FAKULTÄT
FÜR !NFORMATIK
Faculty of Informatics

A Usability Design Approach of Tailored Visualizations for Mobile Applications

DIPLOMARBEIT

zur Erlangung des akademischen Grades

Diplom-Ingenieurin

im Rahmen des Studiums

Wirtschaftsinformatik

eingereicht von

Romana Jakob, BSc.
Matrikelnummer 1227095

an der Fakultät für Informatik

der Technischen Universität Wien

Betreuung: Ao.Univ. Prof. Mag. Dr. Margit Pohl
Mitwirkung: Mag. Dr. Gerhard Engelbrecht

Wien, 1. September 2018

Romana Jakob	Margit Pohl

FAKULTÄT FÜR !NFORMATIK
Faculty of Informatics

A Usability Design Approach of Tailored Visualizations for Mobile Applications

DIPLOMA THESIS

submitted in partial fulfillment of the requirements for the degree of

Diplom-Ingenieurin

in

Business Informatics

by

Romana Jakob, BSc.
Registration Number 1227095

to the Faculty of Informatics

at the TU Wien

Advisor: Ao.Univ. Prof. Mag. Dr. Margit Pohl
Assistance: Mag. Dr. Gerhard Engelbrecht

Vienna, 1st September, 2018

Romana Jakob	Margit Pohl

Erklärung zur Verfassung der Arbeit

Romana Jakob, BSc.
Nabegg 53/2, 3323 Neustadtl

Hiermit erkläre ich, dass ich diese Arbeit selbständig verfasst habe, dass ich die verwendeten Quellen und Hilfsmittel vollständig angegeben habe und dass ich die Stellen der Arbeit – einschließlich Tabellen, Karten und Abbildungen –, die anderen Werken oder dem Internet im Wortlaut oder dem Sinn nach entnommen sind, auf jeden Fall unter Angabe der Quelle als Entlehnung kenntlich gemacht habe.

Wien, 1. September 2018

Romana Jakob

Acknowledgements

I want to thank everyone who has contributed in any way to my study and the making of this thesis. First, I want to thank Margit Pohl, my thesis advisor for her support and not giving up on me, despite longer breaks.
I am grateful to Gerhard Engelbrecht not only for his feedback but also for the opportunity to write the thesis in cooperation with Siemens. Thanks to my boss at Siemens, Herwig Schreiner, for giving me the freedom to pursue this thesis.
Thanks to everyone who spared time to test the mobile application which was developed within this thesis. Your feedback was very helpful and contributed a lot to its further development. Finally, thanks to my friends during my study time for the mutual support.

Kurzfassung

Ihr Text hier.

Abstract

Enter your text here.

Contents

CHAPTER 1

Introduction

In the age of social media, where information is tailored to users' interests, preferences and state of education, the question arises how to integrate this phenomenon into common mobile applications. Especially when the aim of the application is education or changing a user's behavior an adoption of the user interface to various requirements might be beneficial.

This thesis investigates whether tailoring the interface of a mobile application to a user's state of knowledge has effects on the usefulness of the application. The state of knowledge and the needs of the users are gathered into user groups, in order to limit the amount of possibilities.

1.1 Motivating Scenario

This thesis is written in cooperation with Siemens AG Austria, within a research project that deals with the Seestadt in Aspern. The Seestadt is one of the biggest city development projects in Europe [1]. The Aspern Smart City Research GmbH & Co KG [2] (ASCR) is an exclusive technology partner of Siemens AG. The Aspern project has the overall goal of finding smarter solutions for energy consumption with the help of smart grids, power supplies, building systems, intelligent power grids and communication technologies. Another side goal is an optimal interaction of all these components. The ASCR infrastructure manages the data coming from smart grids and smart buildings such as temperature, energy consumption, water consumption, power demand as well as external data sources such as weather, city events, energy market, traffic reports etc.

[1] https://www.aspern-seestadt.at/ Accessed 10.01.2018
[2] http://www.ascr.at/ Accessed 10.01.2018

[PDE15] In total 1.5 million values are measured per day. To create something useful out of this amount of data is a big task. [3]

Take, for example, an application that informs you about your electricity consumption. What can be assumed, is that the user wants an easy-to-use application and the application should be beneficial for the user. Users are different and so are the motives why someone uses an application, e.g. saving energy, monitoring consumption, pure interest etc. A company or an App developer of course wants to develop an application that serves as much people as possible. But what to do when the target group is defined but consist of people with distinct interests and different level of knowledge?

The problem that we observed is that the majority of users lack the feeling for the size of one kilowatt hour. The same can be witnessed when it comes to CO2 emission. The unit of kilograms of CO2 is an information that mostly only experts can grasp and can relate to.

1.2 Problem Statement

In the field of software development the interaction with the user is important, including the consideration of a user's knowledge. Numerous applications aim at motivating the user to save energy or CO2 but neglect the incomprehensibility of units of measurements one does not deal with on a daily basis. The sense of trying to motivate the user to save energy by displaying the electricity consumption in kilowatt hours, might have less impact than setting it at least in relation to an average consumption of electricity or even visualizing it with a gamification approach. On the other hand, for someone who is easy on these types of measurement a visualization with colors or graphs might be too much.

So, the problem we are facing is to develop a mobile application that is beneficial for all types of users, starting from users who do not have a feeling for kilowatt hours or kilograms of CO2 up to users having a great affinity for electricity and carbon-dioxide emission.

To address this bandwidth of user knowledge and visualization possibilities, this thesis investigates the usefulness of tailoring a mobile application to a users knowledge. Furthermore design principles and criteria that shall help front-end developers, usability engineers as well as software architects to develop applications customized to a users level of knowledge shall be investigated.

We evaluate different types of users and their preferred way of gathering information. Ranging from the ones who only show interest in their overall behavior, meaning if they are better or worse than the average, over others, who want to know their power consumption more detailed but still can't grasp the measurement of one kilowatt hour, up to users, who are deep into the topic and are keen on extensive figures.

[3] http://www.report.at/index.php/energie/wirtschaft-a-politik/item/91884-lebendes-stadtlabor Accessed 10.01.2018

1.3 Aim of the work

The overall goal of this thesis is to identify different type of users, to evaluate existing applications and to identify the benefits or even drawbacks of providing a user interface in a mobile application tailored to a user type. We want to investigate if a user makes use of different visualizations or the presented way is excepted and therefore an adaptation of the user to the application takes place.
This thesis contributes (1) a questionnaire for identifying the energy type of a user (2) an evaluation of a mobile application in the field of consumption data and home automation (3) a catalog of criteria of design principles for tailoring visualizations of consumption data.

The central research question is the following:

Are there benefits of providing visualizations tailored to user segments?

The central research question can be answered after having found a solution to the sub-questions:

(a) What are the characteristics of a user segment with the same energy consumption interests? In order to answer this research question we first conduct a literature review in the area, followed by a user survey detecting the state of knowledge in the field of electricity units of measurements, i.e. the size of one kilowatt hour, one kilogram of CO_2. These findings will help in identifying groups and their characteristics.

(b) Which criteria do questions have to meet, that shall identify the type of a user? The findings of the sub-research question (a) will have an influence on the questionnaire needed for defining which group a user can be assigned to. This questionnaire will be the first contact point in the mobile application.

(c) Do the characteristics of user groups correlate with the users' preferred type of visualization? The results elicited for research question a) are the foundation for defining the correlation between groups of users and their preferred type of visualization. Assuming the favorite type of visualization is the most used one, allows to identify the preferred type of visualization by asking the user for his or her preferred type of visualization.

(d) What are the design possibilities when it comes to tailoring interfaces to a user segment in the scope of electricity consumption data? This question can be answered by conducting a literature review, considering the characteristics of a user group, creating paper prototypes and evaluating their usability in workshops with the user segments as target groups.

1.4 Methodological Approach

In order to fulfill the research questions the methodological approach comprises the following steps:

1. **Literature Review**
   The first step is to dive into the topic of usability engineering, especially different forms of visualizations and graphical user interfaces in the scope of mobile applications. That implies a research about paper prototyping, usability testing in the mobile context as well as user classification and evaluation of user interfaces. The goal is to get an insight of all relevant aspects which will serve as foundation for the following steps and also to get a base that shall help at answering the research questions.

2. **Comparative analysis of alternatives and comparison of existing approaches**
   In this step, the market and competition analysis which was done when the problem arose will be done in more depth. The questions that shall be answered in this steps are the following.

   - Which applications are there within the topics of energy saving and CO2 awareness?
   - Which approaches and visualizations do these applications make use of to present feedback?
   - How do these applications tailor their visualizations to different requirements?

3. **Creating a questionnaire for user classification**
   In this step one contribution of this thesis is created, the questionnaire for the identification of the segment a user can be assigned. This will be a short questionnaire that shall identify the correspondence to the main characteristics of a user segment such as interest in energy topics, typical usage patterns of consumption, technical competence etc.. The questions shall help to answer RQ (b) Then the questionnaire will be sent out in order to find at least one person for each user segment.

4. **Design of Paper Prototypes**
   The second step is to create a prototype on paper. This prototype shall follow usability guidelines found out in the previous steps. The whole paper prototyping process will be close to the Step-by-Step guide for creating Paper Prototypes proposed by Arnowitz et al. [AAB10]. This includes first, the definition of the goal followed by identifying the tasks that users shall be able to do with the App. Next, hand-sketched drafts will be drawn, showing the application with menus, dialog boxes, notifications and buttons.

5. **Elicitation of requirements with Paper Prototyping**
   The third step is to do the Paper Prototyping session in order to elicit the requirements for the graphical user interfaces and overall for the app. According to

[Lan04] the numerous benefits of early usability studies are vastly superior. It may seem low-tech, but conducting usability tests at this step show what users really expect on a quite detailed level which gives maximum feedback for minimum effort [Wei03].

At first the people that could be clearly assigned to one user segment will be invited to a paper prototyping workshop. The workshops for each user segment will be held separately in order to avoid the distortion of results and to create a mutual independent outcome. The feedback from the users show what they expect from the app which is of great value for the further design of the app [Sny03] and for the following evaluation.

6. **Evaluation**
   In this step the mobile application from ASCR will be empirically evaluated against the outcomes of the paper prototyping session and its benefits and drawbacks will be defined. The outcomes of the paper prototype sessions will help answering RQ (c), which deals with the correlation of user characteristics and the preferred type of visualization

7. **Refinement of design principles catalog**
   Finally, based on the findings of the evaluation a design principle catalog will be created. The catalog will comprise motivations of the user types, requirements definitions and example implementations from the evaluated paper prototypes.

1.5 Structure of the work

The remainder of this thesis is structured as follows: Chapter 2 provides an overview of related work where the main approaches of tailoring user interfaces are discussed. This chapter is concluded by a comparison of existing approaches.

Subsequently in Chapter 3 the methodology is presented, where the guidelines for the survey for user segmentation and a step-by-step guide for Paper Prototyping is explained.

Afterwards, in Chapter 4 the main work of this thesis, the paper prototypes, the prototyping workshops and the evaluation of the ASCR mobile application, is presented. Within this chapter implementation-specific details are discussed.

Chapter 5 critically reflects and compares the implementation with related work and discusses open issues.

This thesis is concluded in Chapter 6 with a summary and outlook on future work.

CHAPTER 2

State of the Art

In the following sections the theoretical background for the topics that this thesis deals with will be presented. In particular, it starts with a general introduction to usability engineering followed by a definition of usability in the mobile context. Then the field of mobile application is continued with a dive into adaptive interfaces. Of particular relevance to this thesis is the work on user segmentation of Smart Cities Demo Aspern where our user classification is based upon. This chapter goes on with an introduction to paper prototyping containing a comparison of computer-based to paper-based prototypes and outlines paper prototyping as a tool for elicitation of requirements and for usability testing. The use of focus groups is discussed before we compare existing approaches of energy-saving programs including a look at persuasive systems followed by a comparative analysis of used design guidelines in existing approaches.

2.1 General Definition of Usability

The International Organization for Standardization (ISO) defines usability as the "Extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [Bev98]. This definition comprises three measurable attributes which are the following [Din98]:

- **Effectiveness**: Accuracy and completeness with which users achieve specified goals.
- **Efficiency**: Resources expended in relation to the accuracy and completeness with which users achieve goals.
- **Satisfaction**: Freedom from discomfort, and positive attitudes towards the use of the product.

The ISO standard also identifies three factors that should be considered when evaluating usability, which are the user, the goal and the context of use. The user is the person who interacts with the product. The goal is the intended outcome and the context of use applies to users, tasks, equipment (hardware, software and materials), and the physical and social environments in which a product is used.

In addition to the above ones Nielsen [Nie94a] identified five attributes of usability and factors having an impact on how the user interacts with a system:

- **Learnability**: The user should get work done rapidly which is possible if the system is easy to use.
- **Efficiency**: Once the user has learned to operate with the system, the productivity should be high.
- **Memorability**: In case a user does not use the system in a longer period, it should, nevertheless, be easy remembered without having to learn everything all over again.
- **Errors**: When using the system, the user makes few errors and is able to return and recover easily after an error. Further, catastrophic errors must not occur.
- **Satisfaction**: The system is highly accepted as the user has positive attitudes towards the system and finds it pleasant to use.

2.1.1 Mobile definition of usability

The focus on usability and interaction between human and hand-held electronic devices has its origin within the emergence of mobile devices. With the emergence and rapid deployment of mobile technologies a number of additional studies like [Ryu05] and [Gaf09] have focused on the usability of mobile devices. The approach of Nielsen, mentioned above, was expanded with the scope of mobile applications by Zhang and Adipat [ZA05] who highlighted a number of issues by the advent of mobile devices. The issues mentioned are:

- mobile context
- connectivity
- small screen
- different display resolution
- limited processing capability and power and
- data entry methods

They mention that these restrictions are especially a problem when it comes to usability testing methods, as all these issues must be considered in order to select an appropriate research methodology. It must be kept in mind that contextual factors on perceived usability can occur when they are not considered in a study [ZA05].

Almost concurrently, mobile device manufacturers have been developing their own usability constraints, such as Google and Apple. The Apple iOS Human Interface Guidelines[1] states the iOS design principles that should be considered during the application development process, such as: aesthetic integrity, consistency, direct manipulation, feedback, metaphors and user control.

Also Google has developed Android user interface guidelines[2], which guide developers to take into account the following guidelines: the Icon Design Guidelines including the size and location of Icons and Buttons, Contextual Menus and their responsiveness, simplicity, size, and format of text and the Widget Design Guidelines that describe how to design widgets that fit with others on the Home screen. These guidelines also explain how these characteristics should be considered during the development and testing of Android applications.

Harisson et al. [HFD13] build up on the terms mentioned before and introduced a PACMAD (People At the Centre of Mobile Application Development) model which was designed to address the limitations of existing usability models when applied to mobile devices. PACMAD extends the theories of usability with more aspects such as *user task* and *context of use*. The existing usability models such as those proposed by Nielsen [Nie94b] and ISO [Bev98] also recognize these factors as crucial parts on which the successfulness of the usability of an application depends. The difference is that PACMAD includes all the factors into one model to ensure a complete usability evaluation.

2.1.2 Adaptive interfaces in mobile applications

Deka [Dek16] discusses how data-driven approaches are tools for mobile app design. They state that designing mobile apps is a complex layered process that affects researchers, designers, and developers who work together to identify user needs, create user flows, determine layout of UI elements, define visual and interactive properties with the help of design prototypes, and evaluate effectiveness of designs both heuristically and with extensive user testing. His approach is to simplify the app design with a more data-driven process by leveraging design data from the vast array of already existing apps. Deka advocates interaction mining that captures the static part, such as layouts and visual details, as well as the dynamic part, like user flows and motion details, of app design. His approach is in contrast to design mining approaches that mainly have focused on mining static UI layouts and visual details [KST$^+$13], [AY15].

[1] https://developer.apple.com/design/human-interface-guidelines/ios/overview/themes/. Accessed 06.08.2018

[2] https://developer.android.com/guide/practices/ui_guidelines . Accessed 06.08.2018

Fogarty and Hudson [FH03] presented a programmaticaly approach for the optimization problem of usability interfaces. Their approach is numerical optimization and they provide an experimental toolkit to support optimization for interface and display generation.

The decades of research in adaptive user interfaces were summarized by Gajos et al. [GWW08]. They conclude that personalized user interfaces have the ability to improve user satisfaction and performance, when the interface is adapted to the device, task, preferences and abilities of a person. To automatically generate user interfaces they use decision-theoretic optimization which includes functional specifications of the interface, constraints of the devices e.g. screen size and a list of available interactors, a typical usage trace and a cost function. The cost function holds user preferences and the expected speed of operation. Gajos et al. especially focus on the preferred UI elements of a user. As this thesis aims at finding interfaces for users that fit different types we first need to classify users into different user segments.

2.2 User Classification

Weiss [Wei03] discussed the balance of ease of use compared to the ease of learning. A huge emphasis is laid on the first, and according to Weiss, the most important step in the design and development process, the understanding of the audience. The purpose of the audience definition is to describe the target group, its' traits and ranges.

2.2.1 User Segmentation according to Smart Cities Demo Aspern

Aspern Smart City Research GmbH & Co KG (ASCR) also lays emphasis on understanding the user. The research group defines a smart user as a person who has the knowledge for sustainable decisions in relation to his or her lifestyle. Saving CO2 and energy should be the overall goals of a smart user.

Nevertheless, not all smart users are the same and not all share the same state of knowledge or interest. Therefore, in 2015 ASCR conducted a socio-scientific study to find out how much know-how a smart user has in the field of technology and energy and also how much interest they have in the topics of energy and sustainability. The research was done in an apartment block named D12, where the possibility to test solutions is given, as the apartments in this block are equipped with systems that collect data including

- electricity consumption
- room temperature
- warm/cold water consumption and
- air quality.

Over half of the households in the apartment block D12 agreed on making their data available for research purposes and to participate in surveys and workshops. In total, 85 households took part in the study in 2015. In the starting phase two studies were done. At first a qualitative study with personal interviews with selected tenants of the building D12 was done followed by a quantitative study with written questionnaires. One outcome of these studies was the segmentation of users into groups. Different types of users were clustered into four segments according to their state of knowledge and their interest in technology and energy. The user groups also serve as target groups for the development of new technology solutions such as home automation, mobile application and for the development of range of services. The segmentation into groups also makes communication easier as the used methods of communicaiton can be tailored to the needs of a group.

The qualitative study with its interviews was done before the tenants moved into the apartments in Seestadt. Surprisingly the majority stated that it has basic knowledge for the interpretation of the energy consumption and energy data in general. Often they stated that they do not know how much one kilowatt hour is. In most cases the main source of information for energy topics is the energy consumption calculation. Unfortunately the calculation does not state the behaviour or the devices which use up the most energy. Exactly these two aspects are the most wished information for the users when it comes to saving energy.

The aim of a segmentation in its statistical way is to find distinct groups with significant differences [PS83]. Within a group the characteristics should be homogeneous. An established way for segmentation in statistics is to do two statistic procedures, beginning with a factor analysis, followed by a cluster analysis [Tuf11].

The factor analysis reduces dimensions [WOB10]. In the quantitative questionnaires multiple variables are collected and in the factor analysis these variables are reduced to so called latent variables or factors. Therefore, the factor analysis shows which dimensions are underlying the whole questionnaire.

In the socio economic study of ASCR an explorative non-rotating factor analysis was calculated. Afterwards the scree test showed the amount of factors, which was in this case four. In terms of content the analysis of the factor showed the following dimensions:

- **Comfort-centered**: This factor covers aspects like home automation, energy relevant user behavior such as lighting and circulation behavior and hot water usage.
- **Technology-centered**: Also covers aspects like home automation but more with the sense of interest in the technology rather than the comfort aspect.
- **Data sensibility**: Concerns regarding the further use of the collected data.
- **Living in Seestadt**: The aspect of living in the Seestadt as an extra dimension shows that it is some kind of prestige to live there.

Finally a cluster analysis was done to identify the user segments. Cluster analysis is an exploratory process with the aim of finding groups of similar objects [Tuf11]. Different hierarchical analysis were calculated to find an appropriate amount of clusters. Appropriate means in this case having an big enough group of cases/persons and groups having distinct features. The data set comprised 121 handed back questionnaires and the cluster analysis could identify four clusters. The four clusters correspond to the four user groups. The result of the cluster analysis is shown in 2.1 and explained in the following.

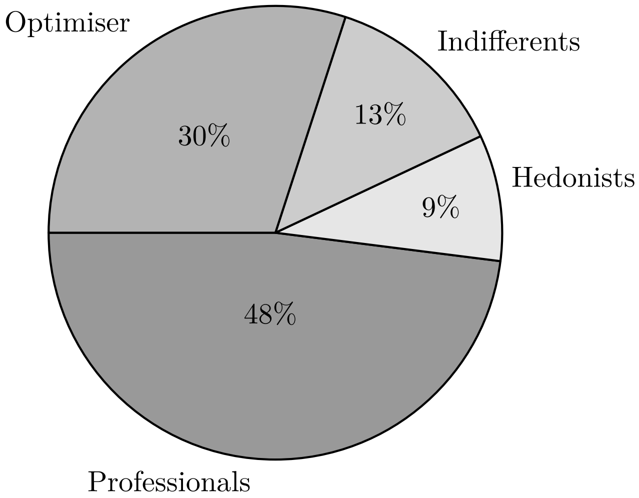

Figure 2.1: Result of the cluster analysis: Four user groups

"Professionals" (48 %): The Professionals are the biggest group. The members of this group are technically competent and interested in topics concerning energy.

The main characteristics are:

- High proportion of persons having an abitur or university graduates
- Highest proportion of people in managerial positions, a quarter works (also) at home
- All household sizes (also households with children)
- Knowledge about energy
- High technical competence and interest in Technology. (Experience with home automation, a quarter has programming skills)
- Interested in sustainability
- Use of media or Internet is primarily for professional purposes

Typical segment behavior regarding home equipment:

- "Reasonable" use of hot water ("I do not shower longer than necessary")
- "Reasonable" use of lighting ("I turn down the light when I leave a room")
- Make use of the "ECO-Button" (installed tool in the apartments of D12 which helps to save energy) when leaving the apartment

Due to their technical expertise, their experience with home automation and their interest in energy issues they are the most appropriate target group for home automation and mobile application solutions. Rationally justified explanations and instructions for use meet their information style. Professionals also expect more detailed information in individual offers such as energy feedback.

"Optimizer" (30 %):

The second largest segment comprises people who primarily aim to optimize energy costs. Optimizer have little knowledge about energy and are no technophiles.

The main characteristics are:

- High proportion of persons having an abitur or university graduates
- Highest proportion of people in managerial positions
- More women
- All household sizes (also households with children)
- Interested in sustainability
- Little to no knowledge about home automation
- no technophiles
- Use of media or Internet is not very noticeable

Typical segment behavior regarding home equipment:

- Prefer to air manually rather than to make use of the automatic ventilation system
- A quarter never uses the "ECO-Button"

The use of the home furnishings indicates a poor understanding of their usability or less time of interaction with them. Due to their much lower competence in energy and technology compared to the professionals, the planned solutions and measures should focus very strongly on the following points:

- Clear and concrete instructions for behavior, for example in the form of energy-saving tips or concrete, close to reality explanations and concrete benefits.
- Avoid technical language in communication and use personalized examples.
- Reduce energy feedback to essential information. Optimizer do not need detailed explanations.
- Enable trouble shooting: Optimizer want a quick solution to an energy problem, as they do not want to spend lot of time on energy topics.

"Indifferents" (13 %):

The "Indifferents" have low competence in energy and technology and no interest in energy topics or sustainability.

The main characteristics are:

- Young segment
- High proportion of Non-workers
- No interest in sustainability
- Low technical competence (no experience with home automation)
- Information research and streaming is above average

Typical segment behavior regarding home equipment:

- Hedonistic use of hot water: They enjoy taking long showers and baths
- Smallest number on different device types
- Little satisfaction with the provided air ventilation

The "Indifferents" have low interest in the research topic and it's solution in general. To address this group with the necessary knowledge and to awaken their interest for energy and sustainability, a bigger effort has to be done than for the above groups. A typical representative of this group is a person who has just moved out from the parental home and who now has to organize the household on his/her own and to develop independence.

"Hedonists" (9 %):

The "Hedonists" are technical competent but are indifferent to energy and sustainability topics.

The main characteristics are:

- Young segment
- More mens, more single households
- Technical competent and partly with programming skills
- Intensive use of mobile Apps and Internet
- Hedonistic use of gaming and social media

Typical segment behavior regarding home equipment:

- Highest number on different device types
- Carefree use of lighting and hedonistic use of hot water
- Frequent use of "ECO-Button"
- High satisfaction with the provided air ventilation
- Weak identification with Seestadt

The youngest segment has good preconditions to make a good use of mobile application with feedback of their energy use. Nevertheless, the motivation to deal with energy topic is rather low. The hedonistic lifestyle with its strong convenience and comfort orientation is in the foreground. Despite the high usage of apps it may be difficult to win them around for energy feedback. The comfort gain is of great relevance.

2.3 Paper Prototyping

With the knowledge of the characteristics of the different user groups, the next step, the Paper Prototyping can be done more easily. It may seem low-tech, but conducting usability tests at such an early stage show what users really expect on a quite detailed level which gives maximum feedback for minimum effort [Wei03].

According to [Lan04] the numerous benefits of early usability studies are vastly superior. Besides saving time and money by solving problems before the implementation even begins, Paper Prototyping stimulates creativity as it allows to experience with different ideas before committing to one [Sny03].

Different types of prototypes for different purposes in software engineering exist. Leffingwell and Widrig [LW] proposed a classification tree for prototype selection that categorises prototypes according their use case. Prototypes are categorised as throwaway versus evolutionary, horizontal versus vertical, and architectural versus requirements prototypes. Prototypes can also be categorized according to their representation into textual and visual prototypes, whereby Asur and Hufnagel [AH93] define rapid prototyping as the use of tools for quick prototype construction. A division into executable and non-executable prototypes can also be made as mentioned from Kotonya and Sommerville [KS98] and Wiegers [WB13].

2.3.1 Computer-based versus paper-based Prototypes

Nielsen has compared the effectiveness of using interactive prototypes with static paper prototypes. The result of this study showed that evaluators discovered significantly more problems with the high-fidelity prototype than with the low-fidelity prototype [Nie90].

Sefelin et al. [STG03] builds up on the same approach as Nielsen and also investigated the differences between computer-based and paper-based low-fidelity prototypes. In contrast to Nielsen, they discovered that both types lead to almost the same quantity and quality of critical user statements although users prefer the comfort of computer prototypes. Similarly, Virzi et al. [VSK96] claimed that the sensitivity to find usability problems does not differ between low- and high-fidelity prototyping.

However, there are still a lot of reasons, as discussed by Rudd et al. [RSI96], to implement a paper prototype for example when the available prototyping tools do not support the components and ideas, which shall be implemented. Another benefit of a paper prototype is the low fidelity, as no software skills are needed for paper prototyping. Besides that paper prototyping leads to a lot of drawings which can contain more ideas than predefined computer-based prototypes . For requirements engineering Vijayan and Raju [VR11] recommend a throwaway paper prototype rather than expensive Prototypes. One reason for that is also the absence of the technology barrier.

Lim et al.[LPPA06] concretized the comparison of high- and low-fidelity prototypes to mobile applications. They figured out that major usability issues were identified by all the three types of prototypes, namely, the fully-functional prototype, the computer-based low-fidelity prototype and the paper-based. The major issues especially in the mobile context are unclear meanings of labels, icon/symbol/graphical representation issues, locating appropriate interface elements, mental model mismatch and appearance/look of the product.

A highly recommended introduction into effective prototyping is provided by Arnowitz et al. [AAB10] as well as by Bernard and Summers [BS10] who inducted into dynamic prototyping. Dynamic prototyping is some kind of mixture between sketches, drawing of ideas and real prototypes, which builds the bridge from low-fidelity to high-fidelity prototyping

2.3.2 Elicitation of Requirements with Paper Prototyping

Research has shown that paper prototypes are beneficial for many users for articulating their requirements as they already see some possible interface elements [VR11]. Clients have a hard time, even sometimes with the help of a software developer, specifying completely, exactly and correctly the exact requirements of a software before seeing some versions of a product [HD98].

Vijayan and Raju propose a new approach to requirements elicitation using paper prototype [VR11]. Their case study indicated that the paper prototype method is a suitable method for requirements elicitation for small and medium sized projects. They describe a paper prototype as a visual representation of what a system will look like which can be drawn or created with graphics programs. Their approach is divided into the following steps:

- Domain knowledge acquisition
- System understanding
- Requirements elicitation
- Prototype validation
- Requirements stabilization

In contrast to many systems development methodologies who address the problem of identifying user requirements but generally focus on the analysis of user requirements Vijayan and Raju argue that paper prototyping focuses more on the elicitation of requirements from the users [VR11]. Sharma and Pandey [SP13] revisited requirements elicitation techniques and listed throwaway paper prototyping as an innovative technique under the numerous other elicitation tools. They conclude that despite the common use case of usability testing, with paper prototyping satisfactory results in requirements elicitation can be obtained.

The parallel activity of Prototyping and requirements gathering is described by Caspers [Jon98]. He even says that especially in agile development methods, the prototypes may even substitute other forms of requirements gathering. Young [You02] also recommended numerous requirements gathering practices. Among the preferred ones are storyboards. As they are multiple drawings depicting a set of user activities that occur in an existing or envisioned system or capability they are very close to or even a kind of paper prototyping. Users and developers draw what they think the interfaces should look like and continued until real requirements and details can be discussed and agreed upon. Being so close to paper prototypes storyboards are also inexpensive and eliminate risks and higher costs of prototyping.

2.3.3 Paper Prototyping as a Usability Testing Technique

Still and Morris [SM10] re-emphasize the importance of usability testing in the user-centered design process and argue that at this early stage usability testing is most effective. They married low fidelity paper prototyping with medium fidelity wireframe prototyping and called this blank-page technique. Meaning that the user navigate to dead-ends and has the task to describe and create what they would expect there. This technique allows insights into users' mental models regarding site content and design which provides developers with useful data concerning how users conceptualized the information encountered. This more substantial early influence of users almost always translates to better usability. The blank-page technique is describe from Maguire and Began [MB02] as brainstorming. Nevertheless, they additionally list Paper Prototyping as a quick and easy way to detect usability issues in response to user feedback.

Focusing on the quickness and risk management of paper prototyping Cynder [Sny96] showed how only six days of doing paper prototyping lowers risk. They spent two days usability testing the paper prototype. For each test session two people were used who matched the profile of a typical user. Their approach in the session was to somehow let the user alone with the prototype without giving a demo or explaining how to use the interface. The only thing they did, was to observe the user at interacting with the prototype. Cynder describes that the team was surprised by many of the issues they saw. In some cases, aspects about which the developers strongly argued the users didn't even notice. At the same time, huge problems that no one had anticipated were uncovered. Summarizing Cynder writes that usability testing with the help of paper prototyping gave everyone on the team a sense of what the real issues that would affect the success of the next release were.

Grady [Gra00] describes usability testing with paper prototypes as a win-win situation for both the designer and the end user. The study revealed how beneficial paper prototyping is for usability issues, as a lot of problems were released even in the first usability test session. The second usability test run allowed a more in-depth evaluation of the fundamental structure of the site and additionally uncovered issues that were missed during the first usability test. The third usability test on the full-blown site revealed even fewer problems than the previous tests.

2.4 Focus Groups

Dumas et al [DDR99] describe a typical focus group as a discussion among multiple real users which is led by a moderator. They argue that focus groups provide information about users' opinions, attitudes, interests, preferences and a self report about their performance. What focus groups usually don't do is giving you an insight into how they behave with the product. The people are carefully chosen, as in usability tests, to represent the potential users of the product.

An experimental prototyping method for play testing was evaluated by Eladhari and Ollila [EO12]. They used focus tests as a type of play test. In a focus test questions are asked in an interactive group setting which comprises of potential users who talk about their perception, belief, opinion and attitude toward the prototype.

A user-centered model for this type of Web site design was developed by Kinzie et al. [KCJK02]. The model includes techniques for needs assessment, goal and task analysis, user interface design and rapid prototyping. The model includes document review, interviews, focus groups, surveys and observation and is proven as effective across diverse content arenas and is appropriate for applications in varied media.

2.5 Existing Approaches of energy-saving Applications

Providing households with better feedback on their energy consumption behavior has been identified as an important tool for achieving sustainable behavior change. But understanding why people engage in environmentally responsible behavior is a complex topic over many disciplines beginning from education to economics over sociology, psychology and philosophy [FFL10]. Feedback on individual or group behavior with the goal of reducing environmental impact is called eco-feedback technology [MM98, HKH$^+$04, FFL10]. Eco-feedback builds up on a variety of domains such as energy consumption [Hol07], water usage [ABS05], transportation [FDK$^+$09, TSF12] and waste disposal practices [HKH$^+$04].

A lot of people lack awareness of energy wasting in their homes. Making people aware about inefficiencies in their energy consumption behaviors could contribute to large energy savings at city level. In course of this assumption Mohammadmoradi [MGM$^+$17] designed several intentionally simple energy-saving activities with the goal of a high user engagement. They argue that often users do not understand what to do exactly to save energy, so they tried to help citizens to understand how they use energy and even to find more ways to do so. One activity per week was given to the users. The activities ranged from counting all lights, appliances and electronics in the home over finding the appliances that consume the most energy to turning all lights of and enjoy the evening with the family. An interesting point of their evaluation was, that to increase the amount of saving activities should focus on evening hours. To summarize the approach of Mohammadmoradi we can say their main principle for the design of eco-feedback is simplicity.

Eco-feedback has similar roots as persuasive systems and it may seem as an extension of the research in persuasive technology but actually it dates back much further to the research in environmental psychology. Models of proenvironmental behavior provide a philosophical approach on which to base the designs of eco-feedback technology, as they explain the why of the behavior but often they lack specific strategies for changing behavior. Froehlich et al. [FFL10] bridges the gap between findings from environmental psychology and the design and evaluation of eco-feedback systems.

2.5.1 Persuasive Systems

Of particular relevance in the field of persuasive systems is the work from Fogg [Fog02] who introduced computers to be persuasive social actors. In order to let the computer be persuasive psychological cues are proposed, such as preferences, motivations and/or personality, in short the computer should seem to have personality. This can be achieved by text messages that convey empathy ("I'm sorry that...") or icons that portray emotions. In the area of psychological cues, one of the most powerful persuasion principles is similarity [Taj10]. The greater the similarity, the greater the potential to persuade, so the more people feel similar to the computer technology products the more they are readily persuaded [Fog02].

Influencing can also happen through language. Whether asking questions ("Do you want to continue the installation?"), offering congratulations for completing a task ("Congratulations! You won!") or reminding the user to update software written or spoken language can lead people to infer that the computing product is animate in some way. Especially, persuading through praise, with the help of language, photos, symbols or sound effects can lead users to be more open to persuasion [Fog02].

Fogg's [Fog02] functional triad and the design principles presented in it constitute the first and so far most utilized conceptualization of persuasive technology. Nevertheless, there is a weakness of this model as it does not explain how the suggested design principles can be transformed into software requirements and implemented as system features.

2.5.2 Comparison of persuasive system design principles in existing approaches

Tailoring and personalizing the content to the potential needs, interests, usage context or other factors is outlined by [OKH09] in the context of a persuasive system. They studied how a persuasive system must be designed with tailored and personalized content to maximize the change in the user's behavior.

Design principles for primary tasks

The weakness of Fogg's model, the absence of concrete realization of the proposed design principles in software requirements, was overcome by Oinas-Kukkonen and Harjuma [OKH09]. Their design principles for the primary task support are explained in the following and we added further example approaches which implemented the proposed design principles and should explain the guidelines even better.

- **Reduction:** The system should reduce the time and effort that a user needs to spend on performing the target behavior.

  An example for a mobile application that made use of this design principle is Matkahupi, which automatically tracks the transportation modes and CO2 emissions of the trips of the user and utilizes this information to present a set of actionable mobility challenges to the user [JNS+13].

  Another mobile application that helps to reduce the time for performing a special behavior is PmEB. It supports healthier eating habits by listing proper food choices at fast food restaurants [LTG+06] and therefore also helps at behaving as wanted by providing support.

- **Tunneling:** Guiding users through an attitude change process by providing means for action brings them closer to the target behavior.

  Spagnolli et al. [SCG+11] proposed EnergyLife, a mobile application with a gamification approach that provides different levels which are adapted to the current state of knowledge.

- **Tailoring:** The System should provide information tailored to potential needs, interests, personality, usage context or other relevant factors for the user group.

  Gamberini et al. [GSC+12] focuses on feedback tailored to users' consumption behavior and giving according recommendations for behavior change.

- **Personalization:** If a system offers personalized content and services for its users it has a greater capability for persuasion.

  PEIR, The Personal Environmental Impact Report [MRS+09] offers personalized estimates of environmental impact and exposure.

- **Self-monitoring:** System should provide means for users to track their own performance or status to support the user in achieving goals.

  Power Advisor, a mobile application developed by Kjeldskov et al. [KSPP12] provides self-monitoring through personalized information about the user's power consumption.

- **Simulation:** System should provide means for observing the link between the cause and effect with regard to users' behavior.

  McCalley and Midden [MM02] proposed a computerized machine washing simulation. Feedback on consumption was given after each wash and in combination with self-chosen or assigned goals 21% less energy than the control group was used.

- **Rehearsal:** A system that provide means for rehearsing a target behavior enables people to change their attitudes or behavior in the real world.

  PowerAgent is a mobile application that let the users first play a simulation game to learn wanted behaviors and then let them enact and rehearse these behaviors at home in the family context [BGK07].

Design principles for dialogue support

An interactive system should of course provide system feedback to a user. Oinas-Kukkonen and Harjumaa also proposed several design principles related to implementing computer-human dialogue support in a manner that helps users keep moving towards their goal or target behavior [OKH09]:

- **Praise:** Praising users can make them more open to change their behavior.

  Petkov et al. [PGKK12] found out that people prefer positive rather than negative reinforcements in persuasive applications.

- **Rewards:** When the target behavior is rewarded a user is given credit for performing the target behavior.

  The Energy Piggy Bank gives users virtual badges and points when performing the target activities [BLWM17].

- **Reminders:** By reminding the user of the wished target behavior it becomes more likely that the user achieves his goals.

  The participants in the study of Kjeldskov et al. [KSPP12] mentioned that it was very important to keep reminding them about their own goals.

  Helen et al. [HGH10] recommend presenting prompts at opportune times to remind individuals to take specific actions and to to establish habits. As the habit becomes well instantiated, these prompts can gradually disappear.

- **Suggestion:** Offering fitting suggestions about how to behave provides the system with greater persuasive powers.

  One of the main techniques of the Energy Piggy Bank, is the habit formation that encourage to do a specific activity during a time period [BLWM17].

- **Similarity:** People are more ready to change their behavior when a system somehow reminds them of themselves in some meaningful way.

  In the pervasive game PowerAgent the person playing has the role of a secret agent and the phone has the role of the boss, the mysterious Mr. Q who gives the player special missions to save the planet from the energy crisis. As the user and Mr. Q, the person in the phone have the same mission, the user share similar goals and therefore similarity is here implemented in one of the best ways [BGK07].

- **Liking:** A visually appealing system is more likely to change a user's behavior.

  The 7000 Oaks and Counting project [Hol07] uses an animation of a series of tree images to show the estimated number of trees needed to offset the emitted CO2.

  The users of PEIR, the Personal Environmental Impact Report, propsed by [MRS+09] see green icons of trees appear if impact and exposure are low relative to friends, and smokey and smoggy icons appear if impact and exposure are high.

  Stepgreen [PQNB12] is a system that presents the information color-coded and changes according to the household consumption, varying from light green when consumption is low to dark red when the consumption reaches abnormal levels.

- **Social role:** If a system adopts a social role, the system is more likely to persuade.

  The ECO project approach is a learning framework with a network in background that [BMM+14] provide learning experience marked by social interactions and participation.

Design principles for system social support

In the social support category the design principles make use of leveraging social influence that shall help at persuading the user's behavior.

- **Social learning:** If a person can observe the outcomes of others who perform the target behavior (s)he will be more motivated to do the same.

  The feedback of the data monitoring system developed by Petersen et al. [PSJ+07] implemented social learning strategies as each dormitory could see how other dormitories were doing during the competition.

- **Social comparison:** By providing means for comparing one's own performance with others the system users have a greater motivation to also perform the target behavior.

  EnergyWiz, a mobile application that enables users to compare with their past performance, neighbors, social media contacts and other EnergyWiz users [PKFK11].

- **Normative influence:** If a system leverages normative influence or peer pressure the likelihood that a person will adopt the behavior of it's peers increases.

  Normative messages put in hotel rooms saying, "The majority of guests in this room reuse their towels." increased the likelihood of towel reuse by hotel guests by 33% [GCG08].

- **Social facilitation:** A system that provides means for discerning other users who are performing the target behavior, system users are more likely to be persuaded.

  Users of the Energy Piggy Bank Game [BLWM17] can recognize how many users are trying to save energy at the same time as them.

- **Cooperation:** A system can make use of the natural drive to co-operate by providing means for co-operation, which increases the motivation of a system user to adopt a target attitude or behavior.

  The mobile application EnergyWiz [PKFK11] provided a group in Facebook which shows the users that they are not alone in energy saving and allowed them to discuss about energy saving topics.

- **Competition:** A system can make use of the natural drive to compete by providing means for competing, which increases the motivation of a system user to adopt a target attitude or behavior.

  The Energy Piggy Bank Game [BLWM17] offers a leaderboard with all the names of the competing users and their points.

- **Recognition:** By offering public recognition for users who perform the target behavior to increase the likelihood that users will adopt a target behavior.

In the Energy Piggy Bank Game each team member's contribution to the group's score is visualized and the number of activities done by each group member is clearly visible in the group area [BLWM17].

2.5.3 Comparison of further design guidelines in existing approaches

The "one-size-fits-all" approach that the majority of energy feedback technologies makes use of is criticized by Helen et al. [HGH10]. Providing the same feedback to differently motivated individuals at different stages of knowledge, readiness and willingness to change is not beneficial. In their paper, they develop a motivational framework based on the Transtheoretical model. So, the design guideline they used for eco-feedback are stages of behavior change. The different stages are precontemplation, contemplation, preparation, action and the last stage is maintenance, relapse and recycling. Criticism to this model is that rather than being in one stage, users can be at a different stages for each action [MPV83].

Fischer [Fis08] specialized on feedback on household electricity consumption and examined which kind of feedback is most successful. Her research concluded the following recommendations for feedback.

In order to be successful, meaning, effective in persuading and satisfying for the users feedback should

- be based on actual consumption data
- be given frequently (daily or more) and over a longer period
- have the possibility to interact and choose
- involve appliance-specific breakdown
- involve historical or normative comparisons
- be presented in an understandable and appealing way

Nevertheless, attention should be paid, as not all recommendations may hold for all target groups.

A critical survey of interaction design for eco-visualization was done by Pierce et al. [POB08]. Their paper described feedback types and use-contexts for classifying eco-visualizations and also strategies for designing effective eco-feedback visualizations. They offer two strategies to support conservations goals. The first strategy is to offer behavioral cues and indicators and the second is to provide tools for analysis. Both should provide clear and useful information or feedback. Two strategies are proposed for creating incentives to conserve, especially for the contexts where financial incentives are not present. As monetary incentives are not possible they suggest to creating social incentives and to connect behavior to material impacts of consumption. They also offer strategies that focus on more experimental aspects visualizing consumption. The first strategy should encourage playful engagement and exploration with energy. The second should project and cultivate sustainable lifestyles and values. Thirdly, public awareness and should be raised and discussion should be facilitated. The final strategy should stimulate critical reflection.

CHAPTER 3

Methodology

In this chapter the methodology including the used concepts such as survey for user segmentation, paper prototyping for usability testing and elicitation of requirements is described. Finally, we describe the design methods for the catalogue of design principles.

3.1 Survey for User Segmentation

The questionnaire that we created for finding test users for the Paper Prototyping Session follows the design guidelines of Andrews et al. [ANP07]. The guidelines say that electronic surveys should be designed to...

- support multiple browsers and platforms [YT00]
- prevent submitting multiple times [YT00]
- to present questions in an adaptive or logical manner [KPM97]
- allow saving the work in long questionnaires with more than 50 questions [Smi97]
- collect both quantified selection option answers and narrative type question answers [YT00]
- have the possibility to thank the users for completing the survey [Smi97].

Google Form is a web application out of the Google Web Apps that follows all these guidelines, which was the reason for choosing it for our survey.

As the motivation to find subjects who completes a survey increases as the question difficulty increases [ANP07], when the aim is to have numerous replied questionnaires the survey should comprise of simple and not to much questions.

Generally online survey platforms offer convenient and reliable data management [CB00]. By design, Google Form protects against the loss of data and facilitates data transfer into a database, in this case Google Spreadsheets for analysis.

Before sending out the survey and after deciding on the survey tools, contents and platforms it is very important to carry out a pilot [Lum07].

3.1.1 Evaluation of the Questionnaires

The user segments on which this thesis builds upon are described in 2.2.1. Smart Cities Demo Aspern did a survey and used cluster analysis to define clusters. These clusters had distinct features. The answer of one user of the questionnaire can then be evaluated against each user segment with it's distinct features. This evaluation amounts to a correspondence of one answer set to a user segment.

According to Kazi and Khalid [KK12] there are three types of validity, which is the degree to which an assessment measures what it is supposed to measure. The three types are content validity, criterion-related validity and construct validity. The validation technique for identifying the correspondence of a user to a user segment is the criterion-related validity as it best describes the equivalence to the segment characteristics.

3.2 Elicitation of Requirements with Paper Prototyping

For the Paper Prototype a Step-by-Step guide proposed by Arnowitz et al. [AAB10] is used. To create a Paper Prototype the following steps should be done:

1. **Create scenario**. Before starting to draw anything the main user goals and tasks have to be portrayed. This can be done in a scenario narration.
2. **Inventory UI elements**. The next step is to make a checklist of all UI elements that may be needed to support the scenario .
3. **Create UI elements**. All the UI elements from the checklist from the previous step are now created in paper form. There are a lot of tools and materials that can come in handy at this step. The following list of materials might help the process: paper, sticky notes, whiteboard, sketchbook, notebook, napkin, cards, overhead sheet, cardboard, carton, scissors, markers, UI stencil, correction fluid and tape and transparency sheet.
4. **Run through scenario**. In this step a dry-run through the scenario with the paper prototype should be done and missing parts should be found an recreated.
5. **Internal review**. The last step in the first round is the internal review with the team where the audience is defined, the goals for each version of the prototype is reviewed, the expectation of the reviewers are found out and the next steps are planned.

The next Step-By-Step Guide is following the first. It was also proposed by Arnowitz et al. [AAB10] and is for testing the Paper Prototype:

1. **Revise scenario**. The internal review may have uncovered some tweaks that you want to change. Be careful for changes at the scenario as it may cause a ripple effect which can lead to necessary changes in user interface elements or even new screens. Keeping changes to minimum is recommended. If changes are necessary keep in mind that this can lead to non comparable results in the end.
2. **Revise inventory UI elements**. Until now maybe multiple run throughs through the prototype have been done and you noticed that some vital pieces of the interface are missing. Now is a good time to check completeness of the UI elements checklist. Developing a set of UI elements for cases that you did not anticipate may be also useful.
3. **Create UI elements**. Check if the collection of the UI elements is still complete and create some more if needed.
4. **Pilot run through scenario**. Before presenting the prototype to the user it has to be tried out first. You can give the Prototype to anyone, e.g. a team member, to try it out. The aim here is to find missing pieces to be prepared for everything they do. The run through will ensure that you haven't created a half-baked prototype.
5. **Internal review**. In this step the scenario and the prototype supplies are revised again with the team. Also the goals and the expectation of the reviewers are revised.
6. **Prepare Kit**. Before running the prototype session the papers have to be arranged in a way that makes it easy to find the various UI elements. Also blank paper, sticky notes and pens should be prepared for further ideas.
7. **The Prototype Session**. The user study session is an interactive process where one ore more participants and a facilitator are involved. In a dialogue the participant completes tasks provided by the facilitator. The session is used to get user opinions about early design and task flow ideas represented on paper. The sessions are typically recorded for later examination. The feedback from the users show what they expect from the app which is of great value for the implementation later on [Sny03]. Weiss [Wei03, p. 144] proposes to invite not only one, but two respondents at a time for paper prototype usability tests. He mentions that two respondents feel more comfortable in the casual environment that paper prototyping creates, whereas one single respondent can easily become overwhelmed by the experience.
8. **Reiterate**. After each prototype session an review and evaluation about what went good and what bad can be done. Although it might be tempting to change things after each session, it is better to wait until all the planned user sessions are done to do an overall comparative review at the end.

3.3 Creating a catalogue of design guidelines

A common challenge is to interpret the results of empirical studies and derive design guidelines which are not too specific but also not too general to make them applicable without additional interpretation effort. The methodology for the deduction of design guidelines for this thesis is inspired by De Bruijn's and Spence's framework for theory-based interaction design.

ID	DA1
Title	Maximisation of information exposure
Description	Expose users to as many representations of information items as possible commensurate with maximising the likelihood of those representations being correctly interpreted in terms of the information being represented.
Effect	The more of these items being presented to the user the greater the likelihood will be that one is perceived that is a relevant to a user's interests.
Upside	(1) Queries need not be explicitly formulated, as the relevant items will be recognized as such when encountered. (2) Irrelevant items will be forgotten with no cost in cognitive effort
Downside	Any display area is finite, giving rise to a trade-off between the number and size of items being presented simultaneously, and their presentation duration.
Issues	Comment is often made concerning the effects of information overload. This is not so relevant here, because no additional cognitive effort is involved in perceiving, interpreting and then forgetting information that is irrelevant. However, any action triggered does require focused attention. It is therefore important that this DA be applied to situations in which the likelihood of encountering a relevant item is relatively small. If multiple items of interest are likely to be encountered, then it is important that either a) the items can be easily prioritised, or b) the items can be dealt with sequentially.
Theory	Current theory suggests that irrelevant information is rapidly forgotten at no additional cost.

Figure 3.1: Exemplary design action of De Bruijn and Spence [DBS08]

The design action is headed by an **identifier** and a **title** indicating as clearly as possible the expected result of applying the design action. The **description** clarifies the brief title, followed by the **effect** that the design action will have. The design action further includes an **upside** and **downside** section that describes advantage and trade-offs respectively. The **Issues** sections considers issues that are neither positive nor negative. In the last part of the design action the **Theory** is provided as an opportunity for the designer to dive deeper. Nevertheless, the designer does not necessarily need to understand it in order to apply the guideline.

CHAPTER 4

Suggested solution

4.1 Questionnaire for user segmentation

In the State of the Art chapter the User Segmentation 2.2.1 from Smart Cities Demo Aspern on which this thesis builds up upon is explained. With regard to the Paper Prototyping session we need users that clearly can be allocated to a user segment. To get them we created a questionnaire. The user survey leaned on to the first questionnaire of the quantitative study of Aspern Smart City Research. The original questionnaire of ASCR comprised of 48 questions. The factor analysis of the returned questionnaire identified the four dimensions: Comfort-centered, Technology-centered, Data Sensibility and Living in Seestadt. The following cluster analysis found out four segments. For the definition of the segments only two of the four factors were relevant for describing the characteristics of a user group. For our study we focused on these two factors which are the comfort and the technology orientation. So, we took all the questions of the original questionnaire which answers were identified by the cluster analysis to be significant for the user segmentation. Out of the 48 questions of the original questionnaire ten were relevant for allocating a user to a user segment.

As the motivation to find subjects who completes a survey increases as the question difficulty increases [ANP07], our questionnaire only comprised of ten questions and the average time for answering the whole questionnaire only took one minute.

FRAGEBOGEN AN DIESER STELLE EINFÜGEN ODER FRAGEBOGEN IN DEN APPENDIX???

For creating the survey and sending it to different people we used Google Forms. We sent the questionnaire to 57 people, trying to have a good distribution of different ages, educational levels, jobs and interests. 31 questionnaires were returned. Answering the 10 questions only took about one minute.

For evaluating the response we used Google Spreadsheet and Microsoft Excel. The answers of each person was evaluated against the characteristics of each the four user segments. Of course not every user could easily be assigned to exactly one user segment. For each user the correspondence to each of the four user segments was calculated and expressed in percent. The ones who had a clear correspondence of more than 50 % to one user type were chosen as test subjects for the paper prototyping, the usability tests and the user study later on. So at least one user for each user type was chosen. The next step was the Paper Prototype.

The participation in this experiment of different users, from a beginner to an expert, enables us to have different opinions, different reactions, as well as inconsistent feedbacks when using the apps (Nielsen 1994). [MIA16]

4.2 Paper Prototyping

In order to elicit the requirements for the graphical user interfaces and overall for the app we make use of Paper Prototyping.

There, hand-sketched drafts will be drawn, showing the app with menus, dialogue boxes, notifications and buttons. Then, different tasks that can be done with the app shall be defined. These tasks are then conducted by the users.

As described before in 2.3.2 we follow the Step-by-Step guide of Arnowitz et al. [AAB10] to create a Paper Prototype:

1. **Create scenario**.

   The main goal of the mobile application that shall be developed is to give feedback about how much electricity, water and heating a user consumed, how much carbon-dioxide was produced and how the values can be made better. The screens shall be adapted to the user type to make the information and tips more attractive to a user's interests.

   Professionals: The user study revealed that Professionals have high interest in energy issues. As they are deep into the topic and prefer more detailed information in individual offers they can have a look on the energy consumption on a very detailed level, such as a consumption rate on a granularity of minutes.

   - Task: Have a look on your consumption rate of the last week/month/year

   Professionals should have a possibility within the application to compare energy consumptions of different time intervals.

   - Task: Compare your consumption rate of the last week with the consumption rate of the same week one year earlier.

Professionals also like to compare themselves to others. Comparing his or her average energy consumption to others should also be possible.

- Task: Compare your consumption rate of the last week with the average consumption rate of your neighbours

Professionals also like rationally justified explanations and instructions for use. Notifications on a daily basis give tips on saving energy or CO2, give concrete instructions for use and provides deeper information in Energy topics.

- Task: Find tips on how to save more energy

Optimizer: Optimizer primarily aim at optimizing energy costs, so the app should give easy to find tips on how to save energy and therefore costs. Optimizers prefer less time of interaction. As Optimizer rather like unclear instructions, the notifications on a daily basis also should give concrete instructions on how to save energy or CO2.

- Task: Find out what to do to save costs for electricity

Professionals like to know the concrete benefits of a certain behavior change. The explanations shall be as close to reality as possible and technical language shall be avoided. The energy feedback is reduced to essential information and the detailed graphs for energy consumption that the Professionals get are not visible at a first glance for an Optimizer. The saved costs after a behaviour change shall also be visible to provide some kind of reward for the new habits.

- Task: Find out how much you have saved in the last week

For Optimizer also trouble shooting shall be easily accessible, in order to reduce the time they are spending with the application and not to loose them on the way.

- Task: Report a problem

Indifferents: The Indifferents have low interest in energy topics in general, so the main requirement of the application for this type of user is in the first run to sensitize them for the topic, to raise awareness and to make electricity and CO2 saving appealing to them.

To awaken their interest for energy and sustainability a gamification approach will be used. For opening the application once a day the user earns points. Points are also earned for clicking on notifications and reading the article. Tips for saving energy or CO2 should not concern longer usage of laptops or entertainment screens, as streaming and use of social media is an important leisure activity for Indifferents.

- Task: Earn points by interacting with the App

Hedonists: The youngest segment, the Hedonists, are keen on developing technical solutions. The interest in technology can be used to give instructions for programming technical devices and using home automation. The primary motive for the Hedonists is not to save energy but the interest in technology. This will be considered in the notifications and tips of the day. The hedonistic lifestyle with its strong convenience and comfort orientation is in the foreground.

For a hedonist the comfort gain is of great relevance. Programming and establishing home automation aspects is a great interface between the aim of saving energy and the affinity of technology.

2. **Inventory UI elements**. The next step is to make a checklist of all UI elements that may be needed to support the scenario.

3. **Create UI elements**. All the UI elements from the checklist from the previous step are now created in paper form. There are a lot of tools and materials that can come in handy at this step. The following list of materials might help the process: paper, sticky notes, whiteboard, sketchbook, notebook, napkin, cards, overhead sheet, cardboard, carton, scissors, markers, UI stencil, correction fluid and tape and transparency sheet.

4. **Run through scenario**. In this step a dry-run through the scenario with the paper prototype should be done and missing parts should be found an recreated.

5. **Internal review**. The last step in the first round is the internal review with the team where the audience is defined, the goals for each version of the prototype is reviewed, the expectation of the reviewers are found out and the next steps are planned.

The next Step-By-Step Guide is following the first. It was also proposed by Arnowitz et al. [AAB10] and is for testing the Paper Prototype:

1. **Revise scenario**. The internal review may have uncovered some tweaks that you want to change. Be careful for changes at the scenario as it may cause a ripple effect which can lead to necessary changes in user interface elements or even new screens. Keeping changes to minimum is recommended. If changes are necessary keep in mind that this may result in the inventory of user interface.

2. **Revise inventory UI elements**. Until now maybe multiple run throughs through the prototype have been done and you noticed that some vital pieces of the interface are missing. Now is a good time to check completeness of the UI elements checklist. Developing a set of UI elements for cases that you did not anticipate may be also useful.

3. **Create UI elements**.

4. **Pilot run through scenario**. Before presenting the prototype to the user it has to be tried out first. You can give the Prototype to anyone, e.g. a team member, to try it out. The aim here is to find missing pieces to be prepared for everything they do. The run through will ensure that you haven't created a half-baked prototype.

5. **Internal review**.

   The last step in the first round is the internal review with the team where the audience is defined, the goals for each version of the prototype is reviewed, the expectation of the reviewers are found out and the next steps are planned.

6. **Prepare Kit**. Before running the prototype session the papers have to be arranged in a way that makes it easy to find the various UI elements. Also blank paper, sticky notes and pens should be prepared for further ideas.

7. **The Prototype Session**. The user study session is an interactive process where one ore more participants and a facilitator are involved. In a dialogue the participant completes tasks provided by the facilitator. The session is used to get user opinions about early design and task flow ideas represented on paper. The sessions are typically recorded for later examination. The feedback from the users show what they expect from the app which is of great value for the implementation later on [Sny03]. Weiss [Wei03, p. 144] proposes to invite not only one, but two respondents at a time for paper prototype usability tests. He mentions that two respondents feel more comfortable in the casual environment that paper prototyping creates, whereas one single respondent can easily become overwhelmed by the experience.

8. **Reiterate**. After each prototype session an review and evaluation about what went good and what bad can be done. Although it might be tempting to change things after each session, it is better to wait until all the planned user sessions are done to do an overall comparative review at the end.

CHAPTER 5

evaluation

CHAPTER 6

Critical reflection

List of Figures

List of Tables

List of Algorithms

Index

Glossary

editor A text editor is a type of program used for editing plain text files.. 5

Acronyms

CTAN Comprehensive TeX Archive Network. 11

FAQ Frequently Asked Questions. 11

PDF Portable Document Format. 6, 10, 11, 15

SVN Subversion. 10

WYSIWYG What You See Is What You Get. 9

Bibliography

[AAB10] Jonathan Arnowitz, Michael Arent, and Nevin Berger. *Effective prototyping for software makers.* Elsevier, 2010.

[ABS05] Ernesto Arroyo, Leonardo Bonanni, and Ted Selker. Waterbot: exploring feedback and persuasive techniques at the sink. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 631–639. ACM, 2005.

[AH93] Sujai Asur and Steve Hufnagel. Taxonomy of rapid-prototyping methods and tools. In *Rapid System Prototyping, 1993. Shortening the Path from Specification to Prototype. Proceedings., Fourth International Workshop on*, pages 42–56. IEEE, 1993.

[ANP07] Dorine Andrews, Blair Nonnecke, and Jennifer Preece. Conducting research on the internet: Online survey design, development and implementation guidelines. 2007.

[AY15] Khalid Alharbi and Tom Yeh. Collect, decompile, extract, stats, and diff: Mining design pattern changes in android apps. In *Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services*, pages 515–524. ACM, 2015.

[Bev98] N Bevan. Iso 9241: Ergonomic requirements for office work with visual display terminals (vdts)-part 11: Guidance on usability. *TC*, 159, 1998.

[BGK07] Magnus Bang, Anton Gustafsson, and Cecilia Katzeff. Promoting new patterns in household energy consumption with pervasive learning games. In *International Conference on Persuasive Technology*, pages 55–63. Springer, 2007.

[BLWM17] Hedin Björn, Anton Lundström, Magnus Westlund, and Erik Markström. The energy piggy bank - a serious game for energy conservation. In *The Fifth IFIP Conference on Sustainable Internet and ICT for Sustainability, Funchal, Portugal, December 6-7, 2017 :*, 2017. QC 20171218.

[BMM+14] Francis Brouns, José Mota, Lina Morgado, Darco Jansen, Santiago Fano, Alejandro Silva, and António Teixeira. A networked learning framework for effective mooc design: the eco project approach. 2014.

[BS10] Chris Bernard and Sara Summers. *Dynamic Prototyping with SketchFlow in Expression Blend: Sketch Your Ideas... And Bring Them to Life!, Portable Documents*. Pearson Education, 2010.

[CB00] Mike Carbonaro and Joyce Bainbridge. Design and development of a process for web-based survey research. *Alberta Journal of Educational Research*, 46(4), 2000.

[DBS08] Oscar De Bruijn and Robert Spence. A new framework for theory-based interaction design applied to serendipitous information retrieval. *ACM transactions on computer-human interaction (TOCHI)*, 15(1):5, 2008.

[DDR99] Joseph S Dumas, Joseph S Dumas, and Janice Redish. *A practical guide to usability testing*. Intellect books, 1999.

[Dek16] Biplab Deka. Data-driven mobile app design. In *Proceedings of the 29th Annual Symposium on User Interface Software and Technology*, pages 21–24. ACM, 2016.

[Din98] E Din. 9241-11. ergonomic requirements for office work with visual display terminals (vdts)–part 11: Guidance on usability. *International Organization for Standardization*, 1998.

[EO12] Mirjam P Eladhari and Elina MI Ollila. Design for research results: experimental prototyping and play testing. *Simulation & Gaming*, 43(3):391–412, 2012.

[FDK+09] Jon Froehlich, Tawanna Dillahunt, Predrag Klasnja, Jennifer Mankoff, Sunny Consolvo, Beverly Harrison, and James A Landay. Ubigreen: investigating a mobile tool for tracking and supporting green transportation habits. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 1043–1052. ACM, 2009.

[FFL10] Jon Froehlich, Leah Findlater, and James Landay. The design of eco-feedback technology. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 1999–2008. ACM, 2010.

[FH03] James Fogarty and Scott E Hudson. Gadget: A toolkit for optimization-based approaches to interface and display generation. In *Proceedings of the 16th annual ACM symposium on User interface software and technology*, pages 125–134. ACM, 2003.

[Fis08] Corinna Fischer. Feedback on household electricity consumption: a tool for saving energy? *Energy efficiency*, 1(1):79–104, 2008.

[Fog02] Brian J Fogg. Persuasive technology: using computers to change what we think and do. *Ubiquity*, 2002(December):5, 2002.

[Gaf09] Ruti Gafni. Usability issues in mobile-wireless information systems. *Issues in Informing Science & Information Technology*, 6, 2009.

[GCG08] Noah J Goldstein, Robert B Cialdini, and Vladas Griskevicius. A room with a viewpoint: Using social norms to motivate environmental conservation in hotels. *Journal of consumer Research*, 35(3):472–482, 2008.

[Gra00] Helen M Grady. Web site design: a case study in usability testing using paper prototypes. In *Proceedings of IEEE professional communication society international professional communication conference and Proceedings of the 18th annual ACM international conference on Computer documentation: technology & teamwork*, pages 39–45. IEEE Educational Activities Department, 2000.

[GSC+12] Luciano Gamberini, Anna Spagnolli, Nicola Corradi, Giulio Jacucci, Giovanni Tusa, Topi Mikkola, Luca Zamboni, and Eve Hoggan. Tailoring feedback to users' actions in a persuasive game for household electricity conservation. In *International Conference on Persuasive Technology*, pages 100–111. Springer, 2012.

[GWW08] Krzysztof Z Gajos, Daniel S Weld, and Jacob O Wobbrock. Decision-theoretic user interface generation. In *AAAI*, volume 8, pages 1532–1536, 2008.

[HD98] Ann Hickey and Douglas Dean. Prototyping for requirements elicitation and validation: A participative prototype evaluation methodology. *AMCIS 1998 Proceedings*, page 268, 1998.

[HFD13] Rachel Harrison, Derek Flood, and David Duce. Usability of mobile applications: literature review and rationale for a new usability model. *Journal of Interaction Science*, 1(1):1, 2013.

[HGH10] Helen Ai He, Saul Greenberg, and Elaine M Huang. One size does not fit all: applying the transtheoretical model to energy feedback technology design. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 927–936. ACM, 2010.

[HKH+04] David Holstius, John Kembel, Amy Hurst, Peng-Hui Wan, and Jodi Forlizzi. Infotropism: living and robotic plants as interactive displays. In *Proceedings of the 5th conference on Designing interactive systems: processes, practices, methods, and techniques*, pages 215–221. ACM, 2004.

[Hol07] Tiffany Grace Holmes. Eco-visualization: combining art and technology to reduce energy consumption. In *Proceedings of the 6th ACM SIGCHI conference on Creativity & cognition*, pages 153–162. ACM, 2007.

[JNS+13] Antti Jylhä, Petteri Nurmi, Miika Sirén, Samuli Hemminki, and Giulio Jacucci. Matkahupi: a persuasive mobile application for sustainable mobility. In *Proceedings of the 2013 ACM conference on Pervasive and ubiquitous computing adjunct publication*, pages 227–230. ACM, 2013.

[Jon98] T Capers Jones. *Estimating software costs*. McGraw-Hill, Inc., 1998.

[KCJK02] Mable B Kinzie, Wendy F Cohn, Marti F Julian, and William A Knaus. A user-centered model for web site design: needs assessment, user interface design, and rapid prototyping. *Journal of the American medical informatics association*, 9(4):320–330, 2002.

[KK12] Abdul Momin Kazi and Wardah Khalid. Questionnaire designing and validation. *Journal of the Pakistan Medical Association*, 62(5):514, 2012.

[KPM97] Colleen Kehoe, Jim Pitkow, and Kimberly Morton. Eighth www user survey. *Retrieved September*, 17:2002, 1997.

[KS98] Gerald Kotonya and Ian Sommerville. *Requirements engineering: processes and techniques*. Wiley Publishing, 1998.

[KSPP12] Jesper Kjeldskov, Mikael B Skov, Jeni Paay, and Rahuvaran Pathmanathan. Using mobile phones to support sustainability: a field study of residential electricity consumption. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 2347–2356. ACM, 2012.

[KST+13] Ranjitha Kumar, Arvind Satyanarayan, Cesar Torres, Maxine Lim, Salman Ahmad, Scott R Klemmer, and Jerry O Talton. Webzeitgeist: design mining the web. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 3083–3092. ACM, 2013.

[Lan04] A Lancaster. Paper prototyping: the fast and easy way to design and refine user interfaces. *IEEE Transactions on Professional Communication*, 47(4):335–336, 2004.

[LPPA06] Youn-kyung Lim, Apurva Pangam, Subashini Periyasami, and Shweta Aneja. Comparative analysis of high-and low-fidelity prototypes for more valid usability evaluations of mobile devices. In *Proceedings of the 4th Nordic conference on Human-computer interaction: changing roles*, pages 291–300. ACM, 2006.

[LTG+06] Gunny Lee, Chris Tsai, William G Griswold, Fred Raab, and Kevin Patrick. Pmeb: a mobile phone application for monitoring caloric balance. In *CHI'06 extended abstracts on Human factors in computing systems*, pages 1013–1018. ACM, 2006.

[Lum07] Joanna Lumsden. Online-questionaire design guidelines. In *Handbook of research on electronic surveys and measurements*, pages 44–64. IGI Global, 2007.

[LW] Dean Leffingwell and Don Widrig. Managing software requirements: a unified approach. 2000.

[MB02] Martin Maguire and Nigel Bevan. User requirements analysis. In *Usability*, pages 133–148. Springer, 2002.

[MGM+17] Hessam Mohammadmoradi, Omprakash Gnawali, David Moss, Rainer Boelzle, and Gene Wang. Effectiveness of a task-based residential energy efficiency program in oahu. In *2017 Sustainable Internet and ICT for Sustainability (SustainIT)*, pages 1–8. IEEE, 2017.

[MIA16] Karima Moumane, Ali Idri, and Alain Abran. Usability evaluation of mobile applications using iso 9241 and iso 25062 standards. *SpringerPlus*, 5(1):548, 2016.

[MM98] LT McCalley and GJH Midden. Computer based systems in household appliances: the study of eco-feedback as a tool for increasing conservation behavior. In *Computer Human Interaction, 1998. Proceedings. 3rd Asia Pacific*, pages 344–349. IEEE, 1998.

[MM02] LT McCalley and Cees JH Midden. Energy conservation through product-integrated feedback: The roles of goal-setting and social orientation. *Journal of economic psychology*, 23(5):589–603, 2002.

[MPV83] Eileen A McConnaughy, James O Prochaska, and Wayne F Velicer. Stages of change in psychotherapy: Measurement and sample profiles. *Psychotherapy: Theory, Research & Practice*, 20(3):368, 1983.

[MRS+09] Min Mun, Sasank Reddy, Katie Shilton, Nathan Yau, Jeff Burke, Deborah Estrin, Mark Hansen, Eric Howard, Ruth West, and Péter Boda. Peir, the personal environmental impact report, as a platform for participatory sensing systems research. In *Proceedings of the 7th international conference on Mobile systems, applications, and services*, pages 55–68. ACM, 2009.

[Nie90] Jakob Nielsen. Paper versus computer implementations as mockup scenarios for heuristic evaluation. In *Proceedings of the IFIP Tc13 Third interational Conference on Human-Computer interaction*, pages 315–320. North-Holland Publishing Co., 1990.

[Nie94a] Jakob Nielsen. *Usability engineering.* Elsevier, 1994.

[Nie94b] Jakob Nielsen. Usability inspection methods. In *Conference companion on Human factors in computing systems*, pages 413–414. ACM, 1994.

[OKH09] Harri Oinas-Kukkonen and Marja Harjumaa. Persuasive systems design: Key issues, process model, and system features. *Communications of the Association for Information Systems*, 24(1):28, 2009.

[PDE15] Josiane Xavier Parreira, Deepak Dhungana, and Gerhard Engelbrecht. The role of rdf stream processing in an smart city ict infrastructure-the aspern smart city use case. In *International Semantic Web Conference*, pages 343–352. Springer, 2015.

[PGKK12] Petromil Petkov, Suparna Goswami, Felix Köbler, and Helmut Krcmar. Personalised eco-feedback as a design technique for motivating energy saving behaviour at home. In *Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design*, pages 587–596. ACM, 2012.

[PKFK11] Petromil Petkov, Felix Köbler, Marcus Foth, and Helmut Krcmar. Motivating domestic energy conservation through comparative, community-based feedback in mobile and social media. In *Proceedings of the 5th International Conference on Communities and Technologies*, pages 21–30. ACM, 2011.

[POB08] James Pierce, William Odom, and Eli Blevis. Energy aware dwelling: a critical survey of interaction design for eco-visualizations. In *Proceedings of the 20th Australasian Conference on Computer-Human Interaction: Designing for Habitus and Habitat*, pages 1–8. ACM, 2008.

[PQNB12] Lucas Pereira, Filipe Quintal, Nuno Nunes, and Mario Bergés. The design of a hardware-software platform for long-term energy eco-feedback research. In *Proceedings of the 4th ACM SIGCHI symposium on Engineering interactive computing systems*, pages 221–230. ACM, 2012.

[PS83] Girish Punj and David W Stewart. Cluster analysis in marketing research: Review and suggestions for application. *Journal of marketing research*, pages 134–148, 1983.

[PSJ+07] John E Petersen, Vladislav Shunturov, Kathryn Janda, Gavin Platt, and Kate Weinberger. Dormitory residents reduce electricity consumption when exposed to real-time visual feedback and incentives. *International Journal of Sustainability in Higher Education*, 8(1):16–33, 2007.

[RSI96] Jim Rudd, Ken Stern, and Scott Isensee. Low vs. high-fidelity prototyping debate. *interactions*, 3(1):76–85, 1996.

[Ryu05] Young Sam Ryu. *Development of usability questionnaires for electronic mobile products and decision making methods.* PhD thesis, Virginia Tech, 2005.

[SCG+11] Anna Spagnolli, Nicola Corradi, Luciano Gamberini, Eve Hoggan, Giulio Jacucci, Cecilia Katzeff, Loove Broms, and Li Jonsson. Eco-feedback on the go: Motivating energy awareness. *Computer*, 44(5):38–45, 2011.

[SM10] Brian Still and John Morris. The blank-page technique: Reinvigorating paper prototyping in usability testing. *IEEE Transactions on Professional Communication*, 53(2):144–157, 2010.

[Smi97] Christine B Smith. Casting the net: Surveying an internet population. *Journal of Computer-Mediated Communication*, 3(1), 1997.

[Sny96] Carolyn Snyder. Using paper prototypes to manage risk. *Software Design and Publisher Magazine*, 1996.

[Sny03] Carolyn Snyder. *Paper prototyping: The fast and easy way to design and refine user interfaces.* Morgan Kaufmann, 2003.

[SP13] Shreta Sharma and SK Pandey. Revisiting requirements elicitation techniques. *International Journal of Computer Applications*, 75(12), 2013.

[STG03] Reinhard Sefelin, Manfred Tscheligi, and Verena Giller. Paper prototyping-what is it good for?: a comparison of paper-and computer-based low-fidelity prototyping. In *CHI'03 extended abstracts on Human factors in computing systems*, pages 778–779. ACM, 2003.

[Taj10] Henri Tajfel. *Social identity and intergroup relations.* Cambridge University Press, 2010.

[TSF12] Johannes Tulusan, Thorsten Staake, and Elgar Fleisch. Providing eco-driving feedback to corporate car drivers: what impact does a smartphone application have on their fuel efficiency? In *Proceedings of the 2012 ACM conference on ubiquitous computing*, pages 212–215. ACM, 2012.

[Tuf11] Stéphane Tufféry. *Data mining and statistics for decision making*, volume 2. Wiley Chichester, 2011.

[VR11] Jaya Vijayan and G Raju. A new approach to requirements elicitation using paper prototype. *International Journal of Advanced Science and Technology*, 28:9–16, 2011.

[VSK96] Robert A Virzi, Jeffrey L Sokolov, and Demetrios Karis. Usability problem identification using both low-and high-fidelity prototypes. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 236–243. ACM, 1996.

[WB13] Karl Wiegers and Joy Beatty. *Software requirements.* Pearson Education, 2013.

[Wei03] Scott Weiss. *Handheld usability.* John Wiley & Sons, 2003.

[WOB10] Brett Williams, Andrys Onsman, and Ted Brown. Exploratory factor analysis: A five-step guide for novices. *Australasian Journal of Paramedicine*, 8(3), 2010.

[You02] Ralph R Young. Recommended requirements gathering practices. *CROSSTALK The Journal of Defense Software Engineering*, 15(4):9–12, 2002.

[YT00] Gi Woong Yun and Craig W Trumbo. Comparative response to a survey executed by post, e-mail, & web form. *Journal of computer-mediated communication*, 6(1):JCMC613, 2000.

[ZA05] Dongsong Zhang and Boonlit Adipat. Challenges, methodologies, and issues in the usability testing of mobile applications. *International journal of human-computer interaction*, 18(3):293–308, 2005.