limit for the carbon footprint in the app.

Table 9.5: Usability questionnaire

Technology Acceptance Model The TAM that was presented in the Background Chapter 3, claims that if an app is perceived easy to use, it will be perceived as useful, and thus the intention to use the app will increase [16]. Figure 9.1 was created to discuss if the TAM is valid. The questions used in the model are the following:

Figure 9.1: TAM with questions



- **Q16.** I find the link between energy, carbon footprint, activity, and expenses motivating.
- **Q24.** I think I would use this app frequently.
- **Q26.** I think the app was easy to use.
- **Q38.** I find the visualization of last weeks historical data useful.
- **Q41.** I find it useful to have a defined daily limit for the carbon footprint in the app.
- **Q46.** Do you think you would like to use this app?

Functionality and General Feedback

The last section of the questionnaire, with a total of seven questions, were asked to identify bugs revealed in the app and get feedback on the functionality of the app. There were also some questions in this section that gave the possibility to give general feedback and recommendations for further development.

ID	Question/Statement
Q42	I would trust the numeric values provided by the app
Q43	During the test period, did you experience that the app tracked the wrong activity (walk/cycle/drive)?
Q44	This app does not require any self-reporting, but the accuracy of the data tracked might be low. Would you rather report the trips you take manually or do you think the ease of use is more important than accurate tracking data?
Q45	Did you find any bugs in the app during the test period?
Q46	Do you think you would like to use this app?
Q47	Why would you/why would not like to use this app?
Q48	What would you like to change about the app? (What did you like the least?)
Q49	Do you have any other feedback that you think could be useful for the further development of the app?

Table 9.6: Functionality questionnaire

9.1.5 Completing the Questionnaire and Ending the Evaluation

The participants completed the questionnaire while looking at the app when necessary. Some people received the link to the questionnaire on email and completed the questionnaire by themselves, while others finished the questionnaire on my computer with me present.

The original plan was to download the application's SQLite database to view the data that had been stored during the test period. When testing this with the first participant's device that was finished with the test period, it was discovered that this did not work. By troubleshooting the problem on Google, it was found that since the APK file generated was in release mode, and not in debug mode, the database dump function described in Chapter 7.1.2 did not work. However, to at least get some insight into what the application had stored during the test period, the participants were asked to take screenshots of the app. They were asked to take screenshots of the following items:

- Dashboard (Today, This Week, This Month)
- History graph (Carbon footprint, Transportation, Energy consumption)
- Leaderboard (Lowest avg. carbon footprint, Most Earth Coins)

- User profile
- Side menu

9.1.6 Interview and Observation

During the evaluations, an unstructured interview was done to reveal things that might have had an impact on the results. These interviews were conducted during the meetings with the participants of the evaluation, that was at the start and end of the evaluation period. Some observations were also made during the installation of the app to see how their immediate reactions were. Some of the participants also provided feedback about the app orally or by chat during the test period.

9.2 Results and Analysis

This section presents the results and findings from the data generation methods used in the user evaluation. First, the results from the pre-intervention questionnaire will be shown, and then the post-intervention questionnaire. After that, some observations made during the test period are described.

The five respondents are anonymized and given the alias R1 (respondent one) to R5, in the order that they finished the test period. They all used different Android devices. The duration of the respondents' test period also varied from between six to eight days. The duration and the specifics of Android device are shown in the Table 9.7.

Respondent	Device	Android Version	Start Date	End Date	Duration
R1	Huawei P9	6.0	1/5/2018	7/5/2018	6
R2	Sony Xperia	7.0	1/5/2018	8/5/2018	7
R3	Samsung XCover 4	7.0	2/5/2018	8/5/2018	6
R4	Huawei Honor 7	6.0	1/5/2018	9/5/2018	8
R5	Samsung S8	8.0	3/5/2018	11/5/2018	8

Table 9.7: Details about respondents

9.2.1 Pre-Intervention Questionnaire

The full overview of each respondent's answers can be viewed in Appendix I. The pre-intervention questionnaire revealed the background information about the participants. The respondents were mainly in the age group 18-24 years old (3/5) and 24-35 years old (2/5). None of the

participants had access to a car, and their primary means of transportation used in everyday commute were Bicycle (4/5), Walk (3/5) and Public transportation (1/5) (here it was possible to choose more than one alternative). This suggests that the participants belong to the user group *Young people*. As no one owned a car or said that this was their means of everyday commuting, this is a group of people that cannot do much regarding making greener choices with transportation habits.

The participants claimed that they were very concerned about the environment. Their transportation habits, listed above, could reflect this. However, the main reasons for their means of transportation for everyday commuting have probably something to do with the respondents being students and young people living in Trondheim, which has a sufficient public transportation offer, and that is accessible by walking or biking if you live in central areas.

They also claimed that they viewed themselves as environmentally conscious people. On the other hand, they had self-knowledge that they had some habits that could be changed to be even more environmentally friendly. These were mostly related to aspects that *Smiling Earth* does not take into account. The list below presents the habits that the participants thought they could change.

- fly and travel less
- buy more local food (short-traveled)
- eat less meat
- recycle
- reduce waste
- bicycle more instead of taking the bus
- use less electricity (this is partly accounted for in the app via the heating aspect in the app)

9.2.2 Post-Intervention Questionnaire

The post-intervention questionnaire was divided into five sections, and the following paragraph will present the results and some analysis of each of them. The results can be viewed in Appendix J.2.

Behavior Change Model

Q1: The overall results from the questions and statement related to the behavior change models were not that surprising given the participants' background. Since they were already using

green transportation means, they did not consider choosing different transportation means in the test period. All except one answered *Strongly disagree* on this, except the one participant that answered *Disagree* which is also the participant that used public transportation for commuting. The fact that the only participant that answered *Disagree* was the one that used public transportation could be a positive thing. The reasoning for this is that this person is closer to the users taking the car to work compared to the users that are only walking or biking on a daily basis. Maybe a person that drives a car would have considered choosing a different transportation means since they have something that can be changed.

Q2 and Q3: As predicted in the planning stage of the evaluations, the participants were not surprised to see their carbon footprint in the app. They were overall neutral to the statement that the visualization of the data would make them want to make changes.

Q4: Question 4 asked if they would like to tell other people about the app to make them aware of their impact on the environment. This question was asked to find out if the respondents saw any purpose of the app, and thought that it might help others to reduce their carbon dioxide emissions. Most people are aware of the climate problem and want to do something about it. They want to engage others, and the response in the questionnaire shows that most of them agreed or strongly agreed with the statement (4/5). This shows that the social aspect is important and it can create engagement to be able to invite friends to join the app.

Q5: The app had not motivated the respondents to buy solar panels or electric car. Just one answered *Agree* to this statement, while two were neutral and two disagreed with the statement. A reason for this could be the life situation of the participants, as it may be years until they would have to take a stand to what car they are going to buy, or years until they live a place where they can decide to install solar panels.

Q6 and Q7: Although their concern for the environment has not seemed to increase after using the app, some of the respondents answered that the app had motivated them to change their behavior to a more sustainable one. That is, three answered *Agree* on the statement, one *Neutral* and one *Disagree*.

Game Mechanics

Q8, Q9, and Q10: Earth Coins was mentioned by four out of five respondents to be the most motivating game mechanic in the app. One respondent mentioned Challenges as the most motivating game mechanic.

In addition to Earth Coins, Leaderboard and having a personal goal and progress bar, were the most motivating game mechanics based on the response from Q9. Three out of five mentioned Challenges (Call to arms) and giving friends a boost (Gifting), so these could also be seen as motivating. The reason for Gifting and Challenges receiving less positive response could be because these game mechanics where the ones that were only partly implemented. So they were only functioning like a prototype, and the participants could not try it out entirely.

Gifting was also the only game mechanic that was mentioned as not motivating by two respondents. Again, this could be because it was not implemented and maybe a bit hidden in the `FriendsActivity`.

Q11 and Q12: On average the respondents said that the game mechanics motivated them to open the app, and most of them were curious to see if they had gained any Earth Coins after a walk or bike ride. This is very positive and shows that the game mechanics makes the user want to open the app, and gives it a reason for checking the app. However, it should be emphasized that the app must track and give out Earth Coins correctly. To not receive an award that has been earned, would be very demotivating and frustrate the user. Feedback received during the test period consisted of quotes such as *"I went out walking for two hours, but the app only said that I was active for 17 minutes and had just walked X km"*.

Q13: There was also a general agreement that the concept of connecting and competing with friends was motivating. This should be a motivation for further development to pursue implementing a server so they can fully implement the game mechanics Leaderboard, Call to arms, Gifting and Earth Coins.

Concept

Questions 14 to 22 were related to the concept of *Smiling Earth*, and the results will be discussed in the paragraphs below.

Q14, Q15, Q16, and Q17: Q14 and 15 showed that they mostly found the concept interesting and that they clearly understood the purpose of the app. They also generally agree with the statement that the link between energy, carbon footprint, activity, and expenses is motivating. However, the app did not manage to create curiosity about energy and environment after using the app.

Q18: 2/5 said that the app made them more aware of how their daily activities affect the environment, and the remaining three said it maybe made them more aware. The participants'

background and preconditions could explain the result of this question, as their activities did not make a lot of impact in the app as these were mostly green.

Q19 and Q20: The respondents had various opinions on how engaging the Earth metaphor used in the app is. 3/5 respondents agreed that the Earth metaphor is engaging, one was neutral, and the last respondent disagreed that it is engaging. Similar feedback was given during the other evaluations conducted of *Smiling Earth* V2 and the digital prototype. Some found the Earth metaphor childish while others found it engaging. However, they agreed that the Earth metaphor teaches the impact of a high carbon footprint, which received an average score of 2.8, which translates to *Agree* on the Likert scale.

Q21: Even though the estimation functionality for solar panel, walking, cycle and the electric car had not been fixed that much, 4/5 agreed that they found the estimation functionality for solar panel, electric car, walk and bike ride motivating. One disagreed though, so there was not a unanimous encouragement for the estimation functionality.

Q22: The last question in this section asked if they could be willing to share their data about electricity use, transportation and carbon footprint with other users. Everyone agreed to this, which is good news for the possibility to implement the social aspect of the app, and creating competition between the users. The terms and conditions added to the registration process (see Figure H.3 (f) in Appendix H) may have contributed to give the participants confidence that it is secure to share data with the application. Obtaining consent is thus an important part of the process of getting people to share their data.

Usability and Usefulness

The questions from Q23 to Q41 was mostly reused from the evaluations conducted in the specialization project to be able to compare the results to see if the changes made in the interface has improved the usability or made it worse. The tables with the comparisons are shown in Appendix J.3. The main findings will be discussed in the paragraphs that follow.

Decrease The sign-up screens (Registration slides) may *contain too much information*, but on the other hand, it contains enough information to understand how they should be completed (Q36). However, the average has only decreased from a ”Strongly agree” to ”Agree” so it is not a major decrease.

The attractiveness of the app has decreased from the evaluation of the digital prototype which received a 3.2 (Agree) to 2.8 (Agree) for V3 (Q25). The score is rounded off to the same point

on the Likert scale, so it is not critical, and it is still an improvement from V2 that scored 2.0 (Neutral) on the attractiveness of the app design.

These decreases are probably due to the overcompensation of adding too much explanatory text to make the app easier to understand and use. However, this has not lowered the usability, but the design is not that attractive as it was when the app contained fewer explanations and was harder to understand.

There was also a small decrease from the prototype in wanting to *recommend the app to people they know*. The prototype scored 3.4, and V3 scored 3.2, but it is still an improvement from V2 that scored 2.6 (Q23).

I find the visualization of last weeks historical data useful dropped a bit from the prototype score, from 3.4 in the prototype to 3.0 in V3, but is still *Agree* on the Likert scale if rounded off to the nearest whole number (Q38).

Decrease for the better Some of the statements have a wording that makes a lower score is interpreted as a positive change.

I did not have enough knowledge to use the app got the same score as in the prototype, that is 1.0 (Disagree), that means that they had enough knowledge to use the app which is positive (Q29). From V1 and V2 the score has decreased from 2.0 (Neutral) in V1, 1.8 (Neutral) in V2, to 1.0 (Disagree) in V3.

I felt very confused when I used the app have also decreased for the better from V2 to V3 (Q28). V3 got an average of 1.2 (Disagree) which is much better compared to the average of V2 that was 2.8 (Agree). This means it has improved from the users feeling confused when using the app in V2, to not feel confused when using the app in V3.

Based on the response from the participants, it seems like there are slightly fewer inconsistencies in the app, as Q32 has decreased from 1.4 in V2 to 1.2 in V3. The inconsistencies in the previous versions could be the color code that was more unclear before and that the functionality for similar actions was inconsistent, and this may have been somewhat improved in V3.

Improvements The user's enjoyment has increased from a score of 2.3 (Neutral) in V1, 2.2 in V2, to a 2.8 (Agree) in V3 (Q27). This is an essential factor for making the app fun of using to be able to create awareness and change the user's behavior.

I would imagine that most people would learn to use this app very quickly went from a score of 2.0 (Neutral) in V2, 1.8 in prototype to a 3.2 (Agree) in V3 (Q31). This is great news as this means that they think the app is easy to learn how to use quickly. It has also been an

improvement on Q26 (*I think the app was easy to use*) from 1.2 (Disagree) in V2, to 2.8 in the prototype and 3.0 (Agree) in V3, which is a considerable improvement.

The results from Q33 indicate that the functionality in the app is better integrated than earlier versions and that information is generally easier to find compared to earlier versions (Q34).

The color code is clear and keeps the same meaning in the whole app has improved from 2.6 (Agree) in the prototype to 3.6 (Strongly agree) in V3 (Q35). When evaluating the prototype, feedback was received that the color used was a bit exaggerated and unclear. This was taken into considerations when implementing the app, and the results show that listening to the feedback helped and improved the consistency of the colors.

The following screens do not contain too much information (Q36) had overall improvements on the various screens listed in the statement. The only exceptions were the screens for Settings, Sign up and User profile that received a bit lower score than in previous evaluations, but not much.

The following screens had all the information I needed to understand them: (Q37) also had a general improvement on the various screens, which is beneficial as an aim for improving the interface was that the screens should contain enough information to be understood. From the evaluations of V2 to the evaluation of V3 there has been a significant improvement as all the averages from V2 spans from 1.0 (Disagree) to 1.8 (Neutral), while the same items in V3 spans from 2.8 (Agree) to 3.4 (Agree).

General observations Overall it seems like the usability has remained the same or improved a bit compared to the results of the evaluation of the prototype. It looks like it is a significant improvement from V2.

Feedback on the historical graphs: Q39 and Q40 were related towards the historical graphs. As visualized in the pie chart for Q39 in Figure 9.2, most of the respondents viewed the historical graphs either several times a day or once a day. None of the respondents answered that they had never viewed the graphs, which is positive. One answered that he/she had viewed the graphs once during the period, and another viewed only a few times during the test period. This may indicate that the graphs were too hidden in the app, and should maybe be displayed on the dashboard at all times or be easily accessible from the dashboard.

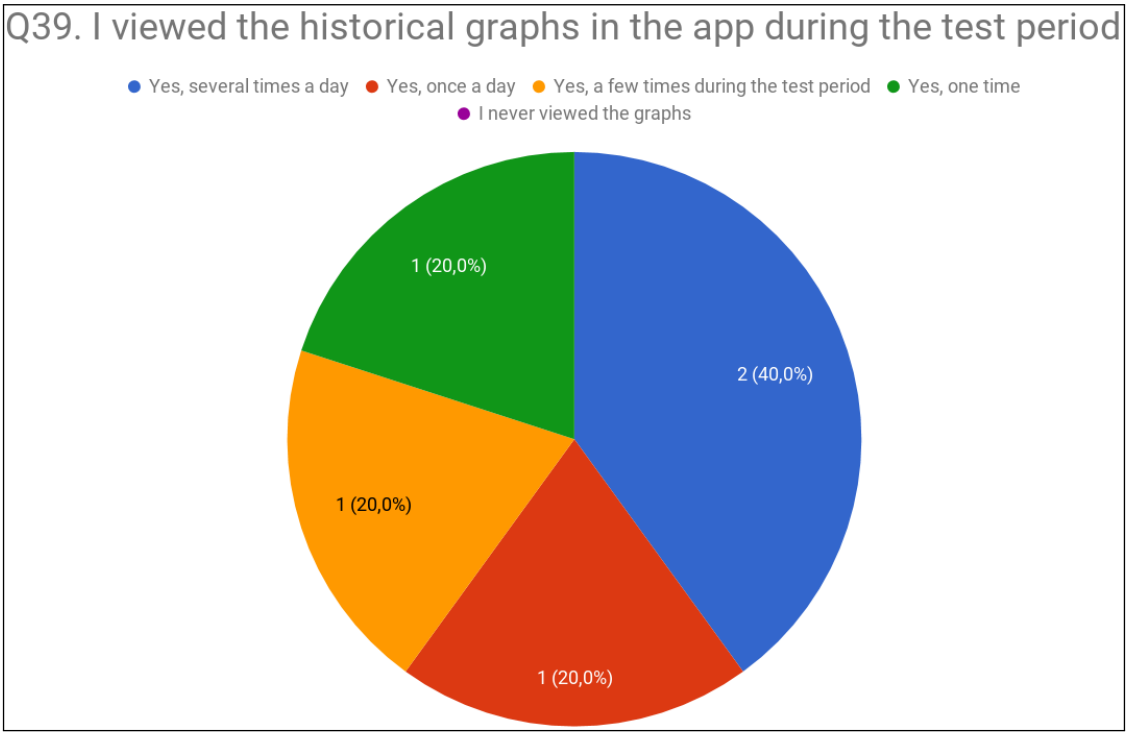


Figure 9.2: Q39. Pie chart

Q40 was asked to get feedback on what kind of historical graphs the respondents would like to see to get some input for further development of the app. Based on the results viewed in Figure 9.3 it seems like they are interested in viewing weekly, monthly and yearly graphs. Daily graphs were not that popular.

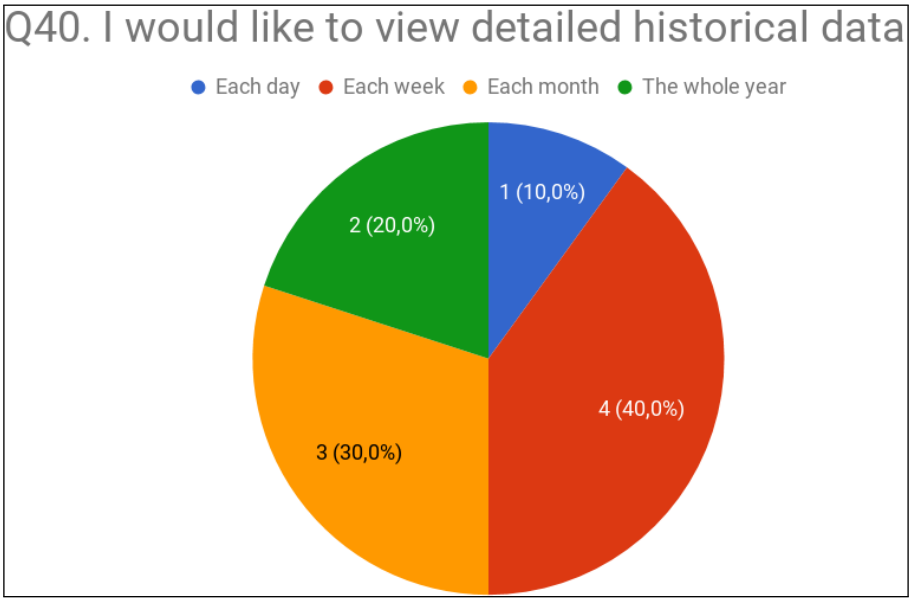


Figure 9.3: Q40. Pie chart

Functionality

The questions in the last section of the post-intervention questionnaire were asked to reveal bugs and get feedback on the functionality and whether they would like to use the app or not.

Q42 and Q43: The respondents were divided on the question about whether they trusted the numeric values in the app. The average of their answers was 2.2 (Neutral). This is a problem, as the app should provide trusted values. All the participants had experienced many or few times that the app had tracked the wrong activity in the app. This could both be because the app was not running actively in the background even though they had it running in the background, or that the *Awareness API* is not as accurate as it should be.

Q44: This question was asked to find out if the participants were willing to do some self-reporting to increase the accuracy of the data that are being tracked in the app. As displayed in the pie chart in Figure 9.4, 3/5 answered that they think it should be possible to edit a trip after it has been completed, so it is possible to correct the app if the tracking was wrong. This could, for example, be done by showing each trip and activity done in a list and being able to edit the trip accordingly if something was wrong, like the length (km) or the time (min). The kcal and active minutes calculations and the carbon footprint (if driving) could then be updated accordingly. On the other side, two of three participants answered that they thought it was more important that the app tracked automatically than having entirely accurate data. This means that they think it will be stressful to have to correct the app all the time and appreciate more that the app does the tracking automatically. Might consider replacing the API with a more accurate one.

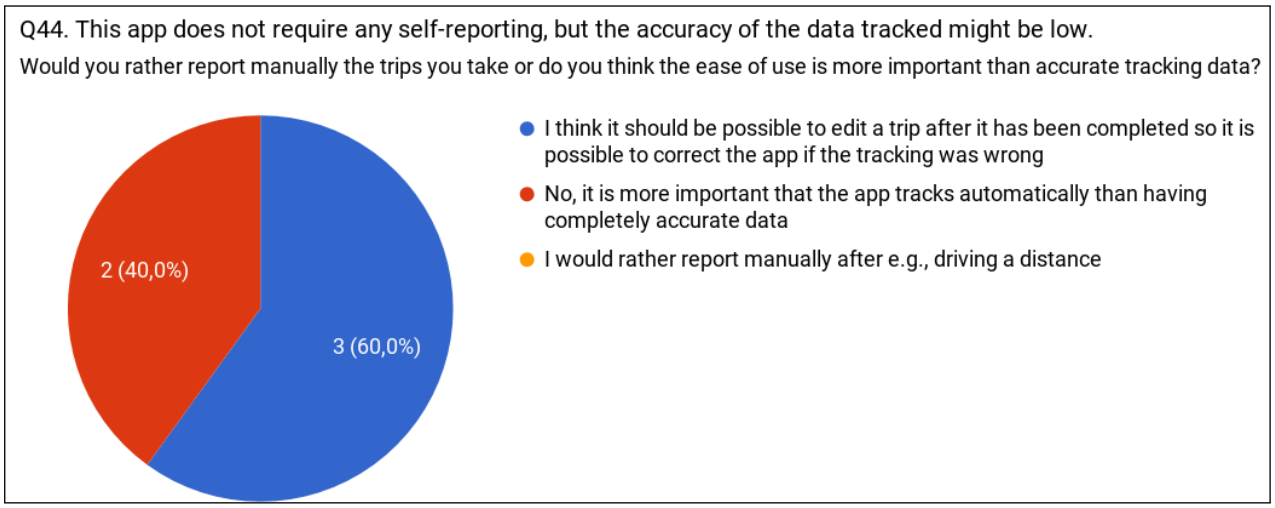


Figure 9.4: Q44. Pie chart

Bugs found during the test period: Table 9.8 shows the bugs reported by the respondents in the post-intervention questionnaire (Q45).

Respon-dent	Device	Android Version	Bugs
R1	Huawei P9	6.0	- Could not view user profile - Only tracked transportation one day out of 6 days
R2	Sony Xperia	7.0	- The app crashed if you clicked the back button a few times, again and again, - Dashboard also hanged/crashed sometimes if clicked - Had to open the app to start the tracking
R3	Samsung XCover 4	7.0	The app did not track when I used my bike or walked for a long distance
R4	Huawei Honor 7	6.0	GPS tracking, but maybe not a bug?
R5	Samsung S8	8.0	The app would crash on random times

Table 9.8: Bugs reported by respondents

Would you like to use the app? On the question asking if they would like to use the app, 3/5 answered yes, one answered maybe and the last respondent answered no (Q46 and Q47). The reasoning for their answers (retrieved from the post-intervention questionnaire) follows in the list below:

- **Yes:**
  - I think it is cool to track my activities to see how they affect the environment. It would have motivated me to, e.g., take the bike instead of the bus
  - Because it is an useful app to be more environmentally conscious
  - I experience the concept of energy use very abstract and hard to measure in my daily habits. At the same time I would like to live a more environmentally friendly lifestyle, and therefore it is nice to be able to get automatic calculations. It is also fun to compete with friends and oneself. In addition it is motivational that one can earn credits.
- **Maybe:** I would like to use it if it actually tracked my transportation. I did not understand exactly how the electricity was calculations worked, since it was different each day.
- **No:** Seems like too much hassle to keep the app running at all times. I'm not really that interested in my carbon footprint either, which is the more prominent reason.

Suggestions for changes: The respondents would like to change the following things about the app:

- *"The challenges and leaderboard were not very helpful now since my "friends" were not real, but I think it would be very motivating if it were actual friends."*
  → **Implement the social aspect for real**
- *"A bit small and a lot of text on some of the screens that made the focus go away from it and ended up mostly on the globe in the middle."*
  → **Remove noise and increase text size.**
- *"Have even simpler layout"*
  →**Remove noise in layout and unnecessary functions.**
- *"Had been nice to see the whole week in history without having to scroll to compare the days easier."*
  →**Change the history graph to fit the screen.**
- *"It is very important that the tracked data is precise in order to trust the rest of the calculations in the app."*
  →**Fix the app to be accurate while tracking.**
- *"It would also be nice to have a description of how the calculations were done to gain trust."*
  →**Show explanations or source behind the calculations.**
- *"I would prefer it to have less functionality, it seems very complicated at the moment and it feels like it is trying to solve too many problems. A simpler carbon footprint tracking app would be more pleasant to use."*
  →**Remove some functionality and concentrate on what is working.**

Other feedback received: The post-intervention questionnaire gave a lot of useful feedback, and it was nice to see that the participants took their time to answer thoroughly and provide suggestions for improvements, bugs and other comments that could improve *Smiling Earth*. These recommendations should be taken into account in the further development of the app. Other feedback that was given in the last question in the questionnaire was:

- *"Maybe it could be useful to get a notification when you're getting close to your weekly limit so you can make some changes and for example take the bike the rest of the week."*
- *"Perhaps make the dashboard easier, there are very many features from there!"*
- *"Estimation to see how much you can save might be your own tab/activity? Nor was it quite intuitive that I had to press "Solar panel" again to return (if I did not use the back button)"*
- *"When opening the estimation features it does not feel too obvious that this is a different*

"mode" as the screens looks quite similar as the home screen. Maybe the active button could be even clearer, like "pushed down", or background color could change?"

- *"The title at the home dashboard could maybe be removed to reduce the information at this page even further."*

9.2.3 Observations

Various layouts

Various screen sizes on the devices resulted in that the layout in the app looked slightly different from device to device (see Figure H.11 in Appendix H). It was useful to see how the app looked on different Android devices and versions as it had mostly been tested on two models during the development. The app should be fixed so that the layout mostly look the same even though the size of the screen is different.

Tracking

It was useful to test the tracking function on multiple devices for a longer period, to test if the app tracked or not. The respondents were all given the direction that they needed to keep the app running in the background on the device for it to work. All the participants followed this instruction, but it seemed like the device that the app worked best on was the Sony Xperia with no sim card. An explanation for this could be that this phone was not used for anything else as this is a test phone. The participant only carried the phone around with the app running, and no other apps were interrupting it. As the other four participants used their phone that they use for all other things, the app may have been interrupted by the other apps that were running on the phone. A device should be able to run multiple apps at the same time, so this is a problem that is crucial to be fixed in future work. It is also not so good that the app relies on running in the background all the time as this may be battery consuming and may slow the device down.

Bugs and other feedback given during observation

A few bugs and comments about the app were discovered during the installation of the app with some of the participants. Some of the bugs were possible to fix quickly (e.g., typos) before letting the other participants install the app. These bugs were reported orally and noted down by me. Other bugs reported during the initial look at the app were:

- The size of some of the text in the welcome slides were a bit small

- During registration, when you choose your transportation habits, the app should remember this on the next slide when you are to insert car details, it should be unchecked if you did not check *car* at transportation habits
- During registration, the text fields should always be above the keyboard, or it should be possible that the text field is automatically bumped up above the keyboard, so it is easy to go to next text field.

This feedback was useful and was this insight was probably missed for the one participant that just got the installation instructions via mail.

First reaction

During the installations that were witnessed, it was observed that the first thing most of them did when finishing the registration was to click on all the button-like functions in the app and start the exploration of the app.

9.3 Limitations

The user evaluation should have had more variety of participants. Different age groups with different backgrounds would have been useful. It was attempted to start evaluations with my supervisors, co-supervisor and another person working at SINTEF Energy, but this was not completed. It would have been useful to let them use the app for a week, as they probably drive a car more often than the students and friends that participated. The user evaluations should also have been conducted with more participants to get more quantitative data.

As previously mentioned, the evaluation should have been conducted over a longer time, because a behavior change takes a long time to happen [3].

Chapter 10

Discussion

This chapter will discuss and interpret the results of the research project. A list of findings and the limitations of the research project and results will be presented as well. Lessons learned and recommendations for future work will be provided in the last sections of the chapter.

10.1 Fulfillment of Research Questions

The main research question for this research project was:

Can gamification increase motivation to use an application and change behavior and if so, how?

Several steps have been conducted to explore the main research question above. Evaluations of the application have been done, a digital prototype has been created an evaluated, and a co-creation workshop was held to design the gamification aspect of the application. A development phase was then conducted with planning, prototyping, and implementation of the changes and the game mechanics. After the development phase was done, the application was tested and evaluated with some users for approximately a week, and data generation methods like observations, unstructured interviews and questionnaires were used. The last step in the project was analyzing the results and reflecting on what can be interpreted from it to answer the main research question.

Seven sub-research question were defined to support answering the main research question above. These will be reviewed and discussed in the following paragraphs. After examining the sub-questions, the main research question will be revisited at the end of the section.

10.1.1 RQ1: How is the user's motivation affected by the app?

This research question would have benefited from a more extended test period for the user evaluation, as this is connected to TTM of behavioral change which claims it may take several months to create a change [22]. Nevertheless, the discussion will be based on the results of the user evaluation, to possibly see if and how the motivation has changed for the respondents after using *Smiling Earth*.

The first thing that is safe to state is that the app has managed to create some motivation among the respondents. What the respondents were motivated for and how they were motivated will be discussed below.

Motivated to change to a sustainable behavior

"The app would have motivated me to take the bike instead of the bus." - R2 (Respondent two in the user evaluation).

In the pre-intervention questionnaire (see Appendix I) Q6 asked if the respondents had any habits that could be changed. The average answer was *Agree*, and the responses from three of the respondents will be highlighted here, namely R2, R3, and R4. R2 answered *Agree* on both Q6 in the pre-intervention questionnaire and in Q6 in the post-intervention questionnaire (see Appendix J) which asked if the app had motivated them to change behavior to a more sustainable one. The quote from the post-intervention questionnaire presented above was given by R2, which shows how the respondent was motivated. This respondent both admitted that he/she had some habits that could be changed and that the app had motivated to change habits. The same can be interpreted from the response from R4, who answered *Strongly agree* on the same question in the pre-intervention questionnaire and *Agree* in the post-intervention questionnaire.

The last respondent R3 disagreed that he/she had any habits to change in Q6 in the pre-intervention questionnaire. However, in Q6 in the post-intervention questionnaire, *Agree* was answered which means that he or she was motivated to change behavior to a more sustainable one.

Motivated to tell others about the app

The participant was generally motivated to tell others about the app to make other people more aware as well. This could be related to the TTM process that is called *Helping relationships* regarding reaching out to others to seek supporting relationship [3]. This process is mainly conducted to support going from the *Action* stage to the *Maintenance* stage, but could also be helpful to advance from earlier stages of changes.

Motivated to use the app

".. it is motivational that one can earn credits." - R4.

On Q11 in the post-intervention questionnaire, the average of the answers was *Agree* when asked if the game mechanics had motivated them to check the app. They also answered that they were curious to see if they had gained any Earth Coins after a walk or bike ride (Q12 - Agree). Three out of five respondents also answered that they would like to use the app (Q46). These results together could be interpreted to that the game mechanics both motivated them to use the app and motivated for usage in the app, that is, making them want to open the app and see if anything has changed and thus making them more aware of how their activities affect the carbon footprint.

The respondents also answered that they found the link between energy, carbon footprint, activity and expenses motivating (Q16 - Agree), as well as the estimation functionality (Q21 - Agree). This means that the central concept for *Smiling Earth* is found motivating, which also have indications for their wish to use the app.

To sum up, the participant's were motivated, and the app created motivation to:

- Change to more sustainable behavior
- Encourage others to use the app
- Use the app and explore its functionality

These findings show that using a combination of theory about gamification and behavior change models is a good way to create motivation for a user of an app. It also confirms proof of concept, since it has been found motivating and wanted to be used. With some further development and more extensive testing, there are good assumptions that the concept will motivate people to change behavior.

10.1.2 RQ2: Which game mechanics seems to be the most effective form of motivation?

The participants of the gamification workshop mostly chose the game mechanics implemented in the app. The survey that they completed was also decisive for what the highest priority should be when developing. The participants had put *Gamification* as the top priority, and connecting with friends as third most important.

The game mechanic *Currency*, or *Earth Coins*, as it is called in the app was rated as the most motivating game mechanic in the app (Q8 in the post-intervention questionnaire). That the *Earth Coins* are a success is also shown in Q12, that asks if they were curious to see if they had

gained any *Earth Coins* after a walk or bike ride. During the gamification workshop, the game mechanics *Points* and *Currency* was mentioned by both groups as game mechanics that applied to various user groups, activities and goals.

Challenges/Call to arms, Leaderboard and *Personal goal and Progress bar* were also selected among the game mechanics that were found motivating.

Gifting received mixed feedback as it both was mentioned by some that it was motivating, while two answered that they did not find it motivating at all. *Gifting* is probably one of the game mechanics implemented that was the most unknown of the game mechanics implemented. In the gamification workshop, *Gifting* was only named for one of the scenario boards that had the activity to keep people using the app, and target group *older users*. The respondents in the user evaluation were all in the user group *young users*, so this could be an explanation for the low interest in the game mechanic. It could also be because *Gifting* was one of the game mechanics that was not fully implemented in the app, so the respondents may not have understood what *Gifting* was about since it may have been poorly explained throughout the app.

The reason why *Gifting* was chosen to be included in the app even though it was a pretty unknown game mechanics was that the workshop participants that pitched it came up with a reasonable scenario and use case and reasoned well for how it would help create usage of the app. The literature behind the game mechanics was also convincing to why it should be included [26, 31].

The positive results of the user evaluation regarding the game mechanics indicate that the prioritization from the survey, and the selected game mechanics that the workshop participants provided, were good. Hence, it can be concluded that the co-creation session was successful. The fact that the session introduced game mechanics that were not thought of initially shows that co-creation is a valuable method when developing a concept and gamifying an app [25].

The social aspect received a high score among the respondents of the user evaluation even though all of it was not implemented. In the survey completed by the workshop participants, the social aspect was ranked third, but the good reception of the concept indicates that this should be of a higher priority in further development.

To sum up, the most motivating game mechanics in the app were:

1. Earth Coins (Currency/Points)
2. Leaderboard
3. Personal goal and progress bar
4. Challenges (Call to arms)
5. Gifting

10.1.3 RQ3: How do we design an app that is easy to use?

Making the app easy to use was highly prioritized by the workshop participants when they completed the survey. Improving the usability was also one of the focus areas in the specialization project, and the digital prototype created tried to solve some of the major usability issues revealed in the user evaluations of *Smiling Earth* V2.

Q26 in the user evaluation asked if the app was easy to use. All the respondents in the user evaluations answered *Agree* on this question, which gave an average of 3.0 (*Agree*). This question has been reused from the questionnaires that have been used throughout the different evaluations of V1, V2, prototype, and V3. The following averaged has been noted from the evaluations:

Q26	**V1**	**V2**	**Prototype**	**V3**
I think the app was easy to use	Disagree (1.0)	Disagree (1.2)	Agree (2.8)	Agree (3.0)

Table 10.1: Evolution of Q26

This is a great improvement, and the aspects that may have had an impact on the ease of use may be the following factors presented in Table 10.2 as these have improved a lot in the last evaluations.

Factor	**V1**	**V2**	**Prototype**	**V3**
Understanding the purpose of the app clearly	Agree (2.5)	Neutral (2.4)	Strongly agree (3.6)	Strongly agree (3.6)
Feeling confused when using the app	Disagree (0.8)	Agree (2.8)	Disagree (1.0)	Disagree (1.2)
Did not have enough knowledge to use the app	Neutral (2.0)	Neutral (1.8)	Disagree (1.0)	Disagree (1.0)
People would learn to use the app quickly	Disagree (0.8)	Neutral (2.0)	Neutral (1.8)	Strongly agree (3.2)
Functions are well integrated	Neutral (1.5)	Neutral (1.8)	Agree (2.6)	Agree (2.6)
Clear and concise color code	Disagree (1.0)	Agree (3.4)	Agree (2.6)	Strongly agree (3.6)

Table 10.2: Factors that have improved ease of use

A theme among the factors appears to be providing necessary explanations and enough information. The Welcome slides have probably had an impact on the results. However, feedback was received that the amount of text was too much and the text size too small for some aspects of the app, which drew the focus away from it, and most of the attention was brought to the Earth in the middle of the screen. The historical graphs also retrieved feedback that it should be possible to view the entire graph without having to scroll between the days to compare.

Technology Acceptance Model

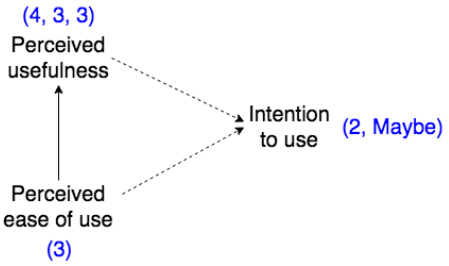
The TAM that was presented in the Background Chapter 3, claims that if an app is perceived easy to use, it will be perceived as useful, and thus the intention to use the app will increase [16]. The model presented in Chapter 9 in Figure 9.1 was created to discuss if the TAM is valid. The questions used in the model are the following:

- **Q16.** I find the link between energy, carbon footprint, activity, and expenses motivating.
- **Q24.** I think I would use this app frequently.
- **Q26.** I think the app was easy to use.
- **Q38.** I find the visualization of last weeks historical data useful.
- **Q41.** I find it useful to have a defined daily limit for the carbon footprint in the app.
- **Q46.** Do you think you would like to use this app?

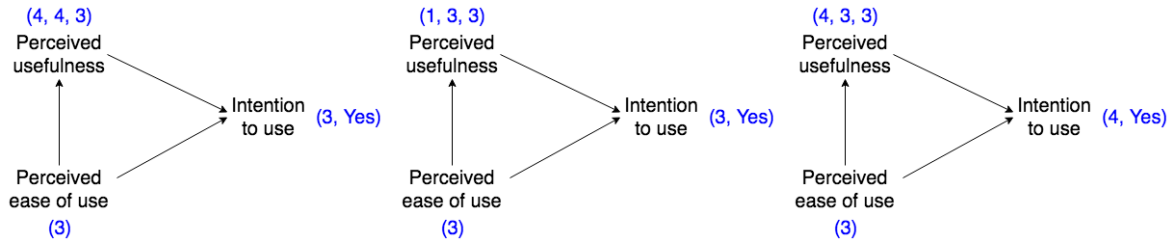
By looking at the responses given and the scores from 0-4 that refers to the value of the Likert scale, the respondent R1-R5 have the following TAM models. A dotted line indicates a weak connection between the factors. A whole line suggests a strong relationship between the elements.

Figure 10.1 shows that R1 has a strong link between perceived ease of use and perceived usefulness as the answers given here are 3 (Agree) and 4 (Strongly agree). Even though the respondent found the app easy to use, and useful, he/she was not sure about the intention to use the app.

Figure 10.1: TAM R1



R2-R4 in Figure 10.2 (a)-(c) affirms the TAM and shows a strong link between all the items.



(a) R2 (b) R3 (c) R4

Figure 10.2: TAM R2-R4

R5 (Figure 10.3) answered that he/she was not interested in using the app, so even though he/she gave high scores for perceived ease of use and perceived usefulness, this was not reason

enough to want to use the app. The reasoning for the answer given in Q46 was that the app seemed like to much hassle to keep running at all times and he/she was not that interested in knowing their carbon footprint. This reveals that the TAM is not applicable for all cases.

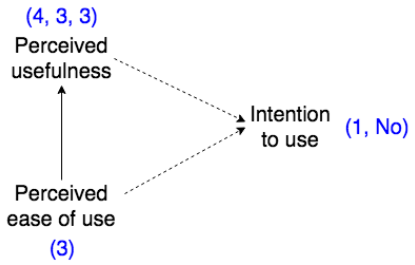


Figure 10.3: TAM R5

The good score for the usability related questions in the post-intervention questionnaire shows that the app is perceived easier to use compared to the previous versions of the app (V1 and V2). Since it is an app that may contain many new terminology and concepts, it is crucial that these concepts are thoroughly explained to get people to use the app. If the app is perceived challenging to use, it will not be possible to change people's habits and create awareness to lower their carbon footprint.

10.1.4 RQ4: Is the concept of the app understood?

In addition to being an app that is easy to use, the concept of *Smiling Earth* must be understood for the app to reach its objectives. Based on their answers in the post-intervention questionnaire, the people participating in the user evaluations understood the concept and found it interesting. They did not get much additional information except the information provided in the app, so it should be representative of how an entirely new user will understand the concept. The respondents answered that they would imagine that most people would learn to use the app very quickly (Q31. 3.2 - Agree). This means that they both think the app is easy to use and that the concept is easy to understand.

The further development of the concept of the application depends on the willingness of the users to share their data, and that they find it motivating to connect with friends. This is important because it will make the app more fun and interesting to use, so it is very positive that the respondents in the user evaluation both find it motivating to connect with friends and that they are willing to share their data.

10.1.5 RQ5: How is the user's enjoyment affected by the app?

B. Bostan has described enjoyment as an essential factor for player motivations in a game [19]. If the user finds an app enjoyable, the likelihood of wanting to use the app is more prominent than if an app is boring. Q27 in the post-intervention questionnaire was asked to explore if the user's enjoyment was affected by using the app. The statement in the question was *"I enjoyed using the app."* The response on this question was good, as the average was *Agree - 2.8*, and the previous version of the app that did not include any game mechanics received scores of 2.3 and 2.2 which is closer to *Neutral*. It could be assumed that the enjoyment is affected by the game mechanics that was chosen by the co-creation method. The gamification workshop was thus important to make the app more enjoyable and fun to use. It might also have had an impact that the usability has improved.

The following quotes from Q47 in post-intervention questionnaire give a picture of the users' enjoyment:

- *"It is cool to track my activities to see how it affect the environment"*
- *"I would like to live a more environmentally friendly lifestyle, and therefore it is nice to be able to get automatic calculations. It is also fun to compete with friends and oneself. In addition, it is motivational that one can earn credits."*

10.1.6 RQ6: Is the user's engagement affected by the app?

In Kapp's definition of gamification, it is mentioned that one of the aims of using game-based mechanics is to engage people [17]. Personal engagement is also vital to create usage of the app and to encourage friends and others to use the app. The co-creation method contributed to creating engagement among the stakeholders that participated in the gamification workshop. Many of the cards in the MyG methodology was aimed at engaging. *Call to arms* (or challenges as it is called in the app), *Leaderboard*, *Bring a friend*. The co-creation session engaged the stakeholders, and a quote from one of the participants was: *"Although it was a new way of thinking, it was fun and a good idea to do the process like a game"*.

Respondents answered that they understood the concept, that is also an essential factor for creating engagement. There was also the question in the post-intervention questionnaire about wanting to tell others about the app. This was positive and indicates that they want to engage others as well. The Earth metaphor is aimed at creating engagement, but as some think it is childish, it does not engage all users. Q20 scored *Neutral* in the post-intervention questionnaire which is not a very good score.

10.1.7 RQ7: How does the app contribute to behavioral change?

One of the primary objectives of the master thesis was to design the app so that it would motivate the user to change behavior to be more sustainable. As already mentioned in some of the other sub-research questions, the results from the user evaluation showed that the app had managed to give the respondents some motivation.

The two respondents (R2 and R4) discussed in RQ1 (Section 10.1.1) were probably in the *Contemplation* stage of the TTM before using *Smiling Earth*, where they are aware that they have habits that can be changed, and they are starting to see the benefits from changing them [3]. After using the app, they might have moved towards the *Preparation* stage where they are motivated to make some changes, and may already have started changing a bit and have a plan for what they need to change. The respondent R3, which was also discussed for RQ1, disagreed that he/she had any habits to change in Q6 in the pre-intervention questionnaire, but in Q6 in the post-intervention questionnaire, *Agree* was answered which means that he/she was motivated to change behavior to a more sustainable one. This respondent was probably in the stage called *Precontemplation* before starting to use the app, and was not aware of any consequences of the behavior and did not see any reason to change [3].

Looking at the TTM of behavioral change and its five stages, it can be discussed the number of stages of TTM *Smiling Earth* currently supports. Table 10.3 includes the five stages and the ten processes of the TTM. A ✓symbolizes that the app supports the process, but a ✓symbolizes that the app only partially supports it. The notes in the right column should be considered as a tip for how to fully support the behavior change model. The Design Chapter 6 describes more thoroughly how the app supports the processes.

Studying the Table 10.3, it seems that *Smiling Earth* with the functionality currently (partially) implemented are most supportive of the stages *Precontemplation* (make people aware and start making them think of doing changes) and *Action* (where people have started taking action and doing the changes). However, there is a lack of support of the stages *Contemplation, Preparation,* and possibly *Maintenance*. This needs to be supported to take the app further, and suggestions for how it can be supported is shown in the notes in the table.

The fact that the stages *Contemplation* and *Preparation* was not fully supported in the app could be because planning to take action (*Contemplation*) and being ready to take action (*Preparation*) are stages that can go very quickly or they may be embedded in the other steps. When a person has gone from the *Precontemplation* stage and have decided to take action, they will probably need the processes of self-reevaluation and self-liberation together with the processes embedded in *Action*, but this may not require a stage that lasts for a long time. This may also prove that the TTM is not linear but can be non-linear and cyclical [3].

Stage	Process	Supported?	Notes
Precontemplation			
	Consciousness raising	✓	give examples of the consequences this has
	Dramatic relief	✓	give examples of how this saves the environment
	Environmental reevaluation	✓	provide the user with concrete examples that translates the carbon footprint to something that is more identifiable
Contemplation			
	Self-reevaluation	✓	introduce game levels that reflects how environmentally friendly the user is
Preparation			
	Self-liberation	-	show the user alternatives to transportation, like availability of city cycles, public transportation, and carpooling possibilities
Action			
	Countercondi-tioning	✓	provide concrete examples of how much, e.g., a bike ride instead of the usual drive saves the environment and the health benefits and the amount of money is saved, could be shown after a trip is completed
	Helping relationships	✓	integrate more ways of communication between the users like giving cheers and functionality to share results on social media like Facebook and Instagram
	Reinforcement management (Contingency management)	✓	have more types of rewards like badges, and levels to further show that green behavior is appreciated and pays off
	Stimulus control	-	have a counter of how much kgCO_2 that have been reduced in total since starting to use the app, and provide the user with examples of how much this has saved the environment
	Social liberation	✓	have a news feed with news about the climate and other actions that shows that being environmentally friendly is the new social norm
Maintenance			

Table 10.3: TTM stages and processes

10.1.8 Main Research Question Revisited

So to round off the discussion, the main research question will be repeated:
Can gamification increase motivation to use an application and change behavior and if so, how?

Based on the review of the sub-research questions it seems like it is safe to claim that gamification can increase motivation to use an application, as the app has received better feedback this round of evaluation compared to previous evaluations where the game mechanics were not implemented.

During the research project where gamification have been explored, implemented and evaluated it is found that gamification both motivates to use the app and motivates for behavior change. However, the game mechanics need to be properly implemented, and the tracking functionality in the app must be more accurate to be able to change peoples behavior. All the stages and processes in the Transtheoretical Model (TTM) must also be supported in *Smiling Earth* to be able to create lasting behavior change.

10.2 General Discussion

10.2.1 Ease of use or correctness of data

One thing that makes this app attractive is that it is not necessary with any self-reporting as the tracking should happen automatically and the user should just be informed about how their habits affect the environment without having to report anything else than the initial registration. The problem with this is that the app relies entirely on the automatic tracking, detection and calculation, that makes it easy for the user. The risk is if the tracker in the app does not work or classifies wrong activity or wrong data about the activity (e.g., less km or active minutes than actually) this could be catastrophic for the app as all its functionality is focused around that. All the participants in the user evaluation experienced from a few to many times that the app tracked wrong or did not track anything at all. It should be mentioned that the reliability of the app and the data collected is essential for building trust in the app, and therefore also crucial to the success of the app.

The question is, would the user be willing to provide more data to the app to ensure correctness, or do they prefer the ease of it now? Assuming that the meanings of the respondents are the same as other potential users on this topic, it seems like it is not a good idea to switch method for data gathering in the app. In *UbiGreen*, that is an application that has been presented before in this thesis, that is an app that relies on wearing an extra tracker and assessing the trip after it has ended [34]. The respondents' answer in the post-intervention questionnaire in the user evaluation indicates that they think it is essential that the trips are registered correctly and that it should be possible to edit the details about a trip later if the app has got it wrong. Two out of five answered that it is more important that the app tracks automatically than having entirely accurate data, so this clearly shows that if the app is too much work, it will probably not be used.

10.2.2 Change people's behavior or get them to use the app

The two goals mentioned in the header of this section are both essential aspects of the app, and they should be thought about when designing the application. One thing is to design for behavior change, and focusing solely on this. The other thing is to design to get people to want to use the app. The first impression is very important here, and this may be abandoned if the focus is solely on the other goal.

Designing for various user groups could also be challenging, especially regarding gamification as very different things might motivate different user groups. The design should try to encapsulate the various needs of the user groups and the multiple needs for achieving the different goals.

10.2.3 Fragments

If the project had been started from scratch, fragments would probably not have been used to implement the functionality. The reason for this is that the concept of fragments was entirely new to me, and at the same time as I see the advantages of using fragments, I also see some disadvantages after dealing with them during development. If it had seemed like the app should be available on various types of devices, like tablets and phones, I would have understood the choice of using fragments. The impression received on the DESENT project meeting January 25. 2018 was that the application is most likely to be used on phones since they are always with us wherever we go. Given this, I think many things would have been easier to fix in the app if it was not in fragments.

10.3 Findings

Findings from the user evaluations suggest that the game mechanics elicited in the co-creation session with the stakeholders worked well in the app. It also revealed that ease of use is essential to create an intention to use the app. Although the feedback from the evaluation was positive for some aspects of the app, there are still some improvements with the concept and the user interface that must be done before the app is ready to be used. It also showed that amusement and ease of use are not enough in all cases to make people use the app, as you may also need to have a certain interest in the topic.

The study for the similar app called *UbiGreen* found that the participants wanted the app to track everything automatically [34]. *Smiling Earth* has found the same but the results also showed that it should be possible to edit a trip later if it has been tracked wrong. The *UbiGreen* research also discovered that the social aspect of competing with others was a possibility [34].

This is confirmed in this research project as the respondents found the social game mechanics motivating. The stakeholders also seemed to believe in them, since they were chosen in the gamification workshop.

Hence, doing the co-creation workshop was very useful to conduct in this process. The game mechanics selected from the workshop were found fun and motivating for the participants in the user evaluation. The most motivating game mechanics in the app were:

1. Earth Coins (Currency/Points)
2. Leaderboard
3. Personal goal and progress bar
4. Challenges (Call to arms)
5. Gifting

A co-creation method should be a part of the research strategy *Design and Creation* to engage and include the stakeholders and others that are interested.

The findings are relevant for the further development of the app and the work in the DESENT project. It can also be applied to other research projects that are developing similar kinds of mobile applications.

10.4 Limitations

The reliability of the findings could have been increased by including more people in both the workshop and evaluation. This is why this is a qualitative study, not quantitative. Evaluation should have been conducted with more people from different user groups and over a more extended period.

The server for the data storage was not set up, hence the social game mechanics of the app was not properly implemented as it was decided that this was hard to do without the server. This affected the user evaluation since the app functioned more like a high-fidelity prototype where all the functionality were not implemented.

10.5 Lessons Learned

The work with the master thesis has been very educational, and a lot of new experiences have been gained throughout the project. This includes both experiences with prototyping and Android development, but also new experiences of running a workshop and user evaluations, and

to deal with stakeholders and project partners in an international project. Running a workshop with multiple mother tongues speakers was demanding, but it was a good experience. For the workshop, pre-selected goal card could have led the participants in desired directions. However, it was useful to see what they thought were suitable goal cards and target groups for *Smiling Earth*.

During this year of working with gamification and learning more about the topic, I have become very aware of how mobile applications I use in everyday life uses game mechanics to motivate me to do different things. It has been valuable to learn more about this and how to use this when developing applications.

Taking over someone else's code project was also a new experience, and it was challenging to get into someone else's code and understand what was done, especially since a lot of the code in the project were related to energy and emission-related calculations which are outside my field of study. Estimating time for development and scheduling tasks for the sprints were difficult when you do not have that much experience. It was also educational to get some more experience in using the agile development methodology *Scrum*. Even if there were only one developer and all the elements of the *Scrum* methodology was not followed, it was a good experience of structuring the development phase this way.

The plan was to download the SQLite database from the application after the participants had used *Smiling Earth* for around a week. When distributing the app to the participants, an APK-file was generated in "release mode". It turned out that the APK-file had to be in "debug mode" to be able to perform the command of downloading the database from the app. This was detected after testing it with the first participant. The four other participants were almost finished with their test period, so it was no use in fixing the problem before starting the evaluation with the remaining participants, as they had already started. A lesson learned from this is to test all the steps of a user evaluation before launching it for real, to hopefully detect mistakes like this before it is too late.

10.6 Future Work

A lot of work remains before *Smiling Earth* is ready for release. Appendix K gives an overview of the requirements fulfilled, and which requirements are left to finish. A few concrete suggestions related to the unfulfilled requirements and how to finish them are listed below:

- Add concrete examples of how much the carbon footprint are affecting the environment. Give recognizable examples to people that are not that familiar with the topic (carbon footprint).
- Work on making the tracking more accurate, then implement functionality to edit tracked

trips to both correct mistakes and to specify details such as car type and the number of passengers.

- Include public transportation as green transportation. Can give out points if a person usually is driving a car, but are taking the bus.

The user evaluation contributed to many suggestions were given for how *Smiling Earth* could be improved. The list below contains some of the suggestions:

- The user can get a notification when he/she is getting close to the weekly limit so you can make some changes and for example take the bike the rest of the week
- Make the dashboard easier as it contains too much functionality. The estimation functionality for solar panels and such could be moved to its own item in the side menu which would open an `EstimationActivity`.
- Make the difference in the layout clearer between the dashboard and estimation functionality to more clearly separate the two ”modes” (e.g., change background color)
- the title in the toolbar at the dashboard could be removed to reduce the information on this page even further

During the specialization project and throughout the design phase it was discussed that because some people own more than one car, that it should be possible to add details about a second car during the registration. The fields for a second car was thus added and added to the settings, but no further functionality was added at this moment. This functionality will enable the possibility to choose which car is driven. A dialog box could appear after a trip has been driven where you could select which car and the number of passengers in the vehicle.

Another idea for future work is to create a business model for the application, and make deals with companies that can provide coupons with discounts that can be bought with the *Earth Coins* in the application. The *Hold App* that has been mentioned as a related app, contains this (see Figure 3.10 in Chapter 3). *Smiling Earth* could make deals with, e.g., transportation companies like *AtB* or *Ruter*, with solar panel retailers that can give a discounted price on a solar panel, electric vehicle retailers, or just other companies such as newsstands that can provide a discount on specific products (e.g., coffee, ice cream).

Chapter 11

Conclusion

The objective of the master thesis was to research if gamification can increase motivation to use an application and change behavior, and if so, how this can be done. By using the research strategy *Design and creation*, this was done by designing and developing an Android application called *Smiling Earth*.

The design phase consisted of background study, requirements elicitation, and co-creation workshop that supported the process of gamifying and designing the application and finding out what functionality was most important for the stakeholders. The development phase was conducted with an agile methodology (Scrum). After the new functionality was added, the app was tested with five people in a user evaluation that lasted around a week.

Findings from the user evaluations suggest that the game mechanics elicited in the co-creation session with the stakeholders worked well in the app. The findings also revealed that ease of use is essential to create an intention to use the app, but it was also found that amusement and ease of use are not enough in all cases to make people use the app, as you may also need to have a certain interest in the topic. Although the feedback from the evaluation was positive for some aspects of the app, there are still some improvements with the concept and the user interface that must be done before the app is ready to be used.

As not all the functionality was properly implemented due to several factors, the contribution to knowledge is a proof of concept. The concept of combining gamification and behavior change models seems to be working based on the results of the user evaluation. There is still some work that needs to be done for the application to be put to use, but the research done in this master thesis proves that it is a promising concept that is worth pursuing.

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Appendix A

Survey

A.1 Survey

Short survey about the DESENT App

Which feature/functionality do you think is the most important to prioritize?

(Rank the elements below from 1-4, where 1 is highest priority and 4 is lowest)

___ User profile

___ Gamification

___ Connect with friends

___ Visualization of historic data

What do you think is most important for this app?

(Rank the elements below from 1-4, where 1 is highest priority and 4 is lowest)

___ The app should be easy to use

___ The values presented in the app should be easy to read and understand

___ The app should show correct values when tracking

___ The app should be fun to use

What do you think will motivate you to lower your carbon footprint?

- ❏ Focus on personal actions and individual goals
- ❏ Focus on community actions and collective goals
- ❏ Both

Suggest other things that will motivate you

_____

_____

_____

Do you think you would like to use this app in the future?

- ❏ Yes
- ❏ No
- ❏ Maybe

Why?

(Explain your answer)

_____

_____

How do you think the app could be improved?

_____

_____

Do you have any other comments or feedback about the app?

_____

_____

Do you have a suggestion to a new name for the app?

_____

A.2 Survey Results

Short survey about the DESENT App

Which feature/functionality do you think is the most important to prioritize? (Rank the elements below from 1-4, where 1 is highest priority and 4 is lowest)								
	R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**
___ User profile	4	4	4	1	4	1	3	2
___ Gamification	3	1	1		3	2	1	3
___ Connect with friends	2	3	3		2	3	2	4
___ Visualization of historic data	1	2	2		1	4	4	1

What do you think is most important for this app? (Rank the elements below from 1-4, where 1 is highest priority and 4 is lowest)								
	R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**
___ The app should be easy to use	3	1	2	1	2	1	2	3
___ The values presented in the app should be easy to read and understand	2	4	1	1	4	3	3	2
___ The app should show correct values when tracking	1	3	4		3	4	4	1
___ The app should be fun to use	4	2	3	1	1	2	1	4

What do you think will motivate you to lower your carbon footprint?	
Focus on personal actions and individual goals	2
Focus on community actions and collective goals	0
Both	6

Suggest other things that will motivate you:

- Money, micro-rewards, ranking, "leveling-system"
- Competition, incentives
- Connection with friends, "goodies" from the municipality for reached goals
- household budget

Do you think you would like to use this app in the future?	
Yes	3
No	1
Maybe	4

Why? Explain your answer)

- Maybe: Will try for a certain period and find out how useful/fun it is
- Yes: I'm interested in my savings <-> carbon
- Maybe: Have to try it first
- Yes: Interested in environment
- Yes: It's very interesting to see your carbon footprint. Can change the behavior.
- Maybe: to use more the bike, to save COs, to do more for my health
- No: I don't use apps private
- Maybe: if the app would help me to achieve the goal

How do you think the app could be improved?

- More accurate information, maybe more transportation mode, include time allocation for activities
- More attractive for younger people, interesting
- Connection with friends, family, connection to real life, connection to other city citizens
- Information accuracy

Do you have any other comments or feedback about the app?

- The app should focus on not too many things, but rather some aspects to not confuse the user too much
- The design is easy to understand and use - i like it

Do you have a suggestion to a new name for the app?

- "This is you - CO2"
- No, smiling earth
- I like smiling earth

Appendix B

Workshop Participants

List of partners in the DESENT project that participated in the workshop:

- 4wardEnergy – Private research institute (Austria)
- W.E.I.Z. – The research center of the Weiz municipality (Austria)
- Weiz Municipality
- Reiterer & Scherling GmbH - Engineering agency working with optimizing energy use (Austria)
- TU/e – Technical University Eindhoven (Netherlands)

Appendix C

Backlog and Sprints

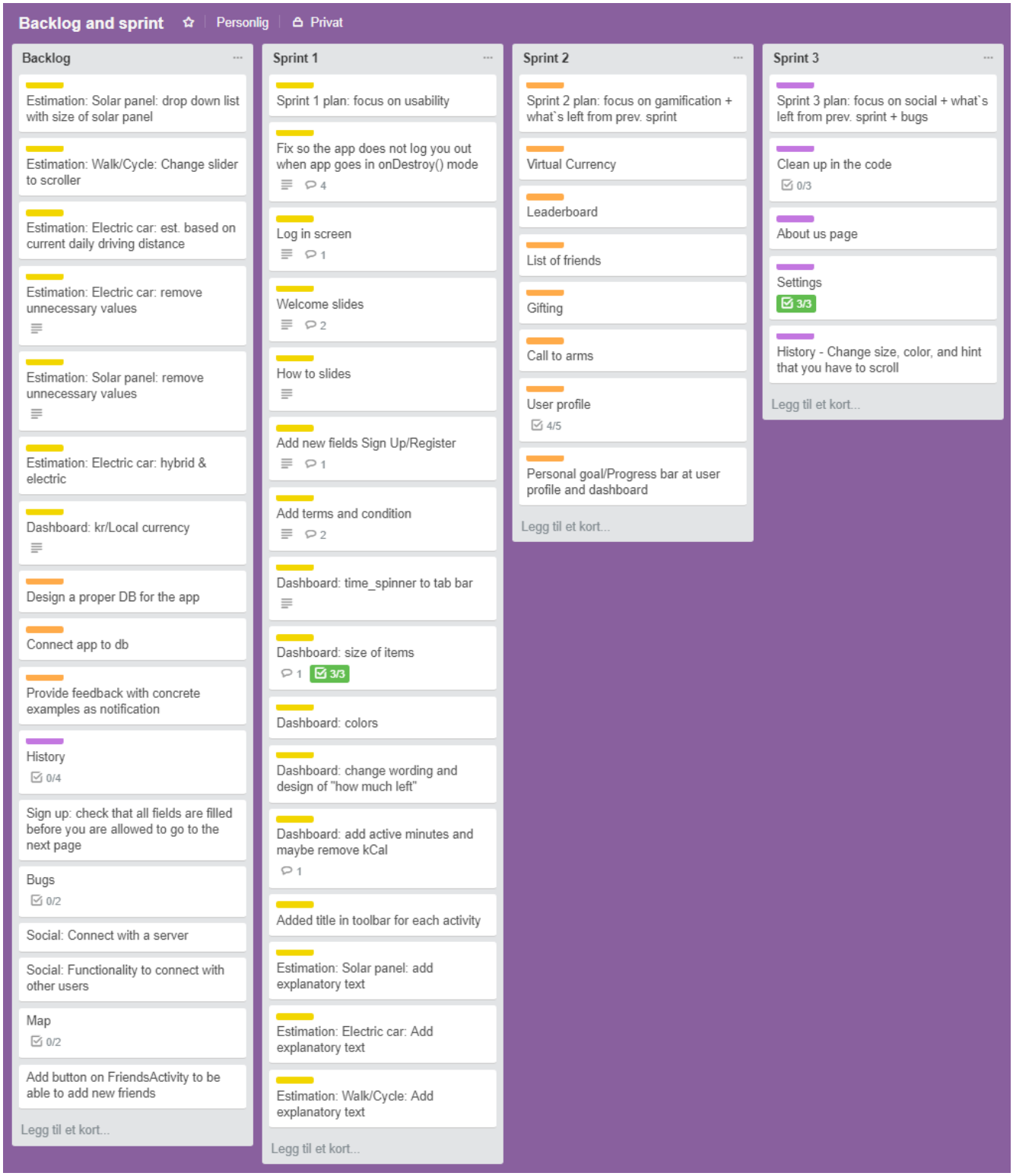


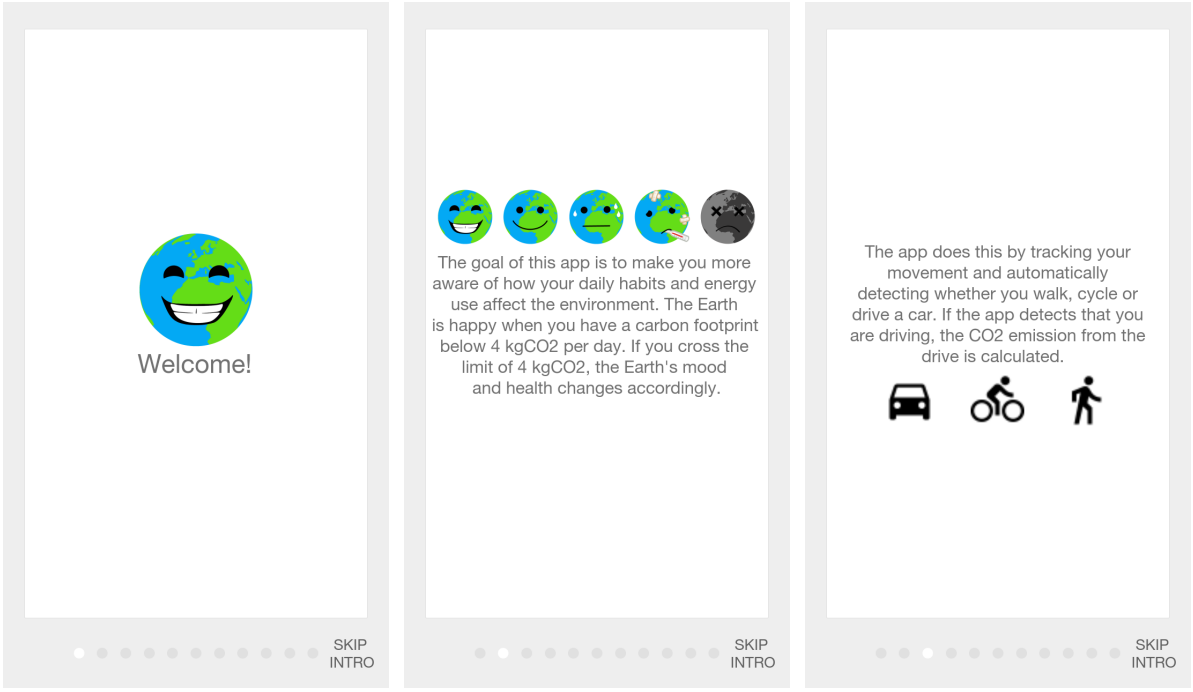
Figure C.1: Backlog and sprint from Trello

Appendix D

Digital Prototype

D.1 Welcome Slides

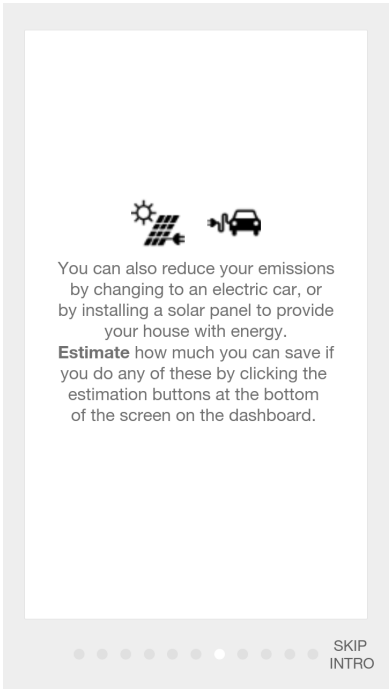
Figure D.1: Welcome slides part 1



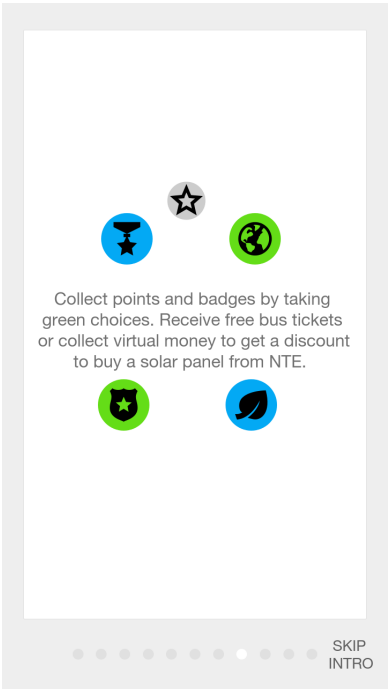
(a) 1 (b) 2 (c) 3

(d) 4 (e) 5 (f) 6

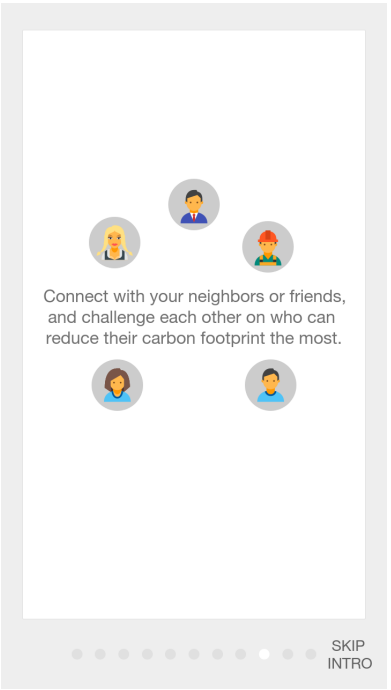
Figure D.2: Welcome slides part 2



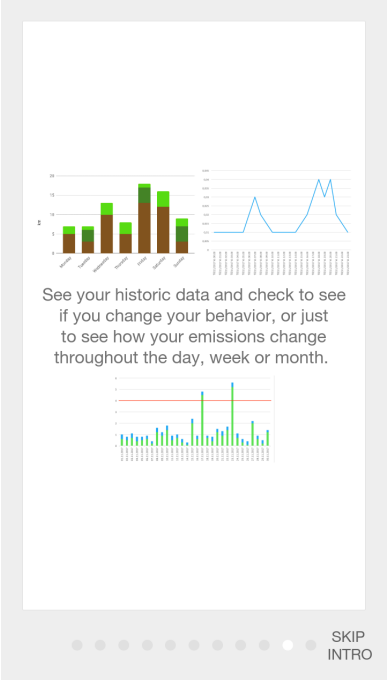
(a) 7



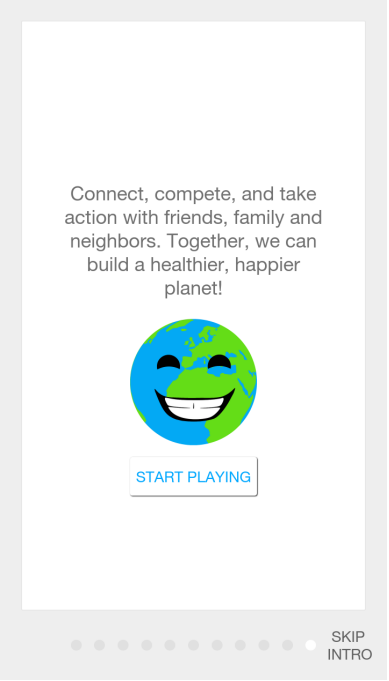
(b) 8



(c) 9



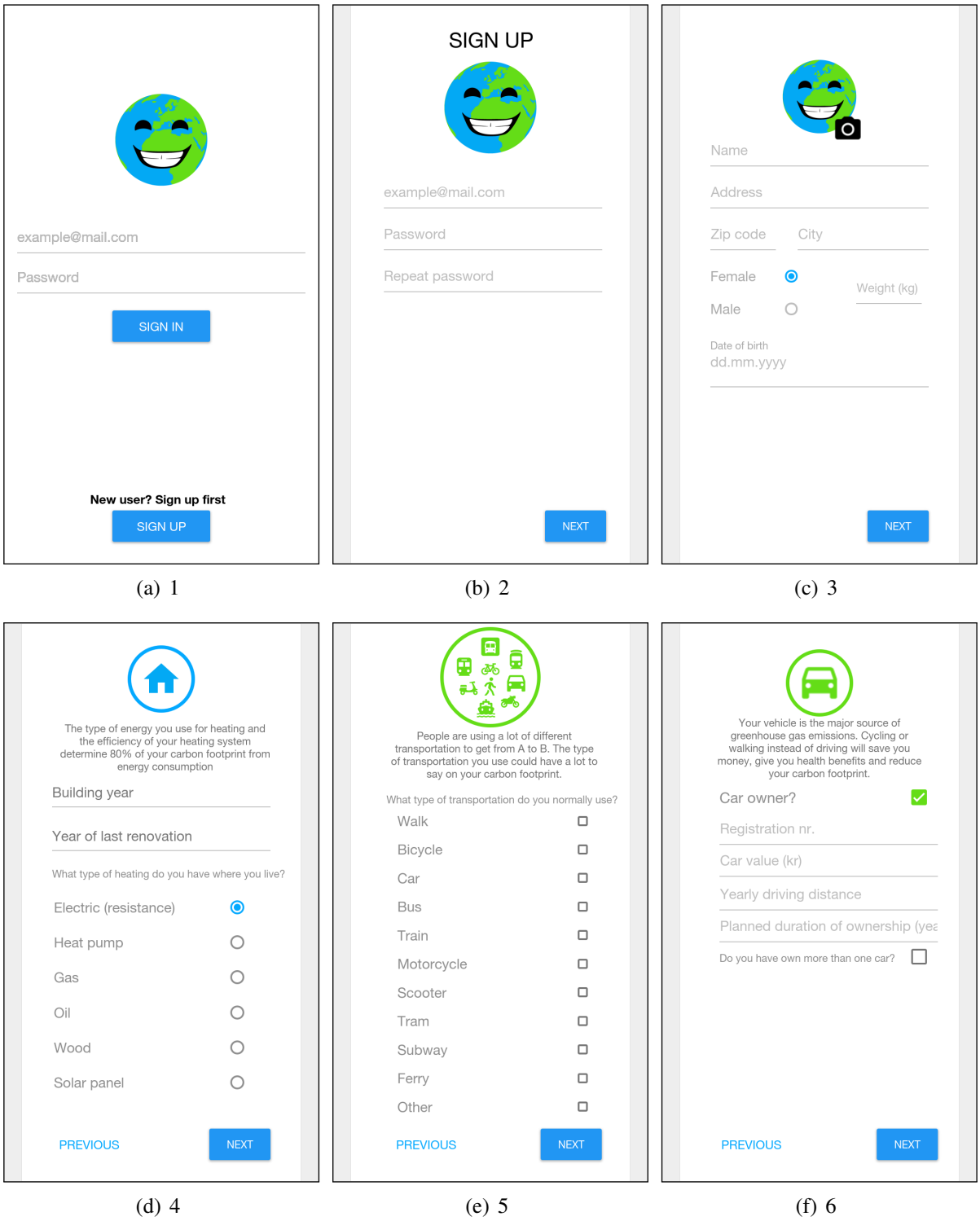
(d) 10



(e) 11

D.2 Sign Up

Figure D.3: Sign up

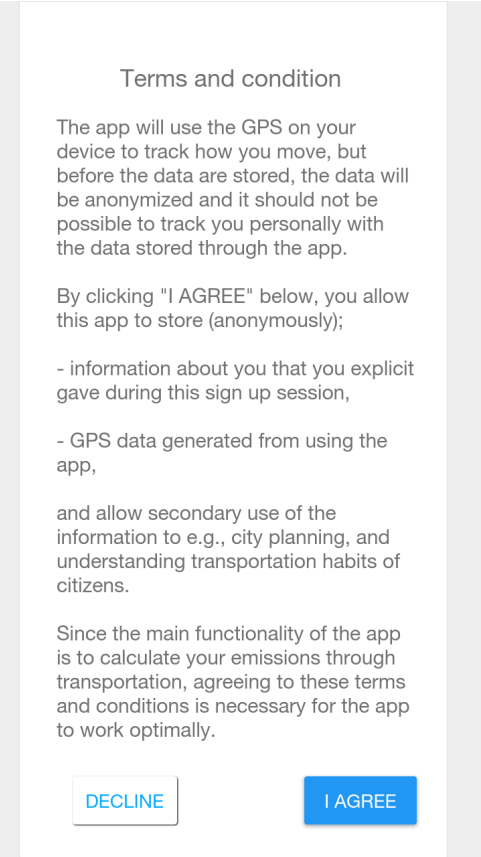


(a) 1 (b) 2 (c) 3

(d) 4 (e) 5 (f) 6

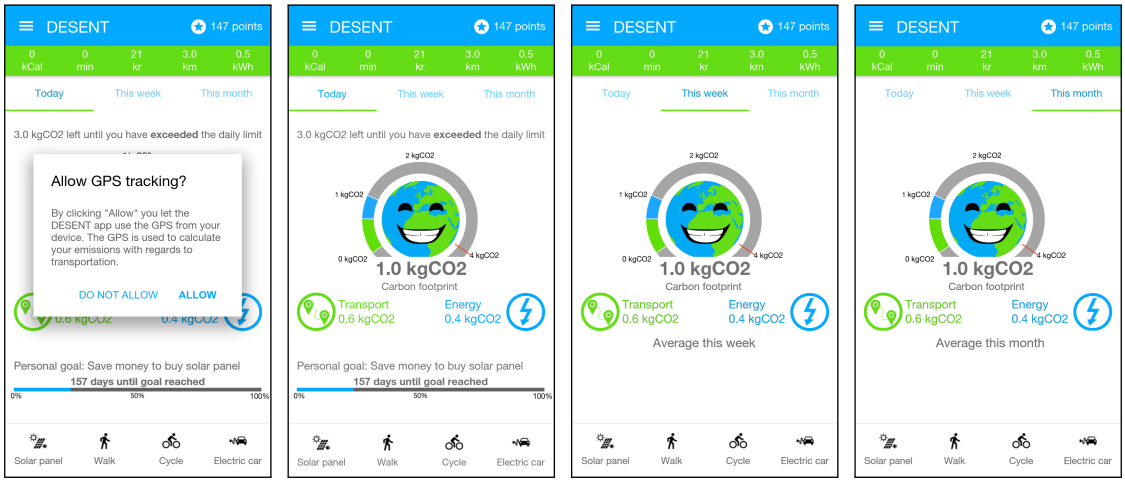
D.3 Terms And Conditions

Figure D.4: Terms and conditions



D.4 Dashboard

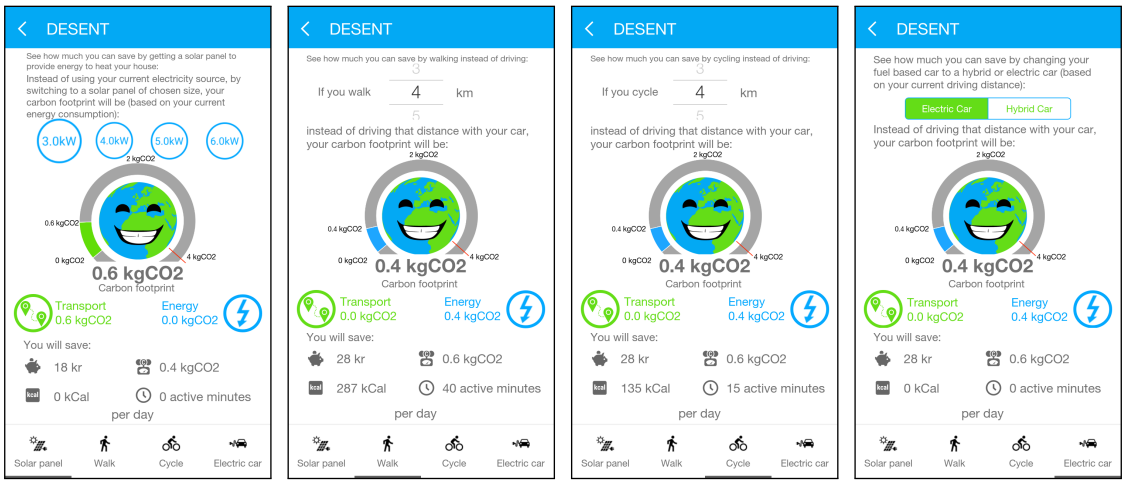
Figure D.5: Dashboard



(a) Allow GPS (b) Today (c) This Week (d) This Month

D.5 Estimation

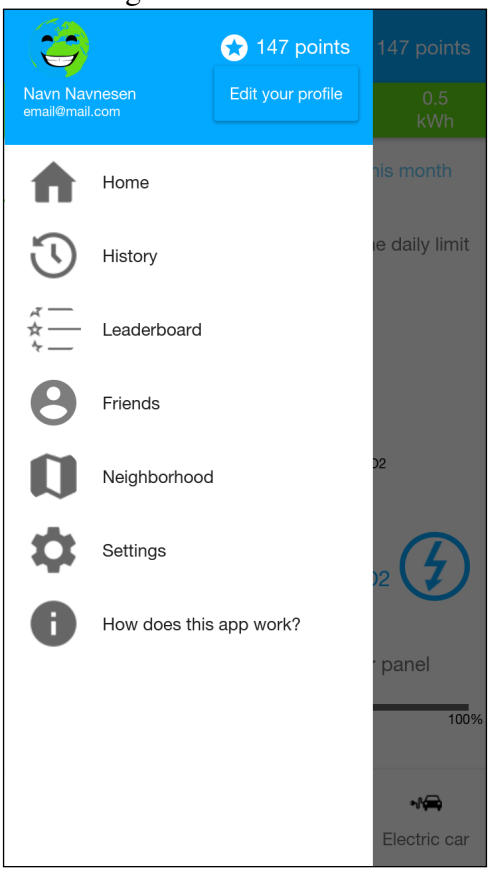
Figure D.6: Estimation



(a) Solar panel (b) Walk (c) Cycle (d) Electric/Hybrid car

D.6 Navigation, Side menu

Figure D.7: Side menu



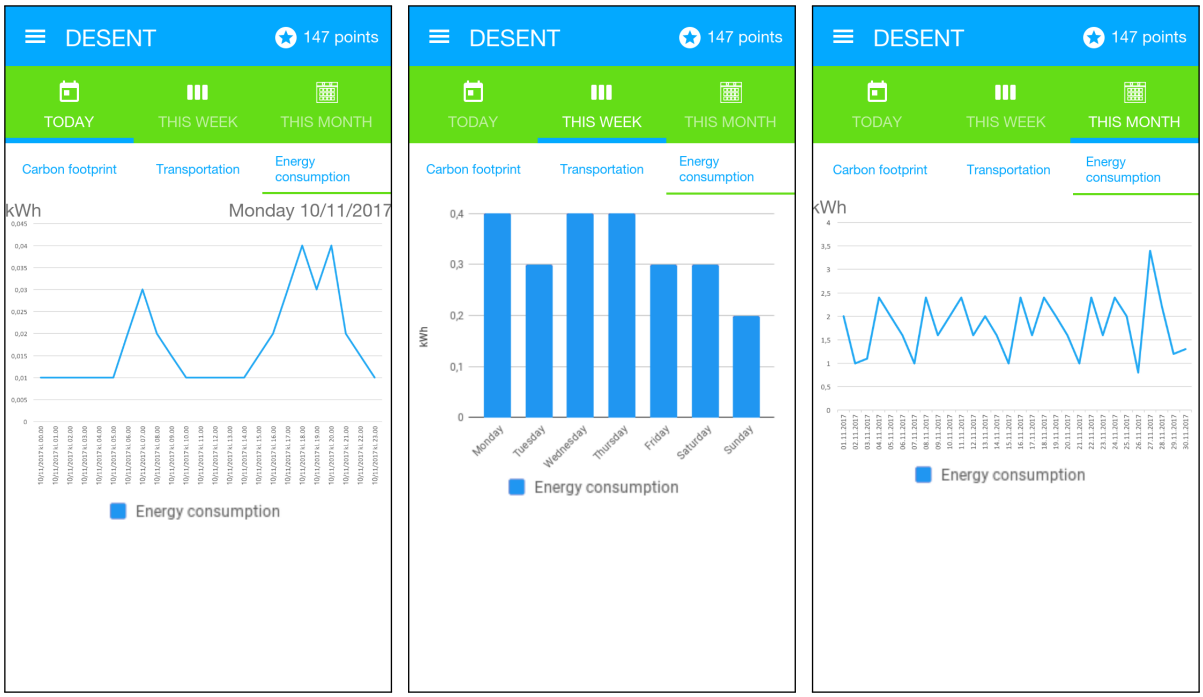
D.7 History

Figure D.8: History: Carbon Footprint

(a) Today (b) This week (c) This month

(d) Today (e) This week (f) This month

Figure D.9: History: Transportation



(a) Today (b) This week (c) This month

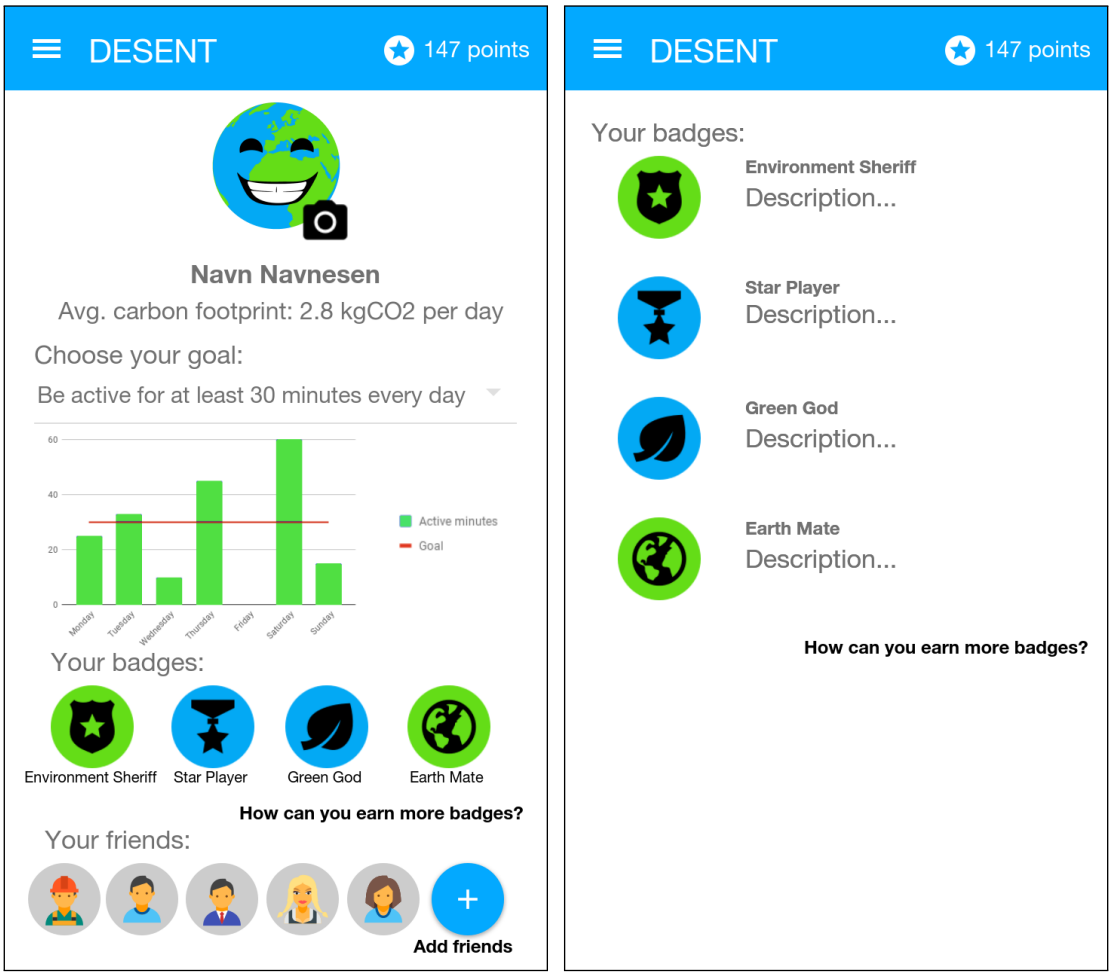
D.8 Leaderboard

Figure D.10: Leaderboard

(a) Lowest avg. carbon footprint (b) Most points

D.9 User Profile And Badges

Figure D.11: User profile, badges

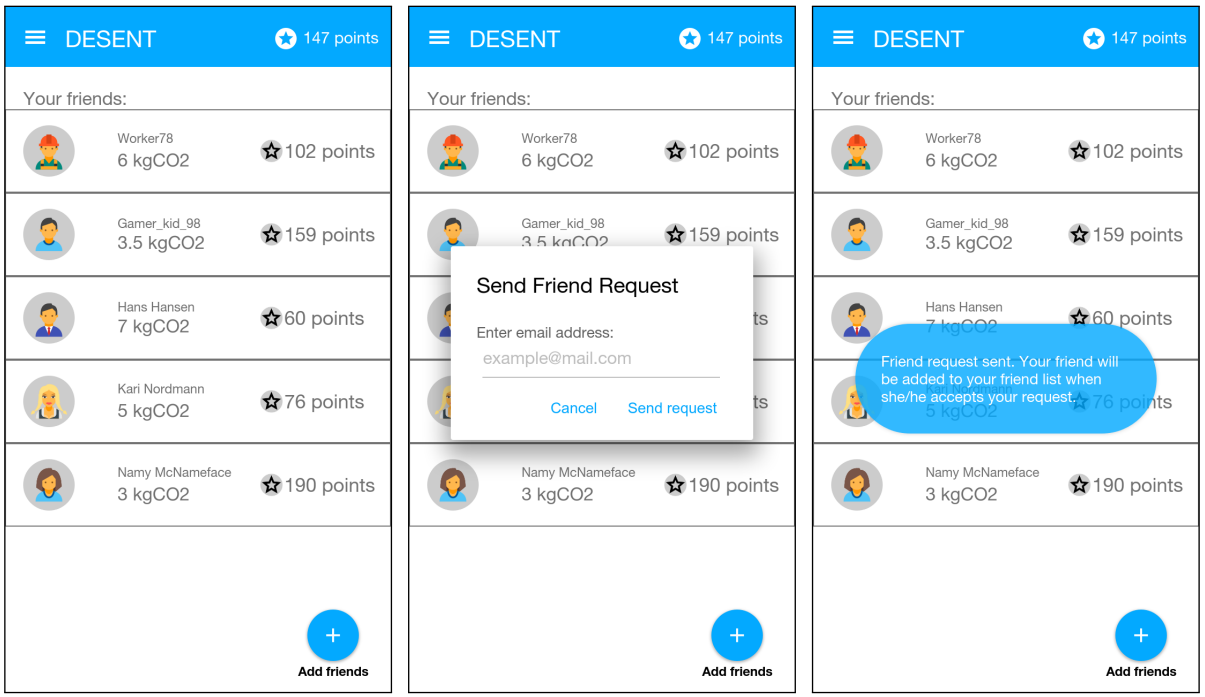


(a) User profile

(b) Badges

D.10 Friends

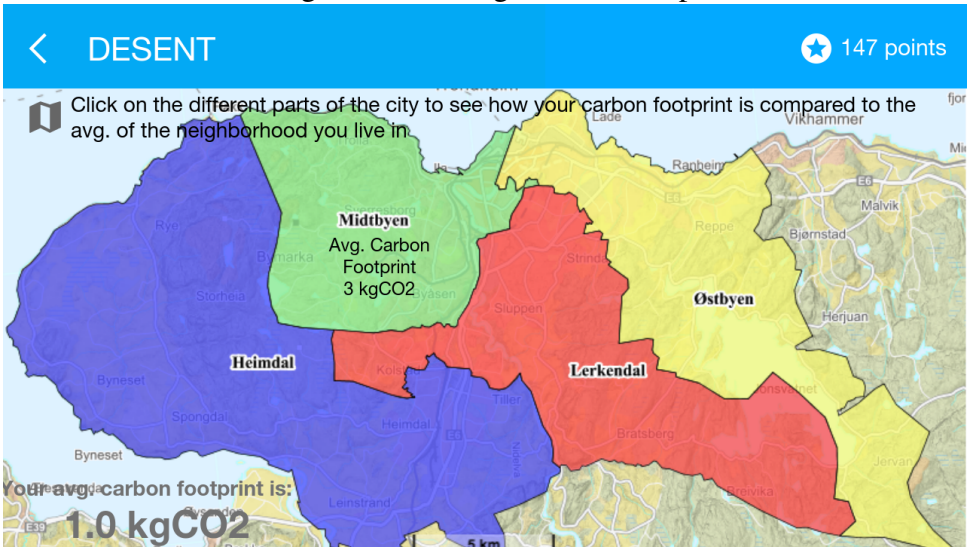
Figure D.12: Friends



(a) Friends (b) Add friend (c) Request sent

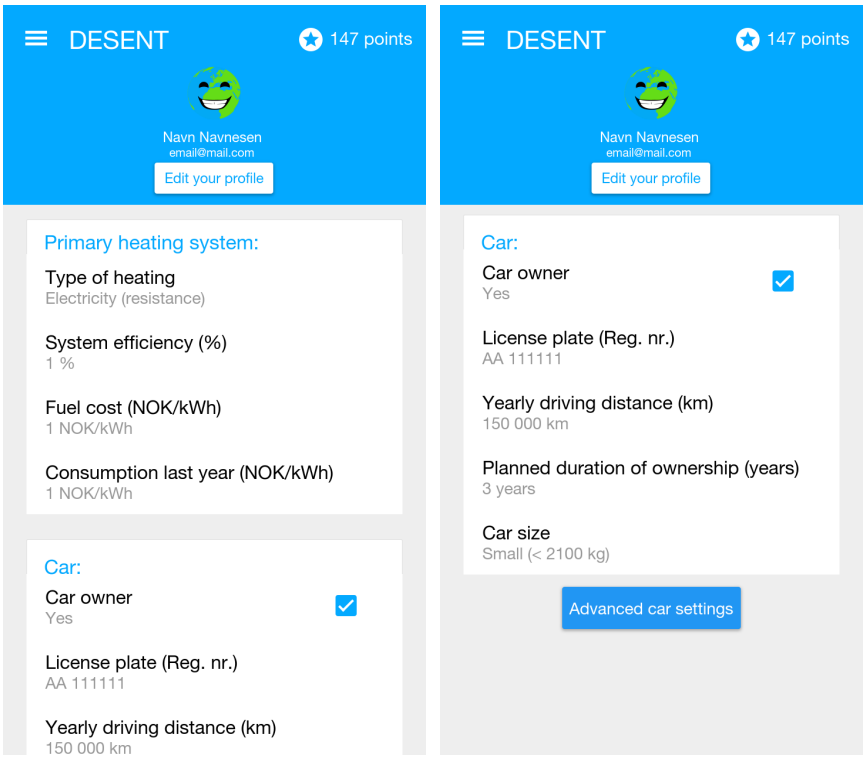
D.11 Neighborhood Map

Figure D.13: Neighborhood map



D.12 Settings

Figure D.14: Settings



(a) 1 (b) 2

(c) 3 (d) 4

Appendix E

Flow Diagrams

E.1 Activity Flow Diagram

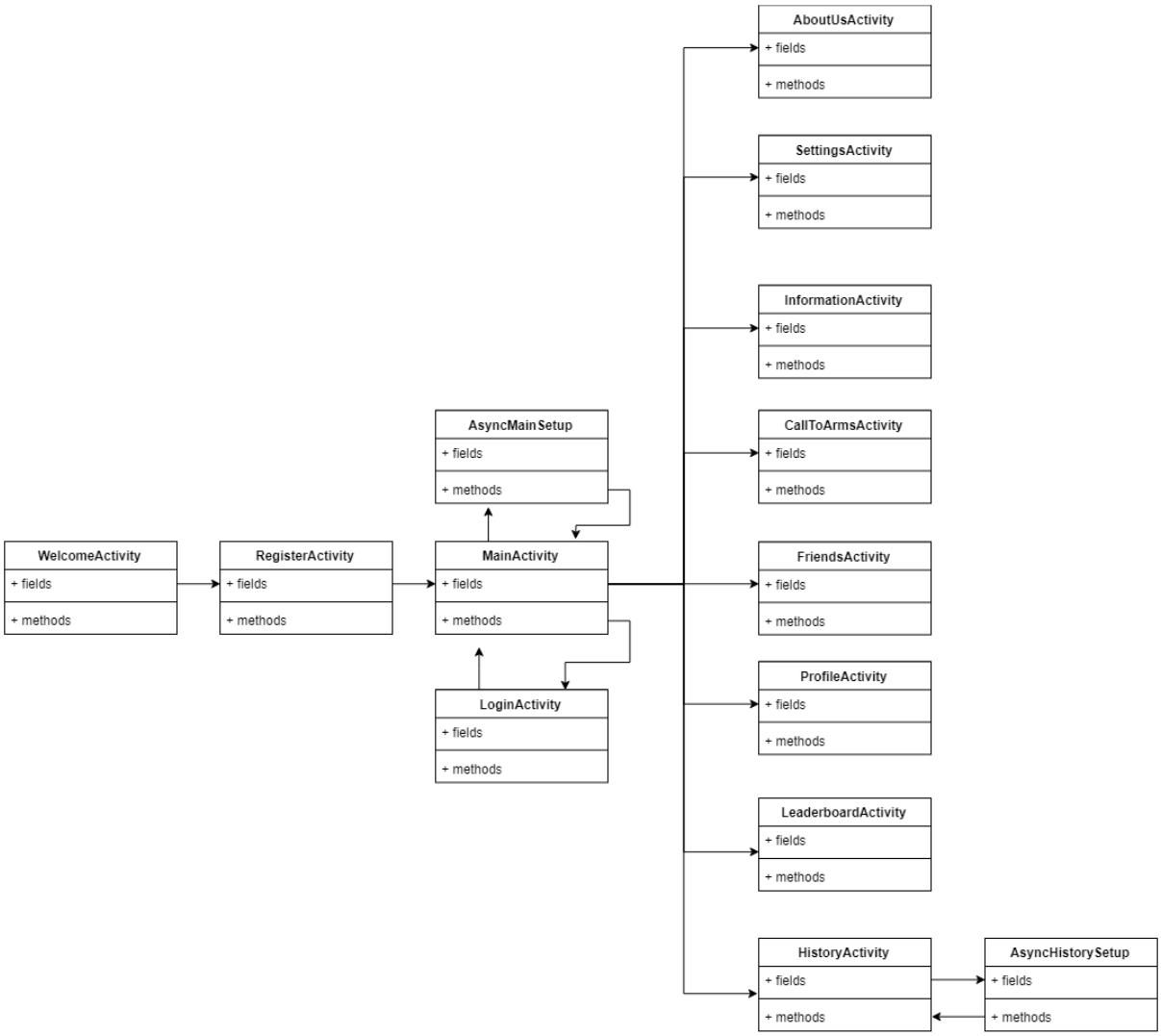


Figure E.1: Activity flow diagram

E.2 Fragment Flow Diagram

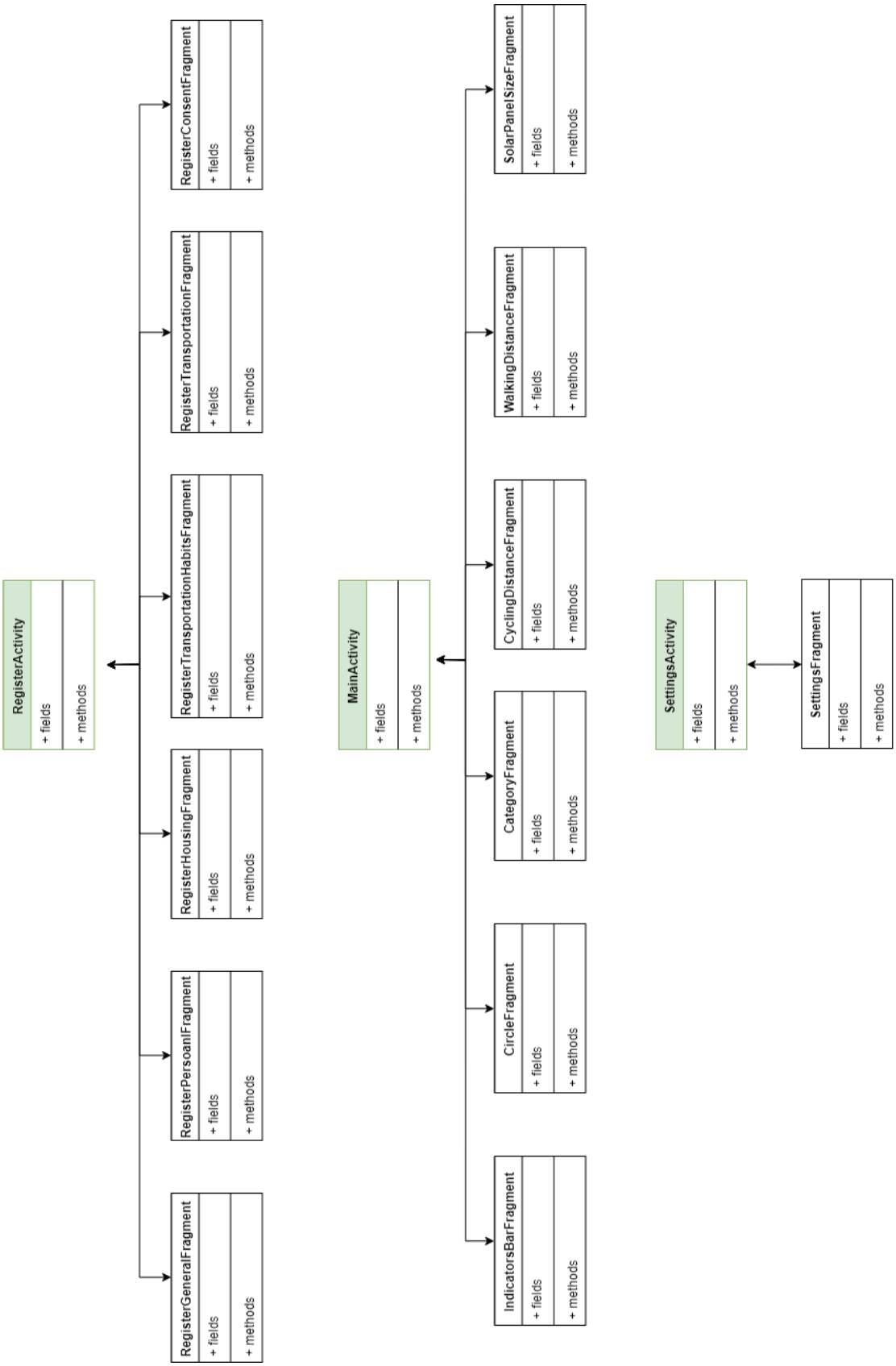


Figure E.2: Fragment flow diagram

Appendix F

Calculations Retrieved from [7]

Appendix C

Calculations

The following document has been written by Peter Ahcin. It describes the calculations used in the app.

C.1 Cost of solar power

The app tries to visualize the impact of investing into a solar installation in an immediate way. All consumption costs and the costs of the user's solar installation are translated into hourly values. Energy consumed is paid for very directly. The electricity company charges the consumer for each kWh of used electricity and the use of the electricity grid (nettleie in Norway), which can be divided generally into fixed charges for billing and with bigger customers for peak load, and per kWh. In Norway, the future trend is toward charging a larger fixed part and a smaller variable per kWh part, since this corresponds better to the actual cost of the distribution system operator. Namely, network costs are predominantly infrastructural costs that depend not on the amount of energy transported but rather on the capacity of the network to support the highest – peak loads that may occur only a few hours in a year.

The cost of energy generated by the solar installation is calculated as the so called Levelised Cost of Electricity generation (LCOE):

$$LCOE = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}} \tag{C.1}$$

Where:

- LCOE – lifetime levelised cost of electricity generation;
- I_t – investment expenditures in the year t;
- M_t - operations and maintenance expenditures in the year t;

- F_t - fuel expenditures in the year t;
- E_t - electricity generation in the year t;
- r - discount rate
- n - economic life of the system.

The above is taken from:

· IRENA: "Solar Photovoltaics" Renewable energy technologies: Cost analysis series, Volume 1: Power Sector Issue 4/5, June 2012.

We take the economic lifetime to be 30 years and a discount rate of 8% which corresponds to the cost of capital for renewable energy projects Europe. The values are calculated with the NREL LCOE calculator[1] and neglect the performance degradation factor. However, due to the high discount factor, this has little effect on the obtained value of LCOE.

C.2 Cost of driving

The cost of driving is estimated using the web service Bilkostnadskalkulator that's available at:
`http://www.smartepenger.no/kalkulatorer/2164-beregn-arlige-bilkostnader-for-bruktl`
The key inputs are:

- current value of the vehicle
- age of the vehicle
- distance on the kilometer counter
- number of years the user will keep the vehicle
- distance driven per year
- fuel consumption per Norwegian mile

The calculator produces a daily cost of the vehicle that includes all variable and fixed costs and an estimate of the marginal cost of every additional kilometer driven. The daily value is divided into an hourly value for the app to which the marginal cost is added for the distance driven every hour.

[1] `http://www.nrel.gov/analysis/tech_lcoe.html`

C.3 Emissions from electricity consumption

The emissions factor for electricity consumption is taken from a SINTEF study[2]. The author's put the value at 157 gCO_2e/kWh. Both consumption and the production of the solar installation use this same factor, with the production obviously having a negative value of -157 gCO_2e/kWh.

C.4 Emissions from driving

Greenhouse gas emissions from driving are calculated from the estimated fuel consumption. For gasoline vehicles the value 2392 gCO_2e/L is used. For diesel vehicles it is 2640 gCO_2e/L[3].

The US EPA uses 2348 gCO_2e per liter of gasoline and 2689 gCO_2e per liter of diesel fuel[4].

For electric vehicles the value used is 157 gCO_2e/kWh.

[2] 2 I. Graabak, B.H. Bakken, N. Feilberg: "Zero Emissions Building and Coversion Factors between Eelctricity Consumption and Emissions of Greenhouse Gases in a Long Term Perspective", Environmental and Climate Technologies, 2014.

[3] `http://ecoscore.be/en/info/ecoscore/co2`

[4] "Greenhouse Gas Emissions from a Typical Passenger Vehicle", Office of Transportation and Air Quality, EPA, 2014.

Appendix G

Code

G.1 SessionManagement

Listing G.1: SessionManagement class

```
public class SessionManagement {
   //Shared Preferences
   SharedPreferences sharedPreferences;
   //Shared Preferences Editor
   SharedPreferences.Editor editor;
   //Shared Preference Mode
   int PRIVATE_MODE = 0;
   //Shared Preference File Name
   private static final String PREF_NAME = "AndroidPref";
   //All Shared Preference Keys
   private static final String IS_LOGIN = "IsLoggedIn";
   //Email address
   public static final String KEY_EMAIL = "
      pref_key_personal_email";
   DatabaseHelper myDB;
   Context context;
   public SessionManagement(Context context){
      this.context = context;
      sharedPreferences = context.getSharedPreferences(
         PREF_NAME, PRIVATE_MODE);
      editor = sharedPreferences.edit();
      myDB = new DatabaseHelper(context);
   }
   //Create login session
   public void createLoginSession(String email){
```

```
        //Storing login value as TRUE
        editor.putBoolean(IS_LOGIN, true);
        //storing email in Shared Preferences
        editor.putString(KEY_EMAIL, email);
        //commit changes
        editor.commit();
    }
    /*checkLogin() will check user login status
    if false it will redirect user to login page
    else won't do anything*/
    public void checkLogin() {
        //check login status
        String email = myDB.getUserEmail();
        if (email == null){
            Intent i = new Intent(context, WelcomeActivity.class)
                ;
            //closing all the activities
            i.addFlags(Intent.FLAG_ACTIVITY_CLEAR_TOP);
            //add new flag to start new activity
            i.setFlags(Intent.FLAG_ACTIVITY_NEW_TASK);
            //starting login activity
            context.startActivity(i);
        }
        if (!this.isLoggedIn() && email != null){
            //user is not logged in redirect him to Login
                Activity
            Intent i = new Intent(context, LoginActivity.class);
            //closing all the activities
            i.addFlags(Intent.FLAG_ACTIVITY_CLEAR_TOP);
            //add new flag to start new activity
            i.setFlags(Intent.FLAG_ACTIVITY_NEW_TASK);
            //starting login activity
            context.startActivity(i);
        }
    }
    public boolean isLoggedIn() {
        return sharedPreferences.getBoolean(IS_LOGIN, false);
    }
    //clear session details
    public void logoutUser() {
        //clearing all data from shared preferences
        editor.clear();
        editor.commit();
```

```
        //after logout redirect user to login activity
        Intent i = new Intent(context, LoginActivity.class);
        //closing all the activities
        i.addFlags(Intent.FLAG_ACTIVITY_CLEAR_TOP);
        //add new flag to start new activity
        i.setFlags(Intent.FLAG_ACTIVITY_NEW_TASK);
        //starting login activity
        context.startActivity(i);
    }
}
```

G.2 Leaderboard

Listing G.2: onCreate in LeaderboardActivity

```
@Override
protected void onCreate(Bundle savedInstanceState) {
    //getting the recyclerview from xml
    recyclerView = (RecyclerView) findViewById(R.id.
        rvLeaderboard);
    recyclerView.setHasFixedSize(true);
    recyclerView.setLayoutManager(new LinearLayoutManager(this)
        );
    //getting the framelayout from xml
    frameLayout = (FrameLayout) findViewById(R.id.
        frameLayoutPodium);
    //initializing the scorelist
    scoreList = new ArrayList<>();
    tempList = new ArrayList<>();
    loadScores(sortListByAvgCf);
    bnveSort = (BottomNavigationViewEx) findViewById(R.id.
        navLeaderboardSort);
    bnveSort.setOnNavigationItemSelectedListener(new
        BottomNavigationView.OnNavigationItemSelectedListener() {
        @Override
        public boolean onNavigationItemSelected(@NonNull
            MenuItem item) {
            switch (item.getItemId()) {
                case R.id.best_avg_cf:
                    tempList.clear();
                    sortListByAvgCf = true;
                    loadScores(sortListByAvgCf);
                    break;
```

```
            case R.id.most_ec:
                tempList.clear();
                sortListByAvgCf = false;
                loadScores(sortListByAvgCf);
                break;
        } return true;
    }
});
}
```

Listing G.3: loadScores in LeaderboardActivity

```
private void loadScores(final Boolean sortListByAvgCf) {
    progressDialog.show();
    if (sortListByAvgCf){
        progressDialog.dismiss();
        // sort list by lowest to highest avg. carbon
           footprint
        Collections.sort(scoreList, new Comparator<Score>() {
            @Override
            public int compare(Score score, Score t1) {
                return Double.compare(score.getAvg_cf(), t1.
                   getAvg_cf());
            }
        });
    } else {
        progressDialog.dismiss();
        //sort list by highest to lowest nr. of Earth Coins
        Collections.sort(scoreList, new Comparator<Score>() {
            @Override
            public int compare(Score score, Score t1) {
                Integer num_coins_1 = score.getNum_coins();
                Integer num_coins_2 = t1.getNum_coins();
                return num_coins_2.compareTo(num_coins_1);
            }
        });
    }
    updatePodium(scoreList, sortListByAvgCf);
    //creating recyclerview adapter
    adapter = new ScoreAdapter(LeaderboardActivity.this,
       tempList);
    //setting adapter to recyclerview
    recyclerView.setAdapter(adapter);
}
```

Listing G.4: updatePodium in LeaderboardActivity

```
private void updatePodium(List<Score> scoreList, Boolean
   sortListByAvgCf) {
   int counter = 0;
   for (Score score : scoreList){
      if (sortListByAvgCf){
         if (counter == 0){
            tvNameFirstPlace.setText(score.getName());
            tvAvgCfFirstPlace.setText(String.valueOf(score.
               getAvg_cf()) + " " + getResources().getString(R.
               string.carbon_footprint_unit));
            imgFirstPlace.setImageDrawable(
               getApplicationContext().getResources().
               getDrawable(score.getImage()));
         } if (counter == 1){
            tvNameSecondPlace.setText(score.getName());
            tvAvgCfSecondPlace.setText(String.valueOf(score.
               getAvg_cf()) + " " + getResources().getString(R.
               string.carbon_footprint_unit));
            imgSecondPlace.setImageDrawable(
               getApplicationContext().getResources().
               getDrawable(score.getImage()));
         } if (counter == 2){
            tvNameThirdPlace.setText(score.getName());
            tvAvgCfThirdPlace.setText(String.valueOf(score.
               getAvg_cf()) + " " + getResources().getString(R.
               string.carbon_footprint_unit));
            imgThirdPlace.setImageDrawable(
               getApplicationContext().getResources().
               getDrawable(score.getImage()));
         } if (counter > 2){
            tempList.add(score);
         } counter++;
      } else {
         if (counter == 0){
            tvNameFirstPlace.setText(score.getName());
            tvNumCoinsFirstPlace.setText(String.valueOf(score.
               getNum_coins()));
            imgFirstPlace.setImageDrawable(
               getApplicationContext().getResources().
               getDrawable(score.getImage()));
         } if (counter == 1){
            ...
```

```
            } if (counter == 2){
                ...
            } if (counter > 2){
                tempList.add(score);
            } counter++;
        }
    }
}
```

G.3 Update Earth Coin Score in Runnable Thread

Listing G.5: Runnable Thread

```
public Runnable ScoreUpdatesRunnableCode = new Runnable() {
        @Override
        public void run() {
            int score = PreferenceManager
                .getDefaultSharedPreferences(getApplicationContext
                    ())
                .getInt("pref_key_personal_score", 0);
            float walkingDistToday = mDatabaseHelper.
                getWalkingDistanceToday();
            float cyclingDistToday = mDatabaseHelper.
                getCyclingDistanceToday();
            float activeMinutesToday = 0;
            for (Indicator indicator : indicators){
                indicator.setEstimationType(EstimationType.NONE);
                if (indicator.getName().equals("Active minutes")){
                    activeMinutesToday = indicator.
                        calculateTotalAverageValue();
                    break;
                }
                if (indicator.getName().equals("Carbon footprint")
                    ){
                    carbonFootprintToday = indicator.
                        calculateTotalAverageValue();
                    break;
                }
            }
            if (currentWalkingDistToday != walkingDistToday){
                if (walkingDistToday >= 3){
                    if (walkingDistToday >= 3 && walkingDistToday <
                        5){
```

```
                score += 1;
            } else if (walkingDistToday >= 5 &&
                walkingDistToday < 7){
                score += 2;
            } else if (walkingDistToday >= 7){
                score += 3;
            }
        }
        currentWalkingDistToday = walkingDistToday;
    }
    if (currentCyclingDistToday != cyclingDistToday){
        if (cyclingDistToday >= 3){
            if (cyclingDistToday >= 3 && cyclingDistToday <
                5){
                score += 1;
            } else if (cyclingDistToday >= 5 &&
                cyclingDistToday < 8){
                score += 2;
            } else if (cyclingDistToday >= 8){
                score += 3;
            }
        }
        currentCyclingDistToday = cyclingDistToday;
    }
    if (currentActiveMinutesToday != activeMinutesToday){
        if (activeMinutesToday >= 30){
            score += 1;
        }
        currentActiveMinutesToday = activeMinutesToday;
    }
    if (currentScore != score){
        SharedPreferences.Editor editor =
            PreferenceManager.getDefaultSharedPreferences(
            getApplicationContext()).edit();
        editor.putInt("pref_key_personal_score", score);
        editor.commit();

        textViewEarthCoinsToolbar.setText(String.valueOf(
            score));
        ((TextView) navigationView.getHeaderView(0).
            findViewById(R.id.textViewNumEarthCoins)).
            setText(String.valueOf(score));
        currentScore = score;
```

```
        }

        //Runnable code repeated very 15 minutes (900000ms
           =900s=15 min)
        ScoreHandler.postDelayed(ScoreUpdatesRunnableCode,
           900000);
     }
  };
```

Listing G.6: Thread started in onStart()

```
@Override
   protected void onStart() {
      super.onStart();
      distanceTracking.start(); // and accelerometer
      registerReceiver(distanceTracking.getFenceReceiver(),
         new IntentFilter(FENCE_RECEIVER_ACTION));
      ProgressBar progressBar = (ProgressBar) findViewById(R.
         id.progress_bar);
      AsyncMainSetup asyncMainSetup = new AsyncMainSetup(this,
            progressBar,
            indicators,
            carbonFootprintCircleFragment,
            indicatorsBarFragment,
            transportationFragment,
            energyFragment,
            walkingDistanceFragment,
            cyclingDistanceFragment,
            solarPanelSizeFragment);
      asyncMainSetup.execute();
      // necessary to read the Weather
      StrictMode.ThreadPolicy policy = new StrictMode.
         ThreadPolicy.Builder().permitAll().build();
      StrictMode.setThreadPolicy(policy);
      energyDatabaseUpdate = new EnergyDatabaseUpdate(this);
         //TODO: async
      mDatabaseHelper = new DatabaseHelper(this);
      EnergyUpdatesRunnableCode.run();
      //Thread that checks whether the score should be updated
      ScoreUpdatesRunnableCode.run();
   }
```

G.4 Active Minutes Indicator

Listing G.7: ActiveMinutes

```
public class ActiveMinutes extends Indicator {

   public ActiveMinutes(String name, String unit, String
      explanation, Transportation transport, Context context) {
      super(name, unit, explanation, transport);
   }

   protected float calculateActiveMinutesFromWalking(float
      distance){
      return 10*distance; //10 min per km
   }

   protected float calculateActiveMinutesFromCycling(float
      distance){
      return 3*distance; //3 min per km
   }

   @Override
   public void calculateValues() {

      switch (estimationType) {

         case NONE:
            averageValues[0] =
               calculateActiveMinutesFromWalking(transport.
               getWalkingDistance(timeScale)) +
               calculateActiveMinutesFromCycling(transport.
               getCyclingDistance(timeScale)/1000);
            break;
         case SOLAR_INSTALLATION:
            averageValues[0] =
               calculateActiveMinutesFromWalking(transport.
               getWalkingDistance(timeScale)) +
               calculateActiveMinutesFromCycling(transport.
               getCyclingDistance(timeScale)/1000);
            break;
         case WALKING:
            averageValues[0] =
               calculateActiveMinutesFromWalking(this.
               walkingDistance) +
```

```
                calculateActiveMinutesFromCycling(transport.
                getCyclingDistance(timeScale)/1000);
            break;
        case CYCLING:
            ...
            break;
        case ELECTRIC_CAR:
            ...
            break;
    }
  }
}
```

G.5 ProfileActivity

Listing G.8: ProfileActivity

```
public class ProfileActivity extends AppCompatActivity
   implements NavigationView.OnNavigationItemSelectedListener,
   AdapterView.OnItemSelectedListener {
   @Override
   protected void onCreate(Bundle savedInstanceState) {
      super.onCreate(savedInstanceState);
      setContentView(R.layout.activity_profile);
      sharedPreferences = PreferenceManager.
         getDefaultSharedPreferences(this);
      changeInfo.setOnClickListener(new View.OnClickListener()
          {
         @Override
         public void onClick(View view) {
            startActivity(new Intent(ProfileActivity.this,
               SettingsActivity.class));
         }
      });
      Uri imageUri = null;
      try {
         imageUri = Uri.parse(PreferenceManager.
            getDefaultSharedPreferences(this).getString("
            pref_key_profile_picture", "android.resource://com.
            example.desent.desent/drawable/earth"));
      } catch (IllegalArgumentException e) {
         e.printStackTrace();
      }
```

```
        Bitmap bitmap;
        try {
            bitmap = BitmapFactory.decodeStream(this.
                getContentResolver().openInputStream(imageUri));
            profilePic.setImageBitmap(Utility.getCroppedBitmap(
                bitmap));
        } catch (FileNotFoundException e) {
            e.printStackTrace();
        }
        name.setText(sharedPreferences.getString("
            pref_key_personal_name",""));
        tvAvgCf.setText("Avg. carbon footprint: ");
        tv_coin_score.setText(String.valueOf(sharedPreferences.
            getInt("pref_key_personal_score",0)));
        // Create an ArrayAdapter using the string array and a
            default spinner layout
        ArrayAdapter<CharSequence> adapter = ArrayAdapter.
            createFromResource(this, R.array.personal_goal_array,
            R.layout.spinner_layout);
        // Specify the layout to use when the list of choices
            appears
        adapter.setDropDownViewResource(R.layout.spinner_layout)
            ;
        // Apply the adapter to the spinner
        spinner.setAdapter(adapter);
        spinner.setOnItemSelectedListener(new AdapterView.
            OnItemSelectedListener() {
            @Override
            public void onItemSelected(AdapterView<?> adapterView
                , View view, int i, long l) {
                switch (i){
                    case 0:
                        //save to buy a solar panel
                        //earn 100 EC: receive a coupon that give 20
                            \% discount
                        tvProgress.setVisibility(View.VISIBLE);
                        personalGoal.setVisibility(View.VISIBLE);
                        personalGoal.setMax(100);
                        setProgressBar("solarPanel");
                        break;
                    case 1:
                        //save to buy an electric vehicle
                        //earn 200 EC: receive a coupon that give 20
```

```
                \% discount
            ..
        case 2:
            //keep average carbon footprint below 2
               kgco2
            //each day the avg is below 2, get one step
               closer to earn EC
            ...
        case 3:
            //keep average carbon footprint below 4 kg
               co2
            //each day the avg is below 4, get one step
               closer to earn EC
            ...
        case 4:
            //be active at least 30 min every day
            //each day being active at least 30 min, get
                one step closer to earn coupon
            ...
            break;
        case 5:
            //create your own goal
            //display dialogbox with title, how to
               measure
            //change text in spinner and display goal
               instead of progress bar
            LayoutInflater layoutInflater =
               LayoutInflater.from(ProfileActivity.this);
            final View inflator = layoutInflater.inflate
               (R.layout.dialog_personal_goal, null);
            final AlertDialog.Builder chooseGoalBuilder
               = new AlertDialog.Builder(ProfileActivity.
               this);
            chooseGoalBuilder.setTitle("Choose your own
               goal");
            chooseGoalBuilder.setView(inflator);
            final EditText input = (EditText) inflator.
               findViewById(R.id.et_personalGoal);
            chooseGoalBuilder.setPositiveButton("OK",
               new DialogInterface.OnClickListener() {
               @Override
               public void onClick(DialogInterface
                  dialogInterface, int i) {
```

```
                        personalGoalString = input.getText().
                            toString();
                        tvGoalExplanation.setText(
                            personalGoalString);
                        tvProgress.setVisibility(View.GONE);
                        personalGoal.setVisibility(View.GONE);
                    }
                }).setNegativeButton("CANCEL", new
                    DialogInterface.OnClickListener() {
                    @Override
                    public void onClick(DialogInterface
                        dialogInterface, int i) {
                    }
                }).show();
                break;
            }
        }
        @Override
        public void onNothingSelected(AdapterView<?>
            adapterView) {

        }
    });
}
public void setProgressBar(String progressBar) {
    switch (progressBar){
        case "solarPanel":
            tvGoalExplanation.setText("Earn 100 Earth Coins to
                receive a coupon with a discount on solar
                panels.");
            progressStatus = PreferenceManager.
                getDefaultSharedPreferences(
                getApplicationContext()).getInt("
                pref_key_personal_score",0); //retrieve
                totNumCoins
            tvProgress.setText(progressStatus+"/100");
            new Thread(new Runnable() {
                @Override
                public void run() {
                    while (progressCount < progressStatus){
                        progressCount += 1;
                        try {
                            Thread.sleep(20);
```

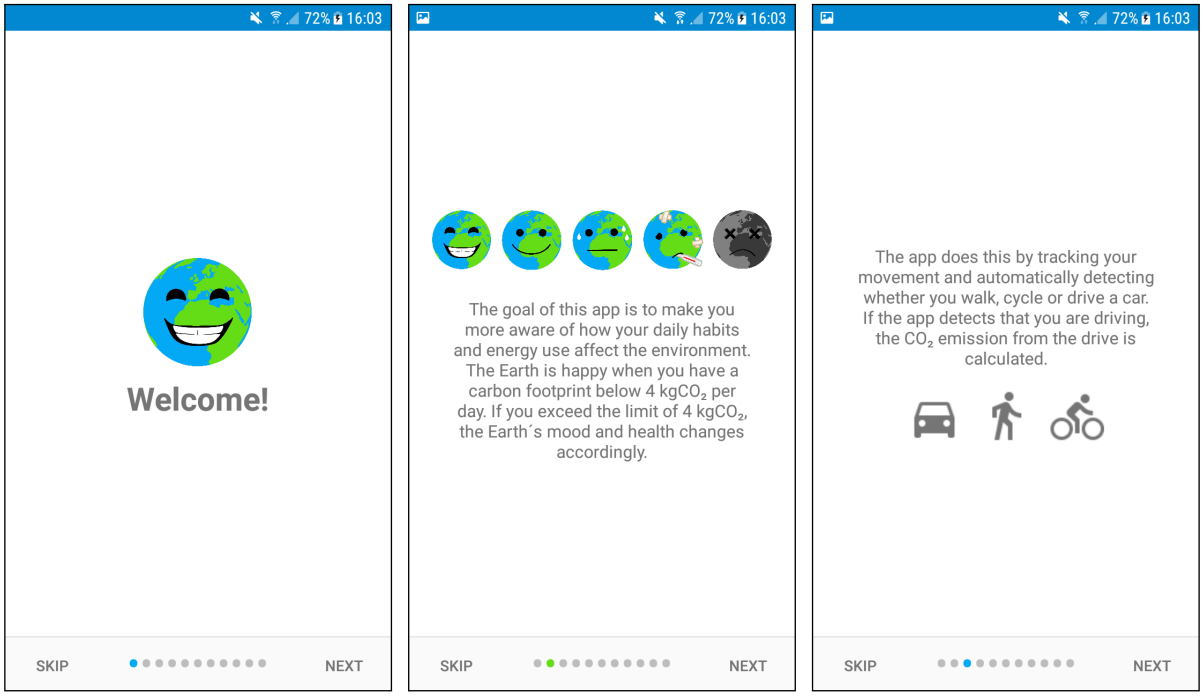
```
                    } catch (InterruptedException e){
                        e.printStackTrace();
                    }
                    handler.post(new Runnable() {
                        @RequiresApi(api = Build.VERSION_CODES
                            .N)
                        @Override
                        public void run() {
                            personalGoal.setProgress(
                                progressCount, true);
                        }
                    });
                }
            }
        }).start();
        break;
    case "electricVehicle":
        ...
    case "avgBelow2":
        ...
    case "avgBelow4":
        ...
    case "activeMinutes":
        ...
  }
 }
}
```

Appendix H

Screenshots from *Smiling Earth* V3

H.1 Welcome Slides

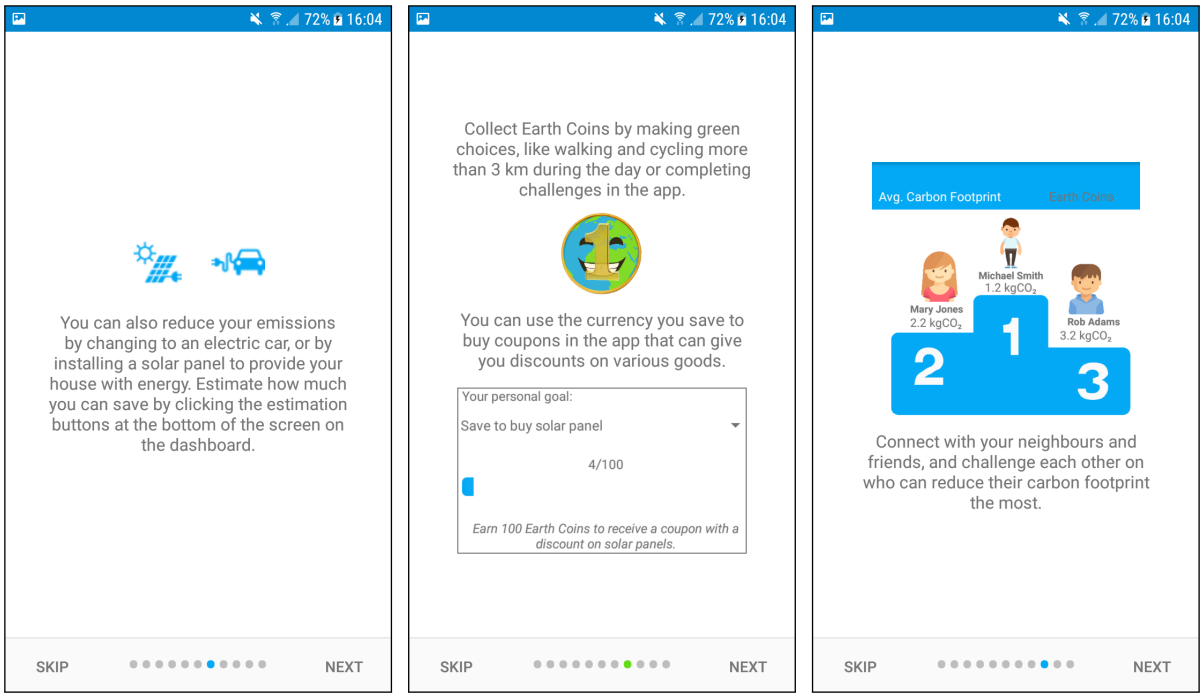
Figure H.1: Welcome slides part 1



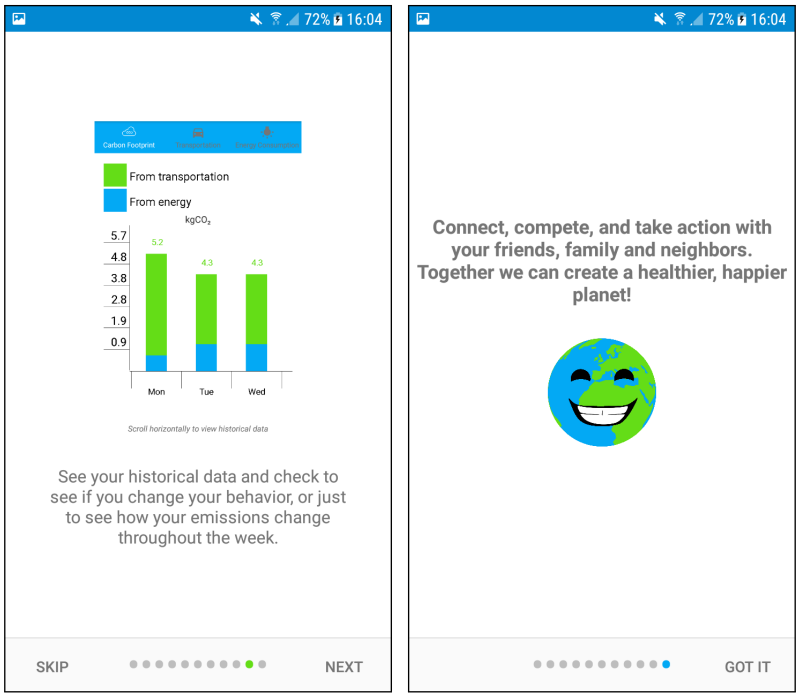
(a) (b) (c)

(d) (e) (f)

Figure H.2: Welcome slides part 2



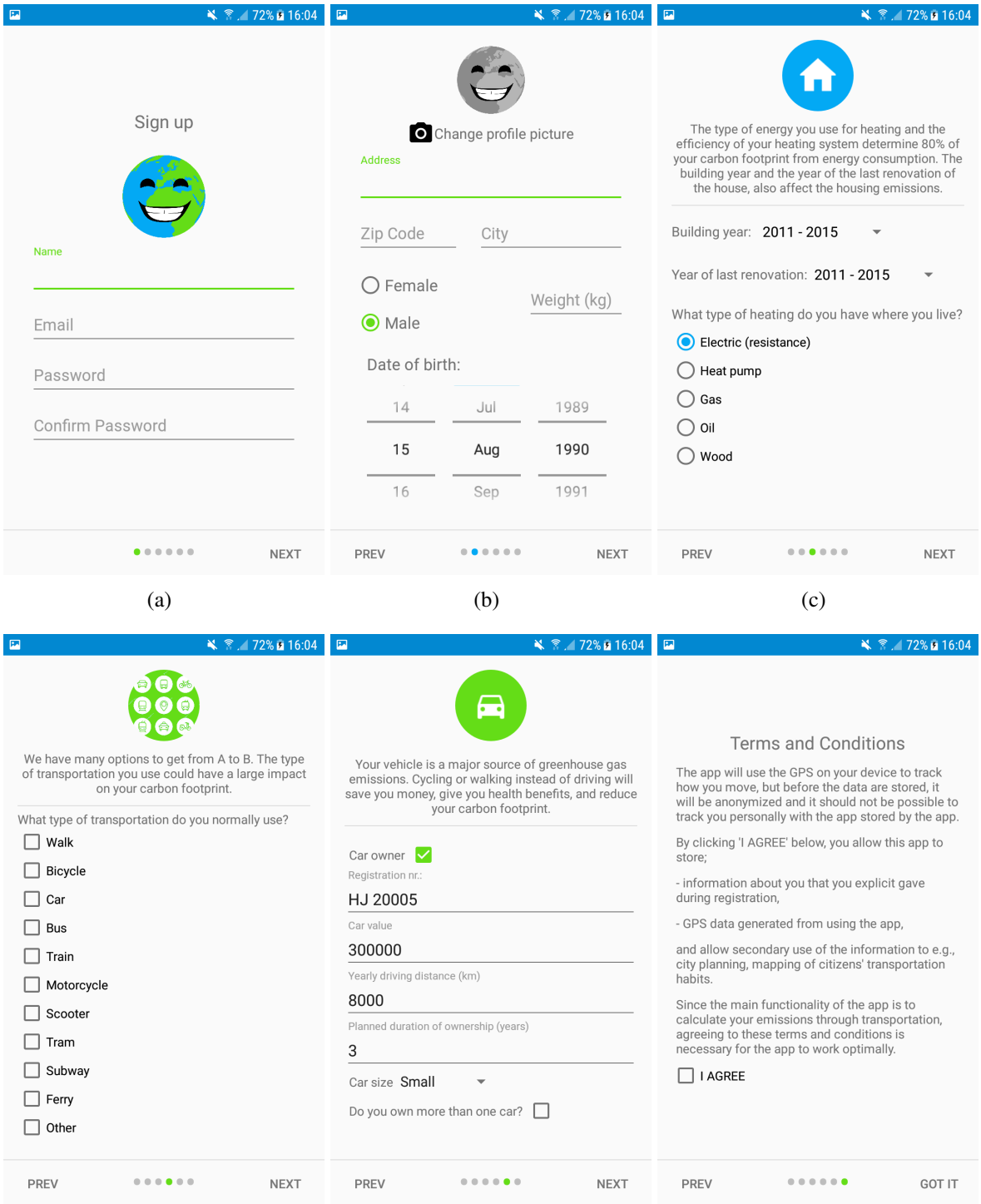
(a) (b) (c)



(d) (e)

H.2 Sign Up

Figure H.3: Sign up

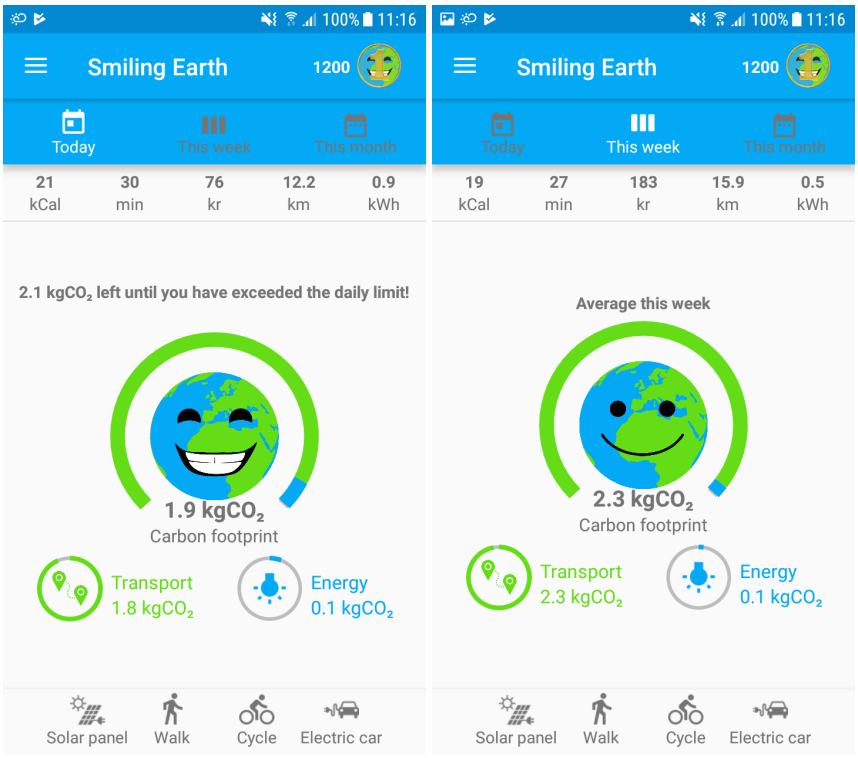


(a) (b) (c)

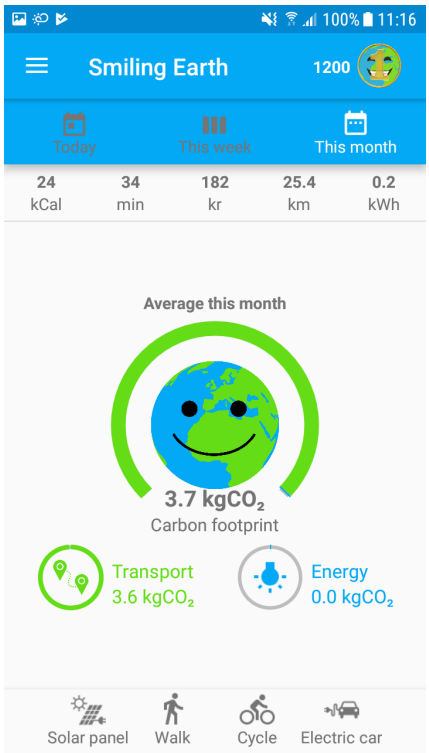
(d) (e) (f)

H.3 Dashboard

Figure H.4: Dashboard



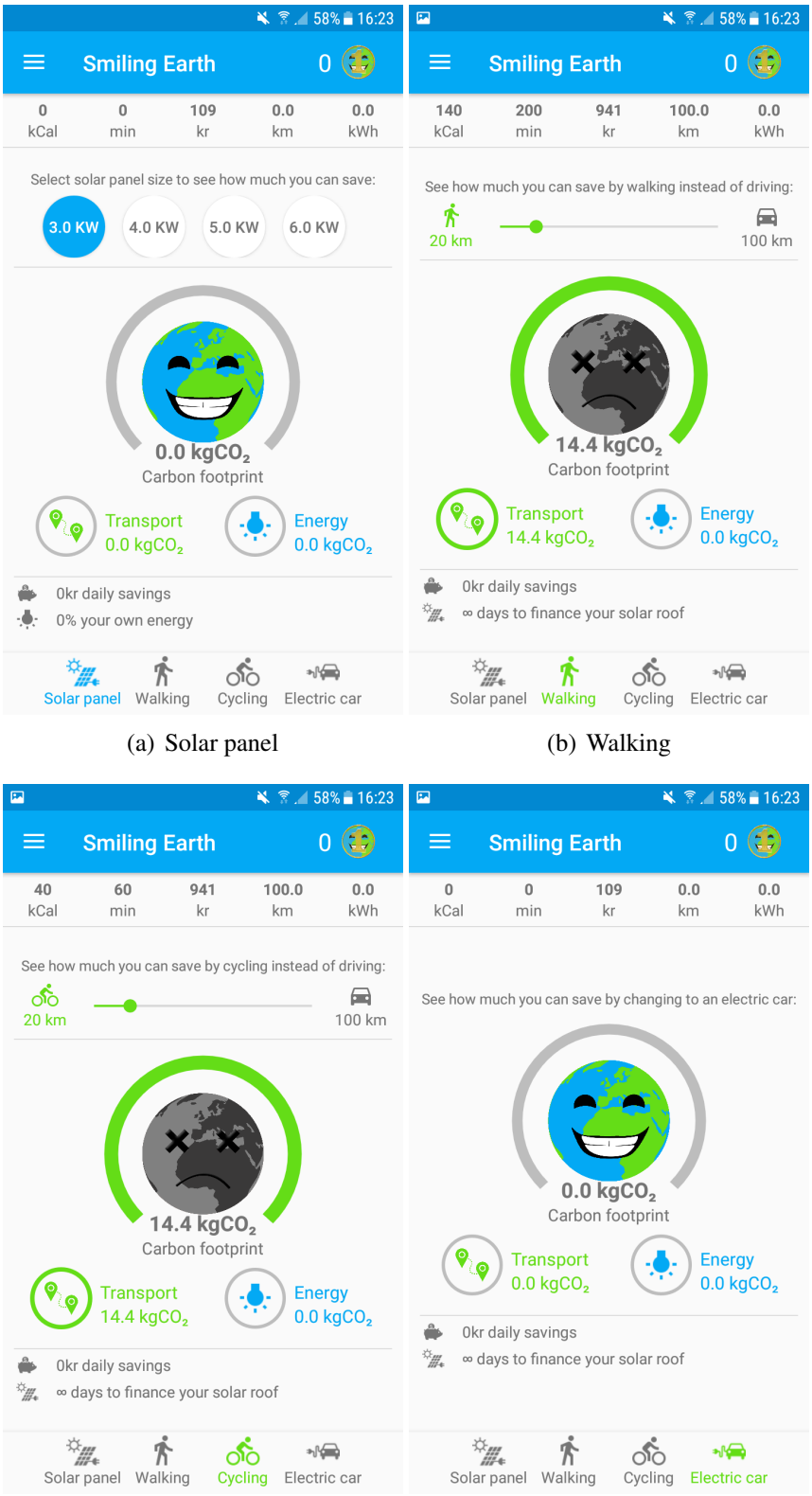
(a) (b)



(c)

H.4 Estimation

Figure H.5: Estimation



(a) Solar panel

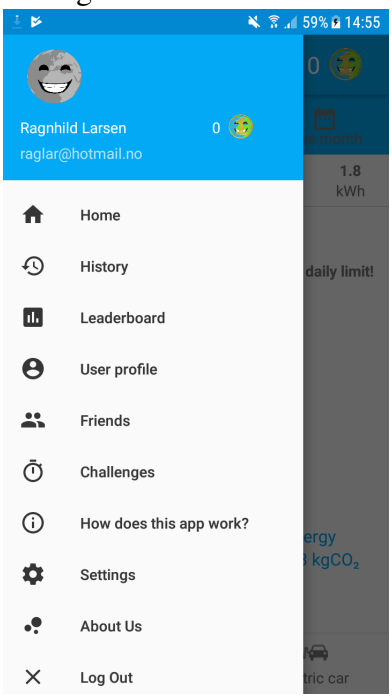
(b) Walking

(c) Cycling

(d) Electric car

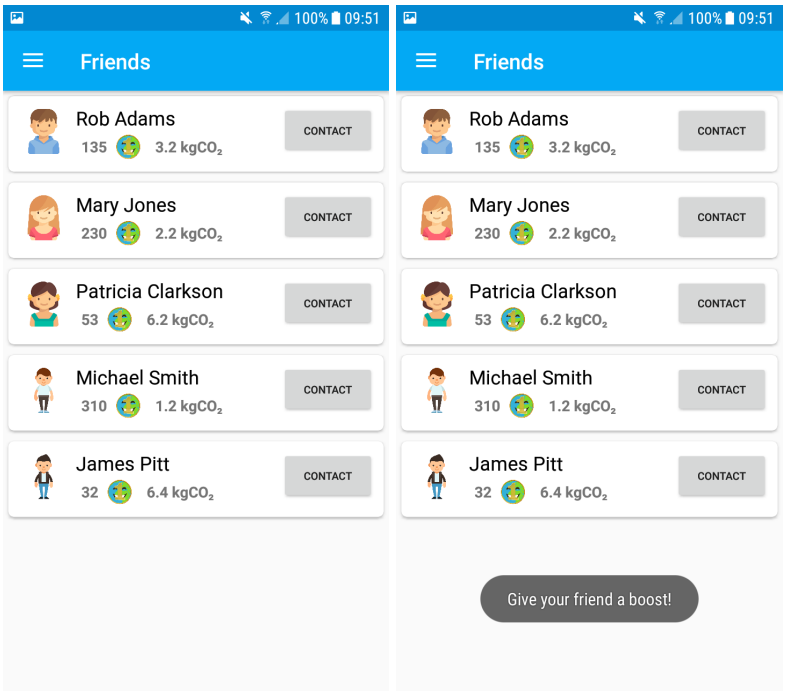
H.5 Side Menu

Figure H.6: Side menu



H.6 Friends

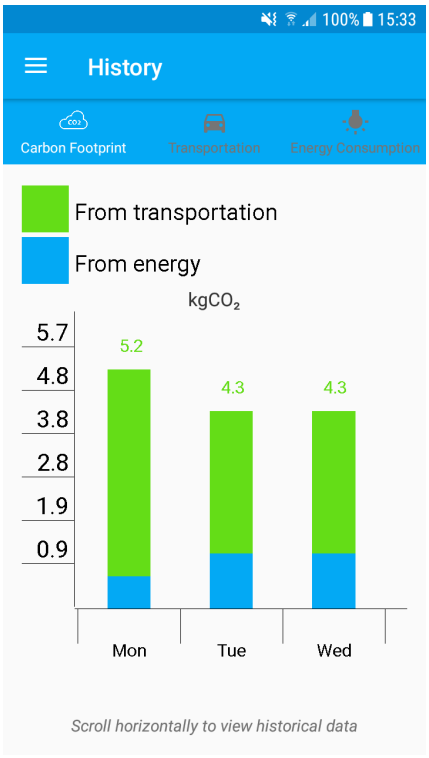
Figure H.7: Friends



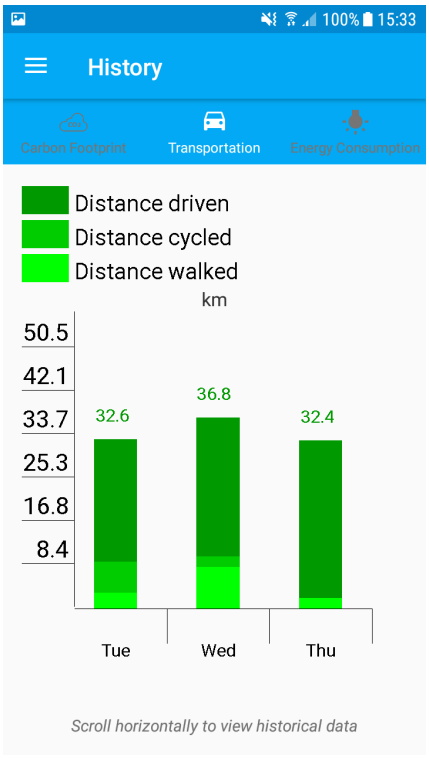
(a) (b)

H.7 History

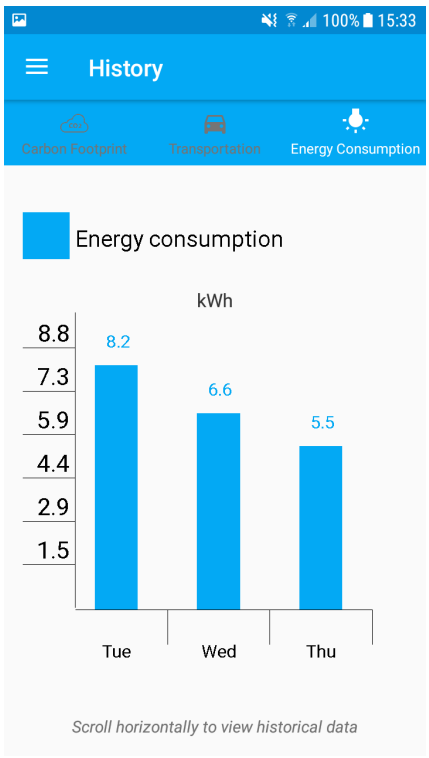
Figure H.8: History



(a) Carbon footprint



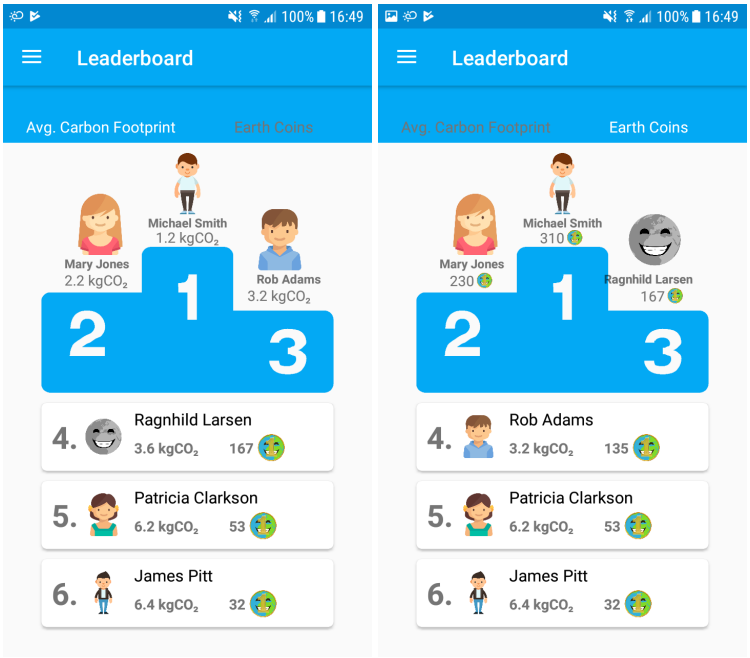
(b) Transportation



(c) Energy consumption

H.8 Leaderboard

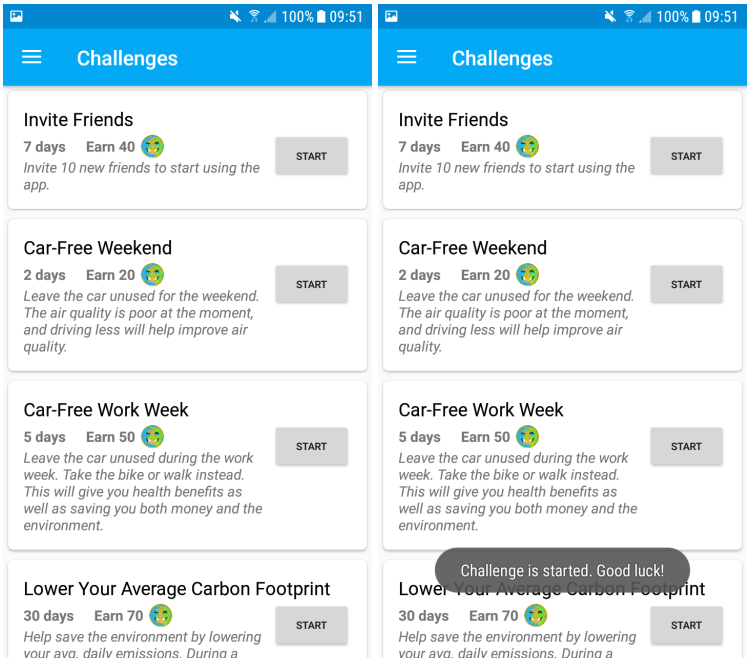
Figure H.9: Leaderboard



(a) Lowest avg. carbon footprint (b) Most Earth Coins

H.9 Challenges

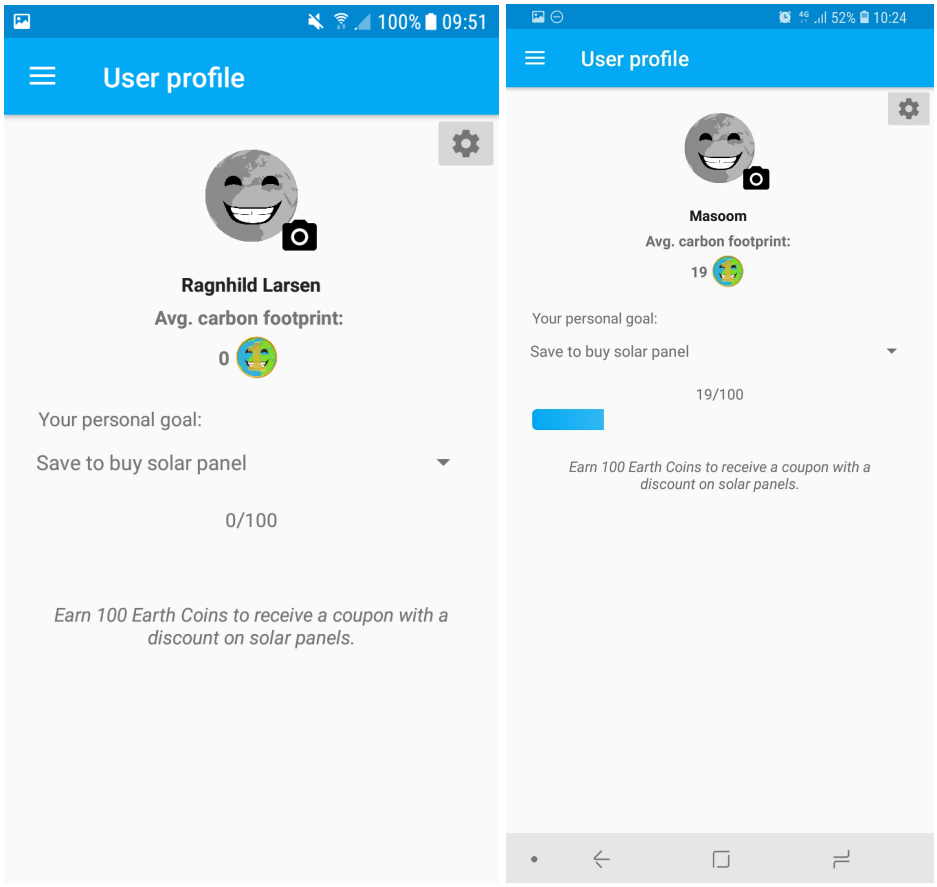
Figure H.10: Call to arms/Challenges



(a) (b)

H.10 User profile

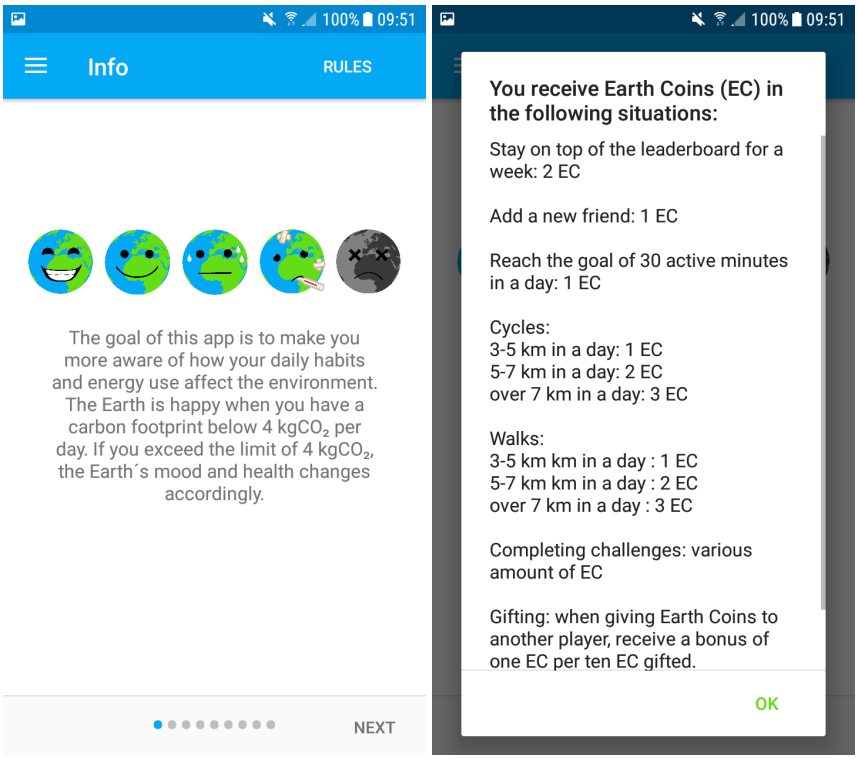
Figure H.11: User profile



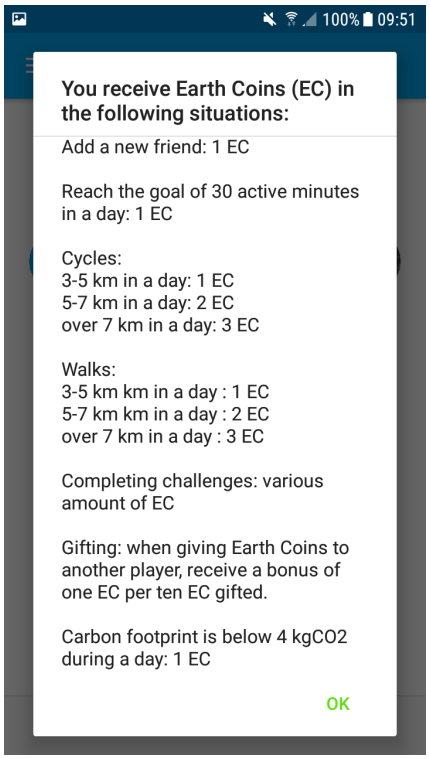
(a) Android Version 7.0 (b) Android Version 8.0

H.11 How to

Figure H.12: How does this app work



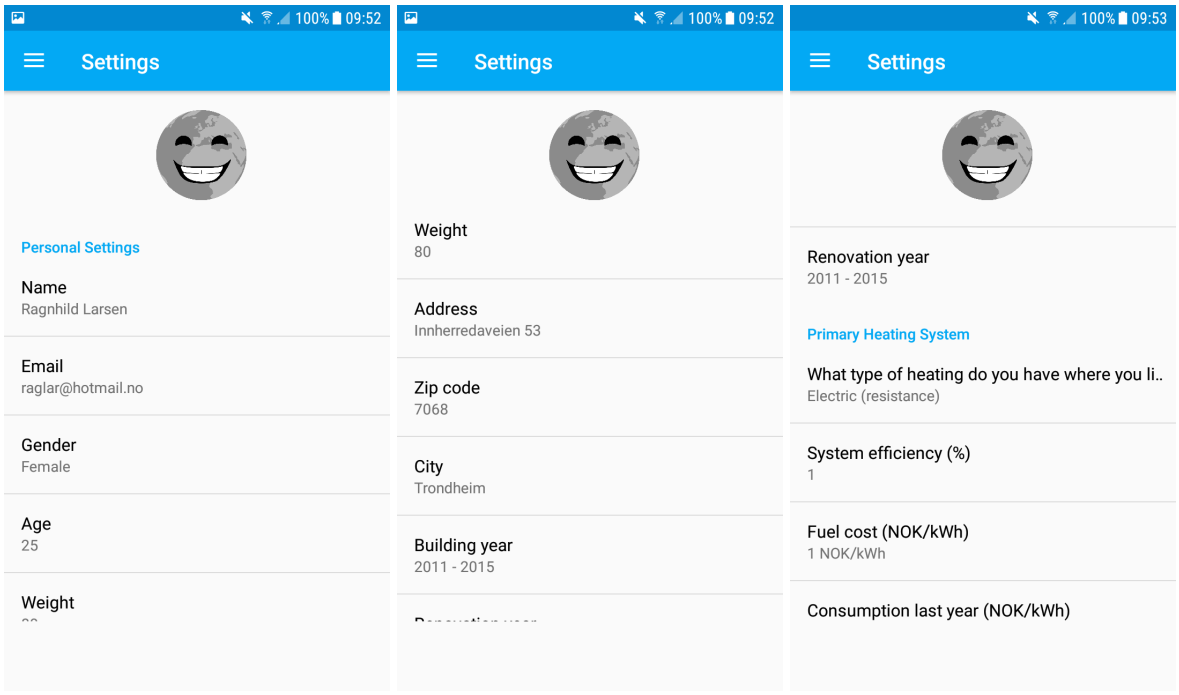
(a) (b)



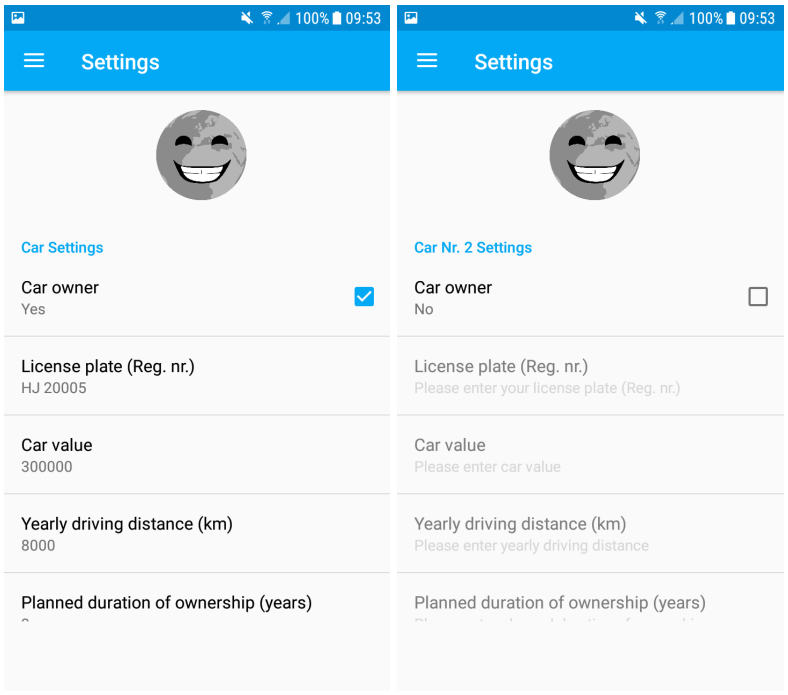
(c)

H.12 Settings

Figure H.13: Settings



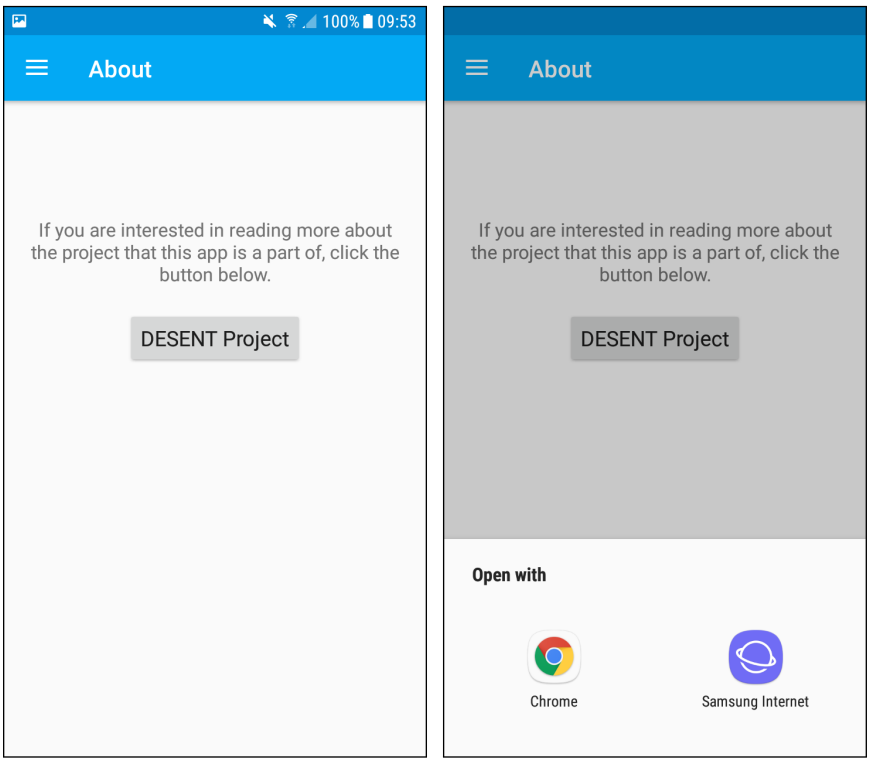
(a) (b) (c)



(d) (e)

H.13 About Us

Figure H.14: About us activity



(a) (b)

(c)

Appendix I

Pre-Intervention Questionnaire

I.1 Questionnaire

Q1. How old are you? *

- ○ Under 18 years old
- ○ 18-24 years old
- ○ 25-34 years old
- ○ 35-44 years old
- ○ 45-54 years old
- ○ 55-64 years old
- ○ 65-74 years old
- ○ 75 years or older

Q2. Please select the option(s) that is suitable for you: *

- ☐ I own a car
- ☐ I have easy access to someone else's car
- ☐ I do not have access to a car
- ☐ Andre: _____

Q3. Which means of transportation do you usually use in everyday commute? *

- ☐ Car
- ☐ Bicycle
- ☐ Walk
- ☐ Public transportation (bus, train, etc.)
- ☐ Andre: _____

Q4. I am very concerned about the environment. *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q5. I am a very environmentally conscious (miljøbevisst) person. *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q6. I have some habits in my everyday life that could be changed to be more environmentally friendly. *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q7. Name some habits you have that could change to be more environmentally friendly: *

For example: Drive less car, use less electricity, eat less meat, recycle, reduce waste...

Svaret ditt

I.2 Results

Pre-Intervention Questionnaire

Nr	Question/Statement	R1	R2	R3	R4	R5	Avg.
Q1	How old are you?	18-24 years old	18-24 years old	18-24 years old	25-34 years old	25-34 years old	
Q2	Please select the option(s) that is suitable for you:	I do not have access to a car	I do not have access to a car	I do not have access to a car	I do not have access to a car	I do not have access to a car	
Q3	Which means of transportation do you usually use in everyday commute?	Bicycle, Walk	Bicycle, Walk	Bicycle	Bicycle, Walk	Public transportation (bus, train, etc.)	
Q4	I am very concerned about the environment	Strongly agree 4	Strongly agree 4	Agree 3	Agree 3	Neutral 2	Agree 3,2
Q5	I am a very environmentally conscious (miljøbevisst) person.	Agree 3	Strongly agree 4	Strongly agree 4	Agree 3	Neutral 2	Agree 3,2
Q6	I have some habits in my everyday life that could be changed to be more environmentally friendly	Agree 3	Agree 3	Disagree 1	Strongly agree 4	Agree 3	Agree 2,8
Q7	Name some habits you have that could change to be more environmentally friendly:	Fly less, buy more local food, use less electricity	Eat less meat, recycle, bicycle more instead of bus	Eat less meat	Less waste, use less electricity, travel less	Use less electricity & recycle more	

Appendix J

Post-Intervention Questionnaire

J.1 Questionnaire

Figure J.1: Smiling Earth's behavior change model

Q1. During the test period, I chose a different transportation means than I normally use to achieve better results in the app. *

For example: I normally drive my car to work, but during the test period I chose to take the bike to work to get a lower carbon footprint in the application.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q2. I was surprised by how much my daily activities were affecting the environment *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q3. Viewing the data visualized in the app made me want to make some changes to reduce my emissions *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q4. I would tell people I know about the app, so that they also become aware of their impact on the environment *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q5. After using the app, I am considering buying an electric car or solar panels in the future, to reduce my emissions *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q6. The app motivated me to change my behavior to a more sustainable one *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q7. My concern for the environment has increased after using the app *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Figure J.2: Smiling Earth's game mechanics

Q8. Choose one game mechanic from the list that motivated you the most: *

- ○ Earth Coins (Point system)
- ○ Personal goal and progress bar
- ○ Leaderboard
- ○ Challenges
- ○ Giving friends a gift/boost
- ○ None of them

Q9. Which of the game mechanics in the app did you find motivating? *

Select all the game mechanics you found motivating/fun

- ☐ Earth Coins (Point system)
- ☐ Personal goal and progress bar
- ☐ Leaderboard
- ☐ Challenges
- ☐ Giving friends a gift/boost
- ☐ None of them

Q10. Which of the game mechanics in the app did you NOT find motivating or fun at all? *

Select all the game mechanics you did not found motivating/fun

- ☐ Earth Coins (Point system)
- ☐ Personal goal and progress bar
- ☐ Leaderboard
- ☐ Challenges
- ☐ Giving friends a gift/boost
- ☐ None of them

Q11. The game mechanics motivated me to check the app *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q12. I was curious to see if I had gained any Earth Coins after a walk or a bike ride *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q13. I find the concept of connecting and competing with friends motivating *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Figure J.3: Smiling Earth's concept

Q14. I find the concept of the app interesting *

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
.	○	○	○	○	○

Q15. I understand clearly the purpose of the app *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q16. I find the link between energy, carbon footprint, activity and expenses motivating *

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
.	○	○	○	○	○

Q17. I am more curious about energy and environment after using the app *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q18. Did the app make you more aware of how your daily activities affect the environment? *

- ○ Yes
- ○ No
- ○ Maybe
- ○ Andre: _____

Q19. I find the earth metaphor engaging *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q20. The earth metaphors teaches well the impact of a high carbon footprint *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q21. I find estimation functionality for solar panel, electric car, walk, and bike ride motivating *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q22. I could be willing to share my data about electricity use, transportation and carbon footprint with other users *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Figure J.4: Smiling Earth's perceived usability and usefulness 1/5

Q23. I would consider recommending this app to people I know *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q24. I think I would use this app frequently *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q25. I find the app design attractive *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q26. I think the app was easy to use *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q27. I enjoyed using the app *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q28. I felt very confused when I used the app *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q29. I did not have enough knowledge to use the app *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q30. The welcome slides shown the first time I used the app was useful to get to know the app *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q31. I would imagine that most people would learn to use this app very quickly *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Figure J.5: Smiling Earth's perceived usability and usefulness 2/5

Q32. I think there is too much inconsistency in the app *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q33. I find the various functions in the app are well integrated *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q34. The following information is easy to find: *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Daily carbon footprint	○	○	○	○	○
Weekly/Monthly carbon footprint	○	○	○	○	○
Daily calories burnt	○	○	○	○	○
Daily active minutes	○	○	○	○	○
Daily expenses	○	○	○	○	○
Daily km driven	○	○	○	○	○
Daily energy consumption	○	○	○	○	○
Distribution between housing and transportation in carbon footprint	○	○	○	○	○
Changed values for carbon footprint/expenses/calories burnt when clicking on the estimation buttons	○	○	○	○	○
How many Earth Coins/Points you have	○	○	○	○	○
How your carbon footprint is compared to your friends	○	○	○	○	○
How long it is until you have reached your goal	○	○	○	○	○

Q35. The color code is clear and keep the same meaning in the whole app *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Figure J.6: Smiling Earth's perceived usability and usefulness 3/5

Q36. The following screens do not contain too much information *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Dashboard (Carbon footprint - Today)	○	○	○	○	○
Carbon footprint - Week	○	○	○	○	○
Carbon footprint - Month	○	○	○	○	○
History - Carbon footprint	○	○	○	○	○
History - Transportation	○	○	○	○	○
History - Energy consumption	○	○	○	○	○
Estimation - Solar panel	○	○	○	○	○
Estimation - Walk	○	○	○	○	○
Estimation - Cycle	○	○	○	○	○
Estimation - Electric car	○	○	○	○	○
Welcome slides	○	○	○	○	○
Sign up screens	○	○	○	○	○
Terms and conditions	○	○	○	○	○
Leaderboard - Lowest avg. carbon footprint	○	○	○	○	○
Leaderboard - Most Earth Coins	○	○	○	○	○
Friends	○	○	○	○	○
Settings	○	○	○	○	○
User profile	○	○	○	○	○
Challenges	○	○	○	○	○

Figure J.7: Smiling Earth's perceived usability and usefulness 4/5

Q37. The following screens had all the information I needed to understand them: *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Dashboard (Carbon footprint - Today)	○	○	○	○	○
Carbon footprint - Week	○	○	○	○	○
Carbon footprint - Month	○	○	○	○	○
History - Carbon footprint	○	○	○	○	○
History - Transportation	○	○	○	○	○
History - Energy consumption	○	○	○	○	○
Estimation - Solar panel	○	○	○	○	○
Estimation - Walk	○	○	○	○	○
Estimation - Cycle	○	○	○	○	○
Estimation - Electric car	○	○	○	○	○
Welcome slides	○	○	○	○	○
Sign up screens	○	○	○	○	○
Terms and conditions	○	○	○	○	○
Leaderboard - Lowest avg. carbon footprint	○	○	○	○	○
Leaderboard - Most Earth Coins	○	○	○	○	○
Friends	○	○	○	○	○
Settings	○	○	○	○	○
User profile	○	○	○	○	○
Challenges	○	○	○	○	○

Q38. I find the visualization of last weeks historical data useful *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q39. I viewed the historical graphs in the app during the test period *

- ○ Yes, several times a day
- ○ Yes, once a day
- ○ Yes, a few times during the test period
- ○ Yes, one time
- ○ I never viewed the graphs
- ○ Andre:

Figure J.8: Smiling Earth's perceived usability and usefulness 5/5

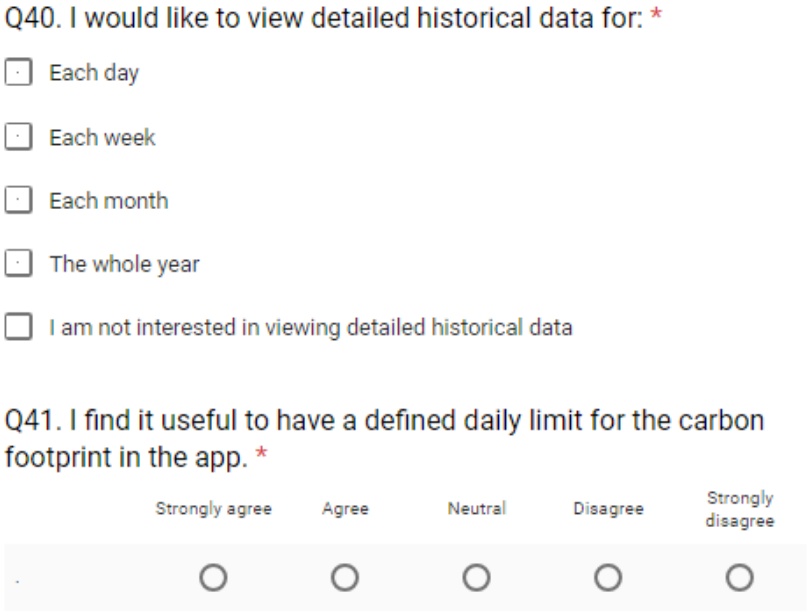


Figure J.9: Smiling Earth's functionality

Q42. I would trust the numeric values provided by the app *

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
.	○	○	○	○	○

Q43. During the test period, did you experience that the app tracked the wrong activity (walk/cycle/drive)? *

- ○ Yes, many times
- ○ Yes, a few times
- ○ No
- ○ Not sure
- ○ Andre: _____

Q44. This app does not require any self-reporting, but the accuracy of the data tracked might be low. Would you rather report manually the trips you take or do you think the ease of use is more important than accurate tracking data? *

- ○ I would rather report manually after e.g., driving a distance
- ○ I think it should be possible to edit a trip after it has been completed so it is possible to correct the app if the tracking was wrong
- ○ No, it is more important that the app tracks automatically than having completely accurate data
- ○ Andre: _____

Q45. Did you find any bugs in the app during the test period?

Svaret ditt

Q46. Do you think you would like to use this app? *

- ○ Yes
- ○ No
- ○ Maybe

Q47. Why would you/why would you not like to use this app? *

Svaret ditt

Q48. What would you like to change about the app? (What did you like the least?) *

Svaret ditt

Q49. Do you have any other feedback that you think could be useful for the further development of the app?

Svaret ditt

J.2 Results

Post-Intervention Questionnaire

Nr	Question/Statement	R1	R2	R3	R4	R5	Avg.
Smiling Earth's behavior change model							
Q1	During the test period, I chose a different transportation means than I normally use to achieve better results in the app.	Strongly disagree 0	Strongly disagree 0	Strongly disagree 0	Strongly disagree 0	Disagree 1	Strongly disagree 0,2
Q2	I was surprised by how much my daily activities were affecting the environment	Strongly disagree 0	Strongly disagree 0	Strongly disagree 0	Neutral 2	Agree 3	Disagree 1
Q3	Viewing the data visualized in the app made me want to make some changes to reduce my emissions	Disagree 1	Agree 3	Disagree 1	Agree 3	Disagree 1	Neutral 1,8
Q4	I would tell people I know about the app, so that they also become aware of their impact on the environment	Neutral 2	Agree 3	Agree 3	Strongly agree 4	Agree 3	Agree 3
Q5	After using the app, I am considering buying an electric car or solar panels in the future, to reduce my emissions	Disagree 1	Neutral 2	Neutral 2	Agree 3	Disagree 1	Neutral 1,8
Q6	The app motivated me to change my behavior to a more sustainable one	Neutral 2	Agree 3	Agree 3	Agree 3	Disagree 1	Neutral 2,4
Q7	My concern for the environment has increased after using the app	Disagree 1	Neutral 2	Agree 3	Neutral 2	Disagree 1	Neutral 1,8

Nr	Question/Statement	R1	R2	R3	R4	R5	Avg.
Smiling Earth's game mechanics							
Q8	Choose one game mechanic from the list that motivated you the most:	Earth Coins (Point system)	Earth Coins (Point system)	Earth Coins (Point system)	Challenges	Earth Coins (Point system)	
Q9	Which of the game mechanics in the app did you find motivating?	Earth Coins (Point system) Leaderboard Challenges	Earth Coins (Point system) Personal goal and progress bar Leaderboard Challenges Giving friends a gift/boost	Personal goal and progress bar	Earth Coins (Point system) Personal goal and progress bar Leaderboard Challenges Giving friends a gift/boost	Earth Coins (Point system) Personal goal and progress bar Leaderboard	
Q10	Which of the game mechanics in the app did you NOT find motivating or fun at all?	Giving friends a gift/boost	None of them	Giving friends a gift/boost	None of them	None of them	
Q11	The game mechanics motivated me to check the app	Agree 3	Agree 3	Neutral 2	Agree 3	Agree 3	Agree 2,8
Q12	I was curious to see if I had gained any Earth Coins after a walk or a bike ride	Strongly agree 4	Strongly agree 4	Agree 3	Strongly agree 4	Neutral 2	Agree 3,4
Q13	I find the concept of connecting and competing with friends motivating	Strongly agree 4	Strongly agree 4	Agree 3	Strongly agree 4	Agree 3	Strongly agree 3,6

Nr	Question/Statement	R1	R2	R3	R4	R5	Avg.
Smiling Earth's concept							
Q14	I find the concept of the app interesting	Agree 3	Agree 3	Disagree 1	Strongly agree 4	Strongly agree 4	Agree 3
Q15	I understand clearly the purpose of the app	Agree 3	Strongly agree 4	Agree 3	Strongly agree 4	Strongly agree 4	Strongly agree 3,6
Q16	I find the link between energy, carbon footprint, activity and expenses motivating	Strongly agree 4	Agree 3	Disagree 1	Agree 3	Agree 3	Agree 2,8
Q17	I am more curious about energy and environment after using the app	Neutral 2	Agree 3	Neutral 2	Neutral 2	Disagree 1	Neutral 2
Q18	Did the app make you more aware of how your daily activities affect the environment?	Yes	Maybe	Maybe	Maybe	Yes	
Q19	I find the earth metaphor engaging	Agree 3	Agree 3	Agree 3	Disagree 1	Neutral 2	Neutral 2,4
Q20	The earth metaphors teaches well the impact of a high carbon footprint	Agree 3	Agree 3	Agree 3	Neutral 2	Agree 3	Agree 2,8
Q21	I find estimation functionality for solar panel, electric car, walk, and bike ride motivating	Agree 3	Agree 3	Agree 3	Agree 3	Disagree 1	Agree 2,6
Q22	I could be willing to share my data about electricity use, transportation and carbon footprint with other users	Agree 3	Agree 3	Agree 3	Agree 3	Agree 3	Agree 3

Nr	Question/Statement	R1	R2	R3	R4	R5	Avg.
Smiling Earth's perceived usability and usefulness							
Q23	I would consider recommending this app to people I know	Agree 3	Agree 3	Agree 3	Strongly agree 4	Agree 3	Agree 3,2
Q24	I think I would use this app frequently	Neutral 2	Agree 3	Agree 3	Strongly agree 4	Disagree 1	Agree 2,6
Q25	I find the app design attractive	Agree 3	Strongly agree 4	Neutral 2	Agree 3	Neutral 2	Agree 2,8
Q26	I think the app was easy to use	Agree 3	Agree 3	Agree 3	Agree 3	Agree 3	Agree 3
Q27	I enjoyed using the app	Agree 3	Agree 3	Agree 3	Agree 3	Neutral 2	Agree 2,8
Q28	I felt very confused when I used the app	Disagree 1	Disagree 1	Disagree 1	Neutral 2	Disagree 1	Disagree 1,2
Q29	I did not have enough knowledge to use the app	Disagree 1	Strongly disagree 0	Disagree 1	Neutral 2	Disagree 1	Disagree 1
Q30	The welcome slides shown the first time I used the app was useful to get to know the app	Strongly agree 4	Strongly agree 4	Agree 3	Agree 3	Strongly agree 4	Strongly agree 3,6
Q31	I would imagine that most people would learn to use this app very quickly	Agree 3	Strongly agree 4	Agree 3	Agree 3	Agree 3	Agree 3,2
Q32	I think there is too much inconsistency in the app	Disagree 1	Strongly disagree 0	Neutral 2	Disagree 1	Neutral 2	Disagree 1,2
Q33	I find the various functions in the app are well integrated	Agree 3	Agree 3	Agree 3	Agree 3	Agree 3	Agree 2,6
Q34	The following information is easy to find:						
	[Daily carbon footprint]	Strongly agree 4	Strongly agree 4	Agree 3	Strongly agree 4	Strongly agree 4	Strongly agree 3,8

Nr	Question/Statement	R1	R2	R3	R4	R5	Avg.
Q34	The following information is easy to find:						
	[Weekly/Monthly carbon footprint]	Strongly agree 4	Strongly agree 4	Agree 3	Strongly agree 4	Strongly agree 4	Strongly agree 3,8
	[Daily calories burnt]	Agree 3	Agree 3	Agree 3	Strongly agree 4	Strongly agree 4	Agree 3,4
	[Daily active minutes]	Agree 3	Agree 3	Agree 3	Strongly agree 4	Strongly agree 4	Agree 3,4
	[Daily expenses]	Agree 3	Agree 3	Agree 3	Strongly agree 4	Strongly agree 4	Strongly agree 3,4
	[Daily km driven]	Strongly agree 4	Agree 3	Agree 3	Strongly agree 4	Strongly agree 4	Strongly agree 3,6
	[Daily energy consumption]	Strongly agree 4	Agree 3	Agree 3	Strongly agree 4	Strongly agree 4	Strongly agree 3,6
	[Distribution between housing and transportation in carbon footprint]	Agree 3	Strongly agree 4	Agree 3	Strongly agree 4	Agree 3	Agree 3,4
	[Changed values for carbon footprint/expenses/calories burnt when clicking on the estimation buttons]	Agree 3	Agree 3	Strongly agree 4	Strongly agree 4	Disagree 1	Agree 3
	[How many Earth Coins/Points you have]	Strongly agree 4	Strongly agree 4	Strongly agree 4	Strongly agree 4	Strongly agree 4	Strongly agree 4
	[How your carbon footprint is compared to your friends]	Agree 3	Strongly agree 4	Agree 3	Strongly agree 4	Agree 3	Agree 3,4
	[How long it is until you have reached your goal]	Neutral 2	Agree 3	Agree 3	Strongly agree 4	Strongly agree 4	Agree 3,2

Nr	Question/Statement	R1	R2	R3	R4	R5	Avg.
Q35	The color code is clear and keep the same meaning in the whole app	Strongly agree 4	Strongly agree 4	Agree 3	Agree 3	Strongly agree 4	Strongly agree 3,6
Q36	The following screens do not contain too much information						
	[Dashboard (Carbon footprint - Today)]	Strongly agree 4	Agree 3	Agree 3	Agree 3	Disagree 1	Agree 2,8
	[Carbon footprint - Week]	Strongly agree 4	Agree 3	Agree 3	Agree 3	Disagree 1	Agree 2,8
	[Carbon footprint - Month]	Strongly agree 4	Agree 3	Agree 3	Agree 3	Disagree 1	Agree 2,8
	[History - Carbon footprint]	Strongly agree 4	Strongly agree 4	Agree 3	Agree 3	Agree 3	Agree 3,4
	[History - Transportation]	Strongly agree 4	Strongly agree 4	Agree 3	Agree 3	Agree 3	Agree 3,4
	[History - Energy consumption]	Strongly agree 4	Strongly agree 4	Strongly agree 4	Agree 3	Agree 3	Strongly agree 3,6
	[Estimation - Solar panel]	Agree 3	Agree 3	Strongly agree 4	Disagree 1	Agree 3	Agree 2,8
	[Estimation - Walk]	Strongly agree 4	Agree 3	Strongly agree 4	Disagree 1	Agree 3	Agree 3
	[Estimation - Cycle]	Strongly agree 4	Agree 3	Strongly agree 4	Disagree 1	Agree 3	Agree 3
	[Estimation - Electric car]	Strongly agree 4	Agree 3	Neutral 2	Disagree 1	Agree 3	Agree 2,6
	[Welcome slides]	Strongly agree 4	Strongly agree 4	Agree 3	Strongly agree 4	Strongly agree 4	Strongly agree 3,8

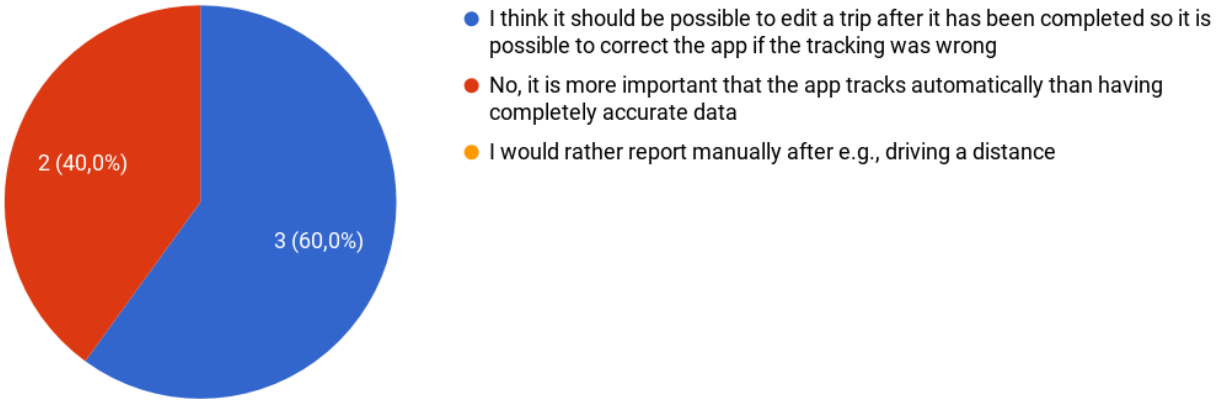
Nr	Question/Statement	R1	R2	R3	R4	R5	Avg.
Q36	The following screens do not contain too much information						
	[Sign up screens]	Agree 3	Agree 3	Disagree 1	Strongly agree 4	Strongly agree 4	Agree 3
	[Terms and conditions]	Agree 3	Strongly agree 4	Neutral 2	Strongly agree 4	Strongly agree 4	Agree 3,4
	[Leaderboard - Lowest avg. carbon footprint]	Strongly agree 4	Strongly agree 4	Agree 3	Strongly agree 4	Strongly agree 4	Strongly agree 3,8
	[Leaderboard - Most Earth Coins]	Strongly agree 4	Strongly agree 4	Agree 3	Strongly agree 4	Strongly agree 4	Strongly agree 3,8
	[Friends]	Strongly agree 4	Strongly agree 4	Agree 3	Strongly agree 4	Strongly agree 4	Strongly agree 3,8
	[Settings]	Neutral 2	Neutral 2	Strongly agree 4	Strongly agree 4	Strongly agree 4	Agree 3,2
	[User profile]	Neutral 2	Strongly agree 4	Strongly agree 4	Strongly agree 4	Strongly agree 4	Strongly agree 3,6
	[Challenges]	Agree 3	Strongly agree 4	Agree 3	Strongly agree 4	Agree 3	Agree 3,4
Q37	The following screens had all the information I needed to understand them:						
	[Dashboard (Carbon footprint - Today)]	Strongly agree 4	Agree 3	Agree 3	Neutral 2	Agree 3	Agree 3
	[Carbon footprint - Week]	Strongly agree 4	Agree 3	Agree 3	Neutral 2	Agree 3	Agree 3
	[Carbon footprint - Month]	Strongly agree 4	Agree 3	Agree 3	Neutral 2	Agree 3	Agree 3
	[History - Carbon footprint]	Strongly agree 4	Agree 3	Agree 3	Neutral 2	Agree 3	Agree 3

Nr	Question/Statement	R1	R2	R3	R4	R5	Avg.
Q37	The following screens had all the information I needed to understand them:						
	[History - Transportation]	Strongly agree 4	Agree 3	Agree 3	Strongly agree 4	Agree 3	Agree 3,4
	[History - Energy consumption]	Strongly agree 4	Agree 3	Agree 3	Strongly agree 4	Agree 3	Agree 3,4
	[Estimation - Solar panel]	Neutral 2	Agree 3	Agree 3	Strongly agree 4	Agree 3	Agree 3
	[Estimation - Walk]	Agree 3	Agree 3	Agree 3	Agree 3	Agree 3	Agree 3
	[Estimation - Cycle]	Agree 3	Agree 3	Agree 3	Agree 3	Agree 3	Agree 3
	[Estimation - Electric car]	Neutral 2	Agree 3	Agree 3	Agree 3	Agree 3	Agree 2,8
	[Welcome slides]	Strongly agree 4	Strongly agree 4	Agree 3	Strongly agree 4	Agree 3	Strongly agree 3,6
	[Sign up screens]	Strongly agree 4	Strongly agree 4	Agree 3	Strongly agree 4	Agree 3	Strongly agree 3,6
	[Terms and conditions]	Strongly agree 4	Strongly agree 4	Agree 3	Strongly agree 4	Agree 3	Strongly agree 3,6
	[Leaderboard - Lowest avg. carbon footprint]	Strongly agree 4	Strongly agree 4	Agree 3	Strongly agree 4	Agree 3	Strongly agree 3,6
	[Leaderboard - Most Earth Coins]	Strongly agree 4	Strongly agree 4	Agree 3	Strongly agree 4	Agree 3	Strongly agree 3,6
	[Friends]	Strongly agree 4	Strongly agree 4	Agree 3	Strongly agree 4	Agree 3	Strongly agree 3,6
	[Settings]	Strongly agree 4	Strongly agree 4	Agree 3	Strongly agree 4	Agree 3	Strongly agree 3,6

Nr	Question/Statement	R1	R2	R3	R4	R5	Avg.
Q37	The following screens had all the information I needed to understand them:						
	[User profile]	Neutral 2	Strongly agree 4	Agree 3	Strongly agree 4	Agree 3	Agree 3,2
	[Challenges]	Strongly agree 4	Strongly agree 4	Agree 3	Strongly agree 4	Agree 3	Strongly agree 3,6
Q38	I find the visualization of last weeks historical data useful	Agree 3	Strongly agree 4	Agree 3	Strongly agree 4	Agree 3	Agree 3,4
Q39	I viewed the historical graphs in the app during the test period	Yes, several times a day	Yes, once a day	Yes, a few times during the test period	Yes, several times a day	Yes, one time	
Q40	I would like to view detailed historical data for:	Each week	Each week, Each month	Each week	Each day, Each week, Each month, The whole year	Each month, The whole year	
Q41	I find it useful to have a defined daily limit for the carbon footprint in the app.	Agree 3	Agree 3	Agree 3	Agree 3	Agree 3	Agree 3

Nr	Question/Statement	R1	R2	R3	R4	R5	Avg.
Smiling Earth's functionality							
Q42	I would trust the numeric values provided by the app	Agree 3	Strongly agree 4	Strongly disagree 0	Disagree 1	Agree 3	Neutral 2,2
Q43	During the test period, did you experience that the app tracked the wrong activity (walk/cycle/drive)?	Yes, many times	Yes, a few times	Yes, many times	Yes, a few times	Yes, a few times	

Q44. This app does not require any self-reporting, but the accuracy of the data tracked might be low.
Would you rather report manually the trips you take or do you think the ease of use is more important than accurate tracking data?



Q45: Did you find any bugs in the app during the test period?

- R1: Could not view user profile. Also, it only tracked transportation for 1 day.
- R2: Noen ganger krasjet den hvis man trykket tilbake noen ganger. Dashboard-skjermen klikket av og til når man trykket på den. Måtte åpne appen for å sette i gang trackingen.
- R3: Yes the app did not track when i used my bike or walked for a long distance
- R4: GPS tracking, but maybe not a bug?
- R5: The app would crash at random times, nothing other than that

Q46 & Q47: Do you think you would like to use this app? Why would you/why would you not like to use this app?

- R1: Maybe, I would like to use it if it actually tracked my transportation. I did not understand exactly how the electricity was calculations worked, since it was different each day.
- R2: Yes, Synes det hadde vært kult å tracke aktivitetene mine for å se hvordan det påvirker miljøet. Ville motivert meg til å sykle istedenfor å ta buss feks.
  R3: Yes, fordi det er en hjelpfull app slik at man kan bli mer miljøbeviste
- R4: Yes, I experience the concept of energy use very abstract and hard to measure in my daily habits. At the same time I would like to live a more environmentally friendly lifestyle, and therefore it is

nice to be able to get automatic calculations. It is also fun to compete with friends and oneself. In addition it is motivational that one can earn credits.
- R5: No, Seems like to much of a hassle to keep the running at all times. I'm not really that interested in my carbon footprint either, which is the more prominent reason.

Q48. What would you like to change about the app? (What did you like the least?)
- R1: The challenges and leaderboard were not very helpful now since my "friends" were not real, but I think it would be very motivating if it were actual friends.
- R2: Litt liten og mye tekst på noen av skjermbildene som gjorde at fokuset gikk vekk fra det og havnet mest på jordkloden i midten. Hadde vært fint å se hele uken i historien uten å måtte bla for å sammenligne dagene enklere.
- R3: ha en enda enklere layout
- R4: It is very important that the tracked data is precise in order to trust the rest of the calculations in the app. It would also be nice to have a description of how the calculations was done to gain trust.
- R5: I would prefer it to have less functionality, it seems very complicated at the moment and it feels like it is trying to solve to many problems. A simpler carbon footprint tracking app would be more pleasant to use.

Q49. Do you have any other feedback that you think could be useful for the further development of the app?
- R1: Good work! Can't think of anything in particular, but maybe it could be useful to get a notification when you're getting close to your weekly limit so you can make some changes and for example take the bike the rest of the week.
- R2: Kanskje gjøre dashboardet enklere, er veldig mye funksjoner derfra! Estimering for å se hvor mye man kan spare kunne kanskje vært en egen fane/aktivitet? Var heller ikke helt intuitivt at jeg måtte trykke på "Solar panel" igjen for å komme tilbake (hvis jeg ikke brukte tilbake-knappen da)
- R4: When opening the estimation features it does not feel too obvious that this is a different "mode" as the screens looks quite similar as the home screen. Maybe the active button could be even clearer, like "pushed down", or background color could change? I don't know if this is any better though. The title at the home dashboard could maybe be removed to reduce the information at this page even further, even though it is not that much.

J.3 Comparison

Smiling Earth's game mechanics

Table J.1: Avg. values from four evaluations - Game mechanics

ID	Question/Statement	V1	V2	Prototype	V3
Q13	I find the concept of connecting and competing with friends motivating	-	-	3,2	3,6

Smiling Earth's concept

Table J.2: Avg. values from four evaluations- Concept

ID	Question/Statement	V1	V2	Prototype	V3
Q14	I find the concept of the app interesting	4	4	3,4	3,0
Q15	I understand clearly the purpose of the app	2,5	2,4	3,6	3,6
Q16	I find the link between energy, carbon footprint, activity and expenses motivating	3,0	3,0	3,4	2,8
Q17	I am more curious about energy and environment after using the app	2,8	2,6	3,0	2,0
Q19	I find the earth metaphor engaging	3,0	1,8	3,2	2,4
Q20	The earth metaphors teaches well the impact of a high carbon footprint	2,8	1,8	3,2	2,4
Q21	I find estimation functionality for solar panel, electric car, walk, and bike ride motivating	2,5	2,2	3,4	2,8
Q22	I could be willing to share my data about electricity use, transportation and carbon footprint with other users	-	2,4	3,0	3,0

Smiling Earth's perceived usability and usefulness

Table J.3: Avg. values from four evaluations - Usability

ID	Question/Statement	V1	V2	Prototype	V3
Q23	I would consider recommending this app to people I know	2,3	2,6	3,4	3,2
Q24	I think I would use this app frequently	2,8	1,8	2,6	2,8
Q25	I find the app design attractive	3,0	2,0	3,2	2,8
Q26	I think the app was easy to use	1,0	1,2	2,8	3,0
Q27	I enjoyed using the app	2,3	2,2	2,8	2,8
Q28	I felt very confused when I used the app	0,8	2,8	1,0	1,2
Q29	I did not have enough knowledge to use the app	2,0	1,8	1,0	1,0
Q30	The welcome slides shown the first time I used the app was useful to get to know the app	-	-	3,4	3,6
Q31	I would imagine that most people would learn to use this app very quickly	0,8	2,0	1,8	3,2
Q32	I think there is too much inconsistency in the app	0,8	1,4	1,2	1,2
Q33	I find the various functions in the app are well integrated	1,5	1,8	2,6	2,6
Q34	The following information is easy to find				
	[Daily carbon footprint]	3,0	3,2	3,8	3,8
	[Weekly/Monthly carbon footprint]	3,0	2,4	3,8	3,8
	[Daily calories burnt]	3,0	3,4	2,8	3,4
	[Daily active minutes]	-	-	2,8	3,4
	[Daily expenses]	3,0	2,6	2,8	3,4
	[Daily km driven]	3,0	3,4	2,8	3,6
	[Daily energy consumption]	3,0	3,0	2,8	3,6
	[Distribution between housing and transportation in carbon footprint]	3,0	2,4	3,4	3,4
	[Changed values for carbon footprint/expenses/calories burnt when clicking on the estimation buttons]	3,0	2,8	3,2	3,0
	[How many Earth Coins/Points you have]	-	-	3,8	4,0
	[How your carbon footprint is compared to your friends]	-	-	3,4	3,4
	[How long it is until you have reached your goal]	-	-	3,6	3,2

Table continues on next page

Table J.3: Avg. values from four evaluations - Usability

ID	Question/Statement	V1	V2	Prototype	V3
Q35	The color code is clear and keep the same meaning in the whole app	1,0	3,4	2,6	3,6
Q36	The following screens do not contain too much information				
	[Dashboard (Carbon footprint - Today)]	2,0	2,2	1,8	2,8
	[Carbon footprint - Week]	3,0	2,0	3,2	2,8
	[Carbon footprint - Month]	3,0	1,8	3,2	2,8
	[History - Carbon footprint]	-	2,0	3,4	3,4
	[History - Transportation]	-	2,0	3,4	3,4
	[History - Energy consumption]	-	2,0	3,4	3,6
	[Estimation - Solar panel]	-	1,6	1,6	2,8
	[Estimation - Walk]	-	1,6	2,4	3,0
	[Estimation - Cycle]	-	1,6	2,4	3,0
	[Estimation - Electric car]	-	1,8	2,0	2,6
	[Welcome slides]	-	-	3,2	3,8
	[Sign up screens]	-	-	4,0	3,0
	[Terms and conditions]	-	-	2,8	3,4
	[Leaderboard - Lowest avg. carbon footprint]	-	-	2,8	3,8
	[Leaderboard - Most Earth Coins]	-	-	2,8	3,8
	[Friends]	-	-	3,6	3,8
	[Settings]	-	-	3,6	3,2
	[User profile]	-	-	3,4	3,2
	[Challenges]	-	-	-	3,4
Q37	The following screens had all the information I needed to understand them:				
	[Dashboard (Carbon footprint - Today)]	3,0	1,8	3,0	3,0
	[Carbon footprint - Week]	3,0	1,6	3,4	3,0
	[Carbon footprint - Month]	4,0	1,6	3,4	3,0
	[History - Carbon footprint]	3,0	1,2	3,2	3,0
	[History - Transportation]	-	1,0	3,0	3,4
	[History - Energy consumption]	-	1,8	3,0	3,4
	[Estimation - Solar panel]	-	1,8	1,8	3,0
	[Estimation - Walk]	-	1,4	3,2	3,0

Table continues on next page

Table J.3: Avg. values from four evaluations - Usability

ID	Question/Statement	V1	V2	Prototype	V3
	[Estimation - Cycle]	-	1,4	3,2	3,0
	[Estimation - Electric car]	-	1,2	3,0	2,8
	[Welcome slides]	-	-	3,6	3,6
	[Sign up screens]	-	-	3,2	3,6
	[Terms and conditions]	-	-	3,4	3,6
	[Leaderboard - Lowest avg. carbon footprint]	-	-	3,2	3,6
	[Leaderboard - Most Earth Coins]	-	-	3,2	3,6
	[Friends]	-	-	3,4	3,6
	[Settings]	-	-	3,0	3,6
	[User profile]	-	-	1,8	3,2
	[Challenges]	-	-	-	3,6
Q38	I find the visualization of last weeks historical data useful	-	-	3,4	3,0
Q41	I find it useful to have a defined daily limit for the carbon footprint in the app	3,3	2,6	2,8	3,0

Smiling Earth's functionality

Table J.4: Avg. values from four evaluations - Functionality

ID	Question/Statement	V1	V2	Prototype	V3
Q42	I would trust the numeric values provided by the app	2,3	2,2	3,2	2,2

Appendix K

Unfulfilled Requirements

Goal setting and feedback

ID	Requirement	Priority	Fulfilled?
FR1	The app shall provide personalized goals	Medium	✓
FR2	The app should provide daily challenges to lower the user's gas emissions	Low	✓
FR3	The app should provide a physical reward	Low	✓
FR4	The app shall provide personalized feedback on how the user is doing, and how that affects the environment	High	
FR5	The app shall provide practical examples of related things that the carbon footprint represent	High	
FR6	The app shall have defined rules for when to receive points and badges	High	✓

Table K.1: Unfulfilled Requirements - Goal setting and feedback

Data visualization

ID	Requirement	Priority	Fulfilled?
FR7	The app shall display information regarding the user's behavior on a daily basis		
FR7-1	The app should explain the cause of the possible deviation from the user's habits	Medium	
FR8	The app shall raise the user's awareness about the effect of gas emission	High	

Table K.2: Unfulfilled Requirements - Data visualization

Community and social media

ID	Requirement	Priority	Fulfilled?
FR9	The app shall provide a comparison of the user's data with the community	Low	✓
FR10	The user shall be able to compare his/her results with his/her friends	Low	✓
FR11	The user shall be able to compete with other users	Low	✓
FR12	The user should be able to join collaborative challenges	Low	✓
FR13	The app should allow the user to share his/her results in external social media	Low	

Table K.3: Unfulfilled Requirements - Community and social media

Settings

ID	Requirement	Priority	Fulfilled?
FR14	The user shall be able to correct the details of transportation used during a journey	Medium	

Table K.4: Unfulfilled Requirements - Settings

Backend Calculations

ID	Requirement	Priority	Fulfilled?
FR15	The app shall distinguish different means of transportation used during a travel		
FR15-1	The app shall detect the use of public transportation	Medium	
FR16	The app should estimate the gas emission during a travel		
FR16-1	Depending on the number of people sharing a car	Medium	
FR17	The calculations of calories shall be realistic	High	✓
FR18	The app shall explain how numbers are calculated	High	

Table K.5: Unfulfilled Requirements - Backend calculations

Data storage

ID	Requirement	Priority	Fulfilled?
FR19	The data generated by the app shall be stored anonymously	High	

Table K.6: Unfulfilled Requirements - Data storage

Usability

ID	Requirement	Priority	Fulfilled?
N-FR1	The app shall have enough explanations, so the users understand what to do in the app	High	✓
N-FR2	It shall be easy to navigate back to previous screen or dashboard from every screen	High	
N-FR3	The buttons in the app shall look clickable, or everything that looks clickable shall be clickable	High	
N-FR4	The app shall scale items to fit every screen size	High	
N-FR5	It shall be easier to switch between categories at the history graph	High	✓
N-FR6	The app shall give an introduction on how to use the app	High	✓
N-FR7	The app should contain information about the app with contact info to report bugs or other feedback	Medium	
N-FR8	The app should show the title of the screen in the toolbar	High	✓

Table K.7: Unfulfilled Requirements - Usability

TTM requirements

ID	Requirement	Priority	Fulfilled?
FR20	The app shall visualize the effect the user's activities have on the environment, and the concrete consequences this impact have	Medium	
FR21	The app should provide concrete feedback that shows the user what reducing emissions would contribute to	High	
FR22	The app should have levels that places the user based on his/hers emissions	Medium	
FR23	The app should provide suggestions for alternative transportation for distances often travelled:		
FR23-1	- Public transportation available	Medium	
FR23-2	- Walking/Cycling distance with benefits	High	
FR23-3	- Car sharing opportunities with users living close by and are travelling the same way	Medium	
FR23-4	- City cycles available	Medium	
FR24	The app shall highlight the positive effects of walking/cycling instead of driving:		
FR24-1	- Health benefits	High	✓
FR24-2	- Expenses saved	High	✓
FR24-3	- Benefits for the environment	High	
FR25	The app shall provide functionality for social interaction between the users so they can encourage each other on the way of reducing their carbon footprint	High	
FR26	The app shall provide the user with prizes to reward positive green behavior	High	✓
FR27	The app shall provide feedback when negative trends in the behavior are detected	Medium	
FR28	The app shall provide the functionality to look back on the user's evolution and give feedback on how much this has helped the environment	Low	
FR29	The app shall provide the user with news from the media related to how the society is changing and what is the social norm	Medium	

Table K.8: Unfulfilled Requirements - TTM requirements

Pervasive

ID	Requirement	Priority	Fulfilled?
FR30	The app shall automatically track the user's movement to calculate the carbon footprint based on transportation means and energy consumption	High	✓
FR31	The app should track as accurate as possible so the user does not feel the need to manually report	Medium	
FR32	The app shall give the user prizes seamlessly during the day when green behavior is detected	High	

Table K.9: Unfulfilled Requirements - Pervasive requirements

Privacy

ID	Requirement	Priority	Fulfilled?
FR33	The app shall be in compliance with the GDPR		
FR33-1	Right to be forgotten	High	
FR33-2	Explicit consent	High	✓
FR33-3	Mandatory data breach notification	Medium	
FR33-4	Privacy by design	Medium	

Table K.10: Unfulfilled Requirements - Privacy requirements

Gamification

ID	Requirement	Priority	Fulfilled?
N-FR9	The app design shall be minimalist and not get overloaded with game mechanics	High	✓
N-FR10	The app shall have clearly define rules of play that is easy accessible for the user	High	✓

Table K.11: Unfulfilled Requirements - Gamification requirements

Appendix L

Project Links

L.1 GitHub Project

https://github.com/ragnhlar/DesentAppWithGamification

L.2 Proto.io

https://pr.to/OH7YYV/

L.3 Specialization Project

https://www.dropbox.com/s/gae0c32y8d10ni9/TDT4501RagnhildLarsen.pdf?dl=0