JÖNKÖPING UNIVERSITY
School of Engineering

Low-impact user interfaces: How can we create a climate-smart approach toward front-end mobile application design?

Evaluation and proposed improvement of existing guidelines – Focused on Online Food Delivery sector.

This final thesis has been carried out at the School of Engineering at Jönköping University within Informatics. The authors of this study are responsible for the presented opinions, conclusions, and results.

Abstract

The use of the Internet and digital services has increased significantly during recent years, and as Human-Computer Interaction (HCI) field keeps on expanding, it is influencing aspects of our daily lives, though not always for the better. Researchers and practitioners, including a small number of designers, are addressing the growing concerns about the Internet's environmental impact, such as electronic waste, increased energy use, resource depletion, and carbon footprint, which have emerged in recent years, and are calling for a more environment-friendly approach to web and app design. However, it is still a relatively new area of concern. This study evaluates existing guidelines for designing low-impact user interfaces in the mobile food delivery sector. First, the study investigates users' food delivery habits and their impressions of low-impact interfaces. The findings from this section are then used to design a low-impact food delivery application (FDA) prototype and are tested with users to see how to make low-impact interfaces attractive for a possible change in user behaviors. This thesis builds on previous research about sustainable web design, but the focus area of this study is to investigate whether applied guidelines and low-impact design features are desired by users on mobile screens as well. The research reveals that low-impact features are indeed useful on smaller screens as well and users are generally open-minded and acceptive of front-end changes that have a more positive impact on the environment. However, it is crucial to communicate clearly about any low-impact modifications made to an application, due to the current low level of user awareness and knowledge in this field.

Keywords

Low-impact App Design, UX Design, UI Design, Sustainable App Design, Food Delivery Prototype, Low-impact Application Design Guidelines, Thesis in informatics

Table of content

1 Introduction

When we consider ways to address environmental concerns, many of us first consider issues such as the importance of minimizing carbon emissions, switching to renewable energy, and cutting back on wasteful products such as plastic. While these should remain top priorities, recent concerns about the environmental impact of Human-Computer Interaction (HCI) should be acknowledged. In recent years, there has been a considerable increase in online activities and the usage of digital services due to the COVID-19 pandemic according to Mouratidis and Papagiannakis (2021). This has also affected consumer behavior, leading to an exponential rise in online sales. The increase in online activities corresponds to increased Internet usage and demand, rising issues such as electronic waste, resource depletion, increased energy consumption, and carbon footprint. Research on this issue was conducted for the Jönköping University final thesis project in 2022, titled "Sustainable web design in the e-commerce sector" (Balogh & Bernataviciute, 2022). As stated in the report, future research implied that it is needed to test if low-impact guidelines apply to smaller screens as well. In addition, this research will expand the subject by conducting additional research in the Food Delivery App (FDA) sector and creating a mobile application prototype. It is important to highlight that the mentioned bachelor thesis is only used as a source of inspiration and for comparing results in this study. This study documents the author's final bachelor's work in Informatics, with a specialization in New Media Design. It intends to assess and expand on existing research in low-impact design, with a focus on front-end user interfaces (UI) and user experience (UX).

1.1 Problem statement

Human-computer interaction (HCI) is a constantly growing field of study that is focusing on the improvement of user-computer interaction. HCI has expanded to cover almost all forms of technology becoming an integral part of our daily lives. In recent years, there has been a growing concern regarding the environmental impact of HCI. The web development industry has begun to shift towards making websites and applications more environment-friendly by switching to hosting providers that use renewable energy sources or optimizing code. Most of these changes happen at the back-end level, which Internet users do not see, consequently, making them unaware of the impact of their online activities and habits. Frick (2016) and Greenwood (2021) have identified key criteria for sustainable web design, such as using SVG vector graphics instead of images, and usage of certain fonts and colors; however, they are not being widely applied in practice. Websites designed following the guidelines result in different UX and UI than the ones users see and use now. The authors further mention that switching to creating websites or apps more sustainably would require a change in

user behavior, which might be one of the main reasons low-impact websites are not being introduced more widely.

According to Marotta et al., (2018), power consumption varies depending on various factors and it is challenging to provide specific statistics on power consumption in different parts of the Internet due to the dynamic and ever-evolving nature of the Internet infrastructure. However, the largest consumption of power can typically be attributed to the server infrastructure. Power consumption on the client side varies based on the type of internet usage. According to Statista (2023a), millions of messages, e-mails, and texts are sent, scrolled, and uploaded in one internet minute, and hundreds of thousands of hours of content are consumed. Users worldwide streamed one million hours of content in 2022. Greenwood (2021) highlights that switching to low-impact interfaces offers several significant benefits, from both environmental and user perspectives. Low-impact interfaces consume less power as they prioritize energy efficiency by optimized design choices, which contributes to a reduced carbon footprint and can also lead to cost savings in terms of energy consumption. Furthermore, as explained more in-depth in the theoretical framework of this study, making thoughtful design choices in user interfaces that have a minimal impact can shorten the user's journey, allowing the user to reach their destination more quickly and efficiently. This leads to increased user satisfaction and reduces the time spent on the applications or websites which is beneficial for the environment.

1.1.1 The internet's impact on the environment

According to (Domo, 2022), as of April 2022, the internet was connected to 63% of the world's population or about 5 billion people. Greenwood (2021) cites data from a nature.com article (Jones, 2018) to highlight the negative environmental impact of the Internet: Putting the issue in perspective, the Internet would rank as the sixth most polluting nation in the world, with annual emissions equivalent to those of Germany. The use of more powerful devices and faster connections by web developers and designers has led to the creation of larger, less effective websites that consume more server energy. A website's energy consumption will increase with its complexity, which can negatively influence the environment. According to Website Carbon (n.d.), an online carbon calculator, the average website reviewed produces about 0.5 grams of CO_2 per page view. That website would have generated 60kg of CO_2 annually if it had 10,000 monthly visitors.

1.2 Purpose and research questions

Based on the problem statement, it is evident that the low-impact approach should be adopted more broadly from the front-end aspect. User habits must be altered in order to further introduce the new approach. As a result, the purpose of this research is to determine how we can create a climate-smart approach by evaluating existing guidelines, putting them to the test, and then proposing improvements to create a new demand As stated in the problem statement, addressing this issue is critical because internet usage is constantly increasing.

The purpose of this thesis is also to build upon previous research about sustainable web design, but this study focuses on mobile app design where current existing guidelines are revised and tested with the users. The goal is to present a low-impact mobile application that appeals to users based on prior research and data gathered from this paper. The following research questions have been developed to fulfill the study's objective:

1. What are users' impressions and current knowledge of low-impact user interface designs?
2. How can we make low-impact mobile applications more attractive to consumers?

1.3 Scope and limitations

As previously stated, this thesis builds on previous studies on low-impact web design, however, the primary aim of this paper is to determine whether applied guidelines and low-impact features are desired by users on smaller screens as well. According to Statista (2023b), mobile internet has been more accessible and popular in recent years, as smartphones have become more widely available and affordable than ever before. Users spent approximately 192 minutes per day online in 2021, mainly on smartphones. According to Statista (2023c), mobile internet accounts for over 57 percent of total web traffic worldwide, supporting the requirement for this study to be conducted on the mobile interface. The number of mobile app downloads reached 143,2 billion in 2020 and increased to 430,2 billion in 2022 according to Statista (2022). The increase in the use of mobile devices has led to the emergence of various online food delivery apps, which now constitute one of the fastest-growing mobile commerce sectors according to Forbes (2021). Online food delivery is a service for ordering and delivering food from various restaurants through an app, allowing users to search for their desired restaurants, select the menus available at those restaurants, and provide their delivery address. According to Statista (2023d), convenience is one of the main reasons to order food online. This suggests that low-impact mobile screen-focused studies in the food delivery sector are relevant and required; therefore, this study is limited to mobile application design in the food delivery sector.

Greenwood (2021) highlights that the environmental impact of the Internet is a broad and large topic that needs to be approached from both the front and back-end aspects. As mentioned in the problem statement, web developers have started transitioning towards low-impact solutions. However, these solutions are relatively new and according to Greenwood (2021) are not commonly known to the users. Guimaraes (2017) explains that consumer preferences and demands play a crucial role in shaping the products and services that are developed. Therefore, increasing user awareness and consumer demand could be a significant driving force for designers and web developers to adopt a low-impact approach worldwide. This study aims to contribute to the introduction of low-impact design to users, focusing specifically on the front-end aspect, and will not cover any aspects of back-end development. Additionally, this thesis is limited to the geographical area of Jönköping, Sweden.

1.4 Disposition

This paper opens with an introduction to the topic of the study. A research gap is identified, after which the study's purpose and research questions are formed. Following the introduction, the methods and their implementation is described. Right after there is an overview of the theoretical background, which provides a foundation and gathers existing knowledge about the relevant fields of study. Following that, the results of the various methods are presented, and an analysis is conducted. The discussion evaluates the analyzed findings about the research questions and the purpose of this study. The paper concludes with suggestions for future research.

2 Method and implementation

A qualitative study, characterized as exploratory according to Maxwell and Reybold (2015), as well as Curry et al., (2009), aims to analyze behaviors, experiences, and perceptions. This type of study is particularly useful when examining phenomena that demand a comprehensive understanding from multiple perspectives. Johnson and Christensen (2014) explain that a qualitative study can be used to test or apply existing theory to the context of a study, assisting this approach to refine or expand the theory and provide new insights. Maxwell and Reybold (2015) have also outlined that qualitative research is preferred when the researcher's focus is on how people make sense of specific phenomena. As a result, a qualitative approach was chosen for the method of this study to identify areas for improvement and provide recommendations that can address the existing low-impact design guidelines as well as give the authors of this paper enough time to design with an iterative process. This study has a deductive research approach as it is built on previous research. The data collection has been divided into two sections, each of which applies an appropriate qualitative method to address each research question. Focus groups were selected as a primary research method to provide rich and detailed data on the participant's knowledge about low-impact UIs, and their preferences and habits when ordering through FDAs. The data gathered addressed the first research question of this study and was then analyzed and used as the basis for the second phase, which involved prototype building and usability testing to address the second research question regarding how to make low-impact apps more attractive to consumers.

2.1 Focus Groups

According to Sutton and Arnold (2013), O'hEocha et al., (2011), and Morgan (1997), focus groups are an appropriate methodological choice for gathering limited data when unexplored and emerging phenomena are being addressed. Using focus groups allows

the researcher to extract insights from participants, by providing a pre-specified topic and open-ended questions, to facilitate interaction among participants and allow the discussion around the topic to evolve. It enables an in-depth exploration of the user experiences, identifying specific design decisions that had a significant impact and exploring those decisions in detail.

2.1.1   Focus group implementation

Morgan (1997) explains that there is essentially no additional knowledge to be gathered when the researcher has reached saturation, which is when the researcher can anticipate what focus group participants are going to say even before they start. Therefore, three focus groups were carried out in the scope of this study as there were clear and visible patterns in participants' discussions. During the sessions, the authors of this research were present as a moderator and an assistant. The moderator's role was to assist the discussion by encouraging both positive and negative comments while remaining neutral and opinion-free. The assistant's responsibility was to watch and note the order of speaking, the participant's body language, interruptions, and speaking tones. Additionally, the sessions were audio recorded, as recommended by Barbour and Kitzinger (1999) for richer data collection from the sessions. The authors propose video recording could provide additional information as well. However, they point out that it can cause participants to feel self-conscious and less open, which was then avoided throughout the data collection. All participants were informed about the session being audio recorded and asked to sign a consent form. To provide the most honest and free discussion, the focus groups were scheduled in a quiet and spacious environment at the Jönköping University Library.

Participant Selection. Selecting participants that are likely to use a product or service in real-world scenarios and contexts can provide more detailed feedback according to Litosseliti (2007), as the first-hand experience will enable the participants to provide feedback based on actual usage, practical considerations, and challenges they may have encountered. According to Alalwan (2020), FDAs tend to target a wide range of individuals who value convenience, time-saving, and accessible options but the popularity and adoption of FDAs have been specifically among younger generations since the younger age groups tend to be more tech-savvy, have busy lifestyles, and are used to the convenience of mobile applications. As a result, students, and young adults between the ages of 20 to 30 were selected as the focus group participants. Nevertheless, it is necessary to keep in mind that this age range is not representative of the entire population and therefore has a potential limitation to the generalizability of the study's findings. Considering this, age-related differences in life experiences, cognitive

abilities, physiological changes, and priorities are common and may have an impact on the study.

It is important to keep in mind that while including participants familiar with the application can be beneficial, it is crucial to have a diverse range of participants to capture different perspectives and understandings as Litosseliti (2007) explains and mentions that it will also ensure effective communication and good group dynamic. To ensure that the chosen participants fit the requirements of diversity, the groups included a mix of females and males with different backgrounds and ethnicities. Five individuals were invited to each focus group, and each participant was invited electronically and then added to a Facebook Event. This provided participants with additional information about the event and allowed them to choose a preferable time to attend a physical focus group session.

Structure. According to Morgan (1997) and Sutton and Arnold (2013), determining an appropriate group structure is an important part of focus group design. The authors present the nominal group technique, a structured way for group brainstorming that fosters everyone's participation in problem identification, solution formulation, and decision-making. A structured group approach was chosen for this research's focus groups as it allows for designing a tailored study for chosen research questions and objectives. An appropriate group structure and composition contribute to gathering rich and meaningful data from the participants which is crucial since the findings of the focus groups serve as the foundation for the next phase of the study, which is the prototype building.

The process. The focus groups were constructed to last for 1-1,5 hours. Refreshments and snacks were provided while the participants were signing the consent form. They were also asked to write their name on a badge to put in front of them for easier communication between the participants. To easier follow along during the focus group, presentation slides were made and shown on a big screen. The session started with a short introduction about what was expected from the participants and general information about the agenda as well as the benefits of the meeting.

The focus group was divided into three parts in the same order as stated below:
1. Topic 1: Food-delivery habits
2. Topic 2: Impressions on low-impact interfaces
3. Topic 3: Changing online user habits

Topic 1 was divided into two parts. The first part served as an ice breaker where everyone got to introduce themselves with their name, where they are from, and what their favorite food to get delivered is. It continued with three shorter questions that they got to answer about their food delivery habits (see Appendix 2). The second part of

topic 1 consisted of an exercise where the participants were asked to open up/download the food delivery app Foodora on their phones or use the moderator's or the assistant's phones. Foodora (n.d.) is Sweden's most popular FDA for home delivery and the company is operating in Scandinavia, therefore a suitable choice for this study. They were then asked to mark down notes on what they found most and least relevant regarding the app's visual and interactive elements. The exercise included three scenarios - when the user is on the start page, restaurant page, and product page. In each scenario, the participants were to analyze the page for a couple of minutes and write down their notes, and when finished with one page the moderator encouraged the participants to discuss their opinions and decisions about the specific page elements. Moving on to topic 2, the moderator began to briefly explain what impact the internet has on the environment and what low-impact design is. The topic continued with an exercise where the low-impact website prototype from the thesis "Sustainable web design in the e-commerce sector" (Balogh & Bernataviciute, 2022) was demonstrated in the form of two printed screenshots (see Appendix 1). Furthermore, the participants were asked to express their first impression of the website and what feelings and thoughts that come to mind when they saw it. They were also asked to discuss what features they think could be implemented or not implemented in a FDA. The last phase of the session consisted of topic 3, which was also divided into two parts. The first part explored the participants' views and thoughts about switching to low-impact apps. The second part was an exercise where the participants got to look at two different printed illustrations about possible ways to demonstrate illustrations in a low-impact design for a FDA. Moreover, the participants got to discuss if they would enjoy/not enjoy seeing these kinds of illustrations in a FDA. As later stated in the theoretical framework, colors are an important feature in low-impact design. However, the colors in the illustrations were not discussed during the focus groups, only the style of the illustrations as these examples included colors that were not low-impact.

2.2 Prototype and Usability testing

To answer the second research question, "How can we make low-impact mobile applications more attractive to consumers?", A low-impact FDA prototype was created and tested for effectiveness with users during a moderated and in-person assessment of user testing. The high-fidelity prototype was designed to simulate the UI and UX of the FDA to allow for more accurate user feedback and a better understanding of user interactions, as according to Greenwood (2021) user journeys are user-centered and focus on experiences, feelings, and emotions. The prototype was built using existing guidelines for sustainable web design by Greenwood (2021) and Frick (2016) and adjusted by gathering information from the previous focus group phase of the data collection. To ensure validity and reliability on the usability testing, the prototype was

created using appropriate UX theories and methods such as an iterative design thinking process, nudging theory, and the hooked model, which are described more in-depth in the Theoretical Framework section of this study.

2.2.1   Prototype implementation

This section presents the design and development process of a high-fidelity food delivery application prototype made in a collaborative web application for UI design called Figma. Inspiration search as well as brainstorming sessions were the first step in the design process to develop a clear design goal and assure efficient communication throughout the process. The incorporation of low-fidelity sketches into the Figma application followed that step. Next, the choice of colors and typography were analyzed accordingly to Greenwood (2021) and Frick (2016) established low-impact guidelines described further at 3.5 in Theoretical Framework. As a result, the application was designed in dark mode, which is a light-on-dark color scheme that uses light-colored text, icons, and infographics on a dark background, as according to Greenwood (2021), darker colors require less power to be displayed on OLED screen technology. Greenwood (2021) explains that OLED displays are used by most modern smartphones, and they allow for individual pixel illumination resulting in a dark-colored background requiring less energy to be powered. Greenwood (2021) and Frick (2016) recommend using system fonts as the low-impact alternative for web designs and ideally fonts that are available on most systems. Because this study focuses on evaluating these guidelines on mobile devices, the system fonts for IOS mobile system, Helvetica and Times New Roman were selected for the typography since the prototype was tested on an IOS device. IOS and Android are different mobile systems and according to Sheikh et al., (2013), they are built using different languages which implies that systems fonts can be adjusted to the system the application will be distributed on to reduce the application's impact. Imagery has been minimized and illustrations were implemented wherever imagery was necessary. The findings from the focus groups were used and carefully analyzed during this stage of the process. The primary objective of the design is to shorten user journeys and reduce the number of page loads, leading to an improved UX and ultimately promoting a more environment-friendly application.

Next, wireframes were created in order to develop an effective UX. Six different types of pages were made: introduction page, landing page, restaurant page, product page, search page, and cart page. These pages were chosen to facilitate users' completion of essential tasks during the usability testing. Figure 1 illustrates two of the designed pages. For first-time users, introduction slides were implemented to provide information regarding the low-impact design. The landing page serves as a starting point and is supposed to capture users' attention and encourage them to explore further.

The restaurant page allows users to browse through the menus and offers of the chosen restaurant. The product page showcases the details of the selected menu items and allows for customization. The search page enables users to easily find their desired restaurant, and lastly, the cart page allows users to check their order and follow through with one of the tasks in the usability test.
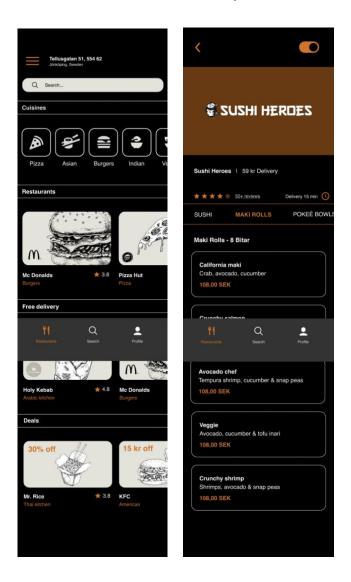
Figure 1
The Prototype's Landing Page (left) and Restaurant Page (right)

It was chosen to hide all images to reduce the image loads to save more energy. However, focus groups findings have shown that it is evident to leave some room for the brands to stand out. Therefore, the app is by default set to low-impact, meaning that all images are hidden and the user needs to toggle either the whole app or just the specific restaurant image in order to view the images. Figure 2 demonstrates the principle of the toggles. The images are replaced with scalable vector graphics (SVG)

illustrations, which is suggested by Greenwood (2021) and Frick (2016) to be a more environment-friendly choice.
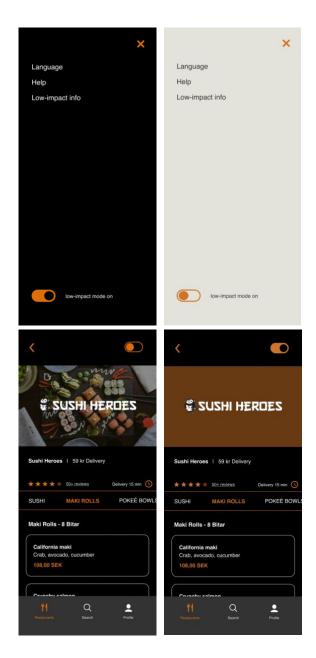
Figure 2

Principle of The Toggles

The mentioned prototype can be viewed and interacted with by **clicking here**.

2.2.2   Usability testing

Two rounds of iterative usability tests were conducted in addition to the data analysis method AttrakDiff Questionnaire to evaluate the prototype's usability and to create a desired design. The target group for the participant selection remains the same

throughout the study, therefore students, and young adults between the ages of 20 to 30, with different backgrounds and ethnicities were selected as the usability testing participants. As mentioned previously, a total of two usability testing rounds were conducted, and five participants were invited for each usability testing round as according to Nielsen (2000) five users are enough to identify any significant flaws in the product design. Each usability test was carried out individually with each participant. Following the usability testing, the AttrakDiff Questionnaire was administrated. The AttrakDiff Questionnaire is a method used for evaluating both the usability and appearance of a product or service. In this study, it was utilized to test how to enhance the attractiveness of low-impact designs to users (read more about AttrakDiff under 4.3).

The user testing began with the participant being given with the following scenario: "You're planning a Friday night with some friends and decide to use a food delivery application to order dinner. You've never used this app before, but you've heard good things about it from your friends saying the app is supposed to generate less carbon emissions than regular food delivery apps. You are curious and want to try it out by making sure it is easy to use and that you can find the food you're in the mood for."

Once the participants were presented with the scenario, they were asked to complete the following tasks:

1. Find out if the restaurant Sushi Heroes has free delivery.
2. Find the restaurant Sushi Heroes, find the Veggie Roll on the menu, and remove the cucumber because you are allergic to it – then place the order into your cart.
3. Find the campaign of the restaurant Taco Bell.

During the tasks, the participants were asked to think out loud and talk through their choices and actions while completing the tasks. The observer had voice and screen recorded the participant's journey with consent to assure detailed comments would be analyzed during the prototype improvement. The tasks assigned to the participants did not focus on identifying any specific low-impact features, since the emphasis was on the overall design and functionality of the prototype.

Once the tasks were completed, the participants were asked to provide general feedback on the prototype, using the following prompts:

1. How would you describe your overall experience with the prototype?
2. Could you point out features that you liked/disliked?
3. Did you encounter any difficulties when adding items to your order?

4. Would you use this app again in the future? Why/Why not?

If the participant hasn't discovered any low-impact features during the task completion, the participant would be asked about certain low-impact features afterward and was given time to explore those. When the testing of the prototype was done the participants were sent an email with a link to the AttrakDiff questionnaire. To ensure that the participant's responses were anonymous and unaffected by the researcher's presence, the questionnaire was administered by the user in private.

2.3 Data analysis

The data collected from focus groups was transcribed from audio recordings, and written into text format. The next step identified key themes and patterns in the data. This involved coding the data, which means assigning labels or tags to specific text segments that relate to the theme. To test the mobile application the AttrakDiff Questionnaire was chosen for extended empirical usability testing. Lastly, the data was interpreted to draw conclusions and make recommendations based on the findings.

2.4 Validity and reliability.

To ensure that the study is both valid and reliable emphasis was put on the trustworthiness and accuracy of this research. In order to guarantee that the study accurately and appropriately measures the concept phenomenon, the methods for data collection, analysis, and the choice of theories are described in detail and the choice of these factors is justified in the accurate sections. The study has consistency and stability of the results obtained from a study because the study is transparent about all the methods being used to allow others to obtain the same results and conclusions if others were to re-conduct the same exact study.

2.5 Considerations

During the planning of this study, important factors were considered to create as reliable and trustworthy research as possible. As mentioned in the introduction, this study is inspired by previous research on this issue, conducted for the Jönköping University final thesis project in 2022, titled "Sustainable web design in the e-commerce sector" (Balogh & Bernataviciute, 2022). The paper addresses sustainable front-end web design guidelines; however, after a thorough examination of Greenwood (2021), the term "low-impact" is more appropriate for this study because the book indicates that the internet cannot be sustainable, but it can have as minimal impact on our environment as possible. The second aspect was to develop specific, well-defined research questions

to guide the research while remaining it broad enough to allow for flexibility in the deductive research approach. The methodology was carefully selected to be appropriate and in line with the research questions, as well as to allow for the collection of necessary data to answer each question. A clear timeline, resources, and ethical considerations were taken into account as well in order to perform the research ethically. This involves containing consent from research participants, protecting their privacy, and following ethical guidelines in the field of Computer Science.

3   Theoretical framework

3.1   User experience

User experience is necessary for all kinds of products and services today. By fusing psychology and technology in design principles, Norman (2013) thoroughly discusses the design and usability of everyday objects in his well-known book The Design of Everyday Things. Rajeshkumar et al. (2013) emphasize the value of beginning UX assessments early in the development phase to ensure that the product meets user needs and is simple for users to understand, ultimately resulting in a positive user experience. The term user experience (UX) is now widely used in the design community, and it is becoming both more frequent and more crucial to comprehend. Law et al. (2009) identify key issues and challenges in defining and scoping the field of UX. Their definition of UX is "the quality of experience a person has when interacting with a specific design" and emphasizes the fact that it is a complex construct with behavioral, cognitive, and emotional components. Garrett (2011) explains user experience as how a product works on the outside and not the inner workings of it. Many companies are now aware of the value of providing a good user experience and the author further claims that this is what sets them apart from their competitors as well as determines whether your customers will return.

3.2   The Elements and Disciplines of UX

To be able to design low-impact applications, it is crucial to first understand the principles of UX and the different elements it is made of to achieve a successful product. To get a deeper understanding of UX we can better comprehend the problem at hand by breaking it into its individual components as shown in Figure 3. The sections that follow introduce the disciplines of Interaction Design and Visual Design as well as the five components of UX design in order to give the reader a broad understanding of the topics that apply to this research.

3.2.1 The five elements of UX design

According to Garrett (2011), we can describe user experience as many layers, and if we peel back the layers of the experience, we may start to comprehend how decisions are made within UX. The author refers to "the five planes," noting that these five parts are built upon one another and will shape the process of the project. Below is an overview of the five elements.

The Strategy Plane

On the bottom plane lays the strategy about the user needs and product objectives. The project is more abstract at this point, and it is needed to understand what the audience expects and how it aligns with other objectives. This is achievable if two basic questions are answered "What do we want to get out of this product?" and "What do our users want to get out of it?".

The Scope Plane

This plane is focusing on the functionality side of a project as well as content requirements. The functional specifications mean that the UX team will identify every single feature of the product while content requirements mean describing and identifying the specific content elements that will be included. Here the questions could be: "Why are we making this product?" and "What are we going to make?".

The Structure Plane

Once the scope of the product has been outlined, it is time to develop a structure for the project. This is where interaction design and information architecture take place and is also a point where it can shift from abstract issues into concrete factors. Interaction design takes care of how the system behaves in response to the user and information architecture is about making the structure of the content as easy as possible for users to find what they are looking for.

The Skeleton Plane

After making the structure of the product, the skeleton can be designed. The author suggests that the skeleton is divided into three components that address information design, interface design, and navigation design. Information design serves as how information is presented to the users. An example could be to group or arrange certain elements or pieces of information that makes the most sense for the user. Interface design is all about arranging elements to make it possible for the users to interact with the functionality of the system. Lastly, navigation design is a set of components that allow the user to navigate the information architecture.

The Surface Plane

At the top of the five-plane diagram lays the surface in which will be what the users will notice first when using the product. This plane is about sensory design or visual design. Content, aesthetics, and functionality bind the design together for the finished result. Here it is important to find a consistent layout, contrast in the design elements, a unique and well-working color palette, and typography to create a distinct visual style.
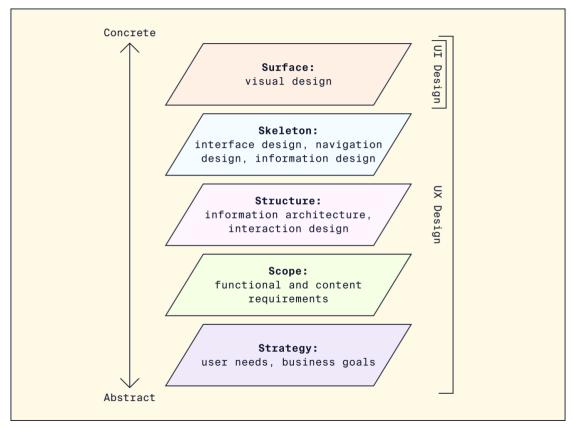
Figure 3
The five elements of UX design (Garrett, 2011)

3.2.2 Visual Design

One of the first things to learn as a designer is visual design since this discipline is vital to attract users to a design. Visual design is like many other principles, rapidly evolving. Watzman (2002) defines visual design as a tangible representation of a product's objectives, including the "look" the method, and the style in which the information is presented. Furthermore, the author introduces the five criteria for good design as guidelines to evaluate solutions during a design process. These five criteria's consist of five questions that can be asked: Is it appropriate? Is it durable? Is it verifiable? Does it have an impact? Is it cost-effective? As human beings, we often see visual aspects of an object as our first impressions according to Tractinsky and Hazzenzahl (2005). They explain that the reason behind that argument is that it is easier to observe aesthetic

qualities, compared to usability and functionality, the evaluation of aesthetics may be fast, and aesthetic evaluations are stable. Consequently, they state aesthetic impressions as fast, enduring, and consequential.

3.2.3   Interaction Design

Interaction design (IxD) was first acknowledged in 1990 by Bill Moggridge. Moggridge's book "Designing Interaction" (2006). explores the history, theory, and practice of digital interaction design. Since the beginning of IxD, the discipline has grown to be practiced by thousands of designers all over the world. The author states that the narrow definition of interaction design is "The design of the subjective and qualitative aspects of everything that is both digital and interactive, creating designs that are useful, desirable, and accessible.". As demonstrated in Figure 4, Saffer (2010) argues about IxD as a tricky subject to define since most of this design is invisible and rooted in industrial and communication design, human-computer interaction, and human factors. Furthermore, the author explains that IxD is a young discipline and stresses that the best-designed products use multiple disciplines working in harmony with each other. As Figure 4 shows, IxD is overlapping many other sister disciplines and explains the relationships between them.
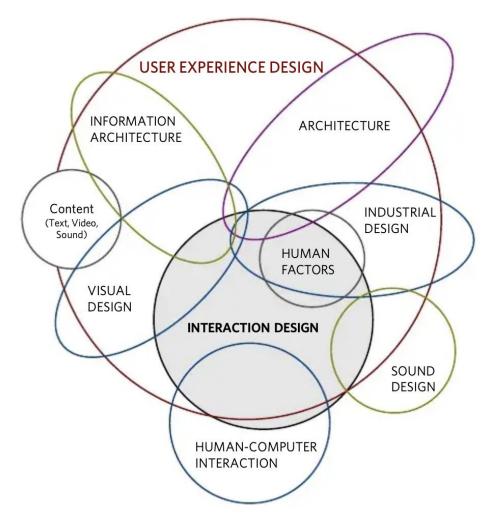
Figure 4
The Disciplines Surrounding Interaction Design (Saffer, 2007)

3.3 The Design Thinking Process

The design thinking process originated in the product design program at Stanford's d.school (the Hasso Plattner Institute of Design) and has now become widely used as a methodology in the fields of innovation and management. Furthermore, the product design curriculum at the d.school emphasized the importance of empathy, experimentation, and iteration in the design process. These principles, along with a focus on user-centered design, would become the foundation of the design thinking approach. Auernhammer & Roth (2021) states that an important factor contributing to the popularity of design thinking in innovation management is its focus on user-centered design and by putting the needs of users at the center of the design process, design thinking can help create products and services that truly meet the needs of users.

Below there are short descriptions of each step in Stanford's design thinking process guide book (d.school, 2010), which was implemented as a theory for building the prototype in this research paper.

3.3.1   Empathize

The first stage of the design thinking process is to Empathize. It is about gaining a better knowledge of the individuals for whom one is designing for. This step involves observing, interviewing, and immersing oneself in the life of potential users in order to obtain an understanding of their needs, desires, and challenges.

3.3.2   Define

Once there is a strong understanding of the end-user, the introduction guide to the design thinking process explains that the next step is to define the problem that is trying to be solved. The findings from the empathy stage must be combined in this stage to create a concise problem description.

3.3.3   Ideate

The goal when ideating is to generate as many potential solutions to the problem as possible. The ideation stage is characterized by brainstorming sessions, where it is encouraged to generate a wide variety of ideas and not to dismiss any idea too quickly.

3.3.4   Prototype

This phase is about creating a physical or digital representation of one's solution that can be tested and refined. The goal of prototyping is to take ideas from abstract concepts to tangible forms that can be tested and refined.

3.3.5   Test

In the final step of the design thinking process, it is necessary to test the solution with real users in order to obtain feedback and insights. This step is crucial for refining and developing solutions since it allows us to examine how the solution operates in the real world and make appropriate adjustments if necessary, making it an iterative process.

3.4   Human-Computer Interaction

Human-Computer Interaction (HCI) emerged in the early 1980s and has changed its original focus from computer science over the past few decades. Today it is something crucial for designers to comprehend. HCI has many definitions. In a journal by Karray et al. (2008) the authors state that "most sophisticated machines are worthless unless they can be used properly by men" and in order to reach a given performance in terms of both quality and optimality of the services, HCI should establish a connection

between the user, the machine, and the necessary services. According to Ghaoui (2006), HCI is a multidisciplinary field that has expanded its area to information systems, visualization, collaborative systems, and numerous areas of design. Furthermore, Carroll and Campbell (1989) define HCI as a design science and propose a framework for viewing artifacts, such as computer interfaces to support users in achieving tasks. The authors apply their framework to HCI by analyzing multiple computer interfaces and they also argue that the analysis of artifacts as psychological theories can help improve the design of HCI.

3.4.1   Human/User-Centered Design

According to Lowdermilk (2013), user-centered design (UCD), which derives from HCI, is a software design process that developers and designers may utilize to make sure an application maintains an excellent user experience. In Lowdermilk's book "User-Centered Design" design principles are brought up. Design principles have been used over many years and guide us through what might be right or wrong with a design. Moreover, the author explains a few design principles that can be used to meet usability goals in UCD. One of them is the **Principle of Proximity** which is useful when grouping objects in a design. The term "Principle of Proximity" means that humans perceive objects that are closer together have a relationship with one another and can be seen as a pattern. Another design principle that the author states is important is **Hick's Law**, which is a model that calculates the time it takes for the user to make a decision and it is stated that the more choices a user has, the longer it will take them to make the decision. Lowdermilk suggests that by applying Hick's Law with the principle of Hierarchy we can better understand and decide the value of the individual item within a menu. **The Hierarchy Principle** (or Visual Hierarchy) means to arrange elements and provide with visual indicators to guide the user in perceiving how an application is organized.

In "The Field Guide to Human-Centered Design" by IDEO.org (2015), it is stated that Human-centered design (HCD) gives designers the ability to design with communities, gain a thorough understanding of the target audience, and develop, generate, and organize ideas that are based on the needs of humans. Norman (2013) explains that HCD can be divided into an iterative cycle of four parts – Observation, Idea Generation (ideation), Prototyping, and Testing. These actions should be done repeatedly until the desired outcome is reached. This process goes hand in hand with the common and widely used design process from Stanford as mentioned above. However, even though most of the design processes today are known to be iterative, the Stanford process is articulated as a linear progression but can be adapted to one's needs. There is not only one process that can be used when it comes to design processes though, on the other hand, it is important to adapt to the specific project. Although UCD and HCD are

closely related, both focused on providing the end-user (human) with a useful and beneficial design, HCD can be seen as a more emotional and psychological approach to design as opposed to UCD, which may be perceived as a more technical approach focusing on the concrete ways users interact with an application.

3.5 Low-Impact Design Strategies

Low-impact approach toward UI design is a relatively new, emerging area and therefore access to this data is currently limited. Greenwood (2021) and Frick (2016) address the challenging aspects of creating low-impact web designs and provide guidelines for developers who wish to apply the low-impact approach to their designs. The principles presented in the book to minimize the carbon impact of the web design's front end can naturally be applied to mobile application designs as well.

Greenwood explains that a low-impact design approach should emphasize justifying the existence of each element in the design and supports that by mentioning the importance of designing a good UX. In other words, Greenwood implies that designers should aim to create intuitive user journeys that allow users to reach their destinations as quickly as possible to reduce the carbon footprint of their visit. Frick mentions that a mobile-first design approach can reduce the impact by requiring designers to focus on the content and interactions that are strictly necessary to meet users' needs given the considerably smaller interface to work with. The authors emphasize that imagery is the most significant contributor to carbon emissions on most websites besides video content. The authors further highlight the importance of carefully evaluating the use of imagery, suggesting that it should be well evaluated to enhance the overall user experience of the site. The authors suggest monochrome imagery and vector illustrations as low-impact alternatives as well as advice against autoplay settings on videos.

Even though the mentioned approaches embrace minimalism, the authors highlight that a low-impact design does not have to be aesthetically dull. Mindful choices of colors, the well-evaluated value of imagery and videos in the design phase, choosing system fonts instead of open-source solutions as typography choices, and wise animation and interactive applications are all important elements that can contribute to the low impact of the design when used wisely. Greenwood (2021) states that specific colors can make a website generate less energy, and the choice of colors is specifically important for mobile phones. It is more and more common that today's modern phones use OLED displays which function by individually lighting each pixel. Further, the author explains that OLED screens are sensitive to brighter colors, specifically white and blue. Moreover, blue should be avoided on mobile screens since it consumes 25% more

energy than green or red. Frick (2016) points out the benefits of darker colors as well; however, he mentions that it could generate issues regarding accessibility guidelines.

3.6 Change in user behavior

When designing low-impact websites or apps, it is of high importance to understand why the user would use them over a standard website or app. Switching to low-impact is not something people are used to today, which means it will require a change in their behavior and seeing it from a psychological view. Therefore, the following sections introduce two chosen theories that were used in this research.

3.6.1 Digital Nudging

Digital nudging is a concept that has gained significant attention in recent years as a means of encouraging desired behaviors in the digital space. Schneider et al. (2018) explore the use of digital nudging as a tool for influencing user behavior in digital contexts. The authors define digital nudging as an approach to steer a person's decision in a desired direction without significantly restricting freedom of choice. Digital nudging is also described by Weinmann et al. (2016) to influence people's choices in certain ways by even making very small changes to the environment in which options are presented. Additionally, they argue that as designers it is crucial to understand the effects of digital nudges to lead users to make the best decision for themselves. On the other hand, nudging does not only need to be within digital aspects. Wee et al. (2021) state that nudging can encourage pro-environmental behavior. To promote pro-environmental behavior it is useful, according to the authors, to implement different nudging techniques such as prompting, sizing, proximity, priming, presentation, labeling, and functional design.

3.6.2 The Hooked Model

In the book "Hooked", Eyal (2014) introduces the hooked model, which is a framework designed to connect users with a design solution that can form a habit. This framework is useful for this study when designing wireframes and the prototype. By keeping this model and questions in mind, it is possible to establish a habit among users by choosing a low-impact version of an app and letting them know the benefits of it. The book explores the psychology behind why products can get users "hooked" and create habits. As described in Figure 5, the hooked model consists of four steps:
1. **Trigger** - The trigger is what prompts a user's behavior to engage with a product. A trigger can be external, such as an e-mail, a link to a website, or an app icon on a phone. However, a trigger can also be internal which occurs when users begin to repeat hooks to create associations with their actions and feelings.

2. **Action -** The action is the behavior a user takes in anticipation of a reward. The author further suggests that "to initiate action, doing must be easier than thinking". A product needs to deliver what is expected from the user to maintain engagement.
3. **Variable Reward -** The variable reward is what benefits the user from certain behavior. A company can only make the necessary adjustments and match the appropriate variable reward to a user by first understanding what matters to them the most.
4. **Investment -** The investment is the effort a user puts into the product to increase the odds that the user will revisit the product in the future.

To use the hooked model the author tells us to ask ourselves fundamental questions to be able to build useful hooks:
1. "What do users really want? What pain is your product relieving? (*Internal trigger*)"
2. "What brings users to your service? (*External trigger*)"
3. "What is the simplest action users take in anticipation of reward, and how can you simplify your product to make this action easier? (*Action*)"
4. "Are users fulfilled by the reward yet left wanting more? (*Variable reward*)"
5. "What ´bit of work´ do users invest in your product? Does it load the next trigger and store value to improve the product with use? (*Investment*)"

Figure 5
The Hooked Model (Eyal, 2019)

4 Results

4.1 Focus groups findings

This section presents the findings related to participants' food delivery habits and preferences. The results of the focus groups were identified through data transcription from the sessions and thereafter organized using Figjam which is a powerful tool for brainstorming, ideation, and organizing ideas and data. Findings are categorized based on the three topics discussed in the focus groups.

Topic 1: Food delivery habits
The first topic covered participants' current food delivery habits through three questions following an exercise with three tasks. When asked about the usage frequency of FDAs, participants commonly answered to use it either once a month or very rarely. The primary reason for choosing FDA that was expressed by participants was convenience, particularly in the context of group settings. They expressed their appreciation for the ease and simplicity of having food delivered to their location, which made it a repetitive choice for social gatherings or situations where cooking was impractical or time-consuming. Among participants, Foodora emerged as the most familiar FDA, as participants mentioned not being aware of the existence of other FDA in their current living area. During the first exercise, the participants were asked to highlight the most and least important features on Foodora stating the restaurant and product page. The features that participants highlighted as crucial on the starting page for an enhanced user experience included categories, navigation, and reviews to assess the quality of the restaurant and delivery time to estimate delivery expectations. Most of the participants expressed that certain features on the Foodora starting page were unnecessary. The pick-up option, friend referral, and Foodora market were among the elements that participants felt could be removed without affecting their overall user experience. Additionally, some participants commented on the lack of color contrast and accessibility issues, pointing out that the colors used on the start page may not be suitable for visually impaired users. Participants had mixed opinions about various elements on the restaurant page. Some felt that stock images, location information, checkout, and cart options were not very important in their decision-making at this stage of the delivery ordering process. On the product page, participants identified price information, ingredient details including allergies, and a scroll bar for the menu as the most significant features. These features were considered crucial for customizing their orders to their food preferences. There was also a suggestion made for an improved ingredient list layout. Participants proposed having checkboxes to allow users to add and remove ingredients as an alternative instead of the current option of leaving

comments. Participants expressed that the comment section feels like it could be easily overlooked, and their needs or allergies might not be considered by a restaurant.

Topic 2: Impressions on a low-impact interface

The second topic had three discussion questions that addressed participants' perceptions regarding the design and functionality of a low-impact grocery store website. The focus was on exploring participants' thoughts and feelings when exploring the website. Most participants acknowledged upon first glance the website as a clean and simple design, however, they later added that the website didn't evoke the feeling of a traditional grocery store. The majority of participants found the toggle function to be a clever tool, but some questioned its necessity for a grocery store website. These participants found it slightly confusing and expressed that it might not align well with the purpose and expectations of an online grocery shopping experience. This discussion continued freely and came down to participants indicating a preference for prioritizing usability over aesthetics. Some participants proposed that the toggle function could be used as a switch to regular, non-low-impact mode, offering users flexibility and control over their browsing experience. Participants also emphasized the need for clear branding of individual brands on the website as they want to be able to make informed choices. Lastly, participants suggested the use of illustrations and icons as an alternative to images. They believed that these elements could effectively convey information without relying on large image sizes, reducing the website's environmental impact while maintaining a visually appealing interface.

Topic 3: Changing online habits.

The third topic consisted of one question and an exercise that covered participants' perspectives on introducing a low-impact approach to the public use and implementation of illustrations in FDAs. The majority of participants expressed that a low-impact approach should be introduced properly for users to adopt it effectively. They emphasized the need for clear communication and guidance on how to utilize the low-impact features, ensuring users understand their benefits and are encouraged to incorporate them into their habits. The conversation then naturally shifted to the topic of greenwashing and the participants stressed the importance of the FDA app clearly explaining its positive environmental impacts while avoiding any perception of greenwashing. They expressed that they want transparent information regarding the app's sustainability, ensuring that they can trust and support the application's intentions. Participants highlighted further that they would be happy to switch to a low-impact application as long as it remains simple to use and provides a simple user journey. They discussed that low-impact features should not compromise the app's usability. When presented with examples of what type of illustrations could be implemented (see Appendix 1) instead of imagery in the FDA, the majority expressed that they were a

fun and aesthetically pleasing concept. Participants continued by discussing feelings, likings, and preferences of displaying the information through illustrations and expressed that illustrations allow for easy recognition, and enhance the visual appeal of the app. However, they also mentioned that illustration usage must be thoughtful in order to avoid clutter on the interface and not affect its usability. Participants expressed familiarity with dark-mode, and the majority confirmed having it already activated on their mobile devices. However, only one participant was aware of its reduced energy consumption.

4.1.1   Analysis of focus groups findings

The findings listed in the previous section provided a broad range of valuable insights that guided the development of a high-fidelity prototype. The importance of efficient navigation and search options while ordering through an FDA has been clearly outlined by the participants, as they mentioned that their goals vary from visit to visit. They discussed that when they know what they want to order, they prefer to quickly search for their favorite dish and proceed, while those who are unsure, would like to navigate the app efficiently to find offers, restaurants, and inspiration. Justifying the existence of each element in the design supports efficient user journeys which as explained by Greenwood (2021), contributes to a reduced time spent on achieving goals, resulting in a more environment-friendly online ordering experience.

Most of the restaurants that offer food delivery through a collaboration with Foodora, display images of their dishes on the app. As stated in the theoretical framework of this research, imagery is one of the most significant contributors to carbon emissions on the Internet, therefore its usage in the low-impact prototype should be evaluated, as it should only be used to inform the overall UX of the app. When participants were presented with low-impact interface designs most agreed, that images are not needed on the product pages. They compared it to not having images on the physical menus in restaurants. They discussed that images could be minimized to only be displayed on the restaurant page and landing page to help users recognize the restaurants. Monochrome imagery and vector illustrations were mentioned as good alternatives for mitigating the image's environmental impact. Participants were shown a grocery e-commerce store interface where vector illustrations were used as the main imagery, and a toggle function was implemented as an alternative for users where they would have to use the toggle to load an image. During the discussions, participants explained that they would rather use this function to toggle low-impact mode on and off in the context of the FDA. Useful categories and well-structured restaurant and product pages, as well as clear labels and icon usage, were mentioned by the participants during the focus groups as important as they found the Foodora application cluttered and frustrating to navigate. During the discussion, participants were asked to consider if they would switch to a low-impact application/mode themselves and how user habits should be adjusted to

implement low-impact solutions to everyday use. They suggested that being informed about the positive impact of their switching to a low-impact application would be helpful. However, they also mentioned that switching to a low-impact mode in an existing FDA wouldn't require users to adjust their habits that much since, as previously mentioned in the focus group findings, a lot of mobile users have a dark mode on or are familiar with it. Although the imagery is a bigger habit adjuster, participants suggested again that an efficient user journey and compromised solutions could be easily adapted.

4.2 Usability test results

4.2.1 Usability test findings

First round of usability testing.
The participants managed to fully complete the tasks with high or medium satisfaction. All of the participants read through the introduction slides and did not turn on the toggle when it was introduced, which means they all proceeded with the low-impact version of the application. None of the participants did either turn on the toggle during the specific tasks. When observing this, two different reasons were analyzed as to why the participants may not have used the toggle function – they were either too focused on the task itself and did not notice it or got enough information from the text and illustrations that they did not feel the need to use it. After the tasks were completed and despite not using the toggle features during the tasks, all the participants got to test it afterward and had positive reactions to it. Comments were expressed about the toggle being a valuable option instead of restricting the user completely from what they are used to. Even though most of the participants found the free delivery section on the landing page, it was also expressed by some that it should be visible on the restaurant page as well since a few of them chose to go straight to the restaurant page instead of looking at the landing page. The participants who were more used to the FDA were expressing that it was easy to navigate the app since they were already familiar with the layout and navigated through the landing page. However, the participants that use the FDA less frequently opted to use the search bar to find the specific restaurant in the task as well as to find the campaigns. When the participants were asked to look for the taco bell campaign, they could not find an icon/text for Mexican food in the search bar or among the cuisine categories on the landing page. When asking the participants open questions about their experience it was evident that all participants reacted positively to the overall layout and visual elements of the prototype. Participants found the prototype easy to use, clear, and aesthetically pleasing. One participant also expressed that the app was less distracting in comparison to existing FDAs. Moreover, one pattern that stood out was that participants explained that it was very helpful to have the toggle option to the "normal" mode in case they would need some more time to get used to the

app or if they wanted to order from a new restaurant. One participant also stated that having both options could be a competitive advantage when compared with other existing FDAs. Lastly, all the participants agreed that they would use a low-impact FDA in the future, as long as they were informed about the benefits of using this app or that it has good deals.

Second round of usability testing.
The first usability test provided relevant data to continue with further improvements for the next iteration round, which was then tested with new participants. In the second user testing round the participants could also fully complete the tasks with high or medium satisfaction. The participants could now find what they needed for their task on all pages without any issues, however; some of the participants suggested minor improvements outside of the specific tasks. The suggestions that were taken into consideration for future iterations were to make the product items more customizable, move the "customize order" higher up on the product page, and make the deals stand out more. Overall, this round of user testing was very similar to the first round, since only small changes needed to be made. As stated in the first round of usability testing, all of the participants proceeded with the low-impact version of the application this time as well. However, one user skipped reading the introduction after the first two slides. Lastly, all the participants agreed this round as well that they would use a low-impact FDA in the future, and the participants appreciated the prototype's intuitiveness, and aesthetic appeal, emphasizing its attractive illustrations. There were no other specific patterns that stood out to what has already been mentioned.

4.2.2 Analysis of usability test findings

Overall, both rounds and each usability test's findings were highly successful, showing a clear pattern among the participants, and demonstrating that they agreed on most aspects of the prototype's design and functionality. Different strategies were used by the participants to complete the tasks, which demonstrates how the prototype can accommodate various user needs and goals. The participants felt like the introduction slides were important and provided them with a quick overview of the low-impact functionality. Findings from the focus groups showed that informing users about the purpose of a low-impact application is crucial in their judgment and for a clear understanding of the issue. However, not more than 3 introduction slides in the prototype were introduced to prevent overwhelming the user with too much information and potential greenwashing. Furthermore, it is clear that giving users early notice of the low-impact features makes them more accepting of them. However, since one participant did not read through the slides completely, further iterations could be implemented to make the introduction slides capture users' attention more. As previously stated, the already familiar layout of a food delivery app and familiarity with

dark mode layouts, proved that this study's prototype was easy to navigate. There were no complaints made throughout the tests regarding not being able to view images of the food or restaurants. This demonstrates a trustworthy and well-designed outcome in that the prototype met the participants' expectations and helped them stay engaged throughout the user journey. Although the toggle was mentioned as a viable alternative in the focus groups, no one used it when doing the required tasks throughout the tests. Additionally, the clear illustrations and icons proved to be enough when ordering food they are familiar with, which eliminated the participants' need to turn on the images. However, they expressed that if they were ordering something new, they felt a comfort to have the toggle there as an option.

4.3 AttrakDiff Questionnaire

4.3.1 AttrakDiff Questionnaire findings

The prototype was evaluated using the original version of 28 items of the AttrakDiff standardized Questionnaire in four UX dimensions:

1. Pragmatic quality (PQ) – the degree to which a user can carry out tasks effectively and efficiently.
2. Hedonic quality identity (HQI) – the degree to which a user may express themselves.
3. Hedonic quality stimulation (HQS) – measures how excited a prototype is for the user.
4. Attractiveness (ATT) – refers to how the user feels and what their impressions are about the prototype in general.

The results are summarized in three diagrams: portfolio of results, diagram of average values, and description of word-pairs diagram.

Portfolio of results.
The portfolio of results is as shown in Figure 6, built on two axes. The hedonic quality is shown on the vertical axis of the portfolio view, and the pragmatic quality is displayed on the horizontal axis. The left and bottom parts of the axis indicate a low extent. The prototype lays in one or more "character-regions" where the prototype is represented by the smaller blue and orange rectangles. Surrounded by the smaller rectangles is the confidence rectangle, which is the transparent color placed on top. The size of it reflects the accuracy and reliability of the results; a smaller confidence rectangle indicates less coincidental and more trustworthy results since it demonstrates if the participants are on the same page with their evaluation assessment.
The orange rectangles are the result from the first round of usability tests and the blue ones are the result from the second round.
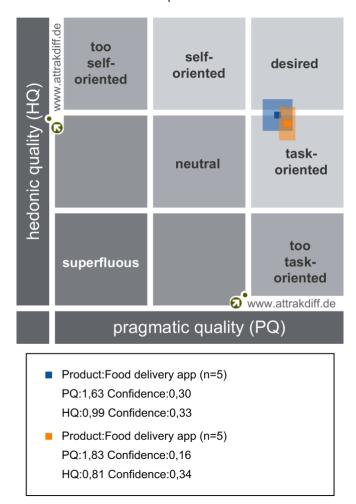
Portfolio-presentation

Figure 6

Portfolio of results from the AttrakDiff Questionnaire

As illustrated in Figure 6, the prototype is positioned in the diagram's upper right corner, between the "desirable" and "task-oriented" character regions. Both confidence rectangles are narrow which shows that the participants' opinions on the prototype were fairly undivided. This also demonstrated that the second round of usability tests got closer towards the desired area. However, the confidence triangle got a bit larger indicating that the participants' opinions were more divided.

Diagram of average values

The diagram of average values (Figure 7) shows the prototype's average scores across the four UX dimensions listed above: pragmatic quality, hedonic quality identity, hedonic quality stimulation, and attractiveness. The diagram demonstrates that the prototype received favorable scores across the UX parameters, with the attractiveness measurement receiving the highest marks.
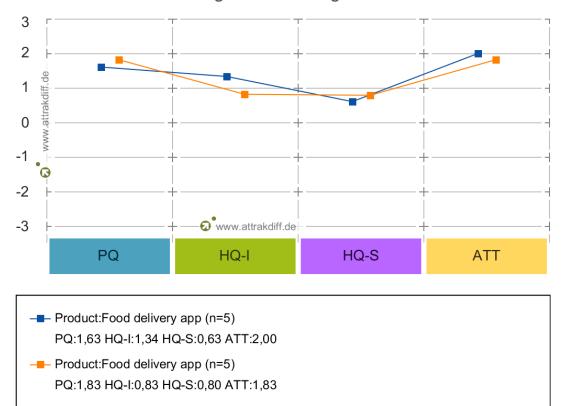
Figure 7

The diagram of average values results from the AttrakDiff Questionnaire

Description of word-pairs diagram

The description of the word-pairs diagram (Figure 8) represents the average values of the word pairs by the participants. The extreme values are of special importance here, since these reveal which traits are important or exceptionally well-resolved with the prototype. The prototype's traits that have attained the highest extreme values are "technical", "undemanding" and "good".

Figure 8

Description of word-pairs from the AttrakDiff Questionnaire

5 Discussion

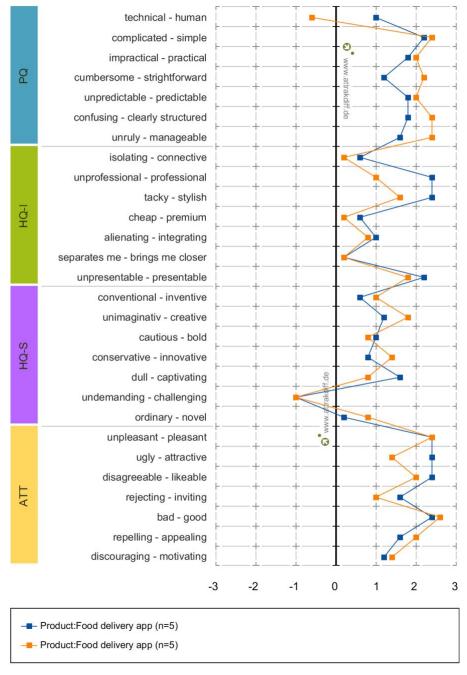This study attempted to evaluate the current guidelines for designing low-impact applications by testing them with users in the context of a food delivery app. Moreover, the study aimed to compare and analyze the findings from an earlier thesis on this topic

to see if the low-impact guidelines would be applicable not only on websites but on smaller screens as well.

5.1 Result discussion

5.1.1 Research question 1: What are users' impressions and current knowledge of low-impact user interface designs?

The first research question was addressing what impressions users have on low-impact interfaces and investigate if they have any current knowledge about this topic. Based on the problem statement and the findings, it is evident that a low-impact design approach needs to be used more frequently. In addition, changing user behavior is necessary in order to implement the new strategy, which is why it was crucial to first dig deeper and understand the user's perspective. This was supported by the focus group findings where most of the participants commented that they were not aware of how much an image or video, for instance, would impact the environment. Furthermore, even though a significant amount of scientific research could not be identified for this study due to such a new emerging field, it was still possible to get inspiration and valuable insights from one previous academic thesis by Balogh and Bernataviciute (2022) as mentioned in the introduction. The authors got valuable quantitative insights from a survey where the respondents indicated that they were not aware of the Internet's environmental impact. Moreover, this proves the need for behavior change in users' existing online habits and the existing low-impact design guidelines also highlight the importance of a change in visual and functional aspects in front-end design to make UI's have a lower impact on the environment. Furthermore, this requires any low-impact app or website to clearly communicate to the user about the environmental issues the internet can contribute to and how it can aim to offset this with a low-impact design. Nevertheless, as evidenced by the focus groups, more than half of the groups talked about greenwashing and the significance of not overwhelming the user with negative information because doing so could affect their decision to switch to a low-impact UI. Szabo and Webster (2021) state that perceived greenwashing can harm businesses in terms of how customers perceive their products as well as how they engage with websites. Therefore, any information about this issue must be presented so the user understands it comprehensively.

5.1.2 Research question 2: How can we make low-impact mobile applications more attractive to consumers?

To fulfill this study's purpose, it was evident to test the current guidelines in sustainable design stated by Greenwood (2021) and Frick (2016) with the users to get answers about how we can make low-impact apps more attractive. We also wanted to investigate if

the current guidelines work not only on websites but on mobile screens as well in the context of a food delivery application.

In our prototype, we applied the following guidelines:

1. Reduced use of images.
2. Use of a built-in typeface.
3. Use of dark low energy colors (only applicable to devices with OLED displays).
4. Short and simplified user journey.

The implementation of the above guidelines was successful on mobile screens, proven by the usability test and the AttrakDiff Questionnaire results. The participants expressed that an easy, straightforward, and short user journey as well as getting information about the low-impact features were highly significant to them and helped them become more aware of and receptive to using a low-impact application. Therefore, we got rid of unnecessary steps and made the layout as clear as possible to understand. We also added nudges and strategies from the hooked model to the prototype. The nudges are prompts such as certain text, infographics, and icons that are intentionally highlighted with a vibrant color or familiar placement. The nudges are meant to direct user behavior and ease the transition to an application with low-impact features. Furthermore, the application being set to low-impact mode by default can work as a powerful trigger as explained in the hooked model. This trigger can occur as users begin to repeat hooks to create associations with their actions and feelings, which is why it could be easier for the users to get used to the low-impact application by setting those features to default. As stated in the theoretical framework, The Hooked Model theory states that due to prior knowledge and experience, the users develop a habit of utilizing the prototype. This means that users that are already familiar with the layout of a food delivery app and have used dark mode before won't see a dark application as something they need to adapt to very much.

Based on our findings, we can agree with Balogh and Bernataviciute (2022) that in order to make low-impact UIs more appealing, it is crucial to involve the user from the beginning of the design process to ensure greater acceptability and appeal of a website, or in this case, a mobile application, to facilitate desired user behavior changes. Designers should also keep in mind that different users have varying UI preferences. As also discussed by Balogh & Bernataviciute (2022), this study also revealed that there is no one-fits-all solution for this. For instance, an image toggle might work in certain fields such as FDAs and grocery e-commerce websites as explored in this study. However, it is of high importance to consider that this could also change depending on the scope of the research as well as what the users' preferences are.

The findings of our study concluded that designing low-impact FDAs is a complex multi-layered process that requires the low-impact design to be evaluated and modified continuously, starting with involving the user at the very beginning of a project. However, as demonstrated in our study, it was still manageable to create attractive low-impact design solutions in a short amount of time, as well as in a smaller scope, to satisfy the majority of our participants. Therefore, the proposed guidelines by Greenwood (2021) and Frick (2016), intentional nudges and hooked techniques, as well as an understanding and implementation of a user-centered design thinking process provide a strong foundation for the design.

5.2   Method discussion

A qualitative method was chosen as the suitable method to conduct this research as this study investigated behaviors, experiences, and perceptions to provide new insights on a new evolving topic. This approach made it possible to get an in-depth understanding of the issue. By conducting focus groups as the primary method, we were allowed to gain valuable insights and answer our first research question about impressions and current knowledge about low-impact user interfaces. The three focus group sessions were successful due to detailed planning, and the findings were highly valuable to move forward to the second part of the study involving prototype building based on those findings and usability testing.

Two low-impact websites were prepared for demonstration in the focus groups, however, when the first focus group took place, one of those websites, (https://lowimpact.organicbasics.com/eur) had technical issues and wasn't accessible during any of the other focus groups either. As a result, we decided to reconsider our approach and only present one low-impact website example. This example was a prototype from the previous thesis that inspired our study (see material under Appendix 2). To prevent similar issues in the future, a backup plan can be implemented in case of technical difficulties to ensure that everything is functioning as intended before the start of the sessions. As mentioned previously in this study, Greenwood's (2021) and Frick's (2016) low-impact guidelines, focus group findings, UX design theories, and the analysis of existing FDA layouts were all crucial factors for the prototype development. The prototype was created successfully using an iterative design thinking process, which as mentioned in chapter 3.3 of the Theoretical Framework section, is a five-phase process that is used to understand users, redefine problems, and create solutions. The first phase, *Empathize*, helped us gain real insights into the participants' needs by having the focus groups. The second step, *Define*, inspired us to define the core problems in our research by analyzing our data with transcription and careful documentation. In this phase, it would have been helpful to create personas to keep our

efforts even more human-centered. However, we skipped that because of time restrictions. The third step, *Ideate*, was crucial to design the prototype. By having smaller brainstorming sessions, we could ideate on new ideas and stimulate creativity, to encourage us to think outside of the box. The fourth step, *Prototype*, was a key part of our process. In this phase, we implemented our previous findings into scaled-down versions of the prototype to allow us to explore. In the last phase, *Test*, two rounds of iterative usability tests were conducted to evaluate the prototype's effectiveness. Usability testing provided valuable and precise insights into the prototype's performance, identifying areas for improvement for further iterations.

To ensure validity and reliability in this study, all necessary steps were taken to its accomplishment. A diverse group of participants was selected for the focus groups and usability test within a specific target group to get a sample that is representative of the population studied. Standardized tests were used for the usability tests (AttrakDiff Questionnaire) and documentation of transcription and results were kept during the study.

6   Conclusions and further research

6.1   Conclusions

This research aimed at investigating how we can create a climate-smart approach by analyzing existing sustainable web design guidelines, testing them with users, and then proposing improvements to create a new demand. The purpose of this thesis was also built upon previous research about sustainable web design. However, this study focused on mobile app design instead of a website to see if the web design guidelines work on smaller screens as well. In particular, the study examined the guidelines in the domain of a food delivery mobile application. The current sustainable web design principles given by Greenwood (2021) and Frick (2016) together with an iterative design thinking process resulted in a mobile application that was perceived as appealing and user-friendly by the participants. The prototype was created with a default low-impact dark mode setting where the products and restaurants are demonstrated with SVG illustrations and infographics instead of images. An image toggle was implemented to allow for restaurant branding, and a toggle to change the entire application to a standard, higher-impact mode in the event that more time was needed for readjustment. By having the application set to low-impact by default energy can be saved by reducing the number of image loads. Furthermore, these features were highly appreciated by the users. Greenwashing was discussed during the focus groups in this study; therefore, the research has revealed that the perspective toward environmentally-friendly applications is significantly impacted by the users' understanding of the application's intention.

Nevertheless, users who comprehend the rationale behind a low-impact design are more willing to utilize it, even if it means sacrificing certain functionalities.

Lastly, this paper shows that current guidelines can serve as a solid foundation for designing low-impact websites and mobile applications. Nevertheless, these guidelines could benefit from being enhanced in the following areas:

1. The importance of raising users' and designers' awareness about these guidelines working on mobile screens.
2. The importance of applying an iterative design thinking process when dealing with changing user behaviors.
3. Being mindful of users' different preferences and carefully considering the context of the use of low-impact guidelines.
4. Ensuring a clear message when proposing low-impact features into a design to avoid greenwashing.

Our study revealed that low-impact features that are appealing to users are indeed not only applicable on websites but also on mobile screens. Our findings have shown that it is crucial to consider the context of use when it comes to applying low-impact features to a product. Moreover, it is crucial to increase user awareness, make sure change is implemented gradually, listen to the users' perspective, and test it in many iterations. By doing so, we can avoid greenwashing and design authentic low-impact UIs that have a positive impact on the users and the environment.

6.1.1 Practical implications

The study has discovered that low-impact design is not only essential for the environment but also for the success of businesses. In today's society, consumers are becoming increasingly conscious of their digital footprint, and they prefer to do business with companies that align with their values. Therefore, incorporating low-impact design into a website not only benefits the environment and attracts customers but also enhances an application's overall performance. The focus on efficiency, decrease in carbon footprint, and optimizing user experience leads to faster loading times, improved accessibility, and enhanced usability for all users. This research can help promote low-impact practices, not only in research and theory but also practically, at companies. Additionally, this can inspire the industry to adopt and incorporate low-impact design as a key aspect of product design. The paper also identifies the potential of low-impact features such as image toggles, system fonts, and less-consuming colors to reduce energy consumption which can have a positive impact on the public sector for users to reduce their carbon footprint associated with digital products. Lastly, the study's findings align with several of the United Nations' Sustainable Development

Goals (n.d.), including; Goal 12 – Responsible Consumption and Production, Goal 13 – Climate Action, and Goal 17 – Partnerships for the Goals. It is of great possibility that the industry and public sector can contribute to working towards these goals by reading our research and continue implementing them. In conclusion, the study's practical implications can help to promote low-impact practices in the industry, raise user awareness about the environmental impact of UI's, reduce the carbon footprint associated with digital products, and contribute to achieving development goals in sustainability.

6.1.2   Scientific implication

The findings of this study can have a positive impact on the scientific community. First, the study demonstrated that users are willing to accept low-impact design features that can help promote low-impact design in other contexts beyond web and app design. Furthermore, greenwashing was a topic discussed by the users of this study and it emphasizes the need for effective and clear communication in different domains to support informed decision-making which is relevant for future researchers to keep in mind. Overall, this study's scientific implications can contribute to advancing the understanding of low-impact design and its potential impact on behavior change. The study's findings can inspire future research to investigate the potential of other domains and contribute to the development of new and effective low-impact design strategies to reduce the carbon footprint.

6.2 Further research

Future research should continue to investigate, test, and evaluate current guidelines as well as explore new ones. Such future work could also focus more on evaluating the actual impact and difference between a website and a mobile application. Moreover, further investigation can look at different contexts beyond FDAs and grocery e-commerce, such as in the domains of healthcare, finance, or travel. This could provide a more comprehensive understanding of how different contexts affects a website or app designed with low-impact guidelines. A thorough investigation of potential trade-offs between low-impact features and usability could also be explored more. Although the results of this study indicated that users were open to low-impact features, it is still feasible that some measures may have a negative impact on usability, and further research is needed to discover and resolve such trade-offs. Beyond the toggle function, exploration of alternative low-impact image solutions such as image optimization techniques could be investigated to further reduce the environmental impact of image loading. Examination of the effectiveness of various communication strategies is also important to delve deeper into in the context of low-impact design to raise user awareness about the purpose and benefits of low-impact UIs. This can help to prevent greenwashing and ensure that users have accurate information to make informed

decisions. Nevertheless, it could be important to investigate how low-impact design can influence users' long-term attitudes and behaviors. Furthermore, it would be interesting to see if there are any other specific features, not mentioned by the low-impact web design guidelines, that would be more suitable for mobile screens.

7   References

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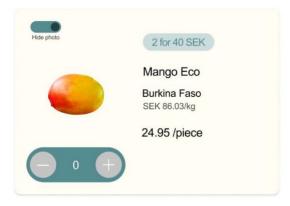
8   Appendixes

Appendix 1 – Focus Group printed exercise material

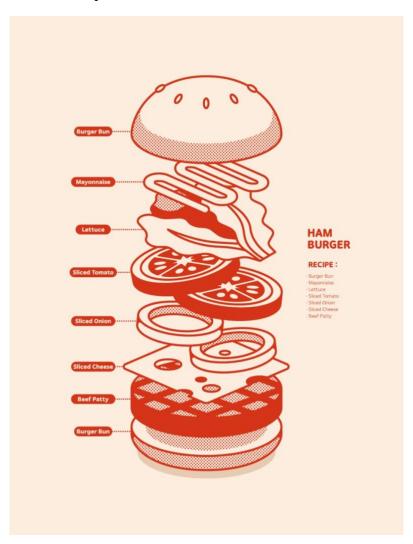Low-impact wireframes from Balogh and Bernataviciute (2021)

Printed examples of illustrations that can be used on FDAs found on Pinterest

Appendix 2 – Focus Group content and questions

<u>Topic 1:</u>

- How often do you order food from an app?
- Why do you order food online?
- Which food delivery app do you use the most and why?

Exercise:

- Mark down what you find is the most important and least important elements on the printed screenshots.
- Discuss your decisions about the elements – tell us why.

<u>Topic 2:</u>
Exercise:

- What's your first impression when you see this website? - What comes to your mind when u see it & what feelings do you get?
- What features could be implemented or not implemented in a food delivery app?

<u>Topic 2:</u>

- What are your views and thoughts on switching to low-impact apps?

Exercise:

- What are your thoughts about showing a product like this in a food delivery app?