CHALMERS
UNIVERSITY OF TECHNOLOGY

UNIVERSITY OF GOTHENBURG

Designing Filtering for an Analytic Software

Master's thesis in Computer science and engineering

Kajsa Bjäräng
Viktoria Enderstein

Department of Computer Science and Engineering
CHALMERS UNIVERSITY OF TECHNOLOGY
UNIVERSITY OF GOTHENBURG
Gothenburg, Sweden 2022

Master's thesis 2022

Designing Filtering for an Analytic Software

Kajsa Bjäräng
Viktoria Enderstein

UNIVERSITY OF
GOTHENBURG

CHALMERS
UNIVERSITY OF TECHNOLOGY

Department of Computer Science and Engineering
Chalmers University of Technology
University of Gothenburg
Gothenburg, Sweden 2022

Designing Filtering for an Analytic Software
Kajsa Bjäräng
Viktoria Enderstein

Supervisor: Staffan Björk, Department of Computer Science and Engineering
Advisor: Gustaf Carlberg & Maria Redström, The Company
Examiner: Mikael Wiberg, Department of Computer Science and Engineering

Master's Thesis 2022
Department of Computer Science and Engineering
Chalmers University of Technology and University of Gothenburg
SE-412 96 Gothenburg
Telephone +46 31 772 1000

Cover: Final Designs of Date Picker, Search & Filter and Filters' Relation solutions.

Typeset in LaTeX
Gothenburg, Sweden 2022

Abstract

The purpose of this master thesis is to answer a the research question "What should be considered when designing filtering for an analytic software?". To this end, a set of guidelines was defined, that could be used as a foundation when designing filters for analytic software. The research question was answered through an iterative design process of research through design, including a pre-study followed by three design iterations. The guidelines were defined and iterated continuously and simultaneously as designing an improved design concepts. The project resulted in three different concepts: Date Picker, Search & Filter and Filters' Relation, that allowed for an exploratory process when designing and defining the guidelines. Date Picker and Search & Filter are both high-fidelity prototypes whereas Filters' Relation is a low-fidelity conceptual solution. The final set of guidelines includes six general design and functionality guidelines for designing filters in analytic software, and five that are more scope-specific. The final set of guidelines can be used as a foundation when designing filters for an analytic software and for future research within the field.

Keywords: information visualization, interaction design, visual analytics, analytical software, filtering

Acknowledgements

We want to express our greatest gratitude toward our advisors, Maria and Gustaf at The Company, for their support and help throughout the project. Additionally, we would like to thank our supervisor Staffan Björk for his valuable support and guidance throughout the project. Finally, we would want to thank all the participants from the interviews, design workshops and evaluations. Their time and insights have been of great value for the project and result.

Table of Contents

List of Figures

1
Introduction

Data in large amounts can be challenging to analyse and understand and many companies today are overwhelmed with an enormous amount of data, both structured and unstructured [1]. However, with good tools, the data can give beneficial insights and tools helping people explore and analyze data visually are called Visual Analytics tools [2]. These helps to enable and discover insight from different sets of data on a competitive market [3], [4]. The insights can be valuable and lead to an understanding of what needs to be changed to optimise development as well as improve operational efficiencies [1], [5], [6].

The interest and need to filter data has been around for decades. In 1994, researchers discovered that data could be filtered and reduced with the help of sliders and buttons and thereby allow users to immediately get feedback in their data [2]. One of the researchers founded a visual analytics software company two years later. The company offers an analytic software product, that allows the user to visualise, interact with and share data to understand and convey insights [1], [3]. This software product will be referred to as The Product in the thesis. One key aspect of having valuable visual analytic software is the possibility of a quick search and animated visual display of results [2]. With such features, visual analytic software could be used both to get an overview and focus on sub-set when analysing data where filtering is one of the critical components [2]. Information can be filtered with the help of sliders and buttons, enable and manipulate the data immediately on the screen and adjust the in- and output parameters see Figure 1.1 [2], [7]. The project was conducted in collaboration with The Company and the authors. The authors are master students from the Interaction Design & Technologies program at Chalmers University of Technology.

1.1 Research Question

This thesis focused on three different contexts where the demands on filtering differed. The filtering needs to be intuitive and visually appealing for consumers filtering relevant data in a dashboard, for ad-hoc analysts trying to get an idea of the data and for the application builder designing a filter experience tailored for a specific solution. Since there are several ways to filter data, there are many factors that needed to be taken into consideration, such as personal preferences of filtering, previous knowledge and the fact that the data can vary. Therefore, how a user interacts with a large set of data can differ and the filters need to support user needs

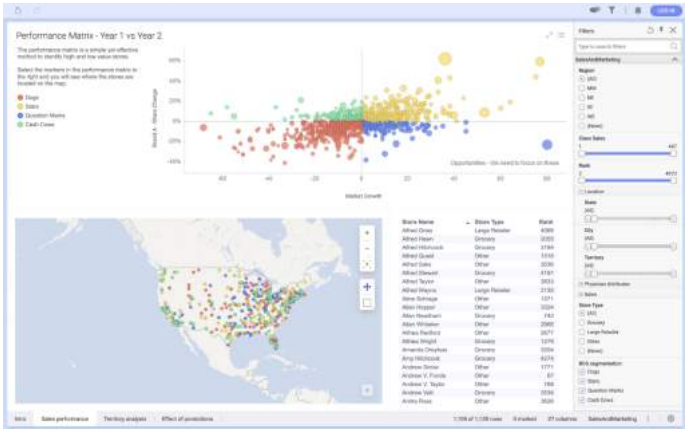


Figure 1.1: Overview of The Companys product.

for them to understand the data through the chosen filter. Based on this research, the master's thesis posed research question was:

What should be considered when designing filtering for an analytic software?

The master's thesis approach to answer the research question and goal was through an iterative design process. The process started with four weeks Planning of Pre-study before continuing with three design iterations, where the focus was to answer the research question by designing an improved concept. This concept was developed to gain practical insights while simultaneously researching the field and developing a set of guidelines. The process was iterative, and the improved concept and set of guidelines was refined, updated and evaluated throughout the project.

1.1.1 Stakeholders

The master thesis was conducted at the Computer Science and Engineering department at Chalmers University of Technology. In collaboration with The Company, the research question has been elaborated as a result of common interest from both parties. Throughout the project, The Company and an academic supervisor guided the project forward. The Company was of great support in understanding The Product and different areas. At the same time, the academic supervisor was of great support from an academic writing and interaction design perspective. The final solution of guidelines and prototypes was shared with The Company and hopefully, the result is of value and enhances the user experience of using The Product's filter functionalities.

1.2 Ethical Issues

It is important to have different ethical issues in mind during the design process to prohibit and limit any ethical issues occurring. As previously mentioned, it might be difficult to extract information from complex data, but hopefully, the visual analytics tool could facilitate this for the user [8]. Guidelines of what should be considered

when designing filters for an analytic software, and different ethical issues should be considered. Privacy is a recurring hot subject within the field of software products to maintain private information secure [9]. How should the data and interactions of filtering be saved? Similarly, in this project, the privacy of the user and how they are informed should be in consideration to create the best possible guidelines.

Another aspect to have in mind is the accessibility of different filtering functionalities. The access of different filtering alternatives should be the same, so the result will not lead to a filtering functionality that might hide or make it difficult to access some data. Meaning the filtering tool shouldn't be affected by the intentions of data analysis. This prohibits skewed results based on the users or analysis intention, and filtering alternatives might be harder to access in different scenarios.

2
Background

This chapter presents The Product that the master thesis will be working on and other Competitors within the analytics software field. Each analytic software tool filtering functionalities are generally described as well as the intended target user group.

2.1 The Product

A visual analytics software was created in the 90s by a software company specialising in data analysis. Today the visual analytic software, or in this thesis called The Product, is used by over 5000 companies, where most companies are situated in the United States. The Product can visualise data with different graphs and let the user interact and share the results. By visualising and giving the user freedom to interact with the data, the goal is to help the user understand and possibly convey insights from the result. The main purpose of The Product is thereby to support data analytics with the help of visualisations. Filtering is a big part of the software. According to Neil Kanungo, an employer at The Company, The Product's filtering features is, for example, a great tool to help the user look at specific values within a specific range by slicing the data. Additionally, The Product allows multiple ways to use and apply filters, such as range filters, item filters, checkbox filters, radio button filters, text filters, list box filters, and hierarchy filters.

Figure 2.1: Overview of The Product.

2.2 Company Scenarios for Product Use

To better understand the typical use of analytics within the data-aware enterprise, The Company has performed over 110 user interviews. Eight scenarios were identified to describe how similar the activities are at the core, but at the same time how different their contexts are.

One central scenario is the *Data Discovery* scenario which refers to people working as Data Analysts, Data Scientists, Business Analysts, and domain-specific roles such as HR Specialists. These sorts of users will, in this scenario, use The Product in a periodical manner as a tool to analyse complex data to find trends that might be significant. The skilled analysts' will have strategies to analyse data while the questions that need to be answered are different every time. They will deep dive into the data with the help of the software to analyse it and answer different questions that might significantly impact the organisation. Another scenario created by the company is *Dashboard Authoring*. This scenario has two perspectives, one being the user that builds dashboards, meaning collecting information in one place to get a comprehensive view of the data. The second perspective refers to the users consuming the holistic view of the data created to gain insights. In contrast to the data discovery scenario, this refers to users checking the status of recurring tasks and regularly reviewing and updating the data. Typical roles for this scenario are Data Analysts, Business Analysts and domain-specific roles such as Digital Marketing Managers.

Application building is another scenario, and it refers to the people working mainly as Developers and Engineers. Applications are built to serve others with data and are quite similar to the dashboard scenario. Application building can be augmented with machine learning and customised with APIs since it is faster and cheaper for companies to build applications on top of a platform rather than building them from scratch.

2.3 Competitors

Filtering data is a functionality that is possible in almost every visual analytic software and is an essential part of The Product and visual analytics [10]. This section examines competitors and their filtering functionalities.

2.3.1 Power BI

Power BI is, according to Enlyft [11], one of the leading analytic software tools. An overview of Power BI can be seen in Figure 2.2. Power BI has two main types of filters: automatic and manual filters. The automatic filters are automatically created filters that get added when building a visualisation [12].

Figure 2.2: An overview of Power BI's desktop application [13].

The manual filters can be dragged and dropped in any section of the filter pane when editing a report. For both the automatic and manual filters, a user with edit permission can edit, clear, hide, lock, rename, or sort the filter in the pane [12]. Power BI uses filters such as Drill-down filters, Cross-drill filters and Drillthrough filters, see Microsoft's website for further information [12]. Figure 2.3 is an example of a Drill-down filter in Power BI.

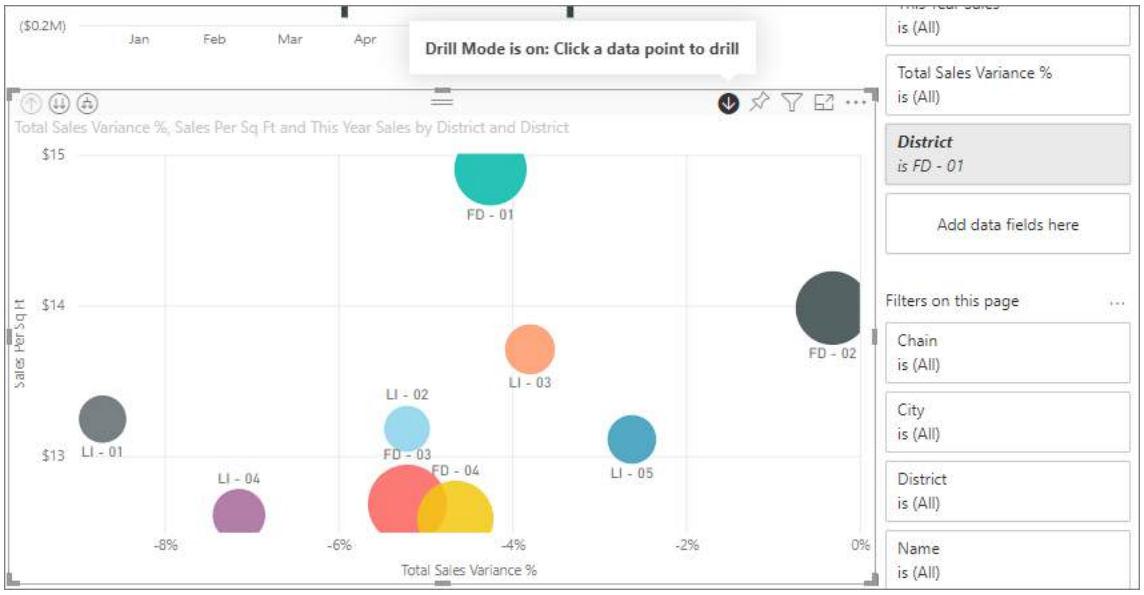


Figure 2.3: An exampel of Power BI's more advanced filter called "DrillDown" [12].

2.3.2 Qlik Sense

Another similar visual analytic software tool is Qlik Sense, see Figure 2.4. Data can, according to Qlik Sense [14], be explored by creating a Filter Pane Visualization.

Figure 2.4: An overview of Qlik Senses desktop application [15].

The Filter Pane allows the user to visualise the displayed data in a list, where the data can be explored by letting the user manage the data. The Filter Pane is created in the software as a visualisation chart. When creating the Filter Pane, dimensions can be added, see Figure 2.5, as well as different criteria and more, see Figure 2.6. The Filter Pane gives Qlik Sense value since it allows the user to find relations and associations of different values by allowing the user to define the data set as wanted [16]. However, if the dimensions have a large number of values, the disadvantage of the Filter Pane is that it is challenging to manage the large number of data [14], [16].

Figure 2.5: When creating a Filter Pane, in Qlik, dimensions can be added [16].

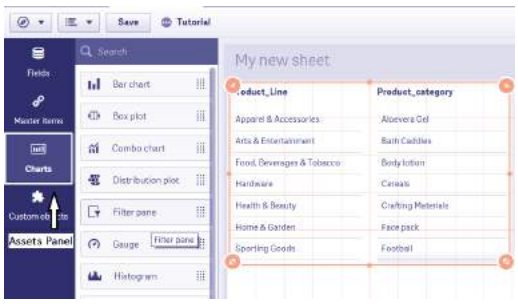


Figure 2.6: When creating a Filter Pane, in Qlik, criterias can be added[16].

2.3.3 Tableau

Another powerful Business Intelligence tool is Tableau 2.7 [11]. According to Tableau, filtering is an essential part of analysing data [17]. Tableau allows the user to display interactive filters and format filters in the view. The order of operation of the Tableau software affects the filtering order to be; extract filters, data source filters, context filters, filters on dimensions and filters on measure [17]. Interactive filters will e.g. appear on the screen as a simple tooltip where the user can either extract or keep data, see Figure 2.8 and 2.9. Additionally, filters could manually be created by drag and drop of different fields, see Figure 2.10.

Figure 2.7: An overview of Tableaus desktop application [18].

Figure 2.8: An example of choosing a selection with Tableaus interactive filters [17].

Figure 2.9: An example of a tooltip when interactiong with the visualisations in Tableau[17].

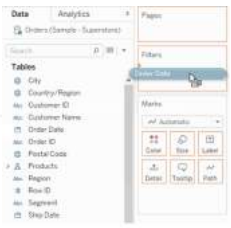


Figure 2.10: A visualisation representing how a filter could be created by the user in Tableau [17].

3
Theory

The theory chapter includes information on different fields relevant to the project, such as Visual Analytics, Business intelligence, User Experience and Filtering.

3.1 Visual Analytics

Extracting information from complex data can be difficult [8]. Since the data collected often can become messy and complex, the increasing problem is that the amount of data collected within, e.g. companies, increases. Cui [8] states how the data can often be so massive and impossible to analyse that different actions need to be taken to be able to extract any valuable information. Additionally, data can be quite boring and overwhelming but is often extremely important to understand since it is a representation of events and real results, and due to that, visualisations have a great significance [19]. Visual analytics is stated by Thomas & Cook [20] to be a process that enables and speeds up reasoning and understanding of complex data with the help of interactive visualisations. In many fields, all from healthcare to astronomy, juggles with problems of being able to understand complex data and due to that visual analytics research started at the beginning of the 21st century to try to solve the problems, and obstacles [8]. According to Cui [8], the research field is rapidly growing, combining the strength of visualisation, data management, perception, human-computer interaction, and much more.

The history of visual analytics is a field that has been created as an outgrowth of two other fields; scientific visualisations and information visualizations [8]. According to M. Lonsdale & D. Lonsdale [21], the only difference between scientific and information visualization is the audience. Both scientific and information visualization purposes are to help the user understand data. Cui [8] and Brigham [22], however, think the field of information visualization and scientific visualisation differs more. Cui mentions that information visualization is a field of visual representations of abstract data such as non-numerical data. In contrast, they advocate that scientific visualisation focuses on graphical representations of spatial data focusing on scientific processes. They both, however, mention that these fields might differ but similarly to M. Lonsdale & D. Lonsdale [21], they mention that the goal is the same as communicating data visually to enhance the chances of extracting valuable understanding of data [8]. These visualisations could either be static or interactive [21], [22]. As Heer & Shneiderman [10] mention, visualisations could give great value by letting the user understand the data. However, they state how the visualisation

itself only could answer a few questions while visual analytics lets the user get an even deeper understanding of the data by being able to make analytical reasonings about it with the help of exploration, refinement and iteratively analyse the visualisation and data.

The subfields of visual analytics, such as information visualization, have many different benefits to enhance visual analytics. Information visualization can make a significant impact on the user if it is well created since it enhances the possibility of communicating information all from key aspects to concepts [21]. However, one great benefit with information visualization is the possibility to engage the user in complex data and give a more straightforward way of understanding a complex problem [22]. This is according to Bursi-Amba et al.[23], since visualisation is easier for a user to understand and take in than a large amount of data in, e.g. text. By letting the user additionally interact with the visual analytics, the possibility of extracting valuable information is possibly increased [8]. According to Cui [8], there are two possible ways to interact with visual analytics on an observational level; through exploratory and expressive interaction.

Similarly, visual analytics is classified into two categories; exploratory-oriented and expressive-oriented [8]. With exploratory-orientation, the user extracts information based on the dynamic visual representation that changes and reacts to the user's interaction. This includes interactions that can adapt the visualisation dynamically with features such as filtering data, modifying zoom level and much more. However, expressive-orientation focuses on another aspect where the interaction is to modify the underlying data and parameters and thereby affect the result [8]. The possibility to interact within visual analytic tools is significant for a visual analytic software since it creates the possibility to change and skew the visualisation to follow and match the users' thought and analysis [10]. Similarly, Heer & Shneiderman [10] mentions how filters within visual analytic software are a great tool to create different visualisations for specific data selections and help the user extract information from the complex data.

Even if visual analytics could facilitate extracting valuable information, there is still complexity in understanding the data, which is another complex process referred to as data analysis. *Data analysis* primarily focuses on analysing the data. At the same time, *visual analytics* refers to extracting opportunities from complex data based on the definition stated by Joseph Thomas, the founder of data analysis [8]. According to Cui [8], the goal of the data analysing process is to enhance the chances of extracting information from complex data that can be helpful. Therefore, logical techniques and statistical procedures can be applied to the data analysis process. Additionally, he states how Confirmatory Data Analysis (CDA) and Exploratory Data Analysis (EDA) are two subfields of the data analysis process in statistical applications. CDA is a process that evaluates, based on the data set, through a statistical hypothesis test from a predefined hypothesis. EDA, however, is a process used when there is no known hypothesis and the intention is to extract different characteristics from the data [8]. This can be done with different techniques; how-

ever, EDA is often more complex than a CDA and mainly uses visual methods to extract unknown patterns.

Due to the complexity of the field, there are some challenges within visual analytics. Scalability is one of those challenges stated by Cui [8]. He mentions that since the amount of data is becoming more and more complex, the full potential is not met since the human ability to interact and analyse the data is becoming a problem due to the complexity. One area of research in focus to facilitate the problems caused by the scalability is larger displays; however, both machine and human capabilities limit the scalability [8]. In conclusion, the research field, visual analytics, can significantly value decision-making by extracting information and combining visualisations with different interaction techniques in several working fields [8]. Visual analytics is a crucial factor for the visualisations of Business Intelligence. However, there is still room for improvement, whereas scalability is one of the current focuses of the research area. New interactions and techniques should be explored to develop the field further.

3.2 Business intelligence

Howard Dressner introduced business intelligence (BI) in 1989 as an umbrella term for describing methods and concepts that can improve decision making for a business using fact-based support [24]. BI combines data gathering, data storage and knowledge management to provide analysis that eases the decision-making process and emphasises analysis of a large amount of data connected to the business and its operations [24].

BI can contribute to increased performance through categorising the business value into dimensions such as financial value, productivity value, trust value, risk value etc [25]. These dimensions can each be evaluated to contribute to increased performance [25]. BI can, through using large volumes of structured data, emphasise analysis and provide actionable information and knowledge at the right time, location and form [24].

3.3 User Experience

User Experience (UX) is a term used to a great extent worldwide. However, there is no clear definition since it often has different meanings. According to the white paper compiled from Dagstuhl Seminar [26], the definition of UX might differ depending on the context of UX. The context can differ from a psychological to a business perspective. However, the term UX is often used with a meaning of customer usability experience [26], [27]. Definitions of UX are presented below.

"... all the aspects of how people use an interactive product: the way it feels in their hands, how well they understand how it works, how they feel about it while they're using it, how well it serves their purposes, and how well it fits into the entire

context in which they are using it." - Alben [28, p. 12]

"Every aspect of the user's interaction with a product, service, or company that make up the user's perceptions of the whole. User experience design as a discipline is concerned with all the elements that together make up that interface, including layout, visual design, text, brand, sound, and interaction. UE works to coordinate these elements to allow for the best possible interaction by users." - Usability Professionals Association [29]

"User experience (UX) design is the process design teams use to create products that provide meaningful and relevant experiences to users." - Interaction Design Foundation [27]

Since the term UX has different meanings, a definite definition of the term would be valuable to more easily teach the basics of UX, clarify different perspectives, facilitate the development within the research field, and much more [26]. Dan Norman, the founder of the term User Experience, defines the user experience of a product as a cohesive, integrated set of experiences to make each set of experiences work flawlessly together [27]. The white paper of the Dagstuhl Seminar UX [26], however, views the term UX as either a practice, field of study or phenomenon. An essential part of viewing UX as a phenomenon is to define what period of the user experience is being analysed with a product. The paper summarize how the team could more easily analyse the product by determining the period since a limitation has been made. The white paper of the Dagstuhl Seminar UX [26], discuss different periods of UX such as momentary, episodic and cumulative UX. They mention how momentary UX refers to the user experience when interacting with the product. Episodic UX, however, reflects on a specific moment of usage, while anticipated UX focuses on the experience and anticipation before using the product. Cumulative UX considers both momentary and episodic UX, meaning the whole experience from the first interaction to most recent. Similarly, Dan Norman refers to UX as a set of several experiences but advocates the importance of making all the sets of experiences work well together [27]. The Nielsen Norman Group [30], argues for the similar importance of creating an overall good experience but mentions the importance to remember that the UI or product's user experience is the key because even if the overall experience would be good if the purpose of the product isn't fulfilled, it won't matter.

Several aspects could affect the user experience, such as the context, the user, and the system [26]. Similarly, Albens [28] definition refers to how UX should cover the overall experience. The Interaction Design Foundation [27], has a similar view of the term but divides the categories into three sub-questions being *why*, *what* and *how* a user would use a product. To achieve a good overall experience, all these aspects that different sources refer to should be considered. The system and its design play a big part in the experience, but the other factors need to be considered. For exampel the surroundings can affect the experience and the motivation to use the product, which might affect the use. As stated by Usability Professionals Association [29]

definition of UX, even the user's environment could affect the perception of the experience. Thereby every aspect should be taken into consideration. A conclusion can be drawn that UX as a practice refers to the people conducting the work to achieve a good user experience [26]. Due to the multidisciplinary nature of UX, the practice within the field, having the user in focus, can be difficult and quite complex [27]. Due to the complexity, the designers must use their expertise in identifying requirements and key components through different methods and tools to create the best user experience possible.

3.4 Filtering

Many websites and applications include a lot of information and data. This can, according to Moran [31] and Vassilatos & Crawshaw [7], be overwhelming and prohibit the user from finding relevant information. Without filtering, finding information can, according to Baymard Institute [32], feel like an impossible task. Therefore, filtering is a key component for improving the user experience for complex systems to facilitate the possibility to find relevant information. By removing irrelevant data and only showing desired results, filters play an important part in e-commerce [33]. In Figure 3.1 and Figure 3.2, an example of how filter can be used to narrow down the result of jackest are shown from asos.com filtering on red jackets.

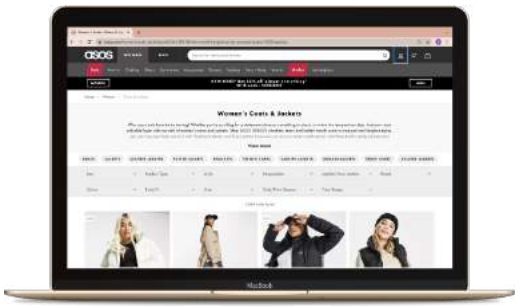


Figure 3.1: Overview of jackets at Asos [34].

Figure 3.2: When filtering so only red jackets are viewed at Asos [34].

Filtering is also a key component for improving the user experience for analytic softwares, but instead of removing irrelevant information, it also filters the scope or type of data [7]. This aligns well with Moran [31], who states the importance of filtering the scope, number, and much more on all sorts of different online services and not only e-commerce. She also advocate how a well-designed filtering possibility gives the user a feeling of control. To be able to narrow down the amount of data without overwhelming the user, a well-designed filtering component should be considered to give the user sense of control of the information [35], [7].

3.4.1 The Anatomy of Filter

Filters could, according to Vassilatos & Crawshaw [7], be divided into three components that together create the filter variable. The filter variable refers to the condition or criteria of a specific filter. To create a good filter variable, they state that it is

necessary and important to understand the data and what structure it should have. The three components creating the variable is; the identifier, the relative and the value.

$$Identifier + Relative + Value \rightarrow Variable$$

3.4.1.1 Identifier

The first component of the anatomy of a filter is the identifier [7]. According to Vassilatos & Crawshaw [7], the identifier stands for the filters targeted category which refers to the categorical filter, see Figure 3.3. When it comes to categorical filters, a category can be described as a property of items, such as a price or a colour, and it usually contains multiple filter values such as “blue” or “less than 100 SEK” etc [31]. Selecting good categories are one of the main reasons to achieve a great user experience, and thereby let the users quickly and effortlessly discover their desired filters. To make sure that the user understands the functionality of the category, the labels of the categories must be as descriptive and precise as possible [31].

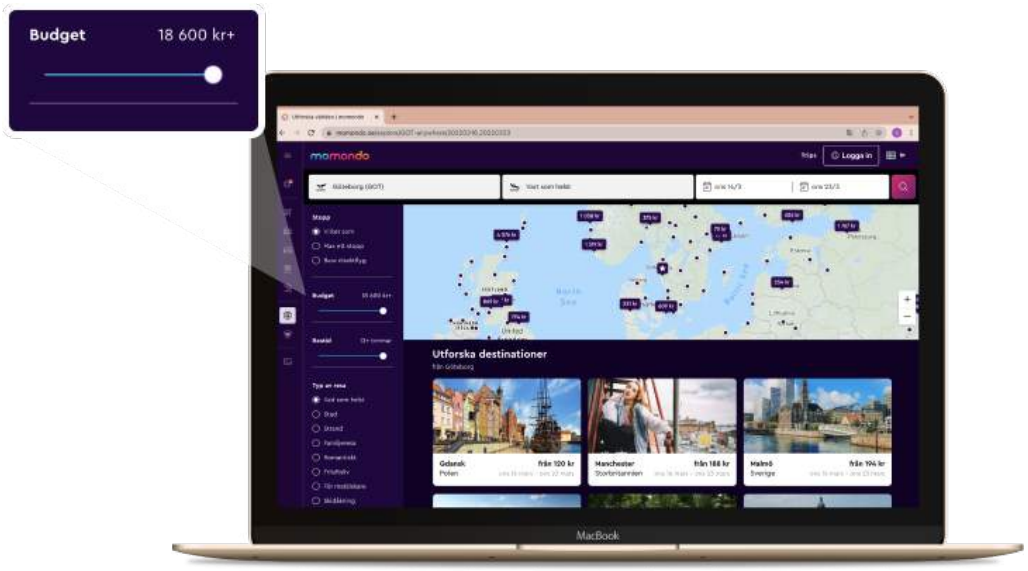


Figure 3.3: "Budget" is an exampel of an identifier at the website Momondo [36].

Suppose that when filters are shown in a menu or a list, it is important to consider the placement of the filters categories. The most high-level and general filter categories should be placed at the top of the list, and the more specific ones towards the bottom [31]. Different filtering categories or identifiers can have multiple items. Some argue that it is important to truncate the list of options when exceeding more than ten options to not overwhelm the user with too many options [37]. It is then important to again try to prioritise the order of options and include the most relevant options at the top of the list.

3.4.1.2 Value

According to Vassilatos & Crawshaw [7] the value stands for the identifier's possible value, meaning what sort of values could the specific category defined by the identifier have. The value can be everything from a sequence of characters, colour, date etc. Since the value type can vary, the preferred way of sorting them can also vary. For numerical values, the best way is to sort from low to high or high to low [31]. When the values are words that the users are likely to know, ordering alphabetically is the default approach. However, sorting in alphabetical order might not always be helpful, and it is important to understand the users' priorities to be able to mirror their expectations in the ordering of filter values [31].

3.4.1.3 Relative

The last component of the anatomy of a filter is the relative [7]. The relative refers to the possible relation between the identifier/categorical filter and value. The relative refers to what expressions the identifier and value will be filtered on, such as IS, OR and AND [7]. For example when selecting two colors with an AND relative the result must be shirts with both colors included while if the relative would have been OR instead the result would be all shirts that are of the first and second color as well as the ones including both colors. How the relative is implemented could differ and be designed in different ways. Additionally it the suitable relative should be well analysed before implementing to create the best suitable variable for the specific filter [7].

3.4.2 Designing Filters

How to design and implement filtering in software could seem like a complex problem since, as UX Design corporation mentions, achieving a good and well-designed filtering possibility, three aspects must be considered; the user, amount of parameters, and the context [35]. Similarly, since the need to filter might vary, the layout and complexity of the filtering functionalities might differ, such as e.g. the placement of the filtering tool. Baymard Institute [38] mentions one standard and well-adapted placement and layout for different filtering functionalities: a vertical sidebar most commonly placed on the left side of the screen. However, they also mention how different design choices become more and more common, such as a horizontal filtering toolbar. With a horizontal filtering toolbar, the user is often given the possibility to sort the data and different filter alternatives. According to an eye-tracking study conducted by Baymard Institute [38], the user's eye movement is often fixed to a position where a horizontal toolbar usually are placed. However, there are still disadvantages to using a horizontal filter toolbar. A horizontal filter toolbar placement leads to more limited space than a vertical sidebar that can use a tremendous amount of space. Baymard Institute [38] thereby argues that a horizontal filtering and sorting toolbar might be better suited to a vertical sidebar depending on the platform, data and context.

When the filtering selection is fetched, it can be applied immediately when a choice

has been made [33], [7]. Another variant is to have an apply button. The fetching of filters is then not applied until all selections have been made and are confirmed. These two different fetching ways are sometimes called batch filtering, when filtering with an apply button, and interactive filtering [33]. They each have different pros and cons. Batch filtering could be beneficial if the platform has some problems with speed, meaning there would be an interruption before the choice would be shown if using an interactive filtering alternative. However, a positive aspect of using interactive filtering, meaning live-filtering, is that the user has fewer actions to execute.

Filters can be designed in different ways, which can affect the user experience. Since filters are complex, there are no specific restrictions or steps to be followed. However, different people and forums advocate for different approaches. Due to the complexity of filters, one approach advocated by Shakuro [33], is first to show the data without any filtering selections and instead give the user the chance to filter and decide. This makes it possible to limit the chance of overwhelming the user, thereby creating a bad user experience. Similarly, Moran [31] argues that the orders of the different filter alternatives should be well-analysed. To enhance the user experience, predictable filters should be placed at the top to make it easier to find the desired filter. Others argue about the importance of including a clear-all button to be able to remove all filters [7], [39]. This approach is also essential since it clarifies what filters have been applied to the user and gives greater control. Other approaches such as including a clear and suitable language are encouraged to decrease the risks of ambiguity and misunderstanding [33].

Allowing multiple selection filters helps the user to narrow down their search for a quicker finding and is extra helpful when a more extensive set of data is analysed [35]. Being able to filter multiple selections in the same category reminds the users to use the filters as well as reduces possible errors and misunderstandings [33]. Another way to quickly filter is through using sliders. Sliders are helpful when the user wants to define an extensive range of values, and it encourages users to explore different options [40]. To support the user's types of interaction, it can be beneficial to provide text input to find a specific value on the range as well as adding +/- for quicker jumps [40].

Another approach that might be of value is to hint to the user how many items there are of a filter, it allows the user to get a quick overview and understanding of the overall data [39]. The number of items should be shown as a number next to the item. Additionally, it should not be possible to filter on categories with no items since it can be very frustrating. Meaning that if there are no items with a filter, they should be excluded from the list or visualised as inactive [33].

4
Methodology

This chapter presents the Design Research along with Wicked Problems. Additionally, the Iterative Design Process and its different phases will be described along with methods and relevant tools for the project.

4.1 Design Research

Design research implies a wide range of methods and approaches that can be followed. Frayling argues that research is the most important nourishment for the practice of teaching design [41]. He also argues that there are three main categories that design research can be divided into. Research into art and design is the most commonly used one, and it implies studying the theoretical perspectives on the design such as social, economic, political, ethical etc. Research through art and design means that research is done through art and design and where a report or similar communicates the results so that it can be used for future research. Research for art and design is the gathering of reference materials to be able to reach an end product of art or design [41].

While research into art and design can help one learn about the theoretical perspectives on the design, research through art and design will help evolve an understanding of how art and design can be used to reach a result [41]. That might be customising a piece of technology, or contextualising a research diary or similar where the result is communicated through both design and the process [41]. The results of these projects can again be researched through design and built upon previous results [42]. Additionally, research through design can also lead to these projects being usefully subverted, suggesting alternatives, or establishing new constructions. Gaver argues that research through design is generative and should be concerned through creating "what might be" rather than "what is" [42]. Developing conceptual theories that are never wrong is not the goal, and the goal is to create theories that are sometimes right [42].

Following the concept of Frayling's research through design, Zimmerman presents a model for bridging the gap between true knowledge and the how knowledge [43]. The true knowledge mirrors models and theories from the behavioural scientists and how knowledge mirrors the technical aspects coming from engineers [43]. He argues that through an active process of ideating, iterating and critiquing potential solutions, the problem will be reframed as the researchers try to do what Gaver calls

the "right" thing [42].

Zimmerman proposes that the result of research through design are models, prototypes, products and design process documentation, an understanding of the preferred state and a substantial problem framing [43]. This facilitates the communication in research through design since an embodiment of theory and technical possibilities are made clear [43]. Research through design does not only give valuable results; it also engages design researchers and engineers to learn about new or current technology and what impact it has or may have on the world [43]. Elaboration, discussions and diversity in a team of different roles (engineers and designers) allow for multiple perspectives to grow and possibly motivate theoretical work to be produced [42]. Additionally, research through design encounters complex problems, such as wicked problems, that are hard to be solved through science and engineering methods [43].

4.2 Wicked Problems

Within the field of design, complex problems that don't have one specific solution due to their complexity are called wicked problems [42]. Horst Rittel, the design theorist that named wicked problems, states how wicked problems have no definitive formula meaning they have no specific or common solution [44]. Additionally, he states the importance of knowing how a solution to a wicked problem is not right or wrong but could only be good or bad. Wicked problems are unique, which is one of the factors of why the problems are so complex. Since each problem is unique, Rittle validates why there is no set of steps that would be possible to apply to all wicked problems to solve them. A good solution for a wicked problem could also never be guaranteed to be done since there is no way of knowing when a solution is final which could be a factor that makes wicked problems seem impossible to solve [44], [45].

Design has a broad meaning, and its meaning is expanding to include more and more dimensions and fields, according to design theorist Buchanan, [46]. Compared to Rittel's definition of wicked problems, Buchanan connects wicked problems with design thinking since wicked problems are commonly addressed within design processes [45]. Wicked problems are common since the dimensions and projects within design are unique, and no general process or combination of methods could be applied to solve all these problems. Both Buchanan and Gaver advocate that wicked problems also are common within design as a consequence of many people being involved, from different fields, in the decision being taken during the design process [42], [46]. This is because communication within different fields and areas might be difficult due to different focus and vocabulary.

4.3 Iterative Design Process

Different design activities can be applied to approach wicked problems [42]. Such activities can be methods and frameworks that have been formed and expanded to a great extent [47]. The common goal of these formed and defined frameworks and methods are to facilitate the process by standardising different methods and processes. These methods and frameworks differ to a great extent and, according to J. Jones, all have one important thing in common, they focus on the parts creating the design and not solely the result [47]. According to the Interaction Design Foundation, a great way to seize complex design problems, such as wicked problems, is through an agile methodology such as an iterative design process [48].

There are several positive outcomes of using an agile methodology compared to previously traditional waterfall methods that are linear progression methods [49], [50]. Time and cost could, for example, be reduced when using an iterative design process since feedback is received throughout the design process, which prohibits the process from making expensive and time-consuming choices that don't give positive results. An iterative design process often consists of different phases with a different focus which can be iterated upon [49]. By splitting the project into small parts, the overall experience of a product might, however, be forgotten and not be focused on and is, according to the Nielsen and Norman group, one of the challenges created by using an Agile methodology [50]. Due to that, it is important when using an agile methodology to not forget the overall experience and iterate both parts of the product as well as the overall experience since, as Cooper et al. advocated, the importance of being able to iterate to be able to achieve the best possible result [51].

Double Diamond is an iterative design process that is divided into four phases; Discover, Define, Develop and Deliver [52]. Another similar iterative design process is the Design Thinking process, which, compared to the double diamond, has five phases instead of four [53]. Design thinking is a human-centred iterative design process, see Figure 4.1, that focuses on trying to understand the user with the help of five phases; Empathise, Define, Ideate, Prototype, and Test [53], see Figure 4.1. One of the goals by iterating upon the five phases is to be able to apply innovative solutions to valuable insights gained through the different phases [53]. Design Thinking is especially good to apply when there are unknown or vaguely explained problems since the problem will be reframed with a hands-on approach with the human and its needs in focus [54].

4.3.1 Empathise

Design Thinking's first phase is *Empathise*, which focuses on trying to get an understanding and empathy of the problem and user [54], [55], [56]. During the Empathise phase, communication with experts within the field should be performed to better understand the product. During this phase, it is also important to personally en-

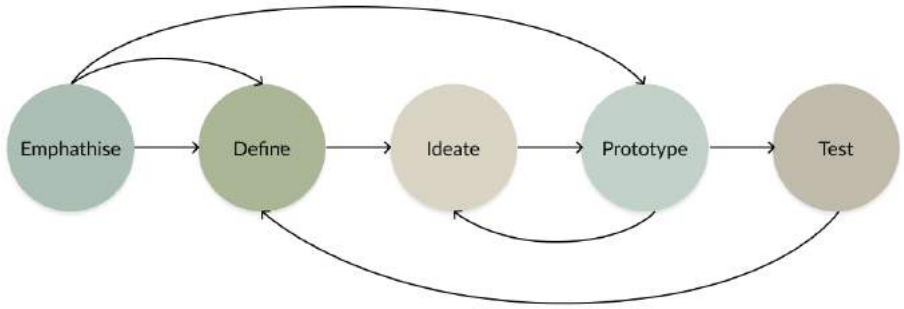


Figure 4.1: An illustartion of the design thinking process and its five phases.

gage yourself in the physical environment to get a better understanding. The goal of the phase is thereby to gain an understanding of the users and their needs by removing personal opinions about the product [55], [56]. During this phase, key information should be gathered to get you one step closer to solving the users' needs and problems. An empathy map is thereby commonly used to understand the users' needs and facilitate upcoming decision making by visualising the gathered information about the user, see Figure 4.2 [57].

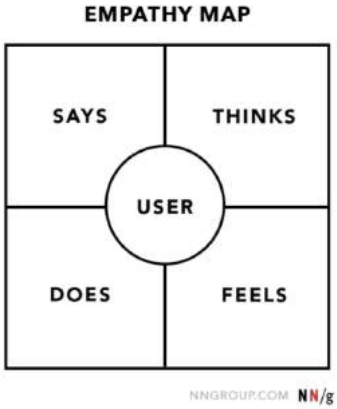


Figure 4.2: Empathy Map visualisation tool to map the users' needs [57].

Different methods could be performed and executed to understand the problem, user, and space. One of these methods is the Literature Review method [58]. Martin & Hanington states how the focus of this method is on gathering relevant information on specific topics from different literature sources such as books, papers, websites, and more [58]. They advocate how it is later possible to gather and structure the relevant information into topics to facilitate the possibility of extracting relevant information for a project. Since great trust is considered to the source's content, they mention that it is important to be source-critical when executing a Literature Review so that the information gathered comes from credible sources. Another method used to gain insight into relevant features and functions of competitors is competitive analysis or also known as benchmarking [59]. This method is great for

understanding the competitors' design choices to give insights and inspiration during the research process. Different methods could be used to understand what the user says, thinks, does and feels about a product, such as Interviews [55], [57], [58]. An interview is a method with direct communication with the user, which could either be conducted semi-structured or structured [58]. Interviews can be conducted in different ways and whenever in a design process. Interviews could also be conducted in combination with the method observation to gain a greater understanding [58].

The observation would then be a semi-structured observation where a checklist or some guiding set of questions could be asked. Another way of observing is through casual observation, where no direct communication should be done [58]. Observations are often executed to get familiarised with the unfamiliar territory and understand and find out different patterns performed by the user. Additionally, observations could be used to get an understanding of how the user does use the product. All observations should be well planned and documented, for example notes and photographs can be gathered. When documenting, it is important to remember to only observe and not draw any assumptions or conclusions about somebody's behaviour [58].

4.3.2 Define

The second stage of the process is the *Define* phase, and the purpose is to define the challenge or problem that needs to be solved [56]. This is done through analysing the findings and observations that were gathered during the Emphasise stage [54]. This stage is primarily focusing on the end-user and should help state the user's requirements and needs to be able to define the problem [56]. At the end of this phase, a user need statement should be defined to prohibit spending time and resources on irrelevant ideating solutions [60]. Gibson defines it as: "A user need statement is an actionable problem statement used to summarise who a particular user is, the user's need, and why the need is important to that user" [60].

To gather the findings and insights from the Empathise phase, an Affinity diagram can be used [58]. Observations, concerns or requirements are placed on individual sticky notes to let each note of design implication be considered independently. The next step is to cluster these notes based on affinity to create different research-based themes. Affinity diagrams are done through a "bottom up" approach, meaning small details clustering into groups, leading to finding more general and overarching themes. The purpose of an affinity diagram is to mirror the voice of the customer as a support for designing [58]. Another technique for gathering insights is Rose, Thorn, Bud, which helps code the research data and helps identify issues and insights [61]. The idea is to identify positive experiences (Rose), negative experiences (Thorn) and new goals and insights (Bud), which helps with focus areas and understanding of future steps [61].

To gain an understanding of the future use of a product from a user's perspective, scenarios can be used to make design ideas explicit and concrete [58]. Scenarios

can, during the design process, be referred back to, making sure that the design is focusing on artefacts that mirror day-to-day activities and thereby avoid the tendency to design toward technical requirements [58]. Scenarios are an excellent method for gathering the team towards a shared product vision. Another method for making sure that the project development is heading in the right direction is through Impact Mapping [62]. When creating the map, the best way is to start with the goal of the product and the user's primary needs and then continue similarly for all the stages of the map: Effect, Target Group, Need & Functionalities. Impact Mapping is an excellent method for increasing the effectiveness of the team and fulfilling needs and behaviours [62].

4.3.3 Ideate

Ideate is the third stage of the Design Thinking process, where the understanding of the users and their requirements from previous phases works as a foundation for generating ideas [56]. The ideation phase focuses on generating diverse ideas, and a well-performed ideation has been shown to result in better designs [63]. Alternative ways of looking at the user statements needed in the define phase can generate new solutions to the problem [56]. The ideation should involve several people and be structured by using ideation techniques [63]. Brainstorming is a common technique for expanding the problem space and stimulating free-thinking and is preferably used at the beginning of the ideation for getting many ideas or problem solutions [56]. The purpose of a brainstorming session is to reach new solutions though building upon others ideas [64]. It is important that all participants feel relaxed and comfortable to express ideas without being afraid of criticism [64].

Sketching is an excellent method to express and concretize thoughts and ideas, making it easier for others to understand as well as elaborate on ideas further while widening the lens of thinking [64]. The sketches should not be detailed or precise, and they should be used as a rough explanation of the idea in a simple drawing. Sketching is a suitable method for deciding on what ideas to elaborate on and work further on since it is easier to discuss, critique and share ideas with others and get a quick overview of the ideas [64]. 10x10 sketch method is a technique for exploring and generating ideas by sketching an idea, theme, concept or icon onto sticky notes [65]. Once each team/person has approximately ten sketches, the ideas are shared with the group, and one of them is chosen as a starting point for the next round [65]. Another sketching method is the Crazy 8, which is a fast sketching exercise that pushes the participants to generate ideas for a concise amount of time [66]. Every person gets a paper folded into eight sections, a timer starts, and eight ideas will be developed for eight minutes. The rapid timeframe for this method can push the boundaries of the participant's creativity and might result in innovative solutions [66].

Solution sketching is a method that is of relevance to perform after a brainstorming of using, for example, 10x10 sketching or the Crazy 8's [67]. The idea is that the participant gets to work on an idea of high interest to them. It can be a combin-

ation of previous sketches/ideas, or a completely new one. The purpose is that it includes detailed frames or states of the concept and how it works [67]. Design workshops are another efficient method that can be performed during the ideation phase [58]. A design workshop is a session with stakeholders and designers and usually involves several activities such as discussions, idea-generating on sticky notes etc [58]. To expedite different findings, workshops could be conducted several times and at different locations, and the time of the workshop itself can vary [64].

4.3.4 Prototype

Prototype is the fourth stage of the design thinking process, which focuses on creating several prototypes that are deducted versions of the final result [54]. This is an important phase since the created prototypes create a possibility to test the product so the team can identify possible problems or possible improvements [55], [54]. From this, a conclusion can be drawn of what components should be accepted, improved or rejected [56]. The prototypes can be created in different small scaled versions and focus on either a specific component or the general user experience.

According to the Interaction Design Foundation, prototypes can be created throughout the prototyping phase with different fidelity levels [68]. By doing low-fidelity prototypes, a model of different components can be tested. They are arguing that the positive aspect of creating low-fidelity prototypes is that they are quickly created and cheap. Low-fidelity prototypes also allow a great possibility of making changes of design based on the feedback [68]. One low-fidelity method is Storyboarding, which is a great method to capture and inform a product's context and intentions through a series of illustrations presenting a scenario or user story [69]. Wizard of Oz is another low-fidelity technique where the participants get the possibility to interact with the prototype before being implemented [58]. The researcher controls the prototype behind the scenes to give an illusion of the possible interaction with the product. This sort of low-fidelity prototype is great to create to be able to evaluate how a user would feel and interact with the product so changes could be done before implementing the final solution [58].

As previously mentioned, low-fidelity prototypes are great to use to gather feedback and decide what to continue, redesign or reject with the product. However low-fidelity prototypes do not create great realism [68]. Due to that, high-fidelity prototypes could be good to use later in a design process when wanting to evaluate more realistic and applicable feedback of the actual final product. High-fidelity prototypes should look and feel like the final product as well as, to a greater degree, operate similarly [68]. Different sorts of prototype methods could be used depending on the form of the final product. Wireframes are a great way to represent the design when developing a software product. Wireframes can be developed in different fidelities, all from wireframes created with pen and paper to more specific wireframes with possible interactions created with design programs such as Figma [68].

4.3.5 Test

Test is the final phase of the Design Thinking process. Even if this phase is the last of the five phases, it does not mean it has to be the final thing the designers do since the process is iterative. During the test phase, the goal is to evaluate if the prototype meets the goal [55]. Tests on prototypes are thereby executed to identify the best solutions, alterations and refinements needed to be done to meet the goal [54]. Tests can be done to evaluate the whole project, components or context to be able to get an understanding of the user and their actions, feelings and more with the product [54]. During this phase, real users are a key component to be able to gather reliable data of the end-user [56]. One way to conduct tests is through the platform User Testing [70]. The platform enables companies to test their products and designs within hours.

According to the Interaction Design Foundation, tests could be conducted in different ways, and it is, therefore, important to have some aspects in mind when planning a test [71]. First, remember that the user isn't being tested, but it is the prototype. Secondly, try to make the context clear for the user to enhance getting relevant information. Additionally, it is important to consider how the communication will be between the user and the executer. Give the user the necessary information, but there is a fine line between necessity and too much information. Finally, the last aspect to consider is how the feedback will be gathered. Is the test being recorded, notes being taken and so on. Additionally to all these aspects to have in mind, some several ways and methods can be used to test a prototype or product. One method possible to use to evaluate the usability of a product is usability testing [58]. A user is advised to execute some simple task to evaluate the experience of the user and possibly be able to extract some empirical evidence of how to improve the usability of the product [72]. Similarly, different design walkthroughs could be executed with different intentions. Heuristic and cognitive walkthroughs are evaluation methods that have to be conducted by a specialist to gain the goal to hopefully extract problems affecting the user [58].

4.4 Tools

This section includes information about relevant software tools. The tools presented are suitable to use for the project and are mostly used for the prototyping and test phases.

4.4.1 Miro

Miro [73] is a collaborative software tool to facilitate collaboration and let several people create and interact together, see Figure 4.3. Miro can be used during workshops since several people could participate and easily create notes, shapes, wireframes and much more to express their feelings and thoughts. The software is an infinite scalable canvas where people's creativity could expand [73].

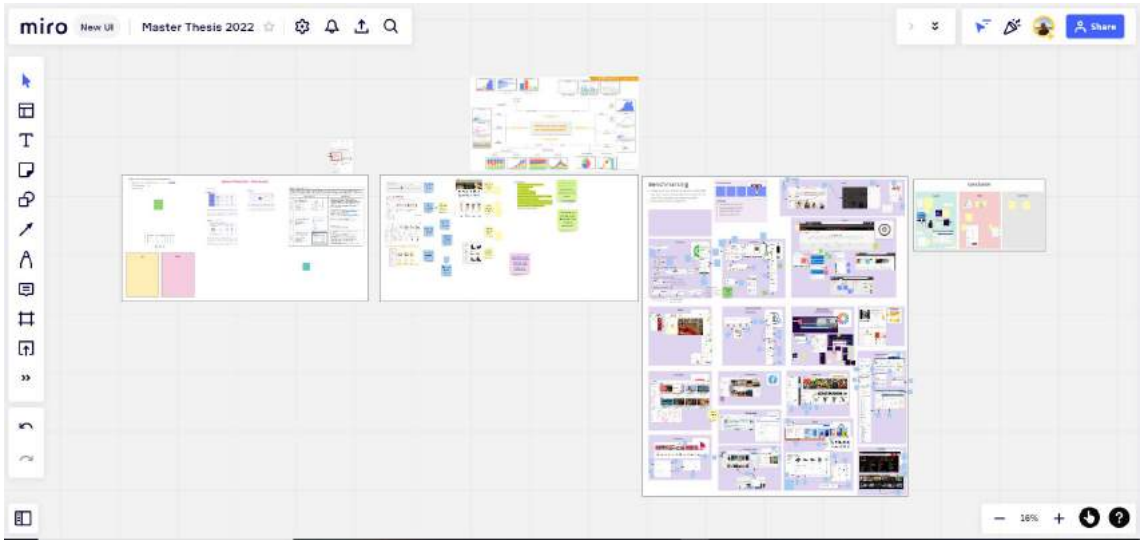


Figure 4.3: Overview of a collaborative dashboard on Miro [73].

4.4.2 Figma

A well known collaborative interface design tool is the design software Figma [74], see Figure 4.4. The software allows creating different wireframes, animations, and graphical interfaces without any code prerequisite [74]. Prototypes can be created with Figma for both low and high fidelity prototypes of different graphical interfaces to present and convey a design. With the design software Figma, it is possible to include interactions to give a greater understanding of the graphical interfaces possible interactions [74].

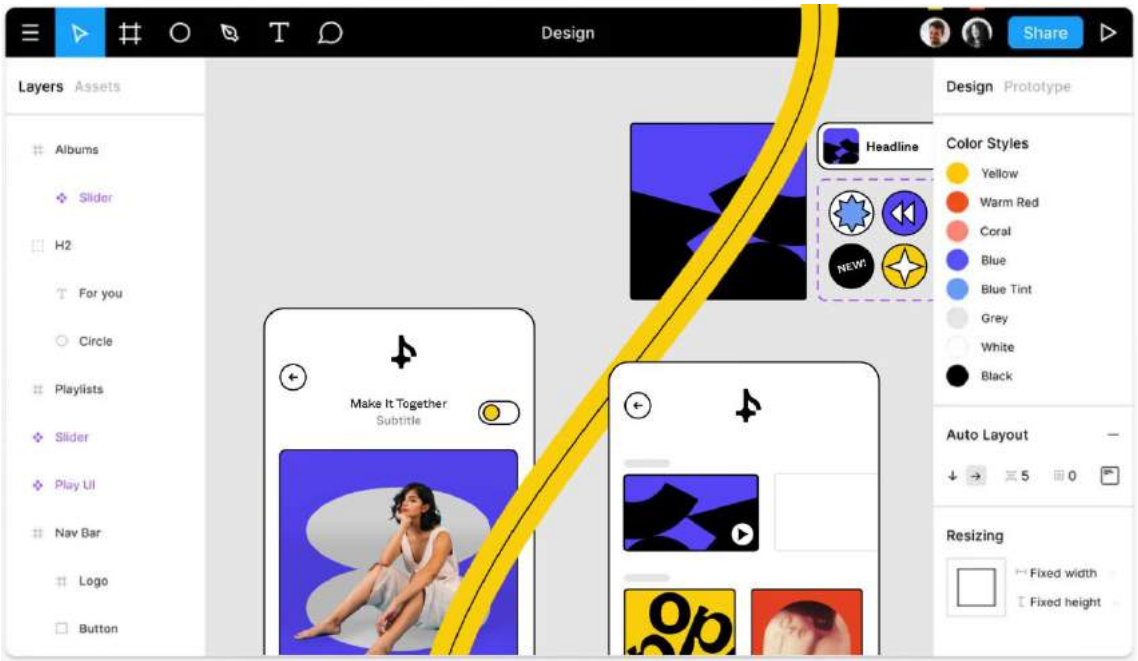


Figure 4.4: Overview of a collaborative dashboard on Figma [74].

4.4.3 Axure RP

Axure RP [75] is one of the leading prototyping tools [76]. Axure Rp is a design software tool that allows the user to create prototypes of graphical interfaces as well as interactive prototypes, see Figure 4.5. Axure RP is a rapid design prototyping tool that allows users to drag and drop components and quickly create wireframes.

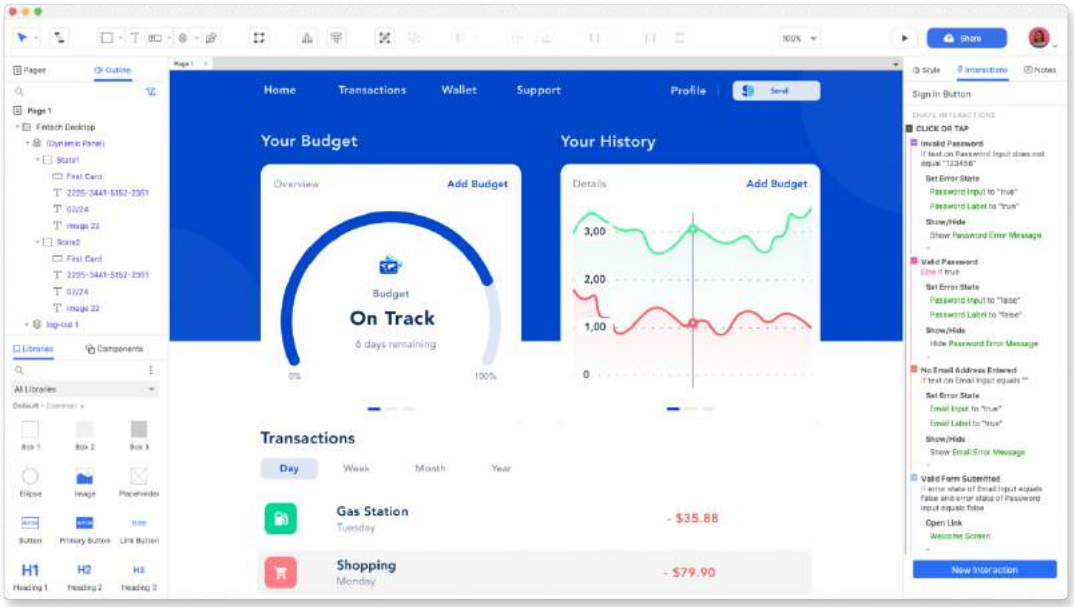


Figure 4.5: Overview of the prorotyping tool Axure RP [75].

5
Planning

The initial plan for the project was to answer the research question and goal through an iterative design process. The plan was to divide the project into four interactions; four weeks of Pre-study before continuing with three iterations. The focus of the project was to answer the delicate design problems of the project by designing an improved concept, a set of guidelines and answer the posed research question. The initial time plan of the project is seen in Figure 5.1.

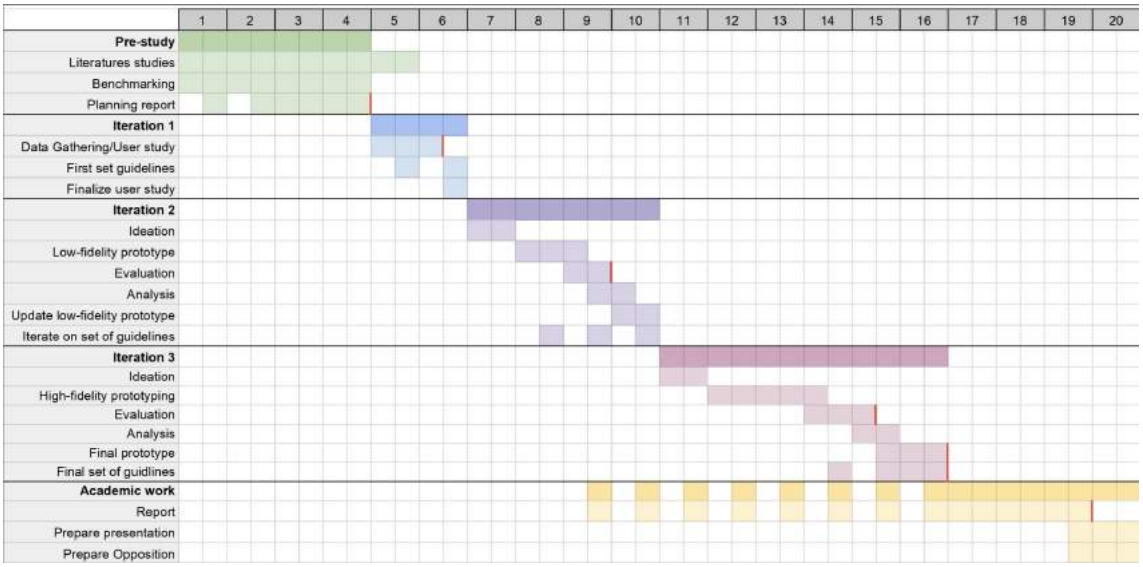


Figure 5.1: Overview of the project's planned execution.

5.1 Planning of Pre-study

The first phase of the project is the pre-study. The pre-study will consist of four weeks dedicated to a literature review and research to understand the problem and gain insights and knowledge on the subject [58]. Additionally, time will be spent learning about how the product works and benchmarking different products on the market since it gives an understanding and insights of the competitors and their design choices [59]. Based on the research done in this phase, a planning report will be written and finalised. The planning will then be used as a foundation for the final thesis report including the background and theory gathered. Additionally, during the end of the first phase, time will be set aside to prepare for the first iteration, such as recruiting participants for user studies.

6
Execution and Process

This chapter presents the executed design process conducted to answer the posed research question. It is divided into a pre-study followed by three design iterations with different focus areas and lengths. The guidelines were ideated and iterated during each design iteration in conjunction with developing prototypes. Each phase in the process is presented chronologically, where each iteration's steps, results, and reflection are presented. The plan created in the planning and study phase, see Figure 6.3, was followed to some extent which is presented below. Throughout the process, scenarios have been in focus, and the projects scenarios are presented and described in Section 2.2.

6.1 Pre-study

At the beginning of the project, a significant amount of time was spent understanding The Product and the users. To better understand The Product, time was spent exploring the application. The Company's different scenarios were also analysed and discussed to understand the users better and the three scenarios *Data Discovery, Dashboard Authoring* and *Application Building* was chosen as primary focus, see Section 2.2. Additionally, a literature review and benchmarking were conducted before defining the first initial set of guidelines. During the pre-study phase, a planning report was also assembled. The project's time plan was updated, and the different steps in each iteration were further decided.

6.1.1 Literature Review

A literature review was conducted to gain an understanding of the subject and possible areas to investigate [58]. Literature about visual analytics, UX and filters was collected from books and online sources such as articles, white papers and conference papers. Knowledge about the topics, appropriate methods and design processes suitable for the project was thereby gained and resulted in some initial keywords such as Visual Analytics and User Experience.

A majority of the books used during the literature review were received from The Company, and the online sources were partly found from search engines such as ACM Digital Library [77] and Chalmers Library [78]. Google searches [79] were done as a complement to find relevant information and websites suitable for the project. The relevant information from valuable sources was collected and used as a

foundation for understanding the scope, which influenced the methodology for the project. Additionally, the most relevant literature was used for creating the first set of guidelines.

6.1.2 Benchmarking

During the Pre-study phase, a competitive analysis, also called benchmarking, was conducted. Benchmarking is a method that is great to perform during a research process to gain inspiration and insights [59]. Based on that, benchmarking seemed like a suitable complementary method to conduct, in addition to a literature study to gain inspiration and ideas about how current platforms have designed and structured their filter functionalities. Different websites were analysed, all from e-commerce websites to similar visual analytic softwares. The Product's competitors were analysed with the help of documentation and demos on Youtube [80] to understand the competitors' filter functionalities. For a summarised result of the benchmarked competitors see Section 2.3. Filters are a standard functionality used in many different fields and websites. Since e-commerce websites are one of the largest fields, the most used e-commerce websites [81] such as Amazon [82] and Alibaba [83], were analysed.

All sorts of e-commerce were analysed, such as websites stated to include great filtering solutions [84] to a familiar travelling website [85]. This sort of website has a significant level of complexity and includes relevant filtering insights and alternatives. Notes and screenshots were collected throughout the benchmarking phase and were gathered on a Miro board to collect interesting outtakes in one place, see Figure 6.1. When the benchmarking was finalised, each note and screenshot were analysed. A summary of the most exciting or recurring outtakes was then gathered in a new Miro board with three different columns as a variant of the Rose, Thorn, Bud: *Good*, *Bad* and *Common* as seen in Figure 6.2.

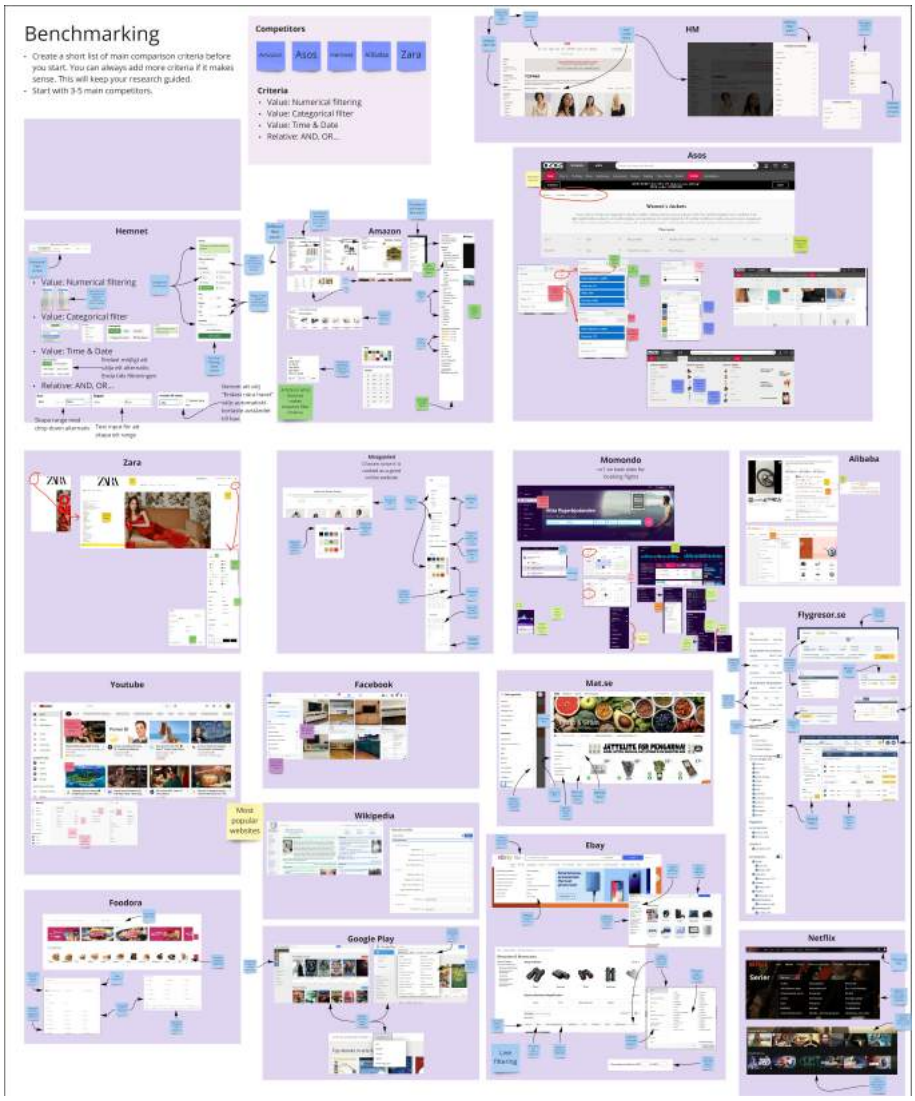


Figure 6.1: The Miro board with all the gathered insights from the benchmarked websites.

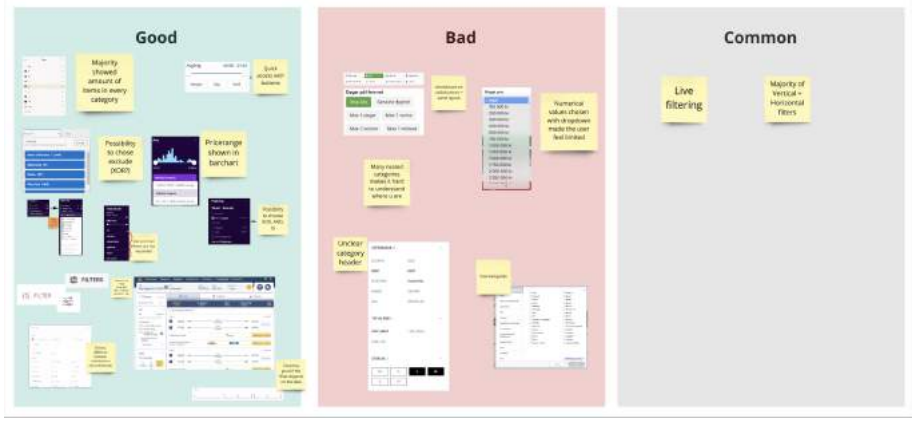


Figure 6.2: The Good, Bad and Common result of the benchmarked websites.

6.1.3 Understanding the User and The Product

To gain a greater understanding of The Product and the users, a demo of The Product was conducted by an internal stakeholder. The demo focused on filter functionality within The Product. Additionally, time was spent trying to understand the scenarios created by The Company further, see Section 2.2 for more information on the scenarios. The Product's users are within various fields and might use filters for different purposes, meaning users have different needs and experiences. To understand how filters within The Product works and understand how they might affect the users, the different scenarios were analysed and discussed to increase the knowledge of The Product's users. Based on the gained knowledge, a decision to focus on the *Data Discovery*, *Dashboard Authoring* and *Application Building* scenarios was done.

6.1.4 Planning of Design Process

During the Pre-study phase, excellent knowledge within the field was gained, and the project's initial plan was updated. The thesis posed research question is intended to be answered through an iterative process starting with a Pre-study phase and three design iterations. The thesis report is planned to be worked on continuous throughout the project but to different extents. Below each iteration's area of focus and the intended plan is presented based on the gained knowledge from the literature review and benchmarking. The design thinking process will be applied since it is an iterative design process that is suitable for wicked problems [55], [42]. Depending on the phase of the project, different design methods will be used during the process. Focus throughout each iteration will be on designing an improved concept, a set of guidelines towards answering the posed research question. An iterative design process is chosen since it aims to ensure that the final result meets the expectations and requirements by refining and evaluating the result several times during the process [49]. An overview of the updated plan of the project is visualised in Figure 6.3.

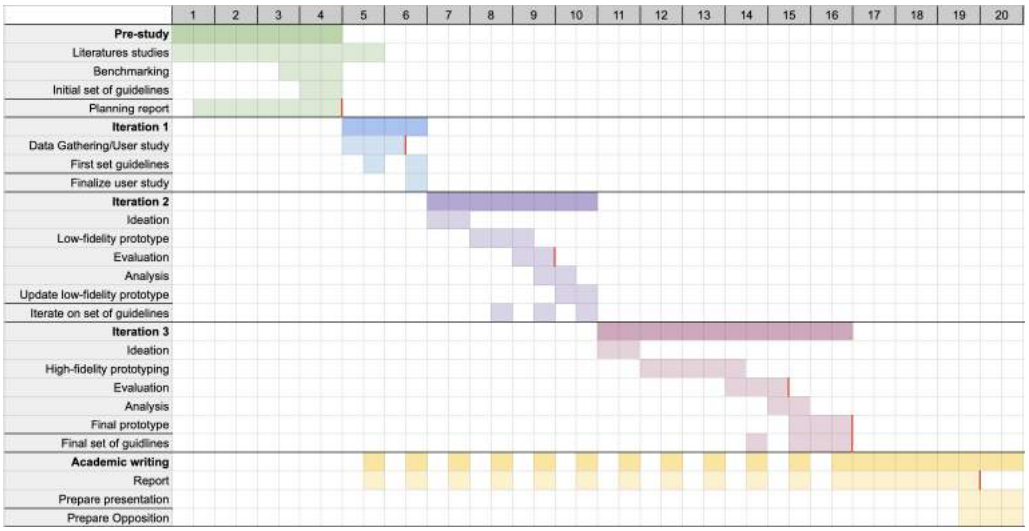


Figure 6.3: Overview of the project's updated planned execution.

First Iteration
The first iteration was planned to be done over two weeks and include gathering data and executing interviews to get insights into the delicate design problem. Interviews was planned to be conducted with stakeholders at The Company to gain an understanding of how filters are being used today and possible improvements [58]. The result of these interviews was then planned to be analysed in Miro [73] through affinity diagramming to mirror the voice of the customer as a support for designing [58]. A user needs statement was planned to be defined to summarise who the user is, what he or she needs and what is essential to the user and was planned to work as a foundation when formulating the initial set of guidelines further [60].

Second Iteration
The second iteration was planned to be executed during four weeks. The first week of the second iteration was planned to be to ideate via brainstorming and creating sketches, to make it possible to test the ideated concept and components. Additionally, to generate ideas and include the stakeholders in the process, a design workshop was planned to be performed [58]. Low-fidelity wireframes was planned to be created based on the key findings from the design workshop to be able to gather the feedback and decide what to continue with [68]. These prototypes was then planned to be evaluated through the Wizard of Oz technique since it makes it possible to evaluate how a user feels and would interact with a product [58]. Additionally, a cognitive walkthrough was planned to be performed to be able to extract problems of the prototype that might affect the user [58]. The evaluations was planned to be analysed through an affinity diagram to again mirror the user, and their needs [58]. Based on the findings, the low-fidelity wireframe prototypes, guidelines and the problem statement was planned to be updated.

Third Iteration
The third iteration was planned to be executed during six weeks, focusing on the details and building upon the work done in previous iterations. The first week of the third iteration was planned to focus on brainstorming ways to visualise the filter functionalities and details. To gain ideas on the subject, the concept was planned to be brainstormed further since brainstorming is a great creative tool for free-thinking [56]. Next, in the third iteration, two and a half weeks was planned to focus on creating high fidelity prototypes to create a look & feel of the concept and ideas. High-fidelity prototypes was planned to be created in Figma [74] with possible interactions to create authenticity of the final result [68]. These prototypes was then planned to be evaluated through usability testing to be able to evaluate the usability [58]. The result of the usability testing was planned to be analysed with an assumption mapping. This method was planned to be used to be able to define what feedback is possible to update at the end of the iteration and what should be referred to as future work [86]. Based on the assumption mapping findings and results, the high-fidelity prototypes was planned to be updated into the final result, the guidelines, and the problem statement. Additionally, a list of future work was planned to be defined.

Academic Writing
According to Björk [87], writing is a tool that allows the author to think and analyse. Due to that, writing on the master thesis was planned to be done simultaneously throughout the project. Additionally, the research question was planned to be answered throughout the project through iterating on guidelines, whereas the writing was planned to be used as a thinking tool for the process. Continuously throughout the project, additional focus was planned to be on the final report to eliminate possible stress when the work burden of the project might increase in the end. However, the final four weeks was planned to solely focus on writing and finalising the report and preparing for the final presentation and opposition.

6.1.5 Reflections on the Pre-study

The Pre-study phase followed the initial plan to a great extent, where outtakes were gained primarily through benchmarking and literature review. Approximately 70 different articles, books, websites and papers were collected and reviewed during the literature review. The result was used as a foundation for understanding the scope and fundamentals of planning the project and methodology. The most influential resource from the literature review was blogs and articles that provided the latest research on how filters should be applied within e-commerce. During the literature review, the complexity of visual analytics emphasised how this project is a wicked problem. An essential step in the Pre-study was to understand The Product further and limit the scope to three scenarios. This decreases the complexity of the problem to some extent, making it easier to start working on the wicked problem.

The benchmarking resulted in a Miro board with common filter features as well as designs that might affect the user experience, either good or bad, see Figure 6.2. A conclusion was drawn that many websites had put extra effort on the order of the filter categories. Common filter categories were often at the top of the filter panel, which gives the user quick access to relevant filters. Additionally, one website had further tried to improve the filter panel and make it less overwhelming by collapsing some filter alternatives, see Figure 6.4. This solution resulted in a clean design without removing any functionalities since the user could expand the filter alternatives if interested. Other websites, however, had difficulties making clear and straightforward identifier headers for the filter categories, which made the websites' filter functionality quite confusing, see Figure 6.5. The filter alternative was often located either horizontally or vertically on the screen and sometimes with both placements, see Figure 6.6. However, some websites let the filter alternatives appear as a dialogue window, see Figure 6.7. This design solution gave an overwhelming feeling of the different filter alternatives.

Figure 6.4: An example of less comon filter alternatives that is collapsed [36].

Figure 6.5: An example of unclear filter labels [88].

Figure 6.6: An example of a website including both a veritcal and horizontal filter bar [36].

Figure 6.7: An example of a dialogue window for filters [89].

During the benchmarking, it was noticeable that websites informed the user how the filtering might affect the result. Some websites included a small indication of the number of items each filter alternative had to indicate how the filtering would affect the result. One website, Momondo [36], included an overview of the distribution by including a visualisation of the distribution in the form of a bar-chart, see Figure 6.8.

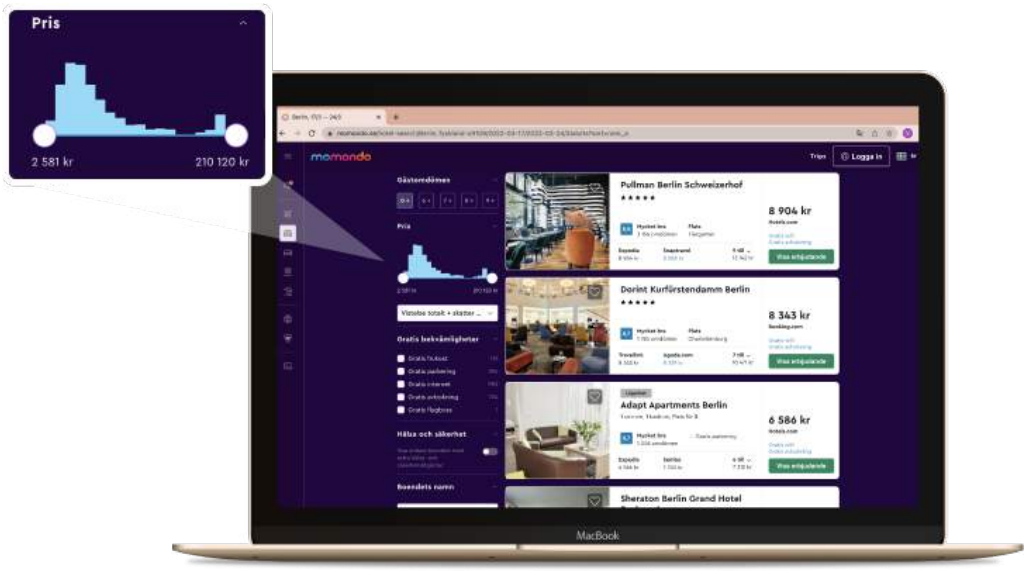


Figure 6.8: An example of a filter design that shows the distribution of data [36].

Additionally, the benchmarked websites solved the relatives of the filtering differently. Some websites included a simple way of the relative action of XOR, such as the user with one button was able to select all alternatives. Then, one by one, the user can remove irrelevant items, see Figure 6.9. However, other websites did not have a consequent design where they differentiated the filters' actions clearly, meaning a multiple selections possibility might look the same as a single selection action, which might be confusing. Many websites had the same design for multiple selections and single selection possibilities, making the filters' actions quite unclear. For selecting a range, value sliders were most commonly used. One website, however, additionally added quick access points by including buttons for quick selections, see Figure 6.10.

Figure 6.9: An example of a website giving the user quick access to selecting all items [34].

Figure 6.10: An example of a website giving predefined ranges alternatives [90].

6.1.6 Initial Guidelines

The initial guidelines were created and defined based on the research done during the literature study and benchmarking of the Pre-study phase. The different guidelines and sources were collected on a Miro board and used at the end of the phase as a foundation when creating the first initial guidelines. Below, the first set of initial guidelines is presented.

- **G1. Filter should easily be removed.** Meaning a chosen filter should have a clear discard or undo option [39], [7].
- **G2. Prioritised filter order.** The order of filters should be prioriotised to make it easier for the user to find the suitable filter that is of most relevance [31].
- **G3. Common language.** The vocabulary within filters should be universal and understandable for all users [35].
- **G4. Allow multiple selections.** If suitable, the user should be able to make multiple selections with filters [33], [35].
- **G5. Text input.** Provide the user the possibility of text input when using

sliders to enhance greater precision [40].

- **G6. Overview of distribution.** Give the user an overview and indication of the number of items to enhance the users' understanding of the distribution and effect of filter [39].

- **G7. Truncate filterlist.** To decrease the risk of overwhelming the user, specific filter lists including more than ten items should be truncated [37]

- **G8. Avoid tiny scrollable panels.** Small scrollable panels can often be frustrating and is a design choice that should be prevented since it forces the user to have precision and concentrate [40].

6.2 First Iteration

The focus of the first iteration was to gain insights and understand The Product and its filter functionalities. During this phase, internal stakeholder interviews were conducted, and the result was analysed. A user statement was created based on the selected themes. The themes were made based on the conclusions drawn by the analysed interviews and discussions with the advisors at The Company. Finally, the previous initial guidelines were iterated upon, extended and updated.

6.2.1 Interviews with Internal Stakeholders

Eight internal stakeholder interviews were conducted to better understand The Product's user and filter functionalities, meaning interviews conducted with employees at The Company. The goal of the interviews was to gain a greater understanding of the current filter solutions and what might be their pros and cons, as well as understand what stakeholders at the company were eager to implement. Each stakeholder had different positions within The Company with different backgrounds and insights related to the subject. Each interview was analysed through an affinity diagram where themes were extracted to be able to decide and narrow the scope of the thesis.

6.2.1.1 Planning of Interviews with Internal Stakeholders

A literature review on conducting interviews was executed since it felt essential to gather as much information and insights as possible from the stakeholders. Relevant and concrete information was therefore gathered in a document used as guidelines when planning and forming the questions and script for the interviews, see Appendix A. Each interview was planned to be conducted digitally since it is an international company that is mostly used to conducting meetings digitally. The guiding questions were relatively open-ended so that the interviewees would feel free to answer however they wanted about the subject. This was to attain as valuable insights as possible and not limit the user to specific responses. A set of initial and final

questions were planned to be asked to all the interviewees. In contrast, some more specific questions were planned to be asked to the different interviewees depending on their position and background. Below the general questions planned to be posed to all stakeholders are listed:

- Can you shortly explain your role at The Company?
- How would you describe the main purpose of having filters in The Product?
- What potential do you see for filters in the future?
- If we remove all limitations, what would the dream filter design have been?

Out of the eight interviewees, three of them were planned to be with Product Managers at The Company. During these interviews, the goal would be to gather different ideas. Since the Product Managers had all been at The Company for many years and had frequent contact with users, it seemed suitable to ask questions related to users. Questions were formed to gather their insights and ideas to gain inspiration and solutions for the project. Below are the specific questions planned to be asked to the Product Managers listed:

- How has the history and design evolution been with filters in The Product?
- What are the main user needs that filters aim to fulfill?
- What is not achieved with the current filtering function?
- Do you see any potential or improvement options with how filters are designed today?
- What is some common feedback from clients on the current filter system?
- What is important to consider when designing filters?
- What is the most important thing to work with to enhance the customer experience with the filter functionality in The Product?

Additionally, four interviews were planned to be conducted with developers at The Company. Questions for these interviews were formed to understand future solutions' technical possibilities and difficulties and the current status of filters. The scope of the master thesis is not to implement the solution; however, since the goal is to partly reach a conceptual solution, it felt necessary to consider the technical limitations and obstacles. Below are the questions focusing on the technical aspects of filter in The Product presented:

- How does the filter tool work today from a technical perspective?
- Are there functionalities that have been under discussion to add to filters but have been too cumbersome to implement?
- How may the filter tools be improved to provide better results?

Lastly, a UX designer was planned to be interviewed. The planned questions were more generally referring to the history and future of the design possibilities and improvements of the filter within The Product. Below, the UX specific questions that were planned to be asked are presented:

- What was the background for the design of the current filter functionalities in The Product?
- Do you have any ideas of what was discussed or left out during the development process?
- What are the reasons for how filters are designed today?
- What needs do you see that filters can address in the future?
- What do you think should be considered when designing filters for the future?

6.2.1.2 Result of Interviews with Internal Stakeholders

The interviews resulted in many valuable insights and an understanding of The Product and its filter functionalities. It also gave a greater understanding of filter's definition and how filters in The Product differ significantly. Additionally, how well it works and suggestions on what should be considered in this project also varied. In this thesis, the Product Managers will be referred to as I1-I3, the four developers will be referred to as I3-I7 and the UX designer as I8. Since the interviewees had different positions at The Company and previous knowledge, it might have affected their point of view on the matter. The interviewees with more technical backgrounds and positions (I4-I7) were for example noticeably more technical in their answers in contrast to interviewees with extended customer interaction (I1-I3, I8) who answered with ideas of the user in mind.

The interview responses showed that The Product has several ways to filter. The Product includes a filter panel where each column of the data gets one respective filter device. However, if the data is not imported, filter devices need to be created manually if there, e.g. is a large amount of data. The filters allow for rule-based selections to get detailed visualisations. One of the many other filter possibilities is the text area, allowing users to write their own filters. The filter devices presented in the filter panel are listed in the same order as the data columns, and the user can drag & drop to change the order. Some interviewees mentioned how the filter panel is quite extensive and takes up a large amount of the screen and that the design is outdated. According to one interviewee (I3), some customers have wished to include dropdowns in the filter panel since that can limit the amount of space and is a common well-used feature.

Something commonly mentioned during the interviews was that the representation of active filters sometimes could be unclear. One interviewee (I8) suggested a clipboard or similar, showing an overview of active filters with the help of visualisations, making it easier to adjust and change the settings. However, an overview of the applied filters already exists in the bottom of the filter panel, see Figure 6.11. It was mentioned not to meet the users' needs when the filtering becomes rather complex. Further, a majority of the interviewees brought up the importance of filtering data over time, improving the current solution, and showing a distribution of the data. Many of the interviewees also answered that a dream filter functionality would be to filter exactly what the user thinks. For example, *"show all men born 1977"*. A solution given by one interviewee (I1) was allowing free writing in a text area using

a non-technical vocabulary to filter. Additionally, allowing multiple selections, such as several time ranges, is a desirable feature currently impossible in The Product.

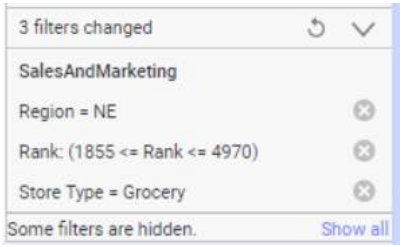


Figure 6.11: The applied filters shown in The Product.

6.2.1.3 Analysis of Interviews with Internal Stakeholders

The result of the interviews was analysed through an affinity diagram. The interviews were video recorded, and notes were taken while re-watching the interviews. Miro was used as a virtual whiteboard to gather all the notes and outtakes gathered from each interview. The notes were separated into different categories on the board to cluster similar responses together. Each colour on the notes additionally referred to a specific interviewee, see Figure 6.12.

Figure 6.12: Resulting affinity diagram after analysing the interviews held with internal stakeholders.

Once all of the interviews were analysed and collected in an affinity diagram, see Figure 6.12, it was possible to distinct areas of focus, see Figure 6.13. The goal of analysing the interviews was to define and understand the stakeholders' general thoughts on The Products filter functionalities. Additionally, a goal was to extract the most relevant and important aspects to focus on during the project. The second affinity diagram was created with the previous affinity diagram as a foundation to limit the outtakes and further define the scope of the project. The most frequently mentioned areas of problems and solutions were thereby gathered into five categories, see Figure 6.13.

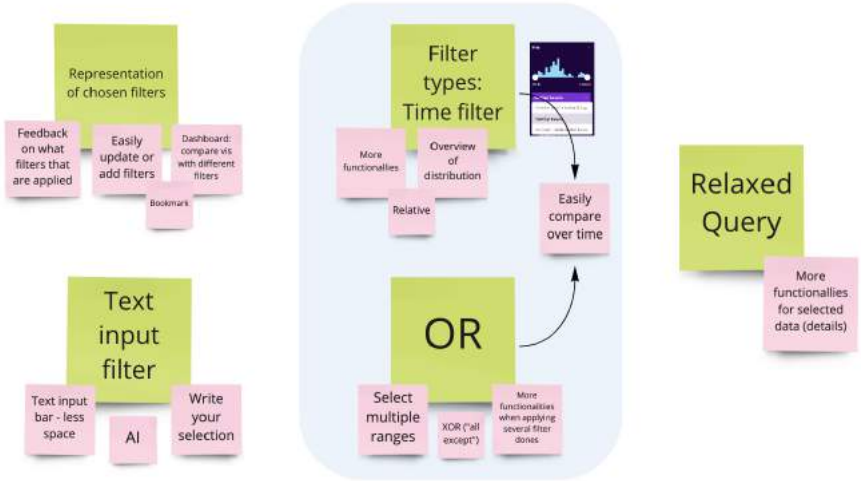


Figure 6.13: The board of the result of the second affinity diagram were the recurring thoughts and ideas are gathered into themes based on the internal stakeholders' interviews.

The second affinity diagram worked as a board, collecting the relevant and essential aspects to consider when deciding the project's direction. The first theme was the representation of active filters, e.g. how the user can get a clear overview of active filters and easily adjust and remove them or have the possibility to apply them to other visualisations. The second theme was time filters, where most of the interviewees brought up the importance of making it possible to filter data over time and the possibilities of indicating the distribution of the data. The third theme was the possibility of creating relaxed queries, meaning selecting both static and dynamic data. The fourth theme was the possibility of filtering with a non-technical vocabulary using text input, e.g. typing whatever the user wants to filter into a text area. The fifth and final theme was exploring the possibility of filtering using an OR relationship, e.g. selecting multiple ranges to compare data over time easily.

6.2.2 Reflections on the First Iteration

The first design iteration followed the plan to a great extent. During the two weeks, great insights were gained into the delicate design problem and a greater understanding of the current solution of filter in The Product. An understanding of further

improvements and wished functionality was received through these interviews from internal stakeholders at The Company. Analysing the insights in affinity diagrams made it easier to conclude and define the project's scope. The plan was only to conduct one affinity diagram; however, during this iteration, two were created to make it easier to recognise themes and to structure the insights further. Even though it was valuable to hear from internal stakeholders with different backgrounds, it is crucial to consider that most people have worked with The Product for a long time. Even though some of them talk to users daily, the responses are not coming from end-users, which is essential to consider moving on.

6.2.3 Design Scope Iteration

After reflecting on the iteration, a meeting with the advisors at The Company was held where the project's scope was discussed. The five themes of the affinity diagram were discussed. A decision to choose three of them to explore further was made in agreement with the advisors in addition to the gained insights from the interviews. This was done to make the project scope reasonable based on the time limit of this project.

The first selected theme was text input, which most of the interviewees mentioned and the advisors thought was an exciting and futuristic scope to explore further. Another futuristic and creative theme that was chosen to explore further was how other relationships than AND can be incorporated into The Product. The advisors argued this to be a functionality that could be very valuable for many users. In addition to the responses from the interviews, it seemed like a suitable scope for the project since it relates to all filters and the whole filtering experience. The third and final theme that was chosen to explore was how the filtering of time could be improved by, for example, adding more suitable functionalities and providing an overview of data distribution. This theme was something that the advisors thought seemed relevant and less futuristic compared to the other themes and could therefore be a great complement to the other themes.

6.2.4 User Need Statement

Based on the interviews and knowledge gained during the process so far, a user statement was defined based on the Nielsen and Norman Groups guidelines presented by Gibbons [60]. A decision was made to scale down the areas of focus, which resulted in the following user need statement:

When: The scenarios *Data Discovery*, *Dashboard Authoring* and *Application building*, see Section 2.2 for more information.

How: Improve the way to filter time, give the user the possibility to filter with the relative of OR and explore the possibilities of including a text input area to

filter with.

Why: To achieve a good user experience and user flow when filtering data in The Product.

6.2.5 Guidelines of the First Iteration

Based on the findings from the first iteration, three additional guidelines, G9-G12, were defined and added to the list. The initial guidelines G1-G9 were not updated during the first iteration and can be seen in Section 6.1.6. However, G6 and G7 were strengthened during the interviews. *G6. Overview of distribution* was strengthened during two interviews where the participants, I4 & I6, stated how being able to understand the data further by somehow being given an overview of the data could be valuable. Additionally *G7. Truncate filterlist* was further strengthened in this iteration. The Product's possibilities to filter are quite complex, and I3 expressed that customers have communicated that the filter panel feels cluttered and could be quite overwhelming. Two interviewees (I4 & I6) explicitly mentioned that with the help of machine learning, the most relevant filters based on the data could give relevant suggestions on what filters can be interesting to apply based on the data. I4 suggested that the less relevant filters could be hidden to ensure that the user does not get overwhelmed with filter possibilities and get a good user flow for filtering.

New Guidelines

- **G9. Freedom to filter.** The user should feel the freedom and flexibility to filter that it feels like all thoughts and ideas should be able to be applied.

- **G10. Show what filters that are applied.** Give the user feedback on what filters that are applied and make it easy to adjust without having to delete and start over.

- **G11. Use reasonable amount of space.** Filter devices and panels should use as little space as possible while still achieving a good user interaction to limit the user feeling restricted by the filter, e.g. use dropdown when possible.

- **G12. Bookmark filters.** It should be possible to save a filter and re-use it on another visualisation or adjust it at any time.

Further, the new guidelines, nine to twelve, are primarily based on the information gathered during the internal stakeholders' interviews. G11 is a new guideline created as a complement to G7. The new guideline was designed to ensure that the filter panel is spacious since at least two interviewees (I3 & I4) mentioned how users can get overwhelmed by the information. One question asked during the interviews was the open-ended question *"What would the dream filter be according to you?"* which resulted in different answers. However, I1 articulated one core meaning of filters when stating that the dream functionality would be the easy answer: *"The Product would show the wanted information"*. This statement was similarly expressed by

I6, which resulted in *G9. Freedom to filter* being defined. Additionally, G10 was designed based on statements from two participants (I3 & I8) during the interview that stated that it is essential to include some feedback and representation of what filters are applied. This is since the interviewees (I3 & I8) thought it could be pretty complex and sometimes challenging to keep track of the applied filters. *G10. Show what filters that are applied* was thereby defined to try to facilitate the interactions when modifying applied filters.

The last guideline, G12, is based on how I8 mentioned how the possibility of saving filter combinations and reusing it could give great value to users that apply similar filter combinations to different data. Since The Product's users have different purposes and use The Product in different ways, it seemed like a valuable insight and guideline to consider when designing a filter for an analytic software. Based on this, guideline twelve was thereby formulated and designed to meet the importance and value of being able to bookmark filter combinations.

6.3 Second Iteration

The focus of the second iteration was to conceptualize ideas based on the new scopes defined in the previous iteration. To conceptualize different ideas, two design workshops with internal stakeholders were conducted. The iteration continued with ideation and concept generation before a third design workshop was conducted with participants that were not internal stakeholders nor users but intended to mirror how a possible user might think. In this thesis, these participants will be referred to as ersatz stakeholders. Based on the result, some simple low-fidelity prototypes were created. Finally, based on the iteration's results and outcomes, the guidelines were refined and updated.

6.3.1 Design Workshop with Internal Stakeholders

Two design workshops with The Company's internal stakeholders were conducted to gain wisdom from knowledgeable people within the field. The goal of the design workshops was to create an inspiring and collaborative environment to be able to generate creative ideas. The participants thereby had the opportunity to ideate upon different ideas within the scope to gather relevant insights and inspirations to include when conceptualising an idea. The design workshops included participants from different positions within The Company to better understand the current solution and possible improvements. The following section presents the planning, result, and analysis of the two design workshops conducted with The Company.

6.3.1.1 Planning of Design Workshop with Internal Stakeholders

Two design workshops of one hour were planned to be conducted with internal stakeholders of The Company. Participants invited had different positions within

The Company, where seven were from within the UX Team, two Product Owners and four developers. The goal of including a diverse group of people was to gain different insights and ideas since they all have different areas of focus and perspectives on the subject. Several UX designers were invited to participate in both workshops to gather inspiration and insights from people designing, coming up with ideas and participating in the design workshops. The purpose of the design workshops was to gather and conceptualize different ideas of the chosen scope before developing and conceptualizing it further. Both workshops were planned to be in a hybrid setting where the participant themself could decide if they wanted to attend the workshop at the office or remotely. A Miro board template was created for the workshops that included different sections to separate the activities and make it easier for the participants to follow the agenda. On the virtual board, sticky notes and dots were added to simplify the execution of the activities by preparing each activity before being conducted. The Miro board template for the workshops can be seen in Figure 6.14.

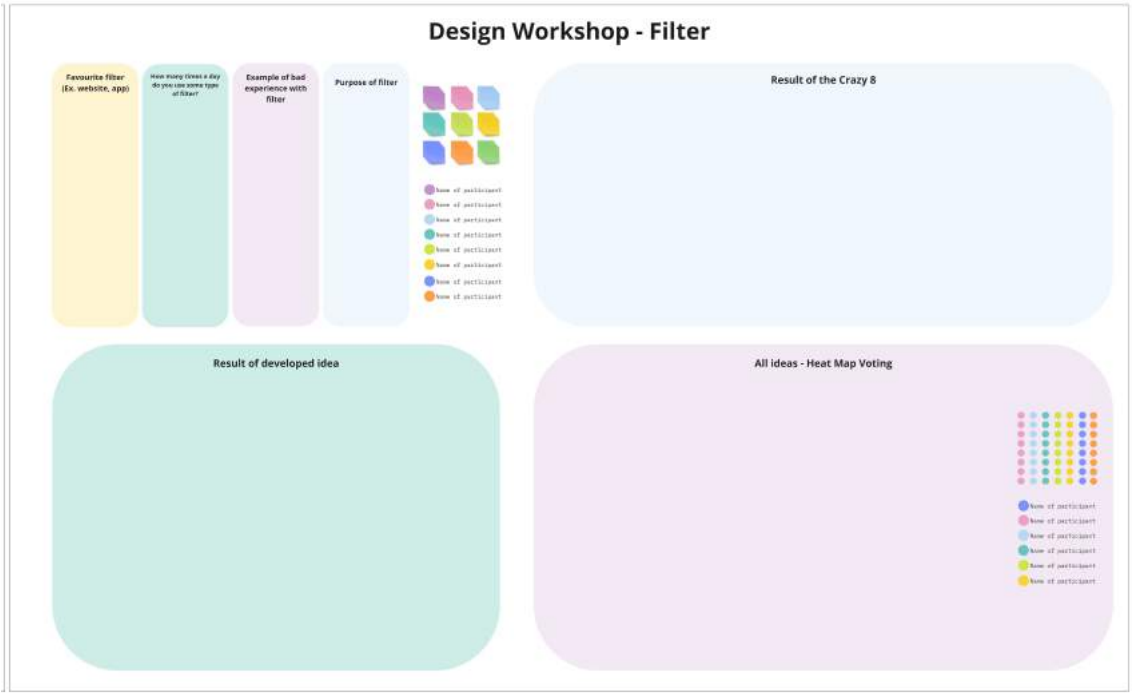


Figure 6.14: An overview of the Miro board created to be used during the design workshops with internal stakeholders.

The agenda for the workshop was to have a short introduction explaining the project and the goals of the workshop, as well as informing the participants that there were no wrong answers or ugly sketches and that they could leave at any time. The participants were also informed that their sketches would be included in the project. If that was something they did not agree to, they could either say so or choose not to attend the workshop. The first exercise was planned to be an icebreaker to warm up the conversation between the participants and make them start thinking about filters in general. Their task was to place sticky notes with their thoughts under four questions related to filters: *"Favourite filter"*, *"How many times a day do you use*

some type of filter?", *"Example of bad experience with filter"* and *"Purpose of filter"*. The following exercise was planned to be the crazy eight. The purpose of conducting the crazy eight was to gain ideas related to the selected focus areas. The conference room where the workshop was planned to be conducted was planned to be equipped with pencils and papers for each participant to sketch on. After the crazy eight, the plan was for each participant to have time to present their ideas to the rest of the group. This activity was planned to let the participants gain inspiration from each other before moving on to the next activity.

The following activity was planned to let the participant develop one idea further in a less limited timeframe. They could either develop one of their previous ideas further, someone else's, or a mix of different ideas. The goal of this activity was to try to capture the participants' most desired functionalities. The final activity planned was for each participant to share their ideas with the group and conduct a heatmapvoting. This activity was planned to be able to get an understanding of the participants' most desired functionalities. The workshop's environment was planned to be creative and have many discussions.

6.3.1.2 Result of Design Workshop with Internal Stakeholders

The two workshops resulted in many discussions and interactions between the participants. Since the setting was to collaborate and elaborate on each other's ideas, it is hard to draw individual conclusions. Therefore, this thesis will refer to the insights gained from the first and second workshops as W1 & W2. The workshops were conducted in a hybrid setting, and different parts of the workshops were executed to a different amount of time than planned. Adding the participants' sketches to the virtual board, took for example longer time than predicted and so did the presentation rounds of the sketches.

As a result of some parts taking longer time the agenda for the second workshop was updated. During W1, developing one idea further was removed from the agenda, and the workshop jumped straight to heatmap voting of the crazy eight sketches instead. One participant in W1 mentioned how he would have liked to develop one idea further since he gained many ideas while hearing the others presenting their crazy eight sketches. Due to that, the participant suggested that we could shorten the icebreaker exercise for W2 instead of removing the activity of developing one idea further. Since time was limited during W1, some updates to the agenda were done for W2. Two of the posed questions were deleted to shorten the icebreaker exercise for W2, as suggested by one participant in W1. *"How many times a day do you use some type of filter"* was conceived somewhat unclear and seemed to confuse the participants rather than create discussions and was thereby decided to be removed.

Additionally, the question *"Example of bad experience with filter"* was removed for W2 since discussions about bad filter experiences naturally were mentioned in the discussions of favourite filter experiences. Further, the crazy eight was adjusted to

a *crazy 4* instead, which halved both the sketching and presentation time. The original workshop agenda, v.1, and the updated workshop agenda, v.2, can be seen in Figure 6.15.

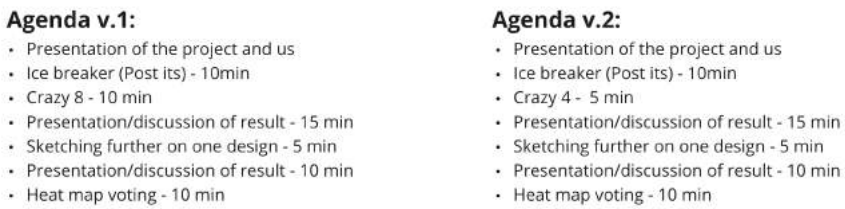


Figure 6.15: The first agenda (v.1) and the updated agenda (v.2), adjusted based on the result of the first workshop (W1) with internal stakeholders.

Apart from some difficulties and delays in the agenda, the participants felt energized and inspired during the workshops. After W1, one UX designer mentioned how it could be of value to explain that *"crazy"* in the context of explaining crazy eight does not have to mean that the ideas must be crazy, which can stress people and make it harder to come up with ideas. This was especially noticeable for one participant that only came up with two ideas and mentioned that he had a hard time coming up with crazy ideas. This was valuable learning and added to the manuscript of W2. The Miro board results from respective workshops can be seen in Figure 6.16 and 6.17.

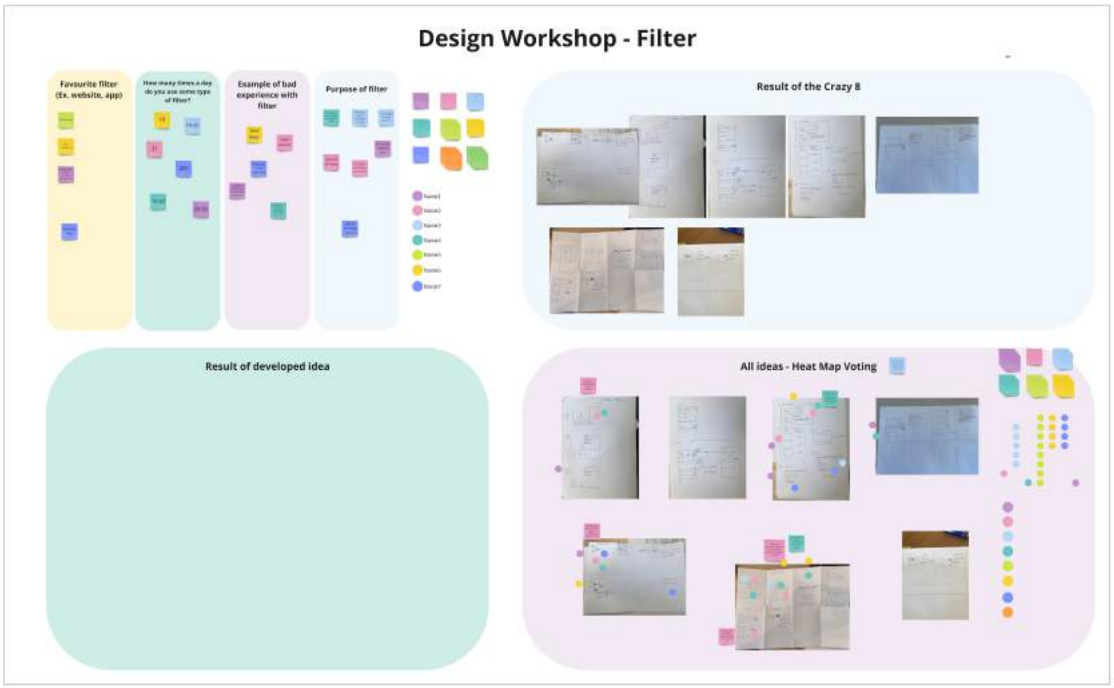


Figure 6.16: Miro board with the result of the first design workshop (W1) with internal stakeholders.

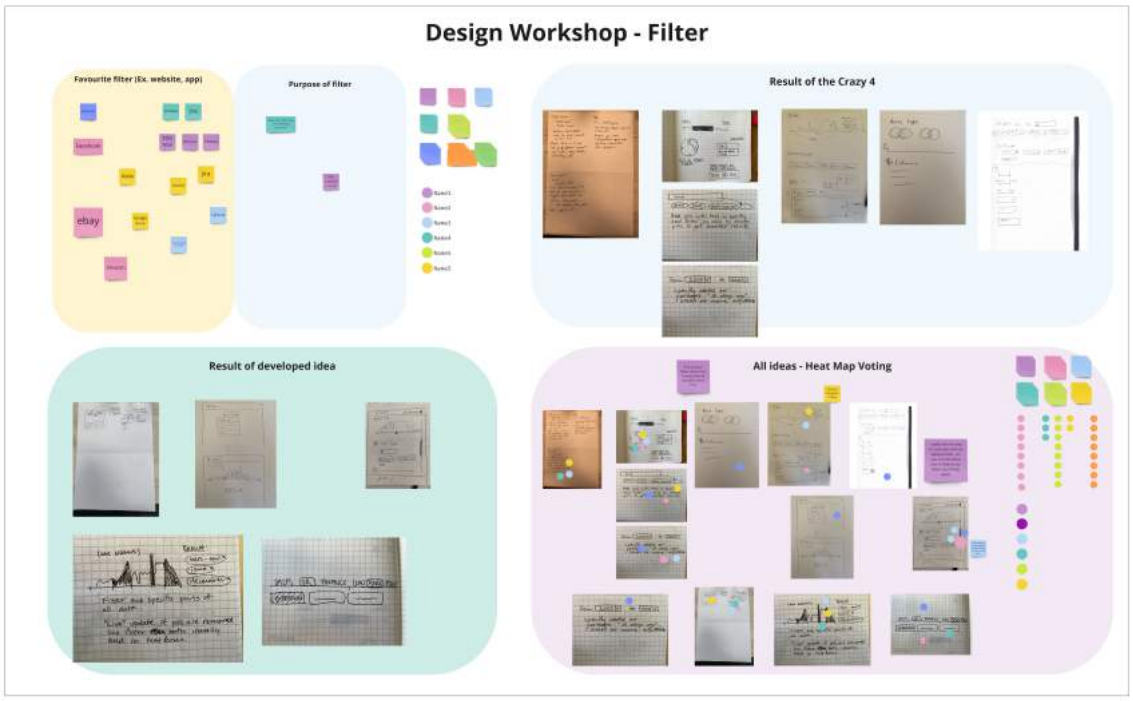


Figure 6.17: Miro board with the result of the second design workshop (W2) with internal stakeholders.

6.3.1.3 Analysis of Design Workshop with Internal Stakeholders

The design workshops resulted in two virtual Miro boards, including several sketches and ideas, as seen in Figure 6.16 and 6.17. In addition, notes were taken during the workshop when the participants presented their solutions and ideas. The result was analysed with an affinity diagram based on the notes and the information gathered on the virtual Miro boards. The different sketches created by the participants were included in the affinity diagram to the relatable notes. Four main clusters were created based on the outtakes of notes and sketches. The four cluster areas were based on the project's area of focus; time filters, AND/OR filters, text input filters, and one cluster referring to general ideas. In Figure 6.18, the affinity diagram created based on the design workshops is presented.

Figure 6.18: Affinity diagram of the two design workshops (W1 & W2) that was performed with the internal stakeholders.

The design workshops resulted, as previously mentioned, in several ideas, some more similar than others. Therefore, the goal of the affinity diagram was to structure the result, get an overview, see if some ideas were the same, what seemed important for the participant, and so on. By clustering the result in the project's area of focus, the goal was to be able to get an overview of the result and structure the ideas and insights within the different areas of focus of the project. The final affinity diagram showed that the participants had many ideas on how time can be implemented and designed in The Product. It included both calendar views as well as how to design for choosing multiple time ranges and ideas on showing the distribution of data, see Figure 6.18. One participant in W1 mentioned that the Google calendar has an intuitive way of setting up recurring time ranges, which was added to the affinity diagram. Another participant in W2 mentioned that it could be relevant to see future predictions through time. Additionally, participants in both workshops

discussed how being able to drag and drop filters to a greater extent could be of great value in The Product.

Within the focus area of filtering using other relations than AND, the participants mentioned that it is important to indicate how the data and visualisations will be affected based on the chosen relationship. One participant in W2 suggested a Venn diagram as visual feedback, while another participant in W2 suggested a pipeline visualisation. This was further discussed during W2, and the participants continued discussing how filtering through AND/OR can be combined with the text input filter. Using text input to filter was something that many participants in both workshops agreed could be valuable. In W2, this was further discussed, and it was suggested to use autocomplete and give the user hints when using text input to filter. The participant discussed how they rather would have the filters being applied immediately instead of needing to use an apply button since that is how they were most commonly used to filters interacting on e-commerce websites. The feedback to the user was further discussed in W2, where it was discussed that the user should get immediate feedback on the visualisations while typing.

Additionally, an idea discussed when ideating upon the text input was representing the applied filters as elements looking like pills, similar to many e-commerce websites. In conclusion, the overall result of the workshops analysed with the help of an affinity diagram included many creative ideas and valuable insights. Many ideas can be developed further in combination with the insights gained that should be considered during the project.

6.3.2 Ideation

Different ideation methods were applied with the ideas, feedback and insights gained from the design workshops in mind. The aim of the ideation phase was to ideate upon the different insights gained and developed during W1 & W2. First, an impact map was created to reiterate on the scope and scenarios, see Figure 6.19. The scenarios and areas of focus were thereby reiterated when creating the impact map. This method helped gain and structure the needs and focus of the project before moving on to sketching. A twist of the 10×10 sketch method was applied where five ideas were sketched (5×5). The similar ideas were then clustered together before reiterating and sketching five new ideas on the clustered topics. The method resulted in many ideas both new and based on previous mentioned solutions or ideas, see Figure 6.20, 6.21, 6.22, 6.23.

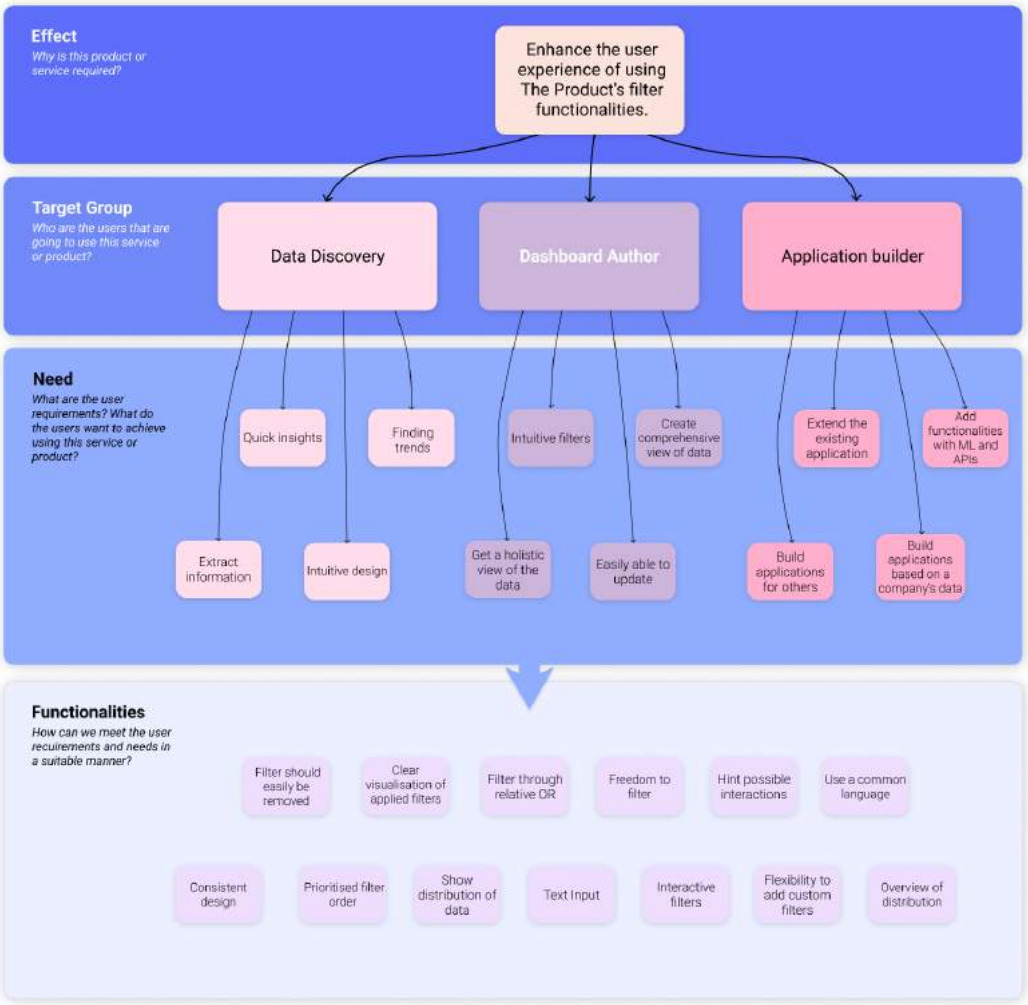


Figure 6.19: Impact map of the project's three main scenarios.

Figure 6.20: Performing the 5×5 sketch method.

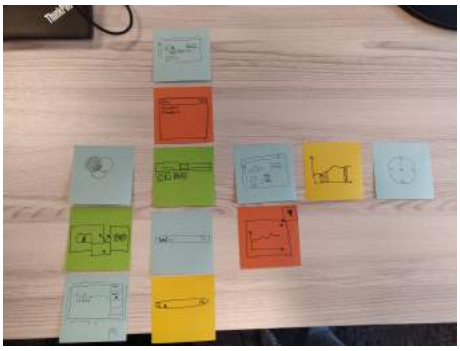


Figure 6.21: Result of first iteration of the 5×5 sketch method.

Figure 6.22: Second iteration of performing the 5×5 sketch method.

Figure 6.23: The final result of the 5×5 sketch method.

Individual solution sketches were then created after discussing the result of the 5×5 sketch method. The individual solution sketches were created in 30 minutes where the focus of the solution sketch could be on either area of focus or time, AND/OR and text input. Another iteration of the individual solution sketches was done after presenting and discussing the two different ideas, see Figure 6.24 and 6.25. During the discussion different notes were taken to gather all the ideas into one final solution sketch. A final solution sketch combining ideas from both solution sketches was then created, see Figure 6.26.

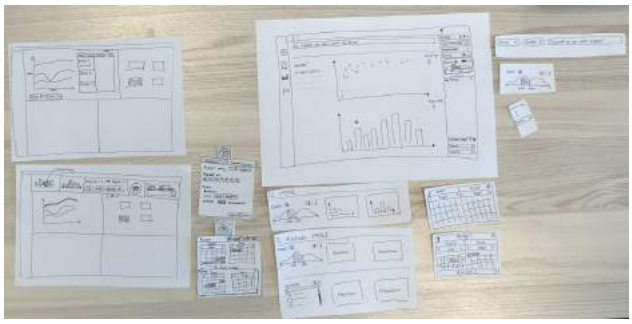


Figure 6.24: Result of the initial solution sketches.

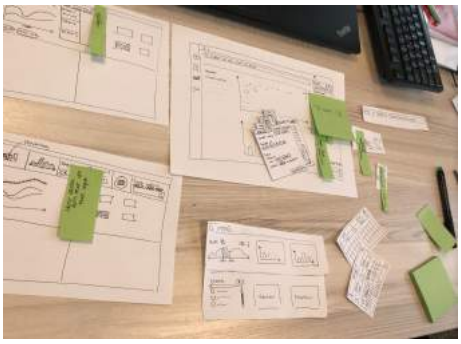


Figure 6.25: Suggestions of possible improvements to initial solution sketches.

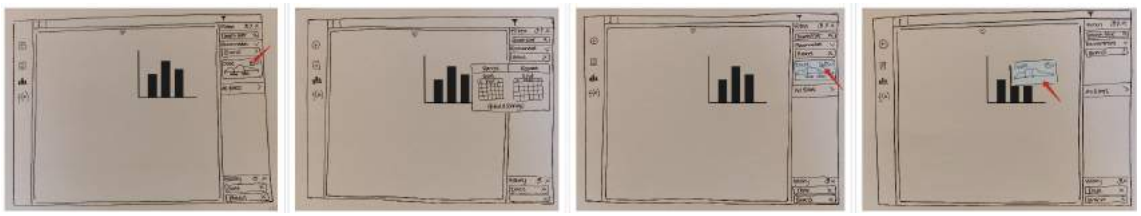


Figure 6.26: Final solution sketches updated based on initial solution sketches.

6.3.3 Workshop with Ersatz Stakeholders

An additional design workshop was conducted with ersatz stakeholders to gain further acuities when conceptualising the ideas. The goal was to gain further insights and ideas from a new perspective to primarily eliminate internal stakeholders' possible unknown limitations of what is feasible to implement or not since they might be biased. This section presents the design workshops' planning, result, and analysis.

6.3.3.1 Planning of Workshop with Ersatz Stakeholders

A one-hour design workshop was planned to be conducted with Interaction Design & Technologies students from Chalmers University of Technology. The students have no previous knowledge of The Product but a great understanding of user experience. The purpose of conducting a workshop with people outside of The Company was to be able to gather ideas, insights and inspiration from people that might not be limited with the knowledge of what might be possible to implement and get a new perspective on the problem. Since filter is a general feature applied on many websites, especially in e-commerce, most people have experience with filters which could be a great advantage for this project.

The workshop was planned to be conducted at Chalmers University of Technology with six students. The agenda of the design workshop was to start with a short presentation of the project before moving on to an ice breaker activity to get the participant thinking within the field of filter. This ice breaker was planned to be the same as the one used for the design workshops W1 & W2. Based on the feedback received on W1 & W2, it was a great activity to get the participants thinking. Since a solution sketch had been created based on the previous design workshops, a choice to use the design workshop to evaluate the solution sketch was made. The solution sketch included a flow of interactions, and the sketches were planned to be duplicated, so each participant got one copy. The activity was then planned for each participant to get a short amount of time, around one minute, to analyse the sketch and what they thought it represented. The plan was to follow the activity with an open discussion of the sketches previously presented. The plan was to let each participant think and create their own opinions before discussing the subject. The plan of the discussion was then to let each participant share their insights and inspire each other before moving on to the last and final activity. The final planned activity of the workshop was to give the participants time to create their own solution sketches. This activity was planned to collect and gather what the participants might think was good and important features. Sticky notes, pen and paper were planned to be used during the workshop to facilitate and let the participant formulate and express their opinions and insights more simply.

6.3.3.2 Result of Workshop with Ersatz Stakeholders

The workshop was planned to take place at Chalmers University of Technology. However, the setup was changed to be performed digitally just one day ahead due to sickness. Therefore, a virtual whiteboard was created through Miro, and the par-

ticipants were sent a zoom link in advance. The workshops were recorded, and the participants were informed of their rights to leave whenever they wanted and that there were no right or wrong answers. The participants were also informed that the recording only would be kept during the workshop's analysis.

The workshop's agenda was to first have an icebreaker activity, the resulting Miro board can be seen in Figure 6.27. The workshop was followed by an activity where each participant could analyse the solution sketches, the resulting Miro board can be seen in Figure 6.28. A group discussion then followed this activity before finalising the workshop. The original plan was to let the participants create their solution sketches. However, during the workshop, the decision to skip the last activity of letting the participants create their solution sketches were made. The participant had a great discussion, and when going through the solution sketches as a group, it took longer than anticipated. During this discussion, however, the participants were good at formulating how they would have designed the solutions in other ways to improve them. Due to that, even if the last activity was not conducted, their thoughts and ideas were gathered.

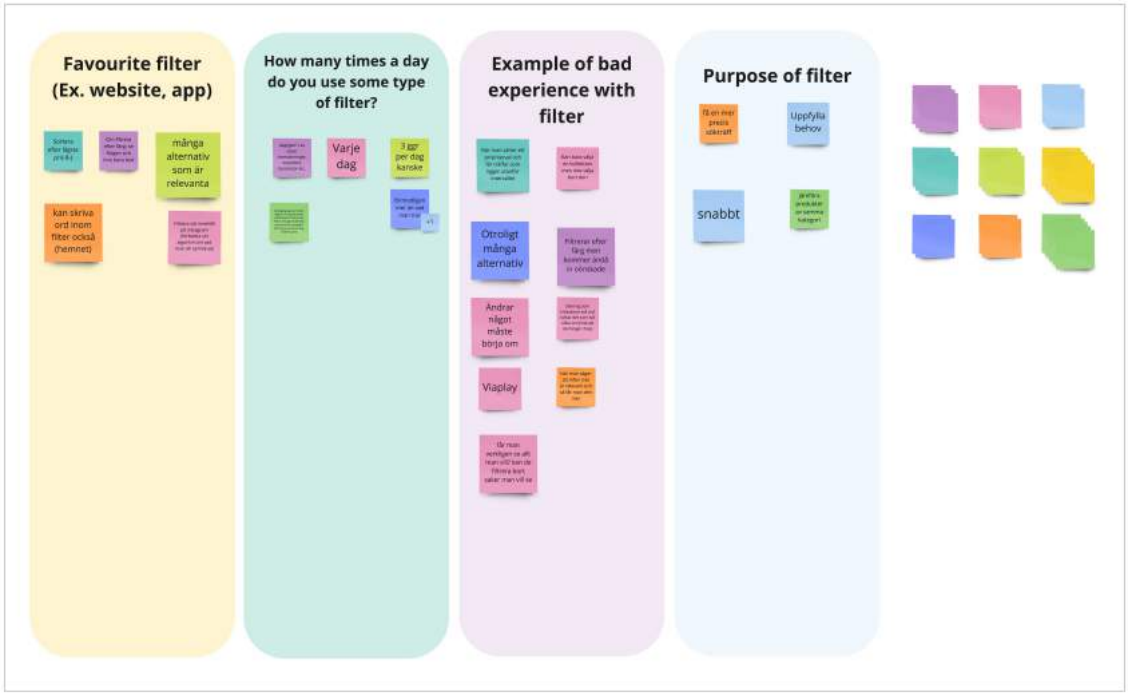


Figure 6.27: The resulting Miro board of the icebreaker activity from the workshop with ersatz stakeholders.

Figure 6.28: The resulting Miro board of the evaluation activity from the workshop with the ersatz stakeholders.

During the ice breaker, there was a good discussion. During this activity, it was clear that filter was used by the participant to a great extent in their everyday life on e-commerce websites. Additionally, what made an excellent filter was when being able to filter precisely what you want. However, a common insight was that filter that did not act as intended made the user frustrated, e.g. when selecting blue shirts, only blue ones should appear. The definition of filters for the users was also not clear. They asked if a Google search could be seen as filter. They were then encouraged to think freely of what they thought was a filter as long as they articulated their thoughts. When text input filtering came into the discussion, it was clear that the majority of the participant often used text filter input on websites by for example typing *"blue shirts"*. During the icebreaker activity, they were encouraged to discuss their best filter experience, which resulted in the participant discussing text filter to a great extent since they mentioned how it gave the user freedom and flexibility when filtering. Similar to W1 &W2, it was a collaborative setting, and the participants discussed and elaborated on each other's ideas. Due to that, it is challenging to draw individual conclusions therefore, this workshop will be referred to as *workshop with ersatz* stakeholders in this thesis.

6.3.3.3 Analysis of Workshop with Ersatz Stakeholders

The design workshop resulted in a large number of insights from the participants. The recording, notes and sticky notes on the virtual board were analysed, and a Rose, Thorn, Bud was done on the result. Rose, Thorn, Bud is an excellent method to identify potential problems [61]. The method was applied to gather the insight and get a better understanding of the next step by making simple outlines of what might have potential and creating a positive or negative experience according to the participants. The different aspects of rose, thorn and bud were analysed from the perspective of how well the participants understood the intended idea of the design, e.g. did the user understand that the graph behind the slider of the date filter represents an overview of the distribution. With the help of Rose, Thorn, Bud it got clear what insights were potential improvements, what was unclear and what currently worked well with the design, see Figure 6.29. In general, the result was that the participants understood the design to a great extent. From the Rose, Thorn, Bud the different outtakes could be divided into categories; Filter panel, Drag and drop, Filter on specific visualisations, Date filter and Text input.

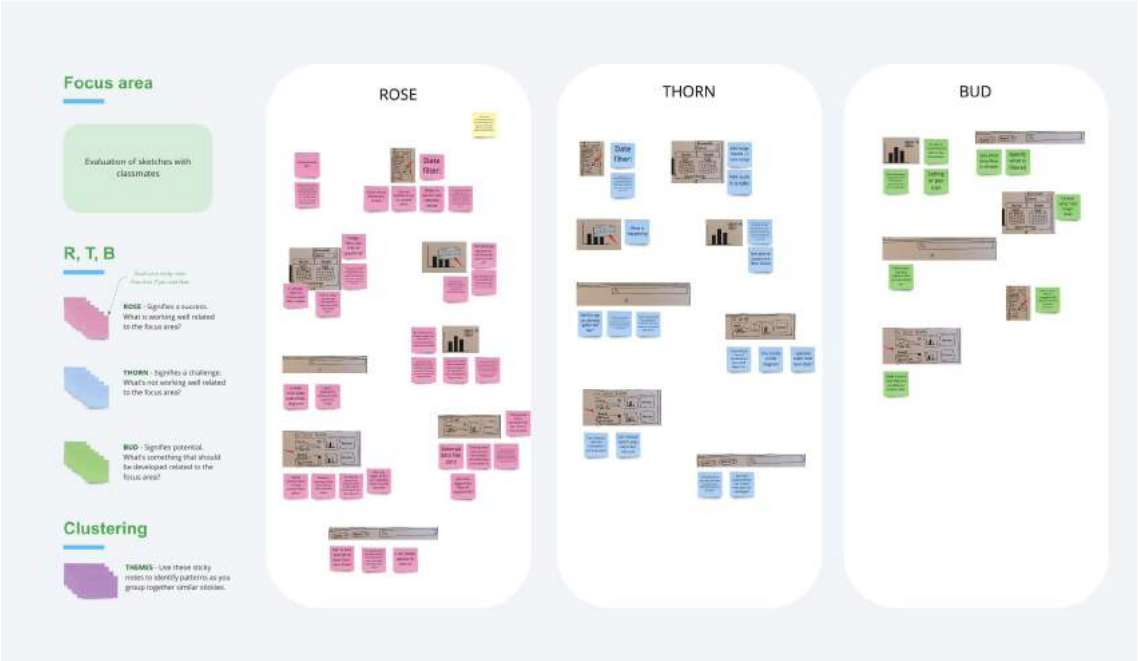


Figure 6.29: Result of the Rose, Thorn, Bud after analysing the design workshop with ersatz stakeholders.

The majority of the participants stated that they thought that the recommended filter at the top of the filter panel had been selected based on the data or used to give the user a better experience. However, that the filter device was draggable was not clear at first sight. One participant stated: *"This would require some experimenting though because it was not obvious for me in the last image"*. However, when the participants understood that the filter devices were draggable on the following wireframe, they thought each filter device could explicitly be applied to a specific visualisation. When a filter was applied to a specific visualisation, the participants

felt limited by only being able to remove a filter and not being able to edit it. The participant stated different ideas, such as adding a pen or a gearwheel symbol next to the cross icon of the pill to make it more clear that the applied filter is editable. Additionally, they mentioned that the pills representing a filter device included limited information. Adding a more informative name for the pills could be valuable, e.g. stating the selection instead of the header name.

Based on the Rose, Thorn, Bud the date filter was understandable to a great extent. The date filter device includes a graph of the distribution in the slider's background, which the majority of the participant understood. However, one participant thought that this was a visualisation instead of a slider and was not thereby editable. All participants understood the calendar icon and were not surprised by the result when clicking on it. Most of the participants thought that the calendar view could be used to make more detailed values ranges, while the slider could be good for more rough assumptions. In the calendar view, many of the participants understood that there were two different tabs where you could choose a specific range or a recurring interval. However, some participants were confused by the add range button on the calendar view. Some thought that adding a range meant saving a specific range interval to be able to apply later. However, one participant thought the plus icon indicated adding a range to the date filter.

As previously mentioned, the participants use text input to a great extent to filter e-commerce websites. The participants, however, did not entirely understand the use of the text input and gave a potential improvement of including some text hints to give the user an understanding of what the text input field might be able to do. When understanding that the text input could be used to search for filter, they had some difficulties understanding the difference between this text input and the text input field in the filter panel. However, on the wireframe, when a value was inserted in the text input, the participants understood the text input and its possibility to a greater extent. However, how the dropdown of the text input could be used differed between the participants. Some thought that you should not be able to interact with the values in the dropdown, while some thought that this might be possible since, e.g. a check box of iPhone is selected, but you see other alternatives. The participant thereby discussed that if it was intended to be able to interact with the dropdown, some updates should be made to make it more straightforward. Lastly, the previews of how the data would have changed if applying the value written in the text input were not clear for all participants. In general, the design was well met and understood. However, different parts should be ideated upon further, from small design choices of icons to increase the affordance of the filter devices to hint that they are draggable.

6.3.4 Evaluation

Based on the insights gained from the Rose, Thorn, Bud analysis, the paper prototype was updated, see Figure 6.30, 6.31. Six evaluations with the paper prototype were conducted with internal stakeholders within the UX Team. The result of the

evaluations was then analysed through an affinity diagram.

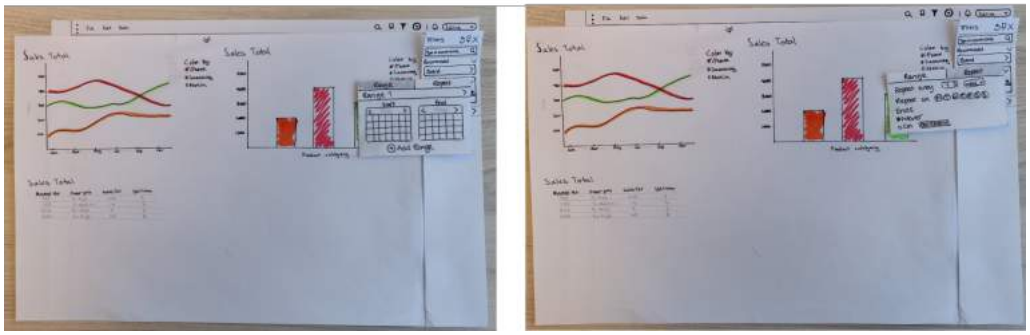


Figure 6.30: Updated sketches of the date picker solution based on the Rose, Thorn, Bud and workshop with the ersatz stakeholders.

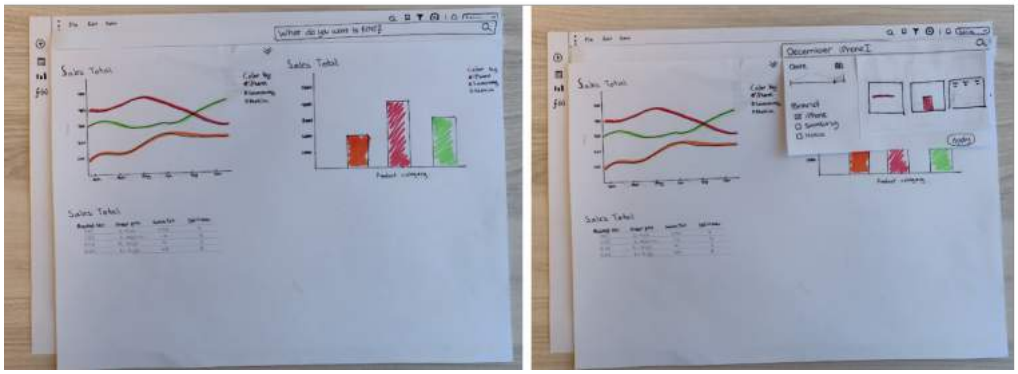


Figure 6.31: Updated sketches of the search and filter solution based on the Rose, Thorn, Bud and workshop with the ersatz stakeholders.

6.3.4.1 Planning of Evaluation

The evaluation was planned to consist of a cognitive walkthrough, Wizard of Oz and Think Aloud. A cognitive walkthrough is suitable for evaluating a product's interaction. Therefore, the method seemed suitable in this phase to gather feedback on the prototype and its different new filter functionalities. Since the prototype, however, is not interactive and only a paper prototype, the cognitive walkthrough in combination with a Wizard of Oz seemed suitable. Wizard of Oz is a method that is good to use when evaluating an unimplemented prototype since a human operator acts to try to replicate the intended interactions [58]. The goal was to use a cognitive walkthrough in combination with the Wizard of Oz to give the participant a greater understanding of the possible interactions, even if it was only a low-fidelity prototype. Additionally, the plan was to motivate each participant to Think Aloud during the evaluation to gather the participants' thoughts and feelings about the design and interaction while executing the given tasks. The plan during the evaluation was to have one moderator of the evaluation simultaneously take notes and the other to act like the human operator trying to replicate the interactions conducted by the participant.

The evaluation was planned to take around 30 minutes and be conducted with five UX designers at The Company. The plan to evaluate with internal stakeholders within the UX team was since they have knowledge of The Product and the chosen scenarios. Additionally, the UX team has a great knowledge of user experience and the design of The Product, which seemed important and a relevant perspective in the project's current stage. The evaluation was planned to start with a short presentation of the participants right to stop at any time and a short decription of the project, followed by presenting the three scenarios of the project. The goal of planning to present the scenarios was to hopefully give the participant an understanding of what to keep in mind while conducting the five tasks. Five tasks were formulated where each possible action was documented in a document. This was created to gather and be able to follow the participants' steps while conducting the evaluation. The documentation of the five tasks and possible actions is presented in Appendix B, Cognitive Walkthrough, while a summary of the planned task is presented in a bullet list below:

- **Task 1:** *Filter time range for the data to be between the 2nd of Feb and 2nd of May 2021.*
- **Task 2:** *Filter the top right visualization further by adding an additional range between 1st of December to 30th December.*
- **Task 3:** *Filter data to December and iPhone with help of the text input filter on the page.*
- **Task 4:** *Add a new date range from 10th to 12th of June 2021.*
- **Task 5:** *Add a recurring time range of every Saturday.*

6.3.4.2 Result of Evaluation

The evaluation was performed with six participants referred to as P1-P6 in this thesis. P2-P5 can be seen in action during the cognitive walkthrough in Figure 6.32. As previously mentioned, it was planned to conduct the evaluation with five participants, but one more participant than planned conducted the evaluation. The additional participant, P6, was able to attend an evaluation since time and interest were brought up. Each evaluation was performed after the other, one session at a time. This made it possible to make minor adjustments after each session to improve the evaluation outcome. For example, when the scenarios were introduced in the first session, P1 mentioned that it was hard to think about all of the scenarios during the test and asked if it was possible to focus on one. Therefore, the participants for the following evaluations were asked to choose one scenario to have in mind to make sure not to get confused about different scenarios. Of the following five participants, four participants decided to think of the tasks from the perspective of

the Data Discovery scenario. In comparison, two participants decided to perform the tasks from the perspective of the Application Building scenario, see Section 2.2.

Figure 6.32: Four of the participants (P2-P5) while performing the cognitive walkthrough in combination with the Wizard of Oz technique.

During the first evaluation, task four was discovered when P1 performed task three. Due to this, the moderator had to be flexible and ask the participant to perform task four while still interacting with the component from task three, even though it resulted in another order than initially planned. Similarly, with P4, executing the tasks with the Application building perspective often gave great feedback, but it was not easy to specify the information for one task. Throughout each evaluation, the moderator was flexible and jumped back and forth between tasks depending on the participants' feedback and insights. However, one general change in the order of the tasks was made. It was decided to *not* take them in chronological order to attain a greater flow. The updated order of tasks was as follows: one, three, two, four and five.

Once the first evaluation was performed, it could be seen that it was difficult for the participant to connect the right citation to the correct interaction. Therefore, it was decided to film the participants for the following sections and ensure that their spoken thought mirrors the correct interaction. This resulted in each participant being informed of their rights and that the recording would only be used for the project before each evaluation began. The following evaluations were thereby recorded, and notes were taken afterwards with the help of the recordings of each evaluation. This made it possible to rewatch each task several times, making it easier to analyse

and gain insights.

The planned time for the evaluation was approximately 30 minutes, however, this varied a lot. For example, P1 had a lot of ideas and thoughts that were shared after the tasks were performed, resulting in the evaluation taking more extended time than anticipated, about 40 minutes in total. Two sessions took exactly 30 minutes and the comprehensive insight was that most of the evaluations took approximately 30 minutes; however, the final discussion, where the participants were encouraged and asked if they had any further thoughts or insights, differed a lot based on the participants. A majority of the participants stayed a bit longer and discussed their general thoughts and ideas. However, each discussion evolved in different ways. Each time, the focus was on different aspects, e.g. after one evaluation, a further discussion was on how AND/OR could visually be represented to make it as easy to understand.

6.3.4.3 Analysis of Evaluation

The evaluation resulted in a mix of notes and video recordings. The recordings were analysed and taken notes of, and through an affinity diagram, the notes were separated into the related tasks, separated by colours, see figure 6.33. Green notes are insights that were clear to the user, whereas red is things that were unclear or something the user disliked. Blue notes were comments connected to the focus areas, and white notes were general comments unrelated to the project's scope.

Figure 6.33: Affinity diagram based on the cognitive walkthrough.

Once all of the notes were created, the notes could be separated into new categories: Horizontal filter panel, single filter visualisations, general comments, time range, text input and pills, see Figure 6.34. The evaluation showed that having a horizontal filter panel could be of value if it was always visible on the page since that would not force the user to perform multiple interactions to start filtering. Opinions were divided when it came to single filtering visualisations. Some users mentioned how to drag & drop a filter on one visualisation can be of value since it is easy, but it might be hard to understand that the interaction is possible for a first-time user. The participant who didn't see as much value in dragging and dropping a filter device to a single visualisation was concerned about what to expect from the action.

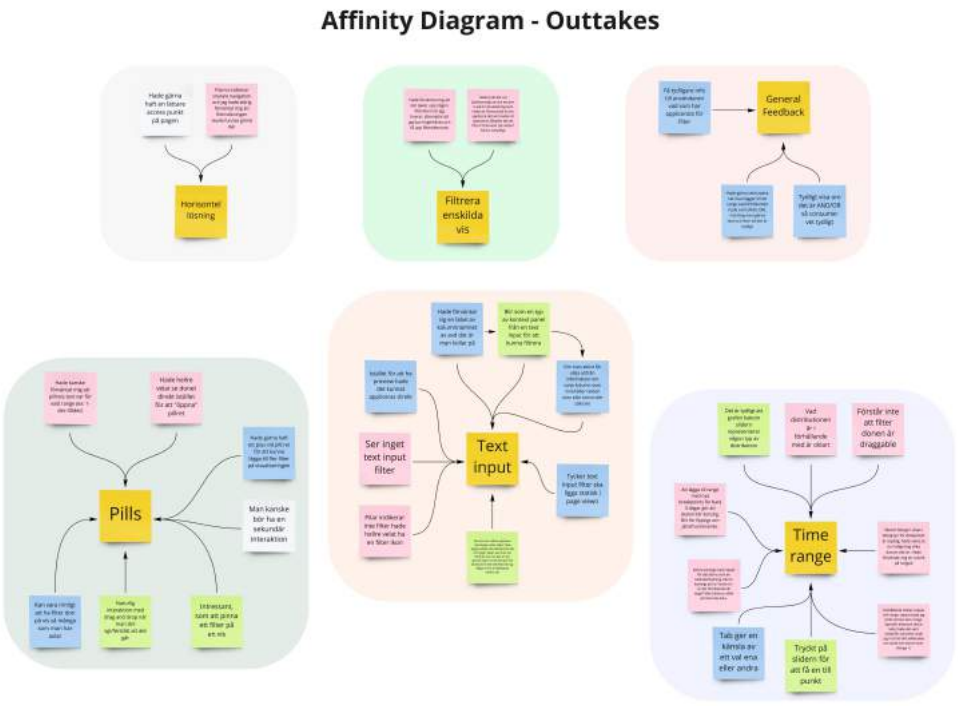


Figure 6.34: Outtakes seperated into themes based on the affinity diagram.

Pills were another category based by the notes. The users wanted the pills to include more specific information about the active filter. Additionally, one user wanted the whole filter device to show instead of a pill. One user suggested adding a plus sign next to the cross to add more pills of the same filter type. The text input element was perceived as helpful and was suggested to be visible and put static on the page since it was otherwise difficult to encounter. Having an apply button felt unnecessary for the majority of the users, as previously stated during W1. However, one user mentioned that having an apply button can be preferable but depends on the data. For a majority of the users, the previews were unnecessary and could be applied to the visualisations immediately as feedback.

The time range filter was perceived as quite clear. However, there were some difficulties in the design. For example, adding a new range with the help of the slider was considered convenient for most users. However, one user specifically mentioned how it would be hard to choose a specific date through a slider, especially if there were many dates. Therefore, having an additional way to pick the dates, such as the date picker, would be preferable. Most users liked that the distribution was shown. However, it was hard to know in what relation it was shown. Another confusing aspect of the design was the relation between the tabs of the date picker. Some participants thought it would overwrite the other tab, while others thought the settings were intertwined. P3 suggested placing the range selection and specific choices in a list instead.

The general thought about AND/OR was how it could be incorporated into the text input filter. Additionally, the representation of the AND/Or relation was discussed and how this could be incorporated into the list of the applied filters. In conclusion, the evaluation resulted in valuable feedback. The insights were further discussed with two stakeholders at The Company, and decisions on how to continue the project were taken.

6.3.5 Reflections on Second Iteration

The second iteration resulted in many great insights and steps forward for the project. Design workshops were an excellent method to apply to conceptualize and gather ideas and insights from stakeholders. The three design workshops resulted in different ideas, and the difference in focus and understanding varied a lot between the internal stakeholders and the ersatz stakeholders. Getting both perspectives were valuable since the internal stakeholders gave valuable insights into what is essential and possible in The Product. In contrast, the ersatz stakeholders had an outside perspective of features without the limitation of thinking about what might be applicable or not. The evaluation of the updated solution sketch resulted similarly in valuable insights.

In conclusion, the second iteration resulted in significant insights, ideas and solutions on improving The Product's filter functionalities and what to consider when designing filters for an analytic software. The second iteration followed the initial plan to a great extent, where the focus was on brainstorming ideas and conducting design workshops before creating prototypes that could be evaluated. However, the initial plan was only to conduct one design workshop. Due to that, more ideas and feedback were gained during the iteration than initially planned, which resulted in many sprawling ideas, making it difficult to narrow down the scope.

6.3.6 Design Scope Iteration

After reflecting on the iteration, a meeting with the advisors at the company was held. The discussion gave great insights into how close the different ideas were to a final solution. A choice to primarily continue and focus on time filter, and text input was made since this topic was met with great feedback during the evaluation. After trying to analyse the different topics, it seemed reasonable to decide to not continue further with being able to apply filters on different visualisations. This decision was based on the fact that several scenarios and perspectives needed to be considered if continuing with it. The current design solution worked to some extent, and research had shown that it might be valuable. Thereby a choice to stop developing this idea in the next iteration was made due to time limitations. However, the design solution and feedback can be relevant for The Company in future projects. In conclusion, the second design iteration resulted in the project continuing to focus on two scopes; time and text input. Moreover, it was decided that the third scope, AND/OR, would be further explored if there was time.

6.3.7 Guidelines of the Second Iteration

Based on the findings from the second iteration, several new guidelines were formulated. G2-G3 & G7-G12 have not been updated and can be seen in Section 6.2.5. During the workshop conducted with ersatz stakeholders, the participant stated how tooltips and hints could considerably value the UI. One example mentioned was how the search and filter text input did not include any hints but could include a short proposition to give the user a hint of what the text input could be used for. Based on this feedback, G13 was formulated.

New Guidelines

- **G.13. Tooltips and hints.** Include tooltips to make it as clear as possible for the user what each component and action refers to.
- **G.14. Icons.** Use icons or visual representations to either clarify or subsitute a text/description to make the UI less clutter.
- **G.15. Interactive filtering.** Selections or interaction with filters should be applied immediately and respond to the users input.
- **G.16. Autocomplete text input.** The user should get an autocomplete suggestions on possible data to filter that is similar to the text input.
- **G.17. Drag and Drop.** It should be possible to drag and drop filters to enhace the users freedom.
- **G.18. Additional filter on a time range.** Making additional filtering features within a time range should be possible, such as selecting a specific day each week within the time range.
- **G19. Write expression.** It should be possible to write an expression as text input to set specific relations between the filters.

Similarly, another guideline was formulated on a similar subject, referring to including icons to give the user a greater understanding of possible actions. As previously mentioned, the ersatz stakeholders mentioned how by including a pen or gear icon on the pills, the user would more easily understand that the pill is interactive and editable. Additionally, during one of the design workshops done with internal stakeholders (W2), it was discussed that icons could be used. During that workshop, Venn diagrams were discussed on how they could help the user understand the filters' relationship. Based on these insights, G14 was formulated.

One element discussed during one of the workshops with internal stakeholders (W1) and during the cognitive walkthrough was whether or not the filters should be applied immediately or not and the possibility of including an apply button. A majority of the users in W1 mentioned that they wanted the filtering to apply to the data immediately and give the user feedback on the changes straight away. Additionally,

this was also strengthened during the cognitive walkthroughs, and therefore G15 was created.

During W2, when discussing how text input can be used as a filtering method, many ideas and sketches were on suggestions and autocompletion related to the data. For example, one participant sketched a solution for autocompletion of text input, see Figure 6.35, where the user gets suggestions on the categorical value. Additionally, during the cognitive walkthrough, a few users mentioned that they would like to get hints and recommendations on what to filter in the text input area related to the data. Therefore, G16 was added to the list of guidelines.

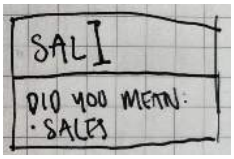


Figure 6.35: A sketched solution for an autocompletion of text input sketched during the second design workshop (W2) with internal stakeholders.

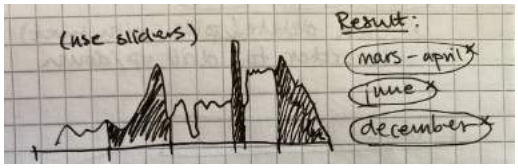


Figure 6.36: A sketched solution for selecting multiple ranges and how that could be represented on a slider was sketched during the second design workshop (W2) with internal stakeholders.

G17 was formulated based on the feedback gathered by the ersatz stakeholders and one of the design workshops with internal stakeholders (W1). They mentioned how drag and drop is a great feature and how that is something they often feel gives them freedom. Due to this, G17 was formulated to emphasize how drag and drop is a feature that could give the user freedom. During W2, many of the participants sketched and mentioned how it would give a great value to be able to add several time ranges when filtering time in The Product, see Figure 6.36. Due to this, G18 was formulated and referred to the possibility of being able to add multiple ranges with time filters. Additionally, the possibility of filtering data with both an AND and OR relationship was discussed in both workshops (W1 & W2). A few suggestions on how that could be implemented were received. However, it was clear that typing an expression in a text input field for filtering was something that all participants agreed should be possible. Therefore, G19 Write Expression was created and added to the list of guidelines.

Lastly, G1, G4, G5, G6 and G9, seen in Section 6.2.5, were further strengthened during the second iteration. G1 refers to the importance of being able to remove applied filters which was discussed during the design workshop with ersatz stakeholders as an important functionalitiy. Due to this, G1 has an additional source that strenghten the guideline. G4 refers to the importance of allowing multiple selections and was strengthed during the workshops conducted with the internal stakeholders, W1 & W2. G5 refers to the possibility of using text input when using sliders to enhance precision. P3 strengthed the problem with precision during the cognitive walkthrough, where they stated how the date picker would have been used for precise

date selections since precision is complex with the sliders. G5 was thereby further strengthened. Additionally, G6 refers to getting an overview of the distribution of the data, which was ideated upon in both design workshops (W1 & W2) with internal stakeholders and was stated as valuable for the user. Additionally, G9 was strengthened in a discussion during W2, where a sketch represented a text input field with suggestions of filters similar to the text input. Below the new additional guidelines are presented.

6.4 Third Iteration

The focus of the third iteration was to re-iterate the previous conceptualised ideas and develop wireframes and high-fidelity prototypes within the new limitations set to the project scope. Solution sketches were created based on the feedback received from the cognitive walkthrough conducted at the end of the second iteration. The solution sketches were developed further by creating wireframes in Figma before developing high-fidelity prototypes in Axure. During the third iteration, the high-fidelity prototype was evaluated in a platform called User Testing. The iteration was finalised by collecting the result, making feasible updates to the design, and re-iterating the final set of guidelines.

6.4.1 Ideation

Based on the previous result, a new ideation session was conducted where new sketches were created. Both authors made solution sketches where minor updates were done on the search and filter design, see Figure 6.37 for one of the sketches. More changes were ideated upon for the date picker. One of the most significant changes was that the new sketches were updated to not include tabs and instead have a section beside the calendars that presents the custom reoccurrence features, see Figure 6.38. The individual sketches of the date picker dialogue were discussed, and the difference was analysed before making a final solution sketch, see Figure 6.39.

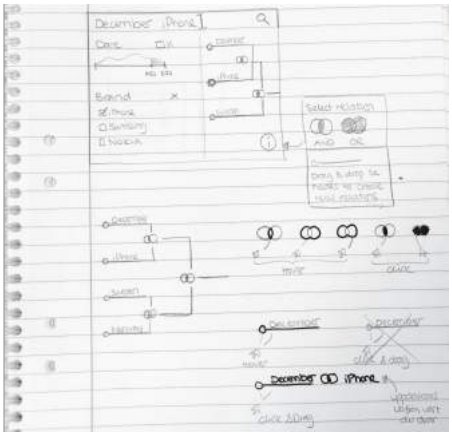


Figure 6.37: Ideation sketches of the search and filter dropdown area when searching for data to filter.

Figure 6.38: Collection of ideation sketches for the date picker dialogue window.

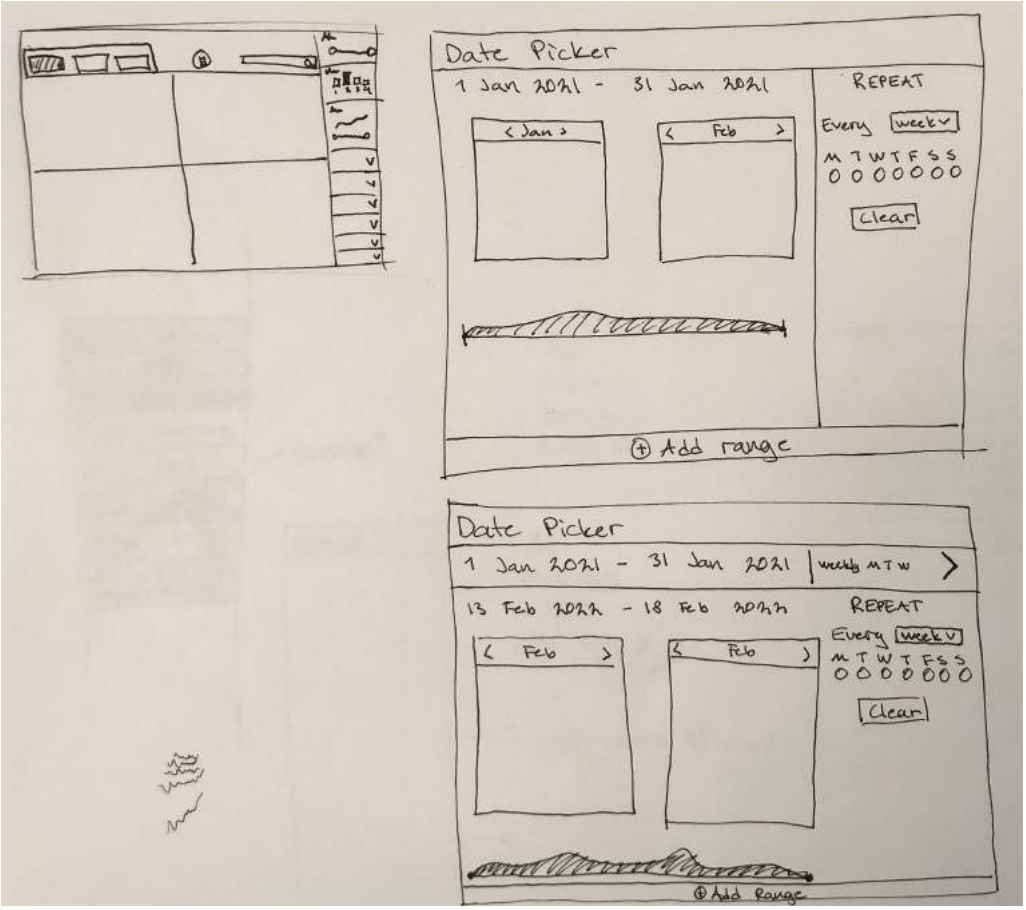


Figure 6.39: Solution sketch of the date picker dialogue window based on the collection of ideation sketches.

Based on the solution sketches, wireframes were developed in Figma, to get an overview of the design as well as try out different placements of the components, see Figure 6.40, 6.41, 6.42 and 6.43. When creating the wireframes, the size of the components was decided to fit the relevant content and suit the rest of the graphical user interface.

Figure 6.40: Wireframe of the search and filter solution.

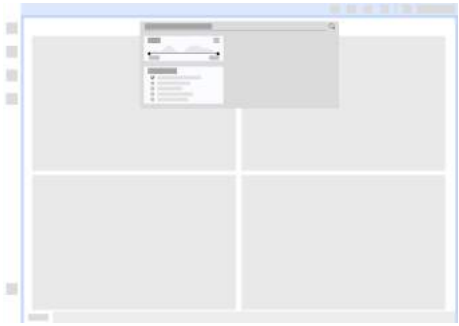


Figure 6.41: Wireframe of the search and filter solution when text is typed into the search area.

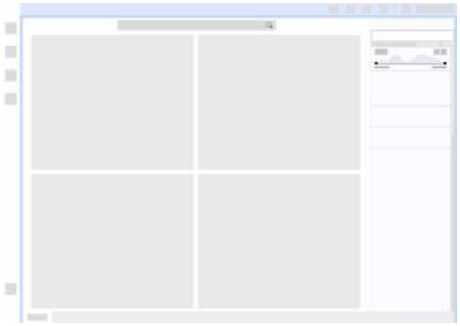


Figure 6.42: Wireframe of the filter panel with the distribution of data shown inside a date filter.

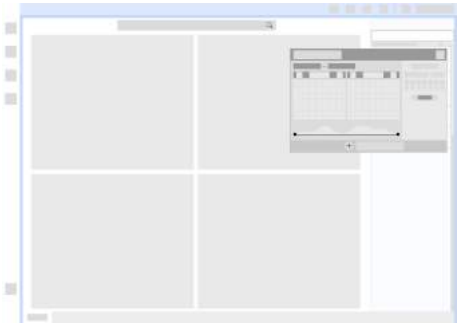


Figure 6.43: Wireframe of the date picker dialogue window.

6.4.2 Prototyping

Based on the wireframes, high-fidelity prototypes were created in Axure. The Company uses the software Axure when prototyping, and due to that, the software seemed suitable to use when creating the high-fidelity prototypes of the result. Additionally, The Company had frames of The Product in Axure, which meant that many of the components already existed and could be built upon instead of starting from scratch. Due to the timeframe of the project and the desire to continue exploring the scope of AND/OR relationships within filters when the two scopes were prototyped, a decision was made, together with The Company, not to make the prototypes interactive. Additionally, having an interactive prototype was not worth its time to implement. The prototypes were created with such high fidelity that the goal was for the user to still be able to understand the design enough to give a trustworthy and reliable feedback. A first version of the Date Picker's dialogue window prototype can be seen in Figure 6.44. Additionally, a first version of the Search & Filter prototype can be seen in Figure 6.45 and Figure 6.46. Figure 6.46 shows a dropdown including filter devices that match the text input. The white space to the right of the dropdown was planned to include a visualisation of the relationship of the filters once and if the concept was developed further.

Figure 6.44: First iteration of the date picker prototype created in Axure.

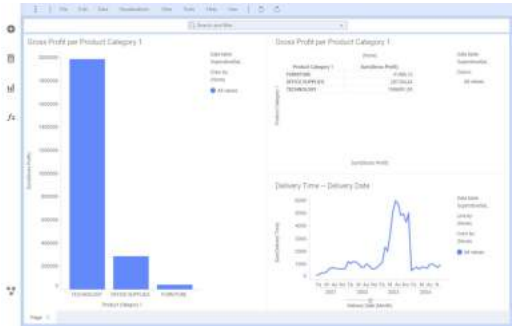


Figure 6.45: First iteration of the search and filter prototype created in Axure.

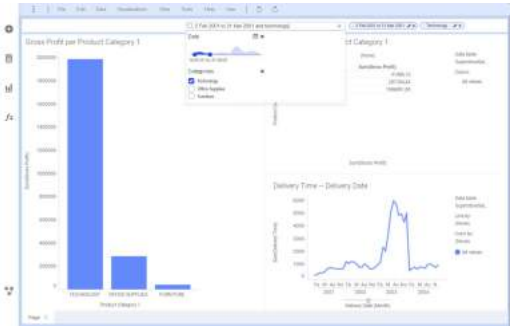


Figure 6.46: First iteration of the search and filter prototype, with the dropdown expanded, created in Axure.

6.4.3 Discussion with Internal Stakeholder

A meeting was conducted with a visual designer at The Company to get feedback on the prototype. The purpose of the meeting was to see if there were any specific notes or opinions the designer had in mind and if any updates should be done. The designer was, in general, content with the design. For the Date Picker prototype, the designer had some feedback on the colour choice of the header of the date picker dialogue window, see Figure 6.47. The designer mentioned how The Product's design only separates different sections with a faint line. Due to this, a choice of updating the header and the *Add Range* section was done, see Figure 6.48. Additionally, during this meeting, the functionality of choosing a year and month was discussed since that was in the current design, a section that felt cramped. Different ways of trying to solve this was discussed. Primarily one was to remove some of the information above each calendar since it took up much space and did not give that much value. Due to that, the design was updated, resulting in a clearer and less cluttery design. Lastly, the visual designer mentioned that there was too little spacing and padding for the *Add Range* button. The Company has some general guidelines that need to be followed when designing, and based on that, the size and spacing of the dialogue window were updated, see Figure 6.48 for updated date picker dialogue window.

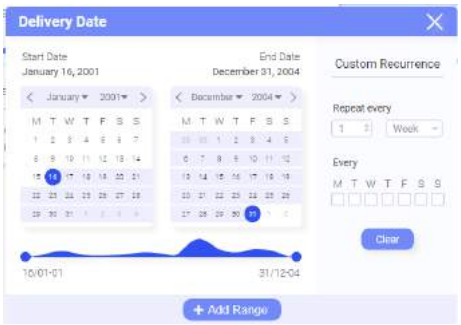


Figure 6.47: The old design of the date picker dialogue window.

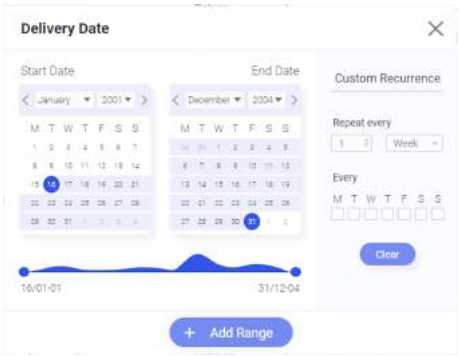


Figure 6.48: The updated design of the date picker dialogue window.

Otherwise, the Search & Filter prototype followed the design and aesthetic of The Product to a reasonable level for this level of prototype and was thereby not updated any further. However, the positioning of the Search and Filter UI element was discussed during the meeting and was suggested to be placed to the top left to generate more space for the applied filters. This means that the element can be static, and the pills (applied filters) will be dynamic with the possibility to add and remove applied filters. The following adjustments can be seen in Figure 6.45.

6.4.4 Evaluation

The final prototypes of the two scopes were evaluated through the platform User Testing. Five tests on the respective scopes were conducted to gain feedback and insights on the prototypes. The tests were video recorded, and recordings were then analysed through an affinity diagram.

6.4.4.1 Planning of Evaluation

Two different tests were planned to be conducted on the User Testing platform, and each test was planned to be performed by five users. A pilot round of each test was planned to be conducted to be able to pinpoint needed changes. This is to prevent having ambiguous or complex questions or finding other problems that might affect the result. The pilot round test was planned to be analysed, and depending on the changes needed to be done, four additional tests were planned to be conducted on each updated test. An additional test would be conducted if the pilot test did not give any valuable results. Since all tests were planned to be conducted remotely without any direct communication, the plan was that the user would have to record the screen and sound when they answered the different questions while seeing different images and GiFs on their screens. Each test was planned to include around 15 questions, and the duration of both tests was thereby planned to be around fifteen minutes. The user was planned to be asked different questions about the images and GiFs where they verbally could express their opinions and thoughts. The plan was to ask the participants to answer with text on some of the task to better understand how they would have formulated their answer in text.

Additionally, it was planned to have different limitations on what sort of users that could conduct the tests. Different requirements were set when recruiting participants to gather the most relevant test users as possible. These requirements were thereby set to be the same as the requirements The Company usually have when conducting tests through the website. The planned requirements were thereby to be of an age of eighteen years old or higher, have a full-time job meaning working at least 30 hours a week and have web expertise of advanced. Additionally, one specific screening was done that only users with some personal knowledge of either Tableau or PowerBI were allowed to participate. This ensures that the user has some fundamental knowledge of what a visual analytic tool is and how it usually works, hopefully making it easier for the user to understand the different graphs shown and referred to in the prototype.

The prototypes created in Axure were planned to be used to gather feedback. However, since both prototypes had a lot of possible interactions, it was decided that the testers were not allowed to interact with the prototypes but instead included images or short videos to guide the tester forward. Two tests were planned to be conducted with different purposes. The purpose of the tests was decided based on the previous feedback and result. The updates made on the date picker since the previous evaluation in iteration two, see Section 6.1.4, have been focused on making specific interactions clearer. Due to that, the purpose of the date picker filter was planned to be: *"See if the users understands how to filter time and add several ranges and with specific selections"*. Since selecting time ranges could be chosen and applied in multiple ways, a choice to a make short Gifs of the one possible way of doing the action was decided to be included in the test to understand the flow without letting the user interact with the prototype. The test was planned to be conducted so the user would get to answer how he or she thought they would perform an action before a GiF or an image would show one of the possible ways of conducting the task, see Appendix C to get an overview of the planned structure of the test and the questions included.

The scenario for testing the Search and Filter prototype differed a little and was planned to be *"You are working at a warehouse that sells Furniture, Technology and Office Supplies. You have received data from the early 2000s and The Company's Gross Profit and Delivery Time during that period. Your task is to understand the data to be able to compare it to today's business"*. Similarly, it was planned to ask the user how they thought they would have acted during different tasks before showing them one possible. The choice to create the test in this way was since the prototype would have been developed to a great extent to take in all possible different text input in the search and filter field. Thereby, the choice to ask specifically for a written answer of what the user would have written was planned. See Appendix D to get an overview of the planned structure of the test and the questions included for the Search and Filter test.

6.4.4.2 Result of Evaluation

A few changes needed to be made when the first two pilot tests were conducted, one for the date picker prototype and one for the search and filter. For example, in the date picker test, some images were placed in the wrong order, and a few of the questions seemed unclear to the user. For example, the Likert scale question "As a User, how satisfied are you with the possibility to filter a time range?" was updated to "As a User, how satisfied are you with the possibility to filter a time range using the delivery date filter dialogue window, shown in this test?". This was done to clarify the meaning of the question further.

An unexpected finding from the pilot test was that the testers took the task of describing what they saw in the visualisations very seriously and spent at least 5 minutes explaining what they saw. Therefore, the questions were rewritten to "Please give a *short* description of what you see on the screen?". It is hard to say if it affected the following participant's answers, but the amount of time explaining was slightly shorter on the rest of the tests than the pilots. However, that can depend

on the tests and is not necessary because of the updated formulation of the question.

The tests were planned to take approximately 15 minutes. The search and filter had an average time of 11 minutes, whereas the date picker test had an average time of 18 minutes. For the date picker test, some of the Gifs restarted too quickly, making it hard for the users to see the changes in data before it started over again, and two users explicitly mentioned it. Additionally, one of the images included in the test did not mirror the set filters on the visualisations correctly, which three users stated, confusing them. However, the majority of the participants did not get affected.

Ten participants were automatically recruited by usertesting for the test and they were all from different countries, such as France, South America, Malaysia, India and Greece. The average age was 29,7 years old, and their income varied from less than 19,999 dollars to 124,000 dollars a year. One of the participants was female, and all of the participants had previous knowledge of a complex software analytic tool. The tests were video- and audio recorded, and an example from one of the test results on usertesting.com can be seen in figure 6.49.

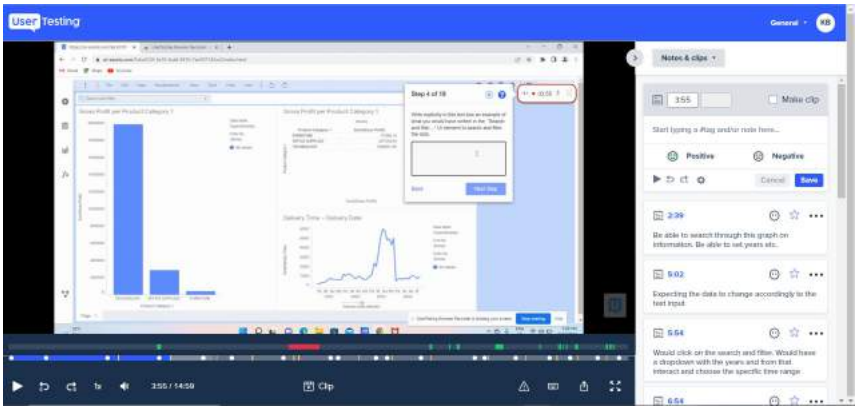


Figure 6.49: Screenshot of one of the users videorecordings on usertesting.com for the search and filter evaluation.

6.4.4.3 Analysis of Evaluation

The user testing resulted in ten video recordings of the participants' tests and opinions, referred to as USF1-USF5 (User Search & Filter) and UDP1-UDP5 (User Date Picker). The video recordings were analysed by taking notes in the User testing platform and notes on a Miro board. Notes were taken for each task of both tests, where they all were colour coded by three colours, see Figure 6.50 and 6.51. The colours referred to the users' general opinion or achievements, such as green for when the action or opinion was positive or clear, while red referred to when the user might have felt confused or disliked a feature. In contrast, blue refers to general notes or points of view. When both affinity diagrams were finalised, the notes were read aloud again and discussed before drawing general conclusions about both tests and its result. As previously mentioned, there were some errors in the tests; however,

after discussing the result, a conclusion was drawn that it didn't affect the result to a great extent.

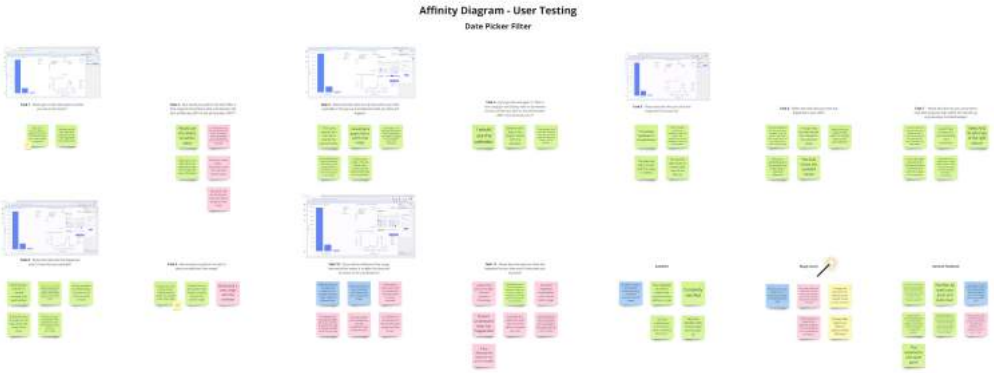


Figure 6.50: Affinity diagram of the user tests performed on the date picker prototype.

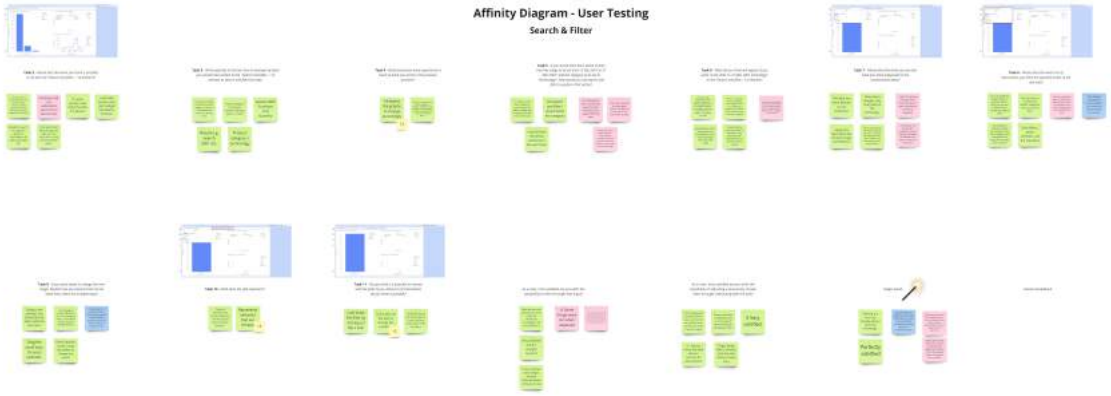


Figure 6.51: Affinity diagram of the user tests performed on the search and filter prototype.

The evaluation of the date pickers user testing showed positive results where the average satisfaction of the experience was rated as 5/5. Most of the users thought that the date picker dialogue window was user friendly and included great functionalities that could give great value. How the user would select a time range differed depending on if it was selected through the filter device or date picker window dialogue. All users mentioned how they would edit the time range in the filter device with the help of the sliders, while later on in the test, when the dialogue was open, all users would have used the calenders to select the range instead of the slider presented in the dialogue. In particular, UDP1 mentioned how good the feature of choosing specific days within a time range was and how valuable that could be in his field of work. UDP1 mentioned that in his field of work, they often want to look at business days within a time range, which is currently challenging in different analytical softwares. He said that the possibility of quickly selecting all business days within a time range

such as Monday to Friday and red days excluded would give great value within his field of work.

Additionally, the tests showed that all users had difficulties understanding the relationship between multiple time ranges. Some users thought that it would be an OR relationship meaning that data of both time ranges would be shown in the visualisations. Other users felt that adding a time range was to compare the data of different time ranges, meaning that they thought that it would be a gap in the visualisation or duplication would be created to be able to compare the data quickly. Similarly, it differed if the user thought it was possible to develop ranges that overlapped or not. The date picker dialogue window was well-received; however, the relationship between multiple ranges was confusing and could be clarified.

The Search and Filter user testing feedback showed that the general perception of the UI was good. The average satisfaction of the experience was 4,2/5. Only one user, USF3, could not identify the Search and Filter UI element. The rest of the users understood that it is possible to write either month, year or a category as an input to filter. What to write as text input differed when the users were asked to write explicitly what they would write as text input. USF5 wrote the following expression: *"product category = technology"*, while the rest of the users wrote only the category, such as *"Technology"* or *"Furniture"*.

All users expected the visualisations to change immediately, corresponding to the text input. One user mentioned that no particular syntax was needed since he assumed that the element was very advanced. However, one french user mentioned that it might be unreliable to use for multiple languages and thereby only work for a default language such as English. The search results dropdown showing filter devices was interpreted as straightforward, and all users mentioned that it was possible to interact with, e.g. the slider and the checkboxes. Additionally, 3 out of 5 users mentioned that the calendar icon was interactive and expected a more detailed date picker if it was pressed. USF3 also mentioned that he thought it was impossible to split the delivery time filter device by pressing on the distribution.

The pills, indicating what active filters, were clear to all users. They explicitly mentioned that the pencil icon made it possible to edit the filter and that the cross icon meant removing the filter. Most users were satisfied with the experience. However, a few users mentioned that they would prefer a filter panel since it is more reliable since that allows the user to make sure that not any data is left behind. USF3 multiple times how he would have wanted a separate element for the date picker to be static and that it would only be possible to search and filter on categorical values and not time. However, he did not explain why he wanted to have it separately. However, one explanation could be that choosing a time range might feel unnatural to do in writing and that the user would prefer a date picker for it, such as a calendar view or a slider.

6.4.5 Second Ideation

A new ideation iteration of the AND/OR concept was conducted since time allowed. As a warm-up, an exercise was to sketch everything you could somehow connect with the concept AND/OR during two minutes. The warm-up resulted in many new exciting thoughts and ideas. Both results were then discussed and ideas were ideated upon, see Figure 6.52. One was, for example, how when you buy ice cream, popsicles have an AND relationship while buying a cone of ice cream has an OR relationship. After the warm-up, it felt easier to start ideating more realistic ideas and concepts and was thereby followed by the crazy eight. However, the crazy eight was conducted with a bit of a twist by first starting out doing four sketches in four minutes. The results were discussed to gain new inspiration in the middle of the crazy eight to have possible new ideas before continuing and making the final four sketches in four minutes. When finalising the four final sketches, the result was discussed. See Figure 6.53 for the result of the crazy eight.

Figure 6.52: Warm-up exercise of the AND/OR scope.

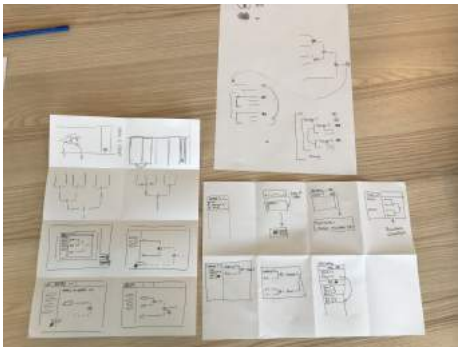


Figure 6.53: Result of the Crazy 8 method performed with focus on the AND/OR scope.

Based on the discussion, different features and ideas were kept or removed, and a new solution sketch was done. To create the solution sketch, a scenario was done to understand the data better and the interactions. The goal was to filter two different stores (Ica Maxi and Gekås) within different time ranges and only present the sales data of the category food. This selection could be made in different ways, but one way was sketched and visualised in the solution sketch. The solution sketch is a concept where the user is able from the filter panel to open a dialogue window where the relation between the filters is visualised in a tree and with the help of Venn diagrams to represent the sort of specific relation, see Figure 6.54. The idea is that the user either can get a visualised tree of the filters' relation or, in the filter panel, get a hierarchy list similar to how layers are presented in other applications such as Axure and Figma. From the solution sketch, a simple wireframe was created in Figma to get a finalised low-fidelity prototype of the concept, see Figure 6.55 and 6.56.

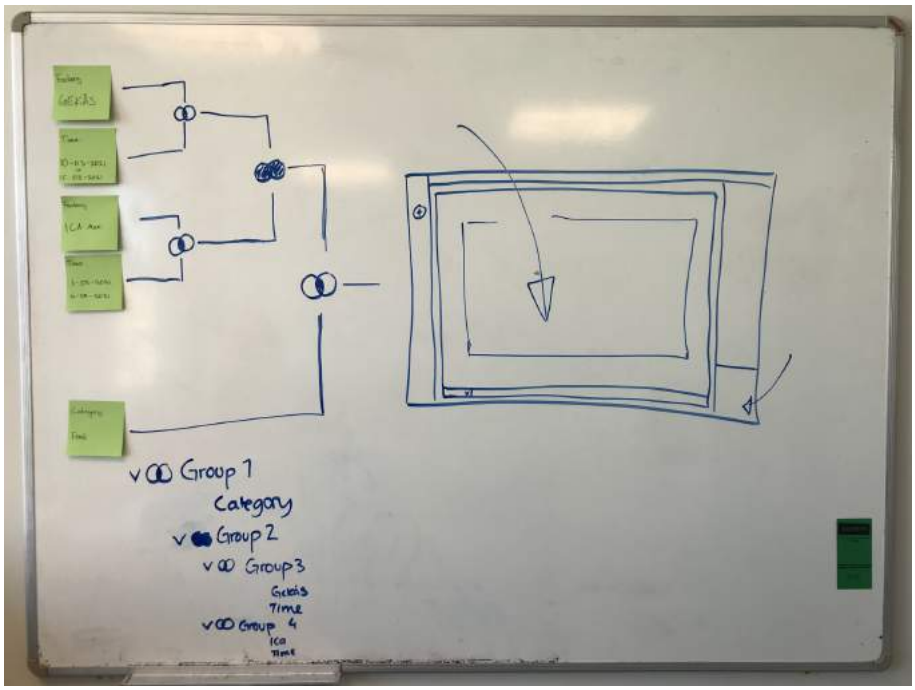


Figure 6.54: Solution sketch of the AND/OR concept.

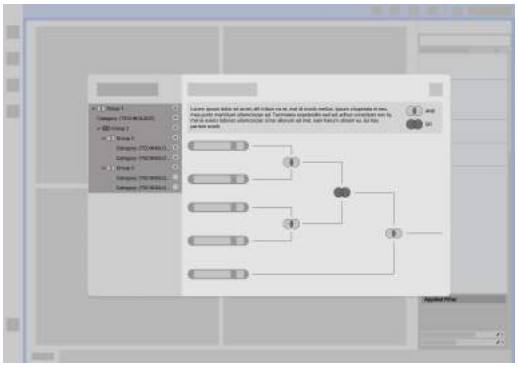


Figure 6.55: Wireframe of the AND/OR concept.

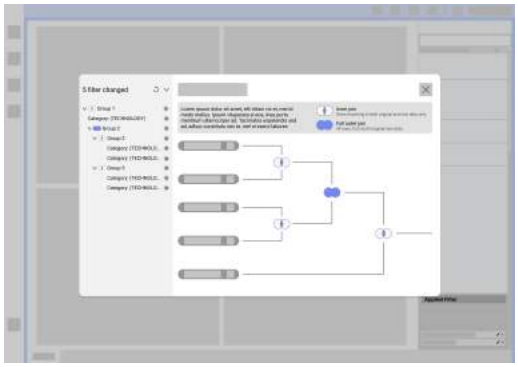


Figure 6.56: Low-fidelity prototype of the AND/OR concept

6.4.6 Reflections on the Third Iteration

The third iteration resulted in many great insights and steps forward for the project. During the sketching phase of the third iteration, it was clear that the result of the author's sketches was very similar, and it did not take long to come up with the final solution sketches. It can be discussed if this was due to both authors being biased at this stage of the project or the knowledge gained from previous iterations that had led to the final solution.

When the wireframes were created in Figma, details such as the size of dialogue windows and components were discussed since a goal was to be able to make the prototype as similar to The Product as possible. The Company had internal guidelines on sizes and styles of elements that were followed during this phase. However, it was

not easy to decide on a reasonable size for the date picker dialogue window since much information was wanted to be presented so that it would not feel cluttered and overwhelm the user.

Getting started with Axure took a longer time than anticipated. Much time was spent on YouTube, watching "Getting started with Axure"- videos. Additionally, one of the employees in the UX team at The Company had a one-hour long meeting, answering questions. A file containing the base product was received, which made it easier to create the prototype. The evaluation on UserTesting.com was decided to be performed relatively early in the third iteration. This made it easier to develop the prototype since decisions on user flow and the purpose of the evaluation were in mind when prototyping to make a prototype that could be evaluated online. The task formulated for the evaluations were quite challenging to formulate to ensure that the tester understood them and did not feel there were any right or wrong answers. This was an important aspect to have in mind since it is impossible to ask additional questions during the test for neither party.

The third iteration resulted in many great insights and steps forward for the project. The initial plan of the third iteration was not followed to the same extent as the previous iterations; however, the key goals of the iteration, brainstorming, prototyping, and evaluation, were followed. For the third iteration, a choice to focus on the date picker and the search and filter scope was decided. Since iterating on the two scopes went well and time allowed, a choice to go back and iterate further on the AND/OR scope was decided at the end of the iteration. This resulted in the initial plan not being followed since more time was spent on ideation later in the iteration. During the third iteration, information on deadlines was received, and the initial date to present was moved forward. Due to this, more time was spent on the report than planned during iteration three, resulting in less time spent on updating the final prototype based on feedback received during the evaluation. Similarly, more time was spent on iterating the guidelines in iteration three than planned. However, this choice was based on the fact that the guidelines were in need to be reformulated and validated further before finalising a set of guidelines.

6.4.7 Guidelines of the Third Iteration

The definition of the meaning of a guideline was defined in iteration three for the thesis. The choice to define a definition was made since the meaning of guidelines can be pretty ambiguous and might affect the structure and meaning of each guideline. The authors thereby defined the following definition for the thesis:

Guidelines are sets of recommendations on how to achieve a good user experience, and are intended to provide designers and developers with instructions.

Based on the defined definition of guidelines, it was clear that the phrasing of the previously defined guidelines differed. Due to this, the first iteration of the guidelines in iteration three was done. In the following section, all previous guidelines will be

referred to as G_pX, where the P refers to *Previous*, and the new updated guidelines as GX. During the first iteration of the guidelines in iteration three, all guidelines were updated and rephrased to follow a similar structure and a more explicit language. After that, a second iteration was done where all guidelines were discussed with the advisors at The Company. This, among other things, gave a new perspective on the guidelines. During this conversation, it was decided to remove *"G_p7. Truncate Lists"* since it did not seem relevant to the scope. Additionally, it was discussed that there were many guidelines, while some had quite similar meanings. Due to this, a third iteration of updating the guidelines was done where many of the guidelines were merged, such as, for instance, previous *"G_p8. Avoid tiny scrollable panels"*, *"G_p11. Use reasonable amount of space"* and *"G_p14. Icons"* were merged into one new guideline named to *"G2. Provide a well designed UI with carefully crafted micro interactions"*. Similar actions were done with G_p12, G_p13 and G_p17 that were merged into a new guideline named *"G3. Indicate possible interactions"*. G_p4 and G_p10 were merged into *"G5. Provide the possibility to filter iteratively"* and G_p2, G_p16 and G_p18 were merged into *"G9. Suggest relevant ways forward"*. After additional discussions with the advisors, a decision to remove *"G_p3. Common Language"* was done. This was done since using a common language is a general guideline applicable for The Product and GUI in general and not only for filters. G_p1, G_p5, G_p6, and G_p15 were reformulated and updated and became, in the same order, G4, G7, G1 and G6. Additionally, to structure the guidelines further, a choice of creating different categories was decided. The guidelines were divided into general *Filter Functionality & Design Guidelines* referring to guidelines G1-G6, while category *Insight/Scope Specific Guidelines* refers to guidelines G7-G11.

One additional guideline was also created based on insights gained during the design iteration. During one of the user tests, UDP1 especially pointed out the importance and value of being able to select specific days within a time range. From that insight, an initial new guideline such as *Business days. It should be easily possible to select business days within a time range* was formulated. After some iterations on the guideline, it resulted in a new guideline *"G10. Provide shortcuts for common selections. Meaning it should be possible to make additional filtering selections to a given data type as well as provide shortcuts for common selections"*. The guideline was reformulated to be more general and include the key factor of having shortcuts to make specific selections. Since the meaning of business days might differ depending on country and company, as well as other specific day selections might be of value, the guideline was formulated to cover the user's needs and how shortcuts based on their needs should be possible to apply. Lastly, *"G_p19 Write expression"* was developed further since during design workshops and the ideation session of AND/OR, it was clear that some visual representation of filters' relationship could give the user a greater understanding. Due to this, the previous G_p19 was updated to include both aspects and was reformulated into G11.

In the third iteration of guidelines, a literature review was performed to see if the guidelines were supported by the theory gathered in the thesis, see the theory presented in Chapter 3. Many confirmations and arguments were found, and

several references were added to the list of guidelines. Each resource is motivated in Section 7.2.

Updated Guidelines

- **G1. Provide an overview of the distribution.** There should be an overview of the data distribution to give the user a quick, compact insight of what the data looks like, and can guide the user to what she needs to look into (e.g. a gap) [39], [8].

- **G2. Provide a well designed UI with carefully crafted micro interactions.** Filters should include relevant information without cramping the functionalities to enhance precision and clarification. Dropdowns and icons should be applied when possible to either clarify or substitute a text/description to avoid overwhelming the user [40].

- **G3. Indicate possible interactions.** It should be possible to re-use filter settings and combinations in different contexts and the filters affordance with help of hints and tooltips, should indicate possible interactions, such as drag and drop [8], [10], [28].

- **G4. Provide resettable filters.** Filters should easily be reset, meaning a chosen filter should have a clear or undo option [39], [7].

- **G5. Provide the possibility to filter iteratively.** The user should be able to adjust and update filter selections. The user should also be able to apply multiple filters, meaning having several filters active at the same time [33], [35].

- **G6. Provide direct manipulation with instant feedback.** Selections or interactions with filters should be applied immediately and mirror the user's input [10], [33], [7], [8].

- **G7. Provide precise endpoint selection.** The user should be provided with the possibility to specify exact ranges with the help of text input on a range's start and endpoints to enhance precision [40].

- **G8. Allow a non-technical vocabulary.** The user should feel the freedom and flexibility to express queries using a non-technical vocabulary [33].

- **G9. Suggest relevant ways forward.** The user should get autocomplete text suggestions and filter recommendations relevant to the data and input, based on the system's interpretation [31].

- **G11. Indicate filters' relationship.** The user should be able to edit the relation between filters, and the relation should be visually represented to facilitate the understanding of the filters' relationship to each other [37], [31].

New Guideline

- **G10. Provide shortcuts for common selections.** It should be possible to make additional filtering selections to a given data type as well as provide shortcuts for common selections [7].

7
Results

The posed research question *"What should be considered when designing filtering for an analytic software?"* was answered by providing a set of guidelines defined while designing improved concepts simultaneously and conducting research within the field. The development of the set of guidelines and improved concepts are presented in Chapter 6. The master thesis's final result is presented in the following chapter, which includes the result of the improved concepts envisioned as prototypes developed throughout the process named the Date Picker, Search & Filter and Filters' Relation, as well as the final set of guidelines.

7.1 Final Prototypes

The final designs are three concepts envisioned as prototypes for three different scopes. The three designs are named: Date Picker, Search & Filter and AND/OR. The designs aim to support different areas of focus. However, they all have a crucial factor in enhancing the user experience when filtering in an analytic software product. Firstly, the Date Picker was developed to enhance the functionality when filtering time. The second is Search & Filter, making it possible for users to filter through text and allow for a non-technical language. Lastly, the third design, Filters' Relation (AND/OR), focus on making it possible to edit the relationship between multiple filters.

The final designs have been created in Figma and Axure as a result of an iterative design process as previously described in Chapter 6. Below, the three different scopes' results are presented and described to understand the step-by-step results of the designs better.

7.1.1 Date Picker

In the following section, the final result of the date picker prototype is presented and described. Firstly the filter device and its placement is defined before going into greater depth about its possible interactions. Secondly, the date picker dialogue window is described before going into details about its possible interactions. The following actions of selecting a range, making specific custom recurrence selections, and adding another additional range are described to give a greater understanding of the artefact and the possible actions.

7.1.1.1 Filter Device

The filter device, Delivery date, is placed in the filter panel located in the right column of the Product, see Figure 7.1. The placement of the filter device is based on The Products current interface that the users are familiar with, where all filter devices for each column of the data are gathered in the right filter panel. Minor design updates have been made on the filter device. The filter device is now collapsable if wanted. This ensures that the user can expand the relevant filter devices and decrease the chances of being overwhelmed with the different filtering alternatives in the filter panel. Additionally, a graph along the slider has been added to give the user an overview of the distribution. The data distribution shown in the filter device works as a compact mini visualisation that conveys essential information to the user and speeds up and guides the analytical process.

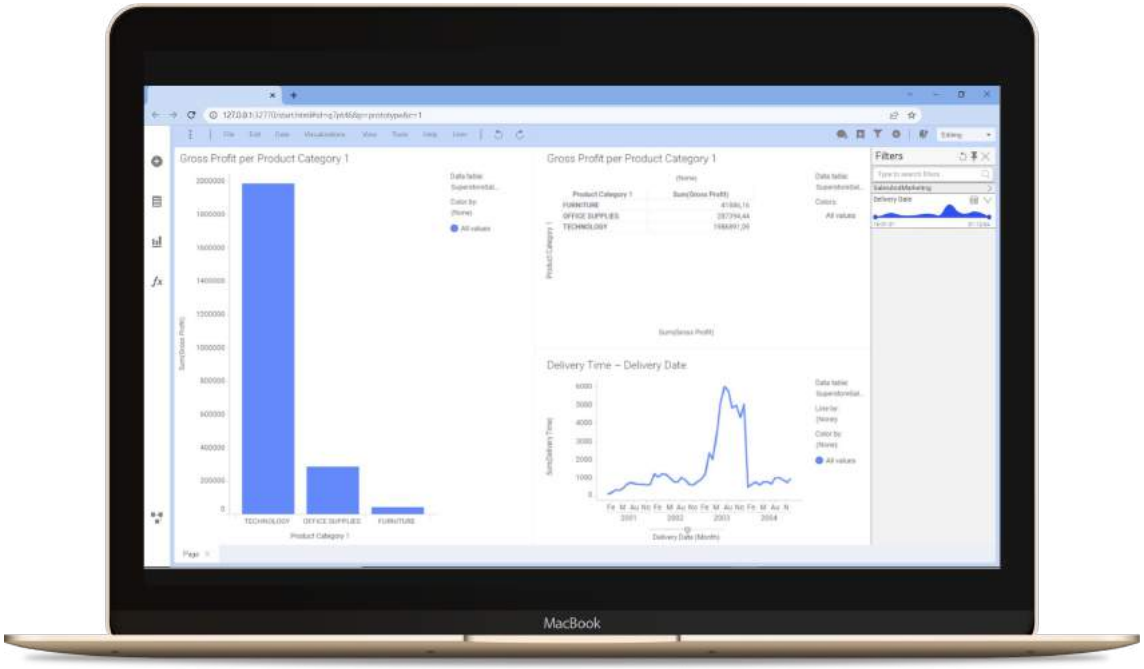


Figure 7.1: The filter for dates shown in the filter panel is shown on the prototype's right-hand side.

Slider in Filter Device

The slider in the filter device has had minor design updates to get a more modern appearance, such as rounded edge buttons instead of squares, see Figure 7.2. Additionally, the colour scheme was updated to be more consistent with The Products applied colors instead of being grey. The slider includes a graph along the bar. The graph's appearance will change depending on the data. The goal of the graph is to give the users an overview of the distribution, which will help them understand the effect of filtering time to a greater extent. The goal of the graph is that it will encourage users to interact with the slider and knowing what and how much data they can expect to see. Therefore the graph on the slider could be seen as a compact mini visualisation that conveys essential information to the user.

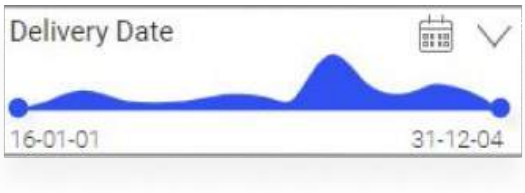


Figure 7.2: A closer look at the slider for filtering delivery time with a calendar icon that opens up the delivery date dialogue window when the user presses it.

Calendar Icon in Filter Device
Since the date filter has gained additional functionalities that were not suitable to cramp into the filter device due to its size, a date picker dialogue window can be opened. The dialogue window can be opened with the calendar icon located in the top right corner of the filter device, see Figure 7.2. The placement of the icon is based on similar actions having that placement.

7.1.1.2 Date Picker Dialogue Window

The date picker dialogue window pops up if the user clicks on the calendar icon in the filter device, see Figure 7.3. The dialogue includes a lot of possible interactions that can be divided into a left and right column. The left column includes functionalities to filter a time range with either a calendar or a slider, see Figure 7.4. The right column includes more specific selections for the chosen range, see Figure 7.5.

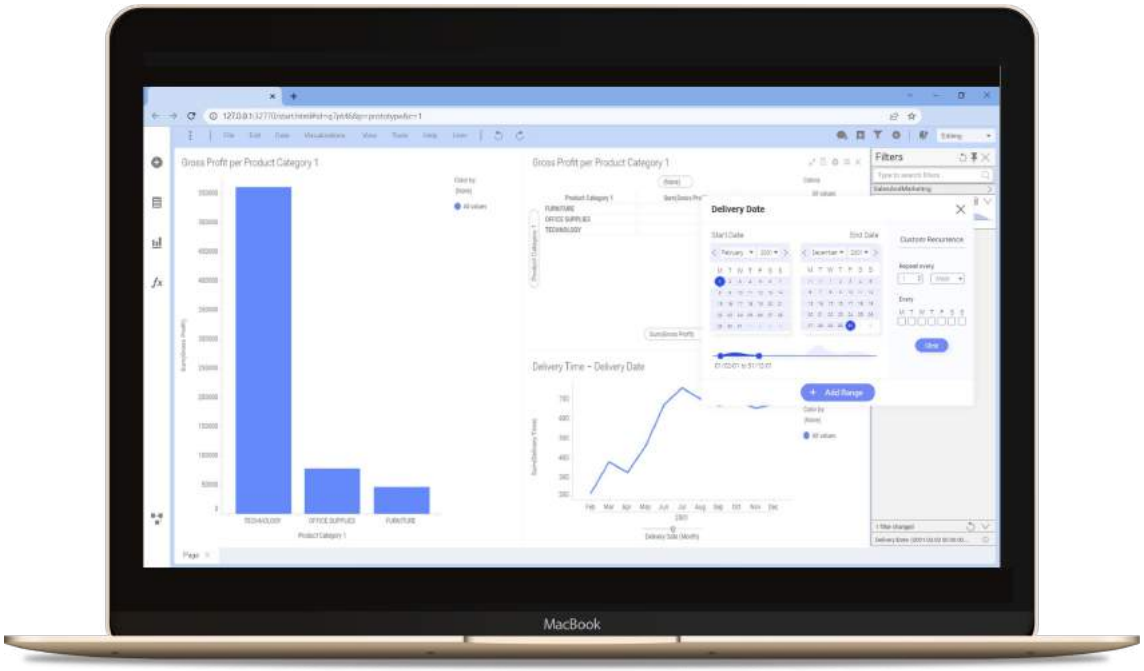


Figure 7.3: The delivery date picker dialogue window expanded where the user can interact with different filters related to time.

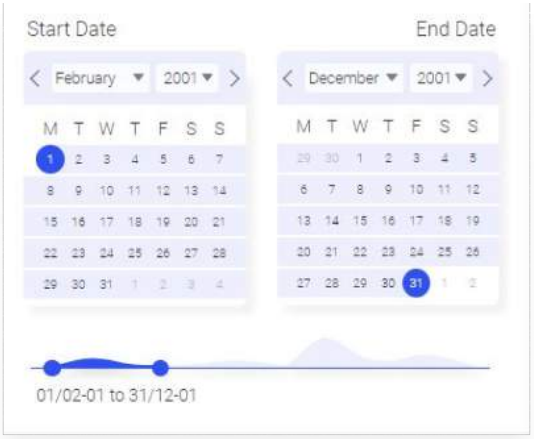


Figure 7.4: The left column of the date picker dialogue window where the user can filter time range through interacting with the calendars and dropdowns or the slider.

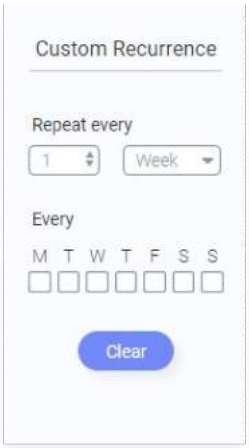


Figure 7.5: The right column of the date picker dialogue window where the user can select specific filters for the chosen time range.

The size of the dialogue window is based on the Company's internal design guidelines. The dialogue window also includes all relevant functionalities that were brought up and confirmed to be important during the process, and the size was thereby based on the content to not make it feel cramped, see Section 6.1.4 for further information. The internal design guidelines were followed for the font, font size, colour and padding to make the dialogue window consistent with the design of The Product.

7.1.1.3 Select Time Range

A range can be selected in multiple ways, either through selecting the range with the filter device or through the date picker dialogue window. The different ways to select a range are presented below.

Select Time Range with the Filter Device
With the filter device, a range can be selected in multiple ways, see Figure 7.2. One way is to interact with the slider, where the edge points can be dragged to the desired position for both the end and start points. Additionally, the informative text under the edge points is editable. By clicking on the label, the user can edit the text to a specific date, which allows the user to make a more specific range selection with the slider. With the filter device, the user can also click on the calendar icon to open the date picker dialogue window to be presented with additional ways to select a time range.

Select Time Range with the Dialogue Window
With the date picker dialogue window, the user can select a time range in multiple ways. The left column allows the user to either use the slider in the dialogue window, similar to how it is used in the filter device. Otherwise, the calenders can be used by clicking on the preferred date, see Figure 7.6. With the arrows in the calendar

headers, the user can go back and forth between the different months, see Figure 7.7. This design choice was based on how the current design of the date picker works. However, some stakeholders mentioned limitations of only being able to use the back and forth arrows when making more major limitations, where the arrows only adjusted the month. Therefore, the user can, with the help of the dropdowns, specify year and month, see Figure 7.8. The selected time range is presented in the calendar and on the slider.

Figure 7.6: The calendars in the date picker dialogue windows are interactive and the user picks the start date in the left calendar and the end date in the right calendar.

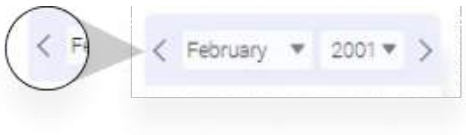


Figure 7.7: The user can interact with the left and right arrows in the calendar to change month.

Figure 7.8: The user can specify year and month by pressing on the dropdown menus.

7.1.1.4 Select Custom Recurrence Specification

During the process, it was brought up that it would be valuable to make specific selections within a time range, see Section 6.1.4 for more information. A *Custom Recurrence* column is thereby added in the date picker dialogue window to allow the user to make further specifications of a range, see Figure 7.5. The user can select specific days and the recurrency of the days within the range. The user can, e.g. select every Monday or every other Monday within the range, see Figure 7.9. Additionally, the custom recurrence column includes shortcuts to the users' preferences. An example presented is business days, meaning selecting all weekdays and removing all weekends and holidays, see Figure 7.10. The shortcuts included in the custom recurrence area can be different and are based on the data and the user.

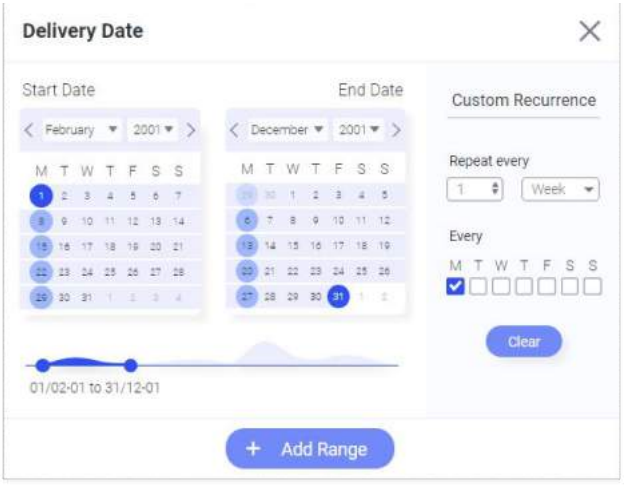


Figure 7.9: An example if selecting every monday within the chosen time range and how the selection is represented in the calendar view in the left column.

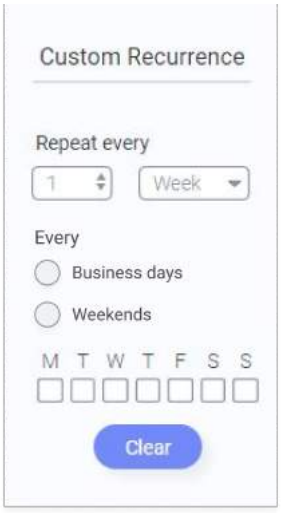


Figure 7.10: An example where custom recurrence is customized based on the data. In this example business days and weekdays might be of relevance to the user and is possible to select.

7.1.1.5 Add Additional Range

Multiple time ranges can be added with the help of the date picker dialogue window and filter device. In the filter device, the user can click on the line of the slider to create an additional breakpoint. One breakpoint will be created on the clicked location while a corresponding endpoint is created on the nearest max or min value, meaning the edge values of the slider, see Figure 7.11. This solution is based on feedback received from one internal stakeholder during the design process, see Chapter 6.1.4 for more information. Similarly, an additional range can be added through the slider in the dialogue window. However, there is one more way to add a range in the dialogue window, and it is with the *+ Add Range* button, see Figure 7.12. The button is located at the bottom in an area separated from the range above to make it clear that it is unrelated to the previous range.

Figure 7.11: A max and min value of a new range appears as dots on the slider with a darker color.

Figure 7.12: The add range button is one of the possible ways to create a new time range.

If an additional range is added, the previous range is collapsed, see Figure 7.13. The previous range is summarized in a section that includes the start date and end date. Any specific custom recurrence set on the time range, see Figure 7.14. The range can be expanded again, and all the previous functionalities and settings are then visible and editable for the range. The newly added range is the one presented within the

expanded section, see Figure 7.13. Similarly, when creating a new breakpoint on the slider, an additional range is created within the most extensive remaining time range. This means either a range before the start date or after the end date is created.

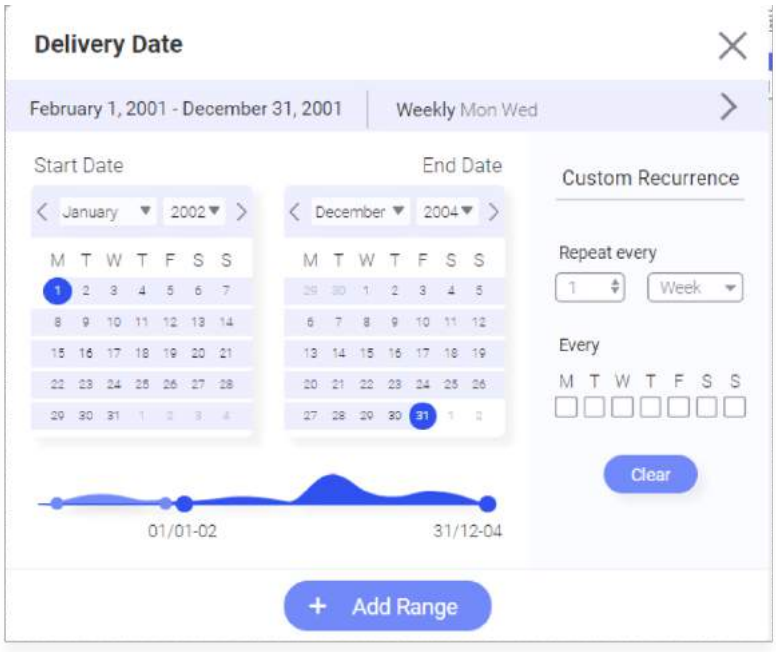


Figure 7.13: What the date picker dialogue window looks like when the user has pressed the add range button.

Figure 7.14: The previously chosen range is collapsed when the user is selecting a new range. The collapsed range shows the start and end date as well as any set custom recurrence.

7.1.2 Search & Filter

The second scope specific design is the Search & Filter UI element incorporated into the page of visualisations. The idea is that the element will be static and placed at the top of the canvas whenever visualisations are presented. The goal of the Search & Filter UI element is to facilitate the use of filters through text input.

7.1.2.1 Placement of Search & Filter UI Element

The Search & Filter UI element is placed in the top left corner of the canvas, see Figure 7.15. The Search & Filter element is placed to the left which generates room for applied filters to appear to the right of the search element, which is where the

user's eye movements are often fixed [38]. The search field has a hint saying *Search and Filter...* to indicate possible interactions and functionalities.

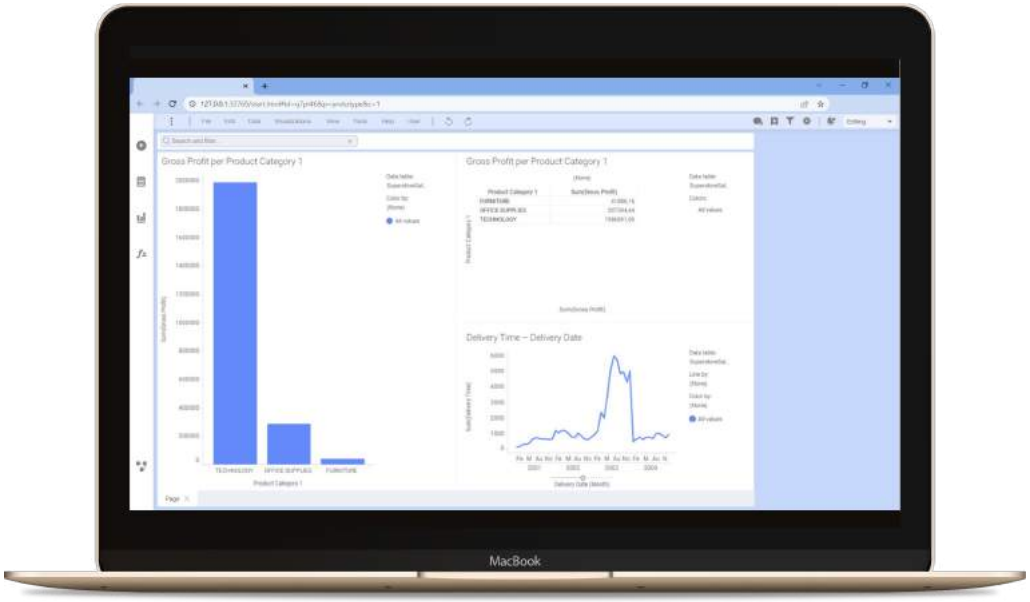


Figure 7.15: The Search & Filter UI element incorporated in the design with visualisations positioned at the top left of the UI.

7.1.2.2 Search for Filters through Text Input

When the user starts typing in the Search & Filter UI element, the visualisations will change appearance according to what they are filtering. For example, in Figure 7.16, the user has been typing *"2 Feb 2001 to 31 Mar 2001 technology"*, the delivery time, as indicated in the dropdown under *"Date"*, have been set to this interval and the category (a column in the data set) has been set to *Technology*. This can also be seen to the right of the text input field, where two pills have appeared with the two applied filters. The user can interact with elements in the dropdown menu, e.g. drag the slider and click on the calendar icon to get a detailed view of date picker dialogue window or check/uncheck checkboxes. Similarly, the visualisations have been updated based on the filter selection.

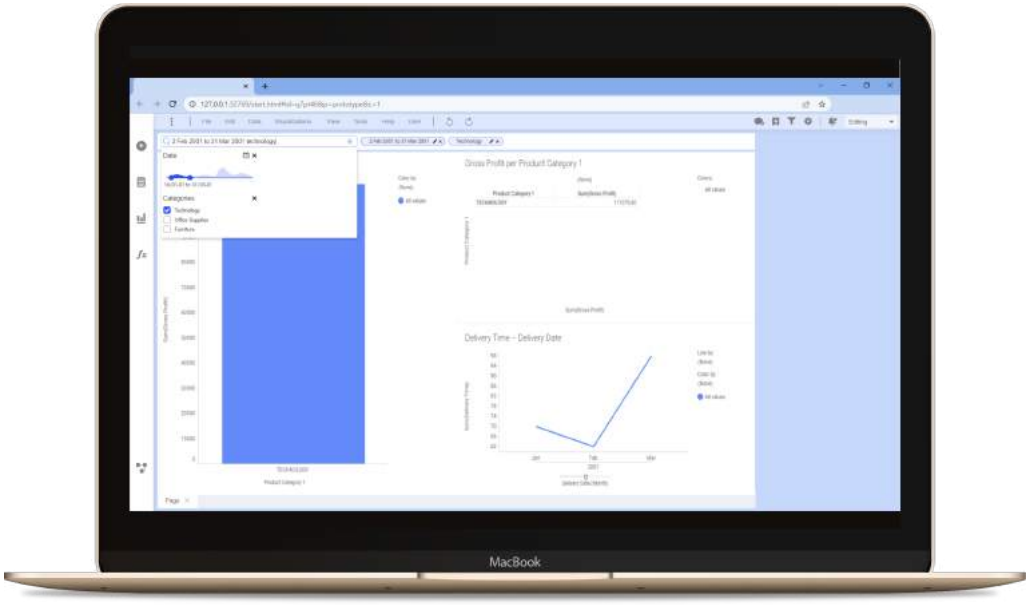


Figure 7.16: An example of how data can be filtered through the Search & Filter UI element.

7.1.2.3 Vocabulary and Hints

The filters in The Product are, by default, set to be filtered with the relationship AND. However, it should be possible to filter on other relations as well since it has been requested to a great extent during the process. This can be done through the Search & Filter UI element. In Figure 7.17, an example is presented of what it can look like if the user has a specific relation in mind. The example shows how the user has defined the relation by writing *"AND"* in the text input. However, any other relation should work aswell.

Through the Search & Filter, the user is able to write whatever they want and get it filtered. This means that the element must support all types of users and their vocabulary, and the UI should guide the user toward a suitable filter. For example, in Figure 7.18, the UI hints to the user what can be filtered by suggesting the most similar filter corresponding to the text input. This feature gives the user a greater feeling of control and guides them toward a suitable filter without forcing the user to use a technical vocabulary.

Figure 7.17: An example of what it can look like is if the user has a specific relation in mind, in this case, an *"and"* relationship.

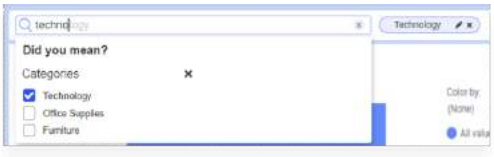


Figure 7.18: An example of an UI hint that is given to the user when typing in the search and filter text input area.

7.1.2.4 Applied Filters

The applied filters are represented as pills to the right of the Search & Filter UI element, see Figure 7.19. The filter can be edited if the user presses the pen icon and is easily removed with the cross icon on each pill. The pills and their functionalities allow the users to play around with filters and the data without worrying about not being able to reset or edit the filters.

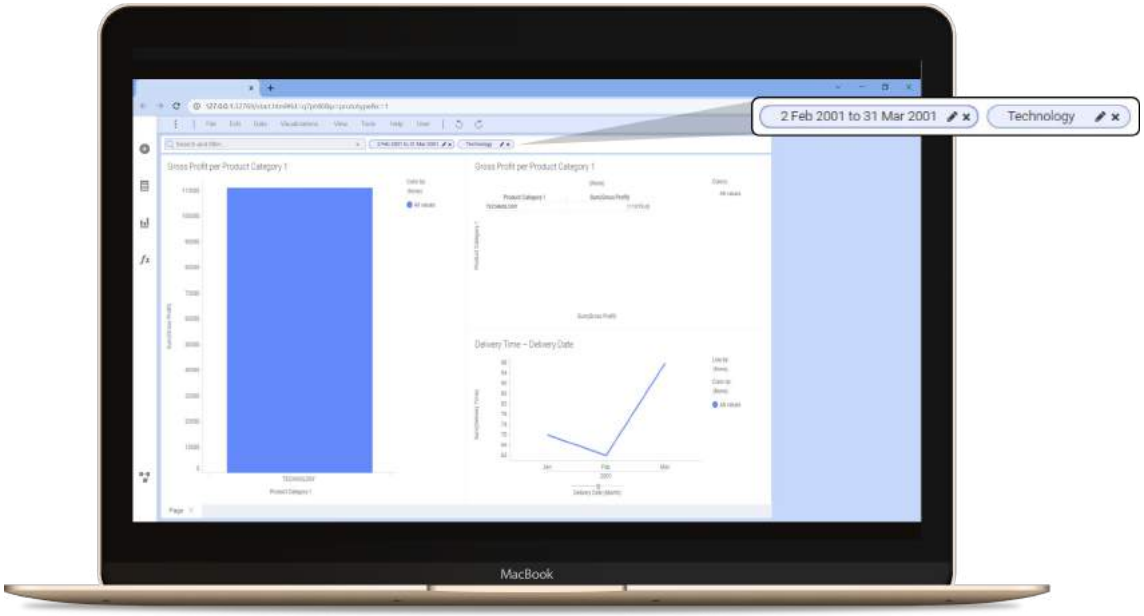


Figure 7.19: The applied filters are represented as pills next to the Search & Filter UI element.

7.1.3 Filters' Relation (AND/OR)

The third scope specific design is filters' relations to each other and how they can be modified and visualised. For example, having multiple time ranges shown in one visualisation, looking at a gross profit for *"fruit from store X"* OR *"candy from store Y"* should be possible to apply with the filter devices, Search & Filter UI and pills. The conceptual design focuses on how the applied filters' relation can be visualised and adjusted. The final result allows the user to open a dialogue window with further information if the user presses on the info symbol presented in the applied filter section in the bottom right area, see Figure 7.20. The dialog window, see Figure 7.21 presents the applied filters to the left in a hierarchy list, see Figure 7.22, and to the right, visualised the applied filters as a tree, see Figure 7.23. The user can interact with the tree through drag and drop and change the filters' relation through the interactive Venn diagram icons. Applied filters are grouped with lines, and the filters' relations are visualised as a Venn diagram to represent the relation. The user is also given a short description of the Venn diagrams to clarify their meaning.

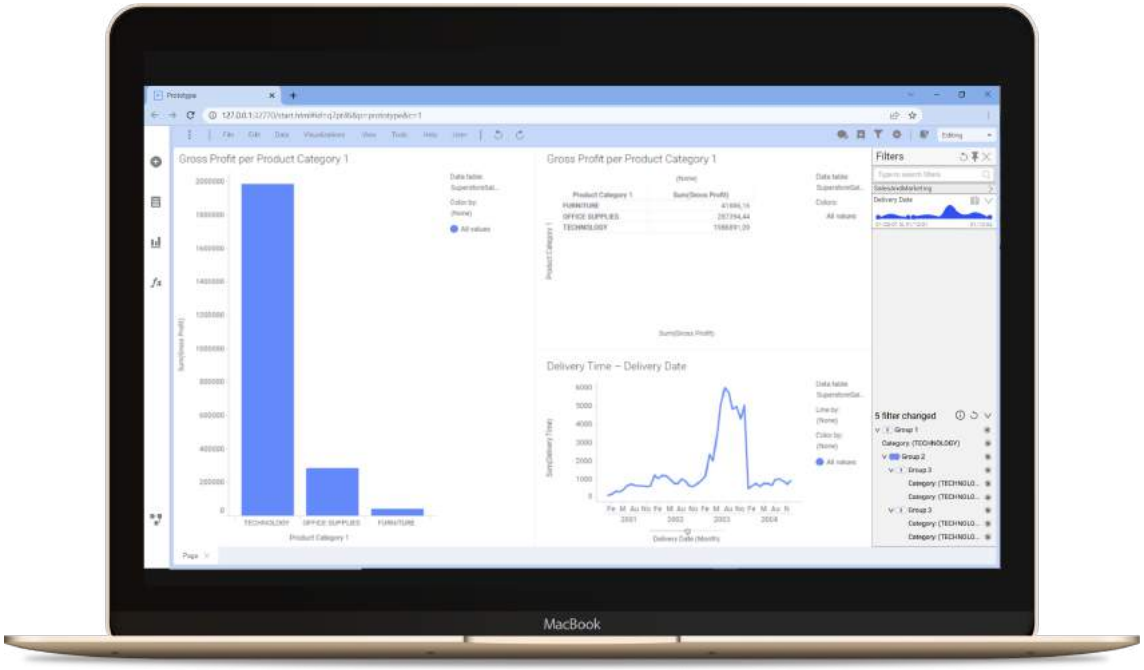


Figure 7.20: The applied filters shown in a hierachical list in the button right corner where the user can press on the info symbol to get to a detailed view.

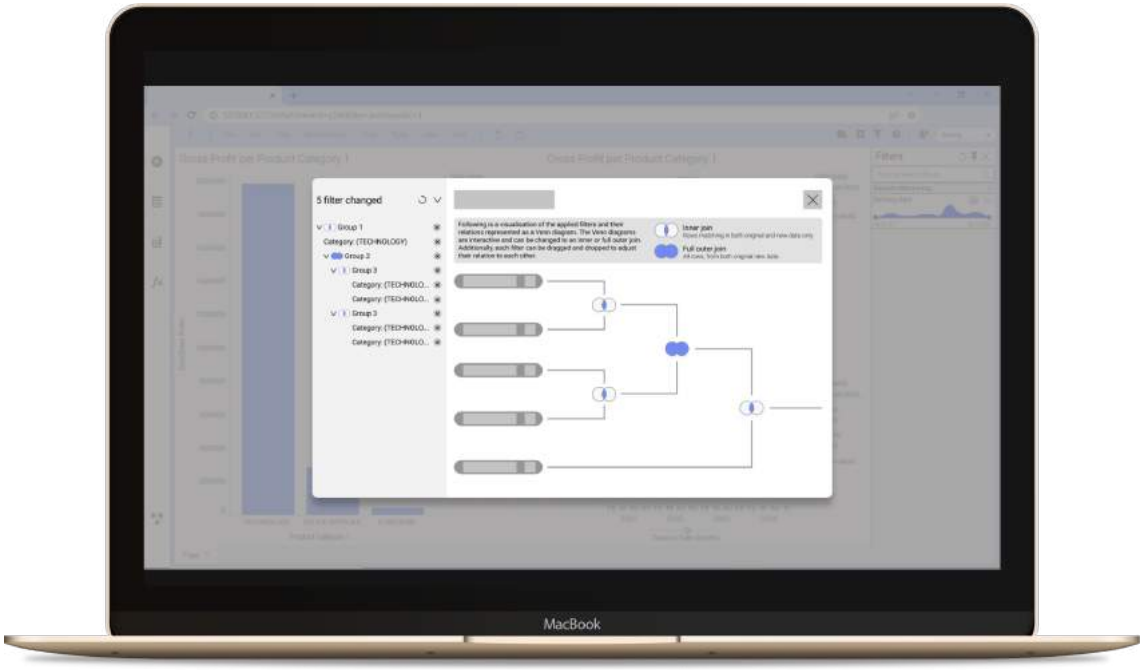


Figure 7.21: Example from the design where the user can edit the relationship between filters' through a dialogue window showing all applied filters.

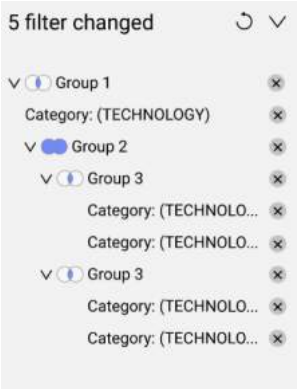


Figure 7.22: A detailed view of the hierarchy list of applied filters.

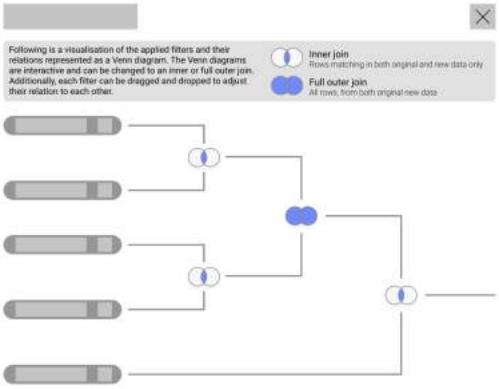


Figure 7.23: A detailed view of the tree visualisation of filters' relationship.

7.2 Final set of Guidelines

In the following section, the final set of guidelines is presented. These guidelines are based on the process of this master thesis and were iterated throughout the project. The guidelines and their descriptions are presented in Appendix E. The definition of what a guideline is was defined during the third iteration as *"Guidelines are sets of recommendations on how to achieve a good user experience, that are intended for designers and developers"*, see Section 6.4.7 for more information. The guidelines were designed to answer the thesis posed research question, and the final set of guidelines is separated into two categories: *Filter Functionality and Design Guidelines* and *Scope Specific Guidelines*. The guidelines' names, short descriptions and motivation are described to understand each guideline better and validate its credibility. The final set of guidelines is presented below:

GUIDELINES

Filter Functionality and Design Guidelines

G1. Provide an overview of the distribution.

G2. Provide a well designed UI with carefully crafted micro interactions.

G3. Indicate possible interactions.

G4. Provide resettable filters.

G5. Provide the possibility to filter iteratively.

G6. Provide direct manipulation with instant feedback.

Scope Specific Guidelines

G7. Provide precise endpoint selection.

G8. Allow a non-technical vocabulary.

G9. Suggest relevant ways forward.

G10. Provide shortcuts for common selections.

G11. Indicate filters' relationship.

7.2.1 Filter Functionality & Design Guidelines

The following section presents the six general functionality and design guidelines.

G1. Provide an overview of the distribution. *There should be an overview of the data distribution to give the user a quick, compact insight of what the data looks like, and can guide the user to what she needs to look into (e.g. a gap).*

Big data sets can be overwhelming and might lead to difficulties drawing conclusions or getting insights [8]. Therefore, providing an overview of the distribution might enhance the user's understanding and how the filter might affect the data

[39]. During interviews in iteration one, see Section 6.1.4, two interviewees (I3 & I4) stated that it could be of value for users to be able to have this sort of overview when filtering. Discussions of how the data distribution can be supportive when deciding whether or not to filter and what to filter to were discussed during the two workshops (W1 & W2) with the internal stakeholders. Additionally, many of the sketches during the workshops included graph solutions with distribution overviews, see Section 6.1.4.

Providing an overview of the distribution can be done differently. For example, it can present the number of rows for each selection. However, if the data is complex, it might lead to information overload. Another way of presenting the data is through a visual representation. An example of this can be seen in the design, see Figure 7.24, where the user is presented with an overview of the distribution when selecting a date in the form of a graph presented along with a slider. This gives the user a greater understanding of the distribution and any specific dates and intervals that might be of interest to filter and gain further insights.

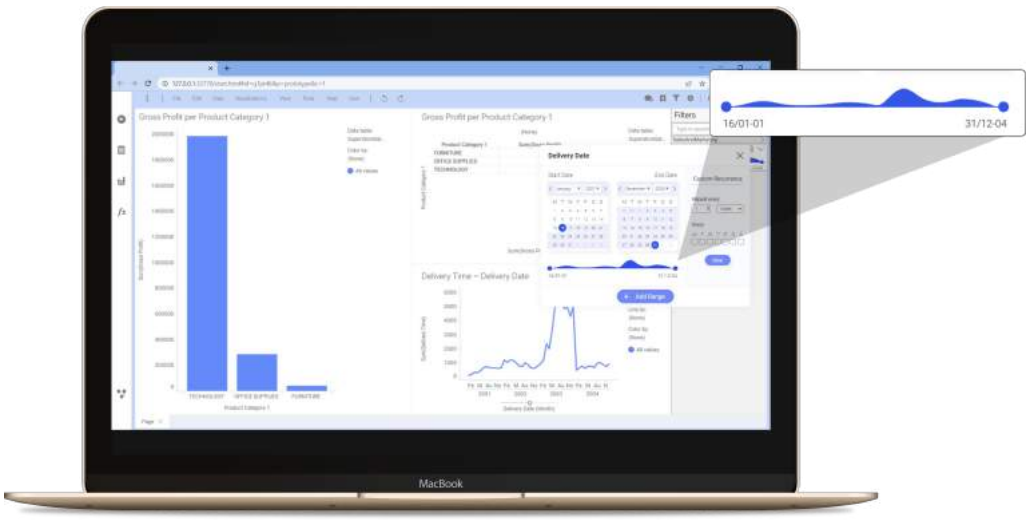


Figure 7.24: Overview of the data distribution when selecting a date in the form of a graph presented along with a slider.

G2. Provide a well designed UI with carefully crafted micro interactions. *Filters should include relevant information without cramping the functionalities to enhance precision and clarification. Dropdowns and icons should be applied when possible to either clarify or substitute a text/description to avoid overwhelming the user.*

Complex software may include a lot of possible interactions where all sets of experiences should work well together. Filters should support these sets of experiences and make it possible for the user to visualise relevant information without cramping the functionalities. When the user wants to define an extensive range of values, sliders are a helpful tool since it encourages users to explore the data [40]. Another helpful tool for precise input is to provide text input to find a specific value on a range [40].

Two interviewees (I3 & I4) highlighted in iteration one, see Section6.1.4, the possibility of using dropdowns when suitable to be space-efficient and thereby make the UI less cluttered and easier to navigate. Additionally, during the workshop with the ersatz stakeholders in iteration two, see Section 6.1.4, a participant suggested how an icon of a pen could be included in the pills to enhance the possibility of editing the applied filters, see Figure 7.25. Similarly, the workshop with the internal stakeholders (W2) showed that many participants thought of a calendar icon as a carefully crafted way to show that there are further possible interactions for selecting days which was incorporated into the design, see Figure 7.26. Similarly, dropdowns are implemented in the date picker dialogue window to try not to overwhelm the user with the possible interactions, see Figure 7.27.

This guideline overlaps to some extent with *G3. Indicate possible interactions*, since they both refers to creating a good overall user experience. However, G3 focus on the visual representation of possible interactions, whereas G2 is more about the functionality and that it should be easy and convenient to use without overwhelming the user with a lot of information of possible interactions. Another similar guideline to G2 is *G7. Provide precise selection* that focuses on that the user should be provided with the possibility to specify exact ranges with the help of multiple ways of selcting a range, which can to some extent be seen as a sort of micro interaction, which makes the guidelines overlap to some extent.

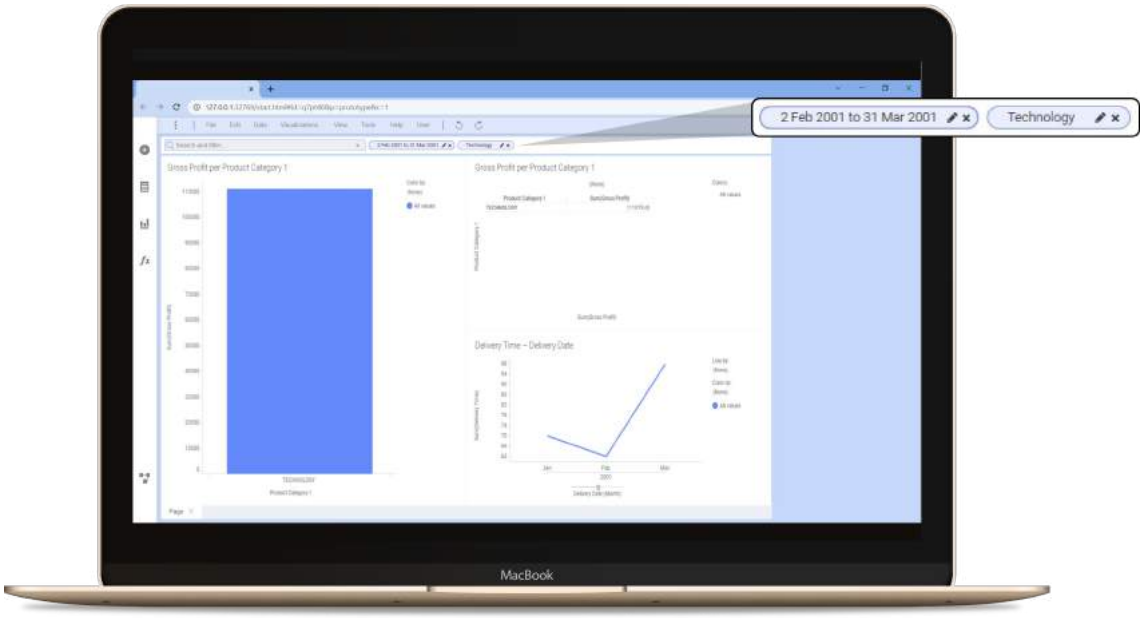


Figure 7.25: Example of an icon that is used to emphasize the possible micro-interactions of a pill.

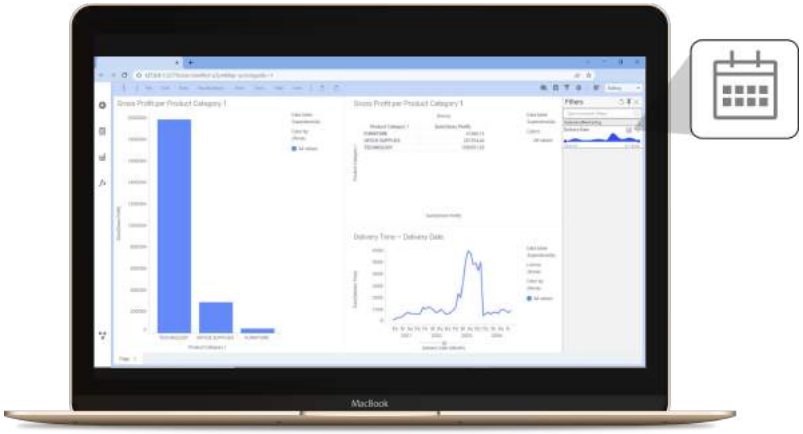


Figure 7.26: Example of a calendar icon used to emphasize the possible micro-interactions of the Delivery date column.

Figure 7.27: Example of how drop downs can be used to try to hide data and aboid a clutter design that might overwhelm the user.

G3. Indicate possible interactions. *It should be possible to re-use filter settings and combinations in different contexts and the filters affordance with help of hints and tooltips, should indicate possible interactions.*

For a filter to reach its full potential, the user must understand the possible interactions in the UI. This can be done by providing hints and tooltips and strengthening an element's affordance. Additionally, it should be possible to re-use filter combinations, this is to facilitate the interactions and be able to apply a filter combination in different contexts. By ensuring that the user understands the possible interactions, it enhances the chances for the user to extract valuable information by interacting with the data and visualisation [8]. Additionally, being able to interact and filter data in a visual analytic tool is significant to be able to twist and turn the data and draw conclusions and gain insights [10].

Apart from the importance of understanding visual analytics software possibilities, a good user experience is, as stated by Alben, everything from design to how well the user understands how it works [28]. During iteration one, I8 argued for the

possibility of being able to save filter combinations to re-use since it can give great value for users to be able to apply filter combinations on different data. Additionally, the importance of indicating the possible interactions was emphasize during the workshop with ersatz stakeholders. One of the participants clearly stated that if the pills in the application included a pen icon, they would have understood that they were editable to a greater extent. Therefore, this was something that was incorporated into the resulting design, see Figure 7.28. Another example of how affordance is incorporated into the design can be seen in Figure 7.29, where the user is given a prompt in the search and filter UI element. This informs the user that there are further possibilities if the user interacts with the element.

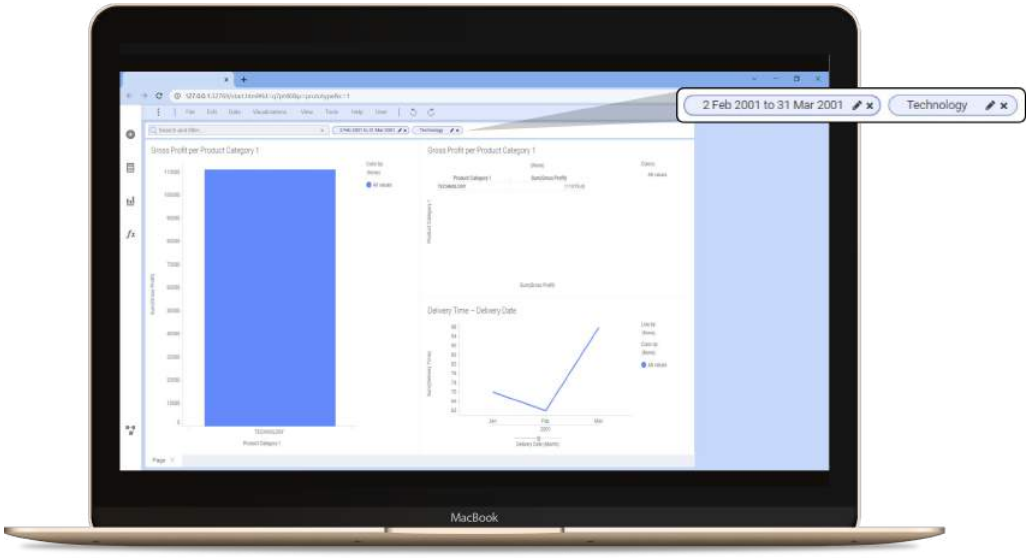


Figure 7.28: The pen icon used in the pills indicates the possibility to edit the filter.

Figure 7.29: The prompt in the Search and filter UI element that hints the user what the possible interactions of the UI element is.

G4. Provide resettable filters. *Filters should easily be reset, meaning a chosen filter should have a clear or undo option.*

Filters should be resettable, meaning that the user should easily be able to edit and remove the applied filters. This ensure the users' freedom and control of the data [39], [7]. This guideline refers to having greater control of all applied filters. The importance of including resettable filters was further confirmed during the design workshop with ersatz users, where one participant stated the importance of being able to control the filters to feel the freedom to filter the data. The design includes an example where a filter applied by the search and filter UI element easily could be removed in the drop-down of the search and filter UI element, see Figure 7.30. Letting the user search and filter whatever they want and make sure that they do not feel limited or restricted by the filter being applied is supported through the simplicity of easily removable filters.

An additional way this was implemented in the design is when a filter is applied in the search and filter UI element. A pill represents the applied filters and is placed next to the search and filter UI element to make it clear to the user what filters that is active. The pills include a pen to show the user how it easily can be edited and a cross icon to indicate how the applied filter easily can be removed, see Figure 7.31. This guideline overlaps with *G2. Provide a well-designed UI with carefully crafted micro-interactions,* where icons are argued to be used to clarify or substitute a text or description to not overwhelm the user with a cluttered UI. In this case, the cross icon in the pills is a substitute for a text saying "remove" or "delete". Additionally, this guideline overlaps *G3. Indicate possible interactions*, since the cross is an indication of the possible interaction of removing a filter.

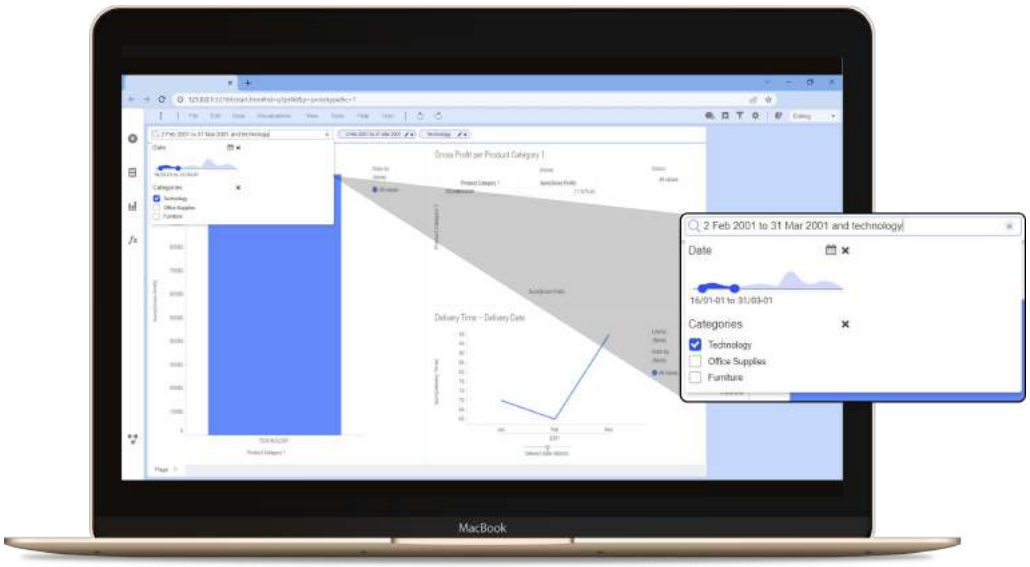


Figure 7.30: An applied filter can be removed by pressing on the cross in the dropdown list

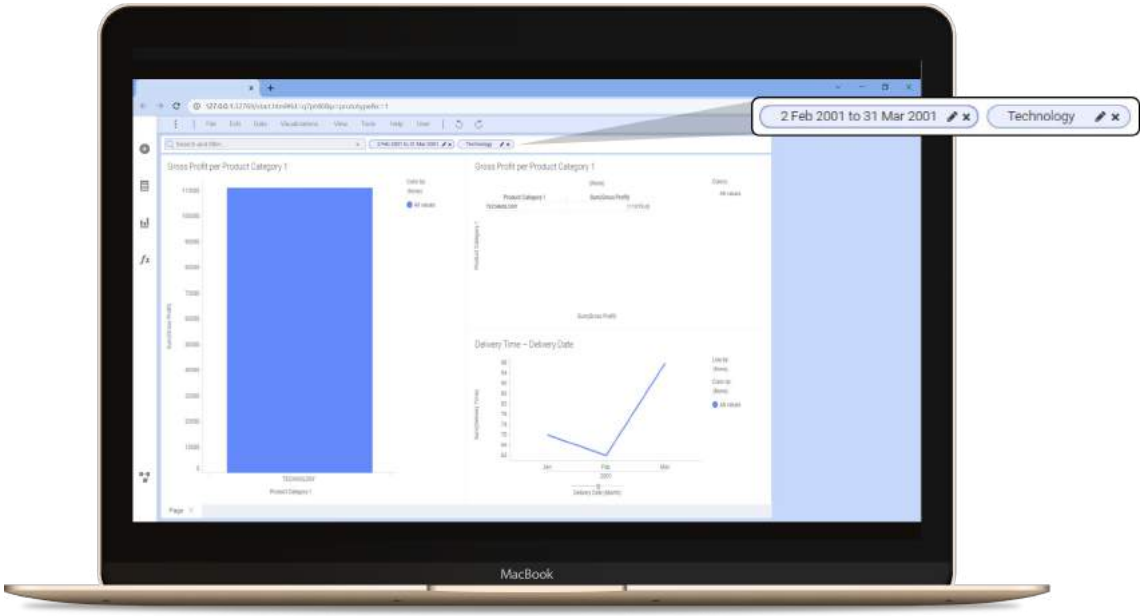


Figure 7.31: An applied filter can be removed by pressing on the cross on their pill.

G5. Provide the possibility to filter iteratively. *The user should be able to adjust and update filter selections. The user should also be able to apply multiple filters, meaning having several filters active at the same time.*

By allowing the user to filter iteratively, the user can adjust and narrow down the data to gain more significant insights and to skew the visualisations back and forth to gain deeper understanding [35]. Additionally, it increases the possibility of removing unnecessary and invaluable data to be able to draw more accurate conclusions [33]. During one of the interviews in iteration one, see Section 5.1, I8 mentioned the how being able to apply several filters to be able to draw conclusions is one of the core features of filters in the Product.

The final design allows the user to apply as many filters as possible as well as being able to create several ranges within a filter, see Figure 7.32. An idea that was discussed during iteration two, see Section 6.1.4 was the possibility to drag and drop filters on visualisations to set different filters on different visualisations. This supports the possibility of comparing visualisations with different filters next to each other and was a wished functionality, brought up during W2 with internal stakeholders.

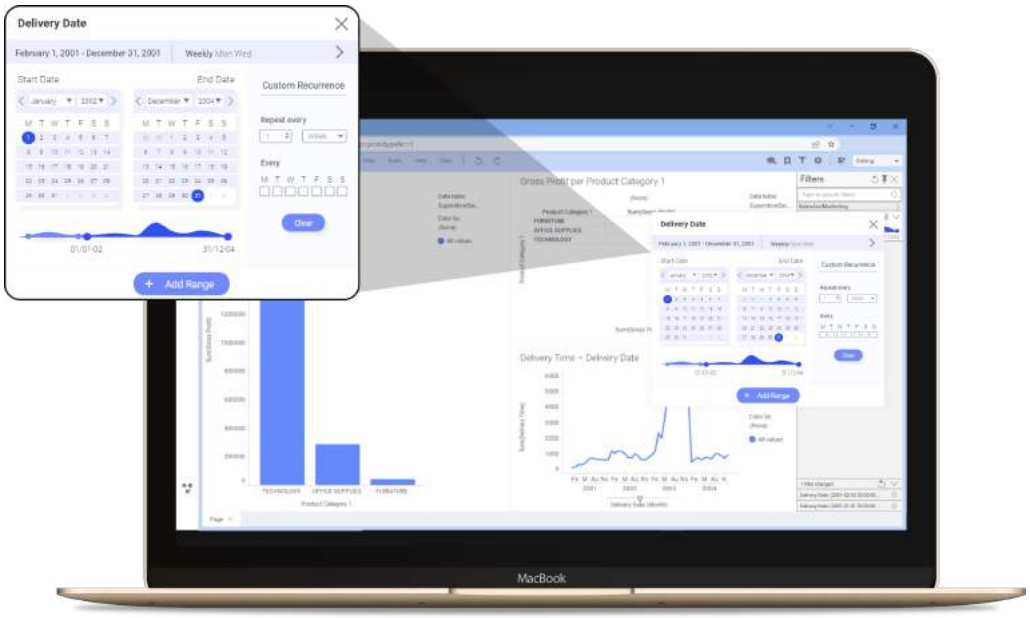


Figure 7.32: An example of how an additional filter to the range can be applied is selecting custom reoccurrences.

G6. Provide direct manipulation with instant feedback. *Selections or interactions with filters should be applied immediately and mirror the user's input.*

Visualisations can give users a great value, however Heer & Shneiderman [10] states how a visualisation itself only can answer some questions. They argue that visual analytics filter and interactions in combination with visualisations give the users a greater understanding of the data [10]. The filtering could either be applied with batch filtering or interactive filtering [33], [7]. Batch filtering is a good solution when there might be a delay when filtering; otherwise, interactive filtering gives the user greater freedom, and fewer actions need to be taken. This was further confirmed during one of the design workshops (W1) with internal stakeholders as well as mentioned by P1 during the cognitive walkthrough. They stated how they want the visualisations to mirror the filtering immediately to be able to explore the data quicker.

By giving the possibility for the user to direct manipulate the data and gain instant feedback, the goal is that the user, as Cui mention, can gain more significant insights from the data and explore it to a greater extent [8]. This is implemented in the design where visualisations are immediately updated based on filter selections. For example, if the user plays around with the slider of the Date delivery column, the user will affect the data and visualisation immediately, see Figure 7.33. This will give the user freedom to play around with the data to be able to, as Heer & Shneiderman [10] mentions, extract valuable insights from complex data. Another example in the design where the user gets instant feedback is in the date picker when the user presses on a specific day of the week, and the chosen day gets highlighted in the calendar view and the visualisation is updated based on the data, see Figure 7.34.

Figure 7.33: To the left all dates are selected while the result to the right shows how the visualisations based on the data and the chosen range on the slider is updated when the user has selected a time range to be between first of February to last of Decemeber 2001.

Figure 7.34: The user gets instant feedback of chosen days highlighted in the calendars when a specific day is pressed, in this case Mondays and Wednesdays.

7.2.2 Scope Specific Guidelines

The following section presents the five scope specific guidelines.

G7. Provide precise selection. *The user should be provided with multiple possibilities to specify precise selections.*

Different filter selections will be applied depending on the user, data and context. Thereby the design should allow the user to make its selection easily. Due to this, Friedman suggests that it could be wise to include the possibility to, e.g. use text input to increase the precision with sliders [40]. He argues that giving different possible ways to make a selection is valuable to meet the users' different needs [40]. By

e.g. allowing text input as an additional feature to a slider it allows the user to be more precise and feel in control of a selection. This was further motivated during a cognitive walkthrough in iteration two, see Section 6.1.4, where P3 stated that they thought the slider was a great tool to make significant limitations. However, the participant (P3) argued that making more precise selections with it could be hard and would then use the date picker instead, see Section 6.1.4 for more information.

There are different ways to support the users freedom and the ability to filter precise selections. One example, implemented in the design, is how the user is given multiple ways of selecting a time range. If the user opens the date picker dialogue window, the user can apply the selection with the help of the slider or a calendar. The slider can be usable when filtering larger sections whereas the calendar is an excellent tool for more precise selections, as further confirmed by P6 during one of the cognitive walkthroughs, see Figure 7.35. By giving the user the possibility to make the selection both by the slider and date picker, the user can filter based on action and preference. Another example is implemented in the designs search and filter UI element where the user can write more or less precise information in the search and filter UI element. Based on the input, the user will then be presented with filter devices and with each possible interaction in the dropdown, see Figure 7.36. This gives the user multiple ways of applying and skewing the selection. The user can thereby make further selections or edits either by text or in the dropdown, allowing the user to choose the suitable interaction to make the wanted selection based on action, preference, and context.

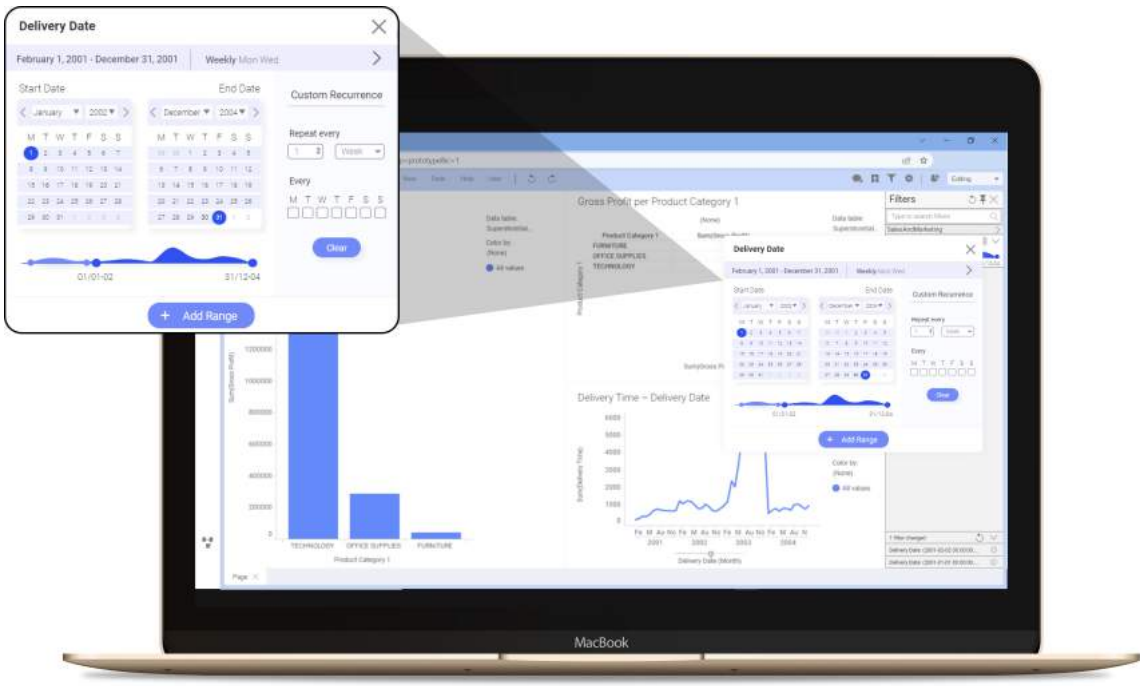


Figure 7.35: The Delivery date dialogue window that allows the user to filter with the slider as well as the calendar.

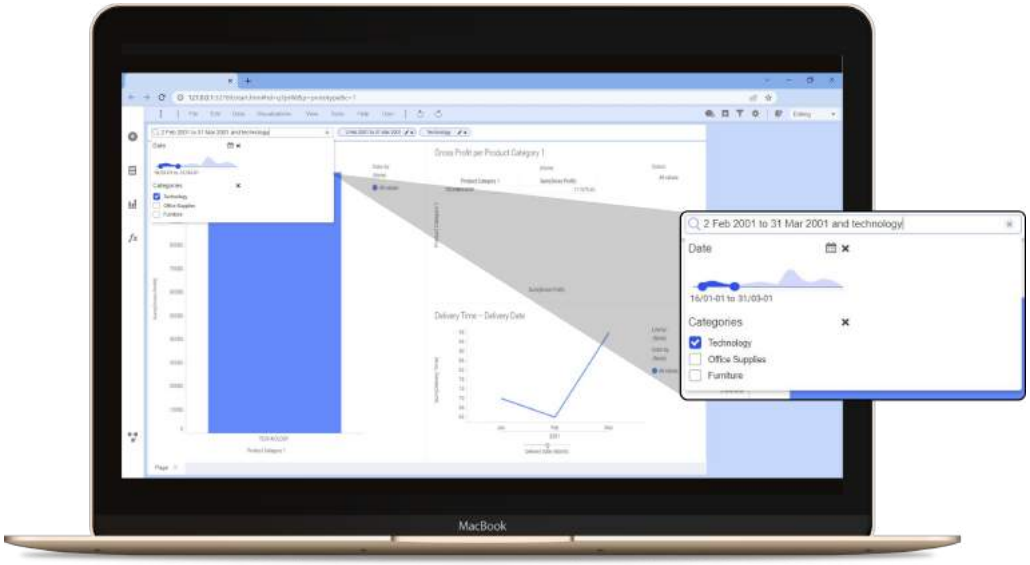


Figure 7.36: The Search and filter UI element that allows the user to write as precisely as necessary or use the possible interactions in the dropdown.

G8. Allow a non-technical vocabulary. *The user should feel the freedom and flexibility to express queries using a non-technical vocabulary.*

Shakuro mentions how a clear and suitable language can encourage the user and decrease the chances of misunderstanding [33]. Additionally, two interviewees (I1 & I6) mentioned how the core goal of filters in The Product is to be able to twist and turn the data precisely as wanted, see Section 6.1.4. This was later elaborated further during W2, where a few participants discussed how it is of value to type text into a search field of something similar to what the user is looking for. Meaning that the user should not be limited to using technical language since, as the interviewees mentioned, the goal is to filter what is on the users mind. Therefore, the user should not be limited to translate the thoughts into a technical vocabulary. An example is implemented in the design, where the user is allowed to use a non-technical vocabulary for the search and filter UI element, see Figure 7.37. The user does not need to write queries such as *"category=X"* since the choice of allowing a non-technical language can encourage the user, as mentioned by Shakuro [33].

Allowing a non-technical vocabulary can be designed differently but is especially applicable for a search and filter UI element. As presented above, one example is to allow the user to use their wished vocabulary, meaning both a non-technical and technical vocabulary is applicable to enhance and encourage the user to interact with the search and filter feature. *G.9. Suggest appropriate ways forward* is to some extent an elaboration of this guideline since suggestions of appropriate ways forward are presented in the same vocabulary as the user has written as text input in the search and filter UI element. Meaning if the user has used a more technical and query vocabulary, the user will be given suggestions in the *"Did you mean?"* list in a more technical manner.

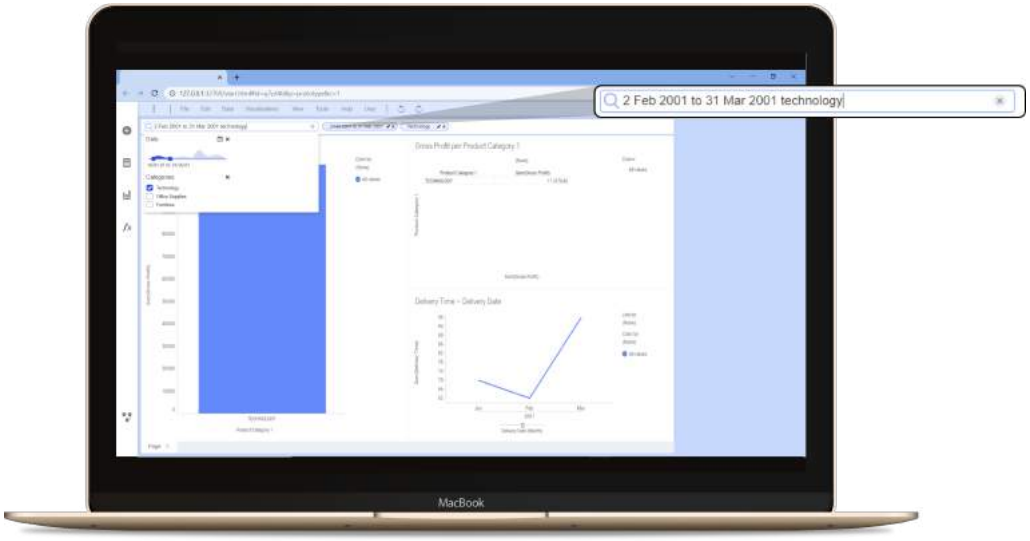


Figure 7.37: A non-technical vocabulary written in the search and filter UI element.

G9. Suggest relevant ways forward. *The user should get autocomplete text suggestions and filter recommendations relevant to the data and input, based on the system's interpretation.*

It is essential to understand the users' priorities to be able to mirror their expectations when it comes to suggestions on filters and relevant ways forward [31]. The goal is to provide easy access to possible relevant ways forward based on the user, data, and context. This reduce and hinders the user from searching and navigating for the upcoming step. One example that is incorporated in the design based on ideas evolved during the design workshop with internal stakeholders (W2) is autocompleted text suggestions. Autocomplete text suggestions do not force the user to type the whole search word to reach the wished filter and next step. The user gets feedback in terms of autocompleted faded text and can use keyboard shortcuts to search for the whole word, see Figure 7.38. During W2, some participants sketched out different solutions where suggestions of possible features were presented. Based on this, another way to suggest a possible way forward to the user is implemented in the designed prototype, where the user receives suggestions on what he/she might want to search for. When typing, the user is presented with suggestions under a *"Did you mean?"*-list based on the input, which might be helpful for both the experienced and inexperienced users, see Figure 7.38.

As previously mentioned, getting suggestions on appropriate ways forward in terms of autocomplete text suggestions as well as suggestions on filters within the search and filter UI element was suggested in both workshops with internal stakeholders. This was something that many participants agreed was important and could give value to the Product, see Section 6.1.4 for more information. The meaning and area of this guideline overlaps with *G10. Provide shortcuts for standard selections.* to

some extent. To some degree, suggesting relevant ways forward can refer to suggesting relevant filters that are, to some extent, covered under G.10. However, this guideline G.9. refers to more specific and context-based suggestions, not by providing general or standard shortcuts but instead, e.g. autocompletes the users' word input. The most significant difference is how G.9. refers to guiding and giving the user suggestions on appropriate ways from the user's current state to provide shortcuts for common selections. Based on this, another example implemented in the prototype design is how the users, when selecting a range, can choose only specific days within the time range, see Figure 7.39. The user is then presented with a possible way forward from the selected time range. In comparision, G10 allows the user to make additional selections to provide shortcuts to common selections, presented further under G.10. However, the user is presented with the possibility to select days within a time range based on how many participants during the workshops with internal stakeholders, mentioned how valuable this could be for the product while analysing data.

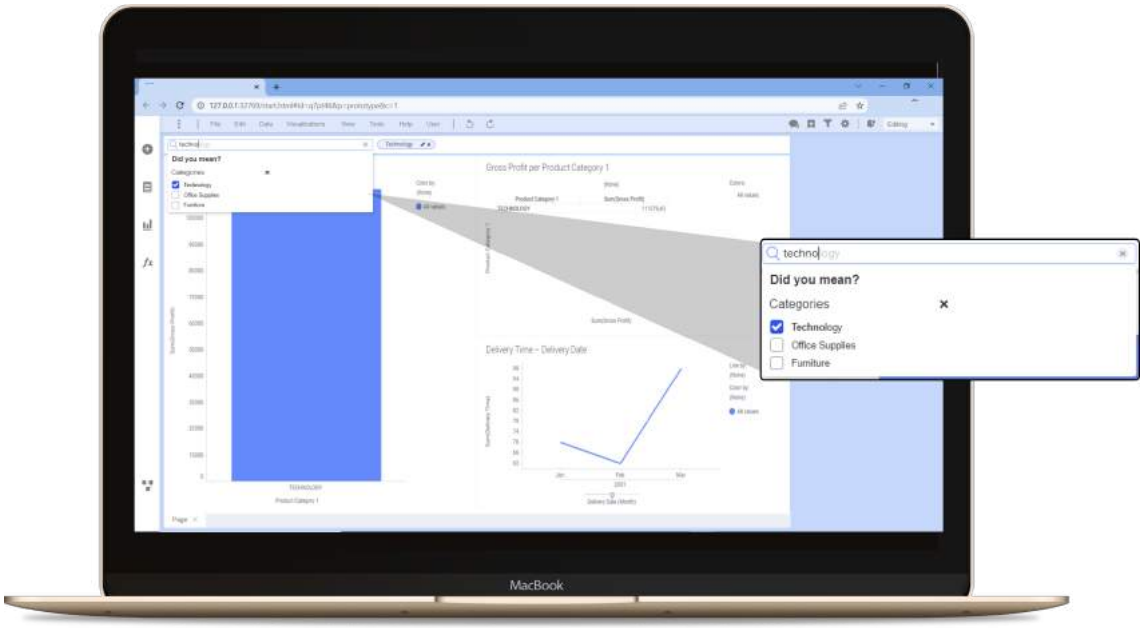


Figure 7.38: Suggestions of relevant ways forward in the design through autocomplete text.

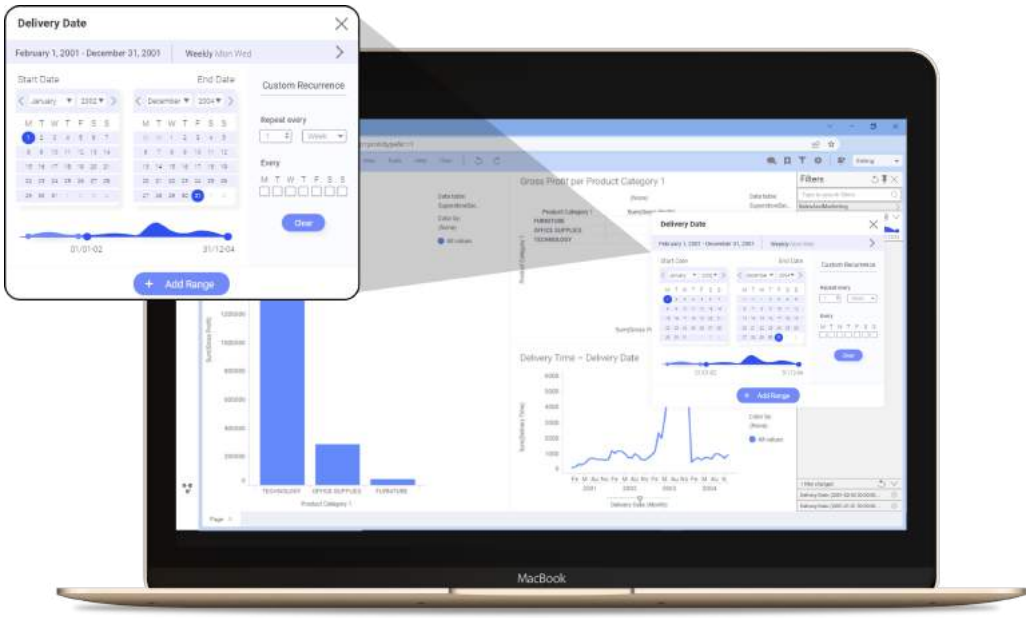


Figure 7.39: Suggestions of relevant ways forward in the design through having the possobility to add specific days of the week.

G10. Provide shortcuts for common selections. *It should be possible to make additional filtering selections to a given data type as well as provide shortcuts for common selections.*

The purpose of this guideline is to make it easier to apply a suitable filter for a specific context. One way of providing this to the user is through shortcuts for common selections. An example of providing a shortcut can, for example, be to show the filters of most relevance in a more accessible way. For example, it could be to present the most relevant filters and hide the rest that might not be as valuable. This makes sure that the user does not get overwhelmed with functionalities since redundant information is hidden [37]. Additionally, the order of the presented information is of relevance [31]. By placing the most relevant information at the top, a shortcut is created by reducing the users' need to find and locate the relevant information and functionality.

Being able to save a specific filter selection as a favourite to get back to or to apply to other visualisations was something that was brought up during iteration one, see Section 6.1.4. I8 mentioned how she missed being able to bookmark a specific filter selection in an easy way to be able to re-use it in another context. Additionally, being able to apply filters to different contexts was brought up in the two workshops held with internal stakeholders. Due to this, filters should be draggable and applicable on specific visualisation as a shortcut for not having to set a filter for all visualisations.

Additionally, UDP1 mentioned how he would have liked to have a way to select only business days during the user testing in iteration three, see Section 6.1.4. This desire could be translated to being able to make shortcuts for specific filtering selec-

tions of the custom recurrence features. This since business days and other specific solutions might differ depending on the company, data and context. Based on this conclusion, a shortcut of being able to create different day selections was incorporated into the design, see Figure 7.40.

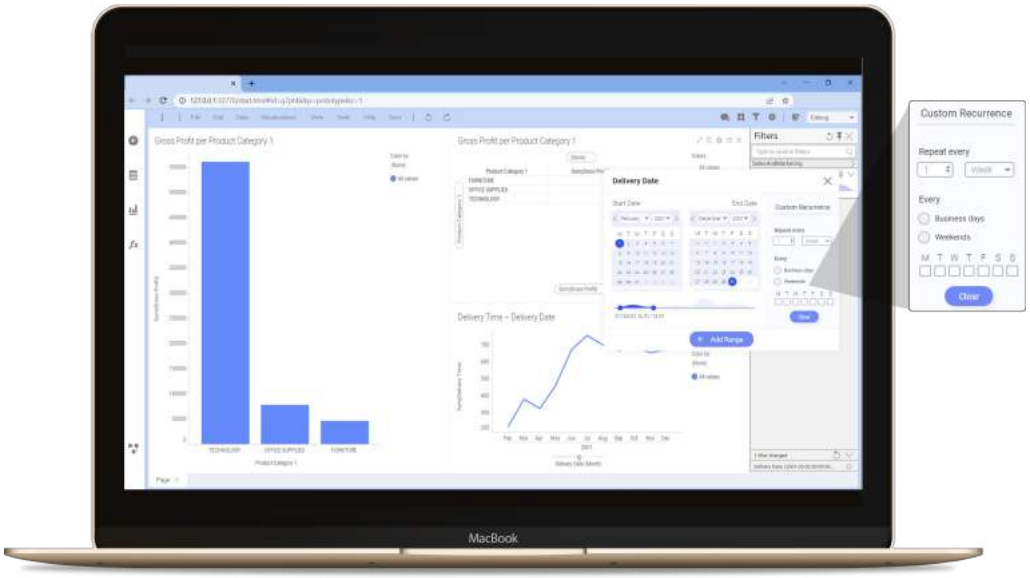


Figure 7.40: The shortcut that allows the user to choose business days.

G11. Indicate filters' relationship. *The user should be able to edit the relation between filters, and the relation should be visually represented to facilitate the understanding of the filters' relationship to each other.*

The filters' relation refers to what expression the identifier and value it will be filtered on, such as AND, IS and OR [7]. Filtering e.g. *"fruits from store X"* AND *"candy from store Y"* in the same plot can give the user a greater understanding of the data and its gross profit. Additionally, it was further confirmed by the participants of the two design workshops (W1 & W2) conducted with The Company that this sort of feature can be of great value to the users to analyse the data further, see Section 6.1.4.

The Product currently often uses icons for visualising different interactions. Similarly *G2. Provide a well-designed UI with carefully crafted micro interactions* to some extent refers to including icons and visualisations to clarify information or possible interactions. During W2 with the internal stakeholders, there were discussions on if filters' relation could somehow be visualised to facilitate the meaning of the relation. One example is that the user can explicitly write the filter relation such as *"Red OR Blue"*. This allows the user to select another relation but AND, which is applied per default if nothing else explicitly is written, to facilitate the interaction. The relation is not visualised with an icon when applying the relation through the search and filter UI element. However, in the wireframe, once the filters are applied, the filters' relation is represented in a hierarchical list as well as with Venn diagram icons to represent the relationships visually in the applied filter list in the filter

pane, see Figure 7.41. The user can get a more visual representation of the applied filter list by clicking on the info button. The user can then get a more detailed and visual representation in the form of a list with Venn diagram icons and a tree in combination with the interactive Venn diagram icons representing the relationships between filters, see Figure 7.42.

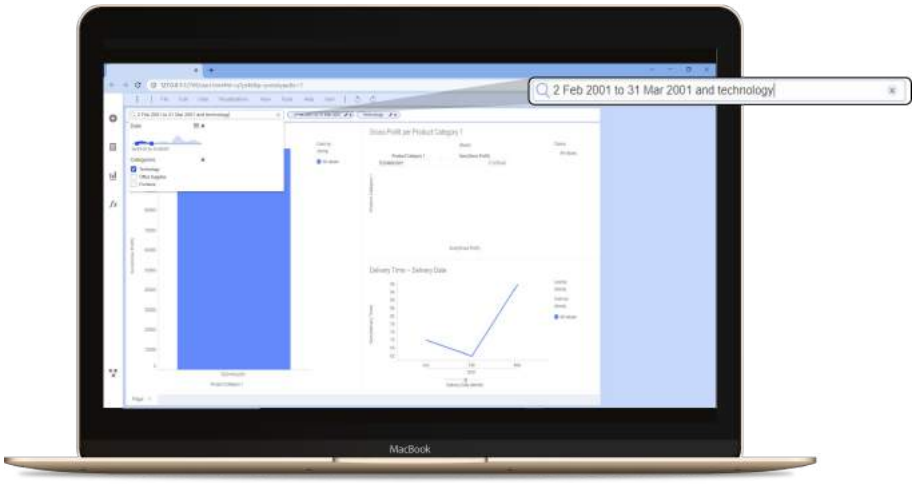


Figure 7.41: Example from the design where the user can edit the relationship between filters' through text input.

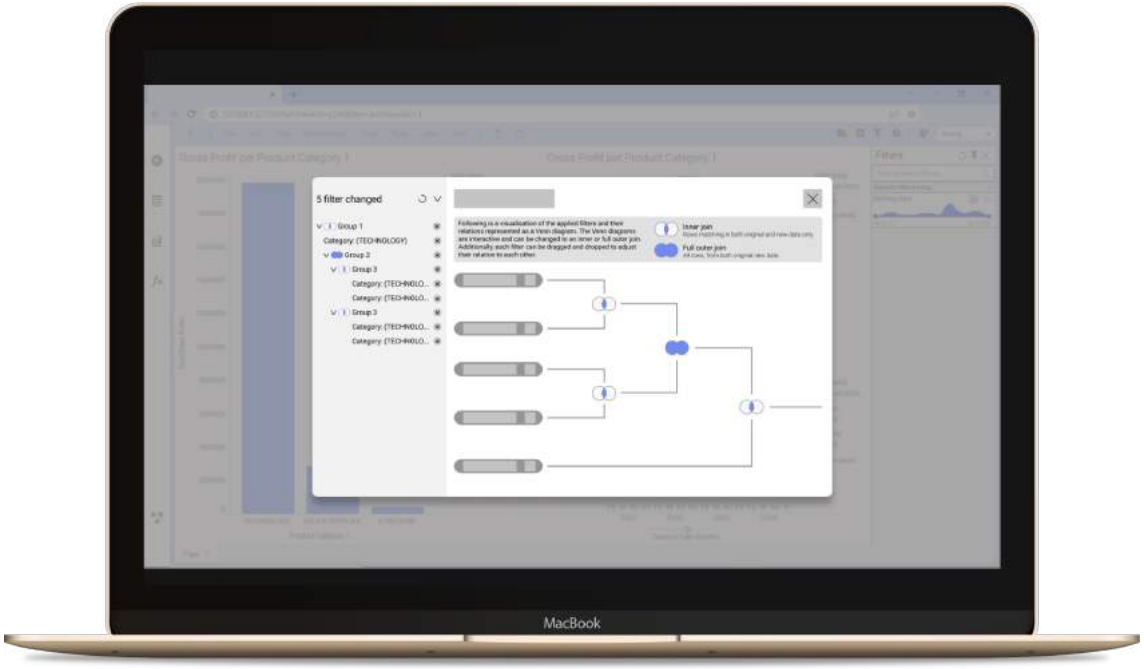


Figure 7.42: Example from the design where the user can edit the relationship between filters' through a dialogue window editor showing all applied filters.

8

Discussion

This chapter discusses ethical issues, potential future work of this master thesis as well as the final prototypes and the final set of guidelines. Additionally, what impact the reviewed literature, chosen methodology and execution and process had on the results are also reflected upon in the following chapter.

8.1 Execution and Process Discussion

The goal of the process was to answer the posed research question *"What should be considered when designing filtering for an analytic software?"*. Many master theses have been conducted in collaboration with The Company. These reports have been read and analysed during the project, and the previous theses planning was read when creating the project proposal. However, the previous master theses discussion and conclusion should have been read before making the initial plan to gather their insights and on their process and update the plan accordingly.

The project started with four weeks of Pre-study, where the project's scope was quite broad. The scope has been relatively broad throughout the project, with some delimitations made along the way. The initial plan was first to have a broad perspective and then narrow down the project's scope. However, during iteration two, a choice to continue with three scopes was decided based on the results and interest. This resulted in many different conceptual ideas and allowed for creativity in different areas, meaning many valuable prototypes and ideas that are possible to implement and ideate upon further were defined. However, this broad scope resulted in less developed prototypes that could be evaluated and updated further. Thereby the project's final and last evaluation was more formative than summative. Suppose the project's scope had been limited further during the project, it could have resulted in higher fidelity prototypes and guidelines that would have been evaluated to a greater extent. However, we are satisfied with the choice of keeping a broad scope since more aspects were covered. It would have been difficult to narrow down the scope earlier since all the scopes felt essential and relevant to the project and were challenging to rank.

Including the users' opinions and thoughts to a greater extent would have been valuable. Early in the project, interviews were conducted with internal stakeholders at the company, such as Product Managers who have consistent communication with users and thereby tried to mirror their opinions in the project. However, including

actual end-users would have resulted in their opinions and thoughts not being interpretations. Additionally, the final prototypes were tested through the User Testing portal. A restriction was made that only participants with analytic software knowledge were allowed to conduct the test, which enhanced the users to be possible product end-users. However, including end-users throughout the process could have increased the final results' chances of satisfying their needs and requirements. However, including end-users in the process can be a risk since users sometimes find it hard to know what they need. Thereby, the choice to include Product Managers to mirror the users' opinions felt like a suitable choice, especially since it is challenging and time-consuming to include actual end-users since they are difficult to recruit and schedule a meeting with.

Lastly, some parts of the project have been conducted in a hybrid manner, partly due to The Company's restrictions and regulations based on the COVID-19 pandemic. The interviews with internal stakeholders at The Company performed during iteration one, see Section 6.2.1, were all digital. Our perception was that all interviewees felt relaxed and talked without any limitations even though they were digital; however, conducting the interviews face to face might have increased the possibility to e.g. perceive the interviewees body language. The workshops conducted with internal stakeholders at The Company (W1 & W2) were conducted in a hybrid format. The hybrid setting could have affected the design workshops since the goal of the design workshops was to be creative and innovative. The creativity might have been limited since discussion and interactions can be restricted. Due to that, conducting the design workshops at The Company in a physical setting could have been valuable. However, since The Company is an international company, the participant is used to conducting interviews and workshops digitally, facilitating the process.

8.2 Discussion of the Results

The following section discusses the final prototypes design and the final set of developed guidelines. The produced results are a reflection of the gained knowledge gathered throughout the project and should be used as a foundation for future work and possible implementation in The Product.

8.2.1 Final Design

The final design of this thesis consists of three different prototypes within three different scopes related to the research question. The fidelity of the scopes' final prototypes differs. The Date Picker and Search & Filters prototypes were of high fidelity, whereas the Filters' Relation (AND/OR) was more conceptual. The high-fidelity prototypes were interactive but only to some extent. The Date Pickers interactive prototype was interactive for one unique case. The Search & Filter prototype was only interactive for one case without the possibility of typing into the search field. This decision was made since there are various ways to filter through text input, and implementing these seemed time-consuming for its value. Therefore, a choice was made to make the prototypes interactive to a limited extent that seemed suitable

for the project and the prototype's purpose. The final solution for Filters' Relations was a conceptual design in the form of a low-fidelity prototype. The final result was not evaluated, and thereby the validity of the result cannot be argued to the same extent. The prototype could have been tested to a greater extent to evaluate its usability and value, even though this was strengthed throughout the process. Incorporating the possibility to filter with an OR relationship can be very complex for cases where many filters are applied. However, our advisor expressed that having a solution that works for general cases will be valuable for a majority of the use cases since a detailed solution to this wicked problem would have been excessively time-consuming. Due to that, the conceptual solution for the Filters' Relation could have been developed further and evaluated to a greater extent; however, it has been strengthed its importance and value throughout the project.

The final design of the Date Picker got great feedback, on the overall filter experience, during the final user testing and received a 5/5 average score. However, one participant explicitly wondered how an added range relates to an existing range. The participant in the question discussed whether or not two ranges can overlap. However, a decision has not been made due to insufficient knowledge and evaluations. Due to that, this is something that should be further explored. A user suggested incorporating the possibility to filter on business days during the final evaluation, which was incorporated into the final design. This was a valuable idea however, and there might be other similar filter selections, such as selecting school breaks or only women, that have not been investigated and might be relevant for some users. It would have been interesting to evaluate and investigate further this sort of filter selection.

The final design of the Search & Filter got a relatively high average score of 4.2/5 on the user's response to the overall experience. The majority of the participant gave an overall experience score of 5; however, one user stated that he would have been afraid to use the Search & Filter since he did not trust and understand what vocabulary was applicable and that all data would be covered. He thereby mentioned how he would prefer using the filter panel for a greater feeling of control. This was a similar concern stated by one internal stakeholder who stated that she would be unsure if all the wished data would be selected when applying filters through text. However, the Search & Filter design was overall received as a good user experience but ensuring the user that all relevant data is shown in by the Search & Filter is an aspect that should be worked on further.

Additionally, the white space to the right in the Search & Filter dropdown was in the final result left empty. The initial plan was to include the visualisation of Filters' Relation final solution, but since it was only developed to a lower fidelity and conceptual level, a choice not to include it in the final result was made. The final result was left with an empty white space that could be designed and evaluated further as future work.

8.2.2 Guidelines

The final set of guidelines includes eleven guidelines, where six are more general guidelines for designing filters for analytic software, and five are more scope-specific guidelines. The guidelines have been iterated throughout the project based on insights gained during the Pre-study and process while designing and evaluating the prototypes. Since the guidelines have been defined and developed continuously throughout the project, the guidelines have strongly impacted the final prototypes. For example, *G8. Allow a non-technical vocabulary* is more effortlessly applicable if the analytic tool has a text input functionality such as the Search & Filter result. Some of the guidelines can thereby be argued to be more efficiently applicable in specific contexts. However, the purpose of the guidelines is to be useful when designing filters for analytics software. Similarly, a great extent of the guidelines is so general that they probably are applicable in other contexts. Many of the guidelines may be useful when designing filters for e-commerce and other platforms that may require filters in a complex context.

Due to the iterative design process, all guidelines have been iterated upon. The majority of the guidelines have support from both literature and the process, indicating that most of the guidelines' validity can be argued from both a general filter perspective and an analytic perspective. This is since the literature is based to a great extent on filters in general. Similarly, the process has primarily included internal stakeholders, meaning participants with an analytic perspective on filters. The final result can be considered a final set of guidelines when designing filters for analytic software that has been evaluated, but the guidelines could also be strengthed further. Each guideline could be analysed and developed to reach a more elevated level of explicitness. Similar and overlapping guidelines could be distinguished to a greater extent or be merged into one, e.g. *G9. Suggest relevant ways forward* and *G10. Indicate filters' relationship* that overlaps to a significant degree. In conclusion, we are satisfied with the final set of guidelines since they are strengthed to a great extent based on the literature study and iterative design process.

8.2.3 Validity and Generalisation of the Result

The aim of the master thesis is, as previously mentioned, to answer the posed research question with a set of guidelines defined through research and continuously while ideating upon different concepts. The process and journey toward the result can be generalised and applied to a similar project as a foundation and inspiration. The thesis process, see Chapter 6, could be read and generalised and valuable for similar projects.

The final set of guidelines can be seen as a generalised contribution and result since the guidelines should be possible to apply in different contexts and other analytical softwares. However, the validity of the thesis result is arguable to some extent. It would be valuable to evaluate the language of the guidelines further to ensure that they are understandable. Another aspect that might affect the validation of the thesis and result is the size of the thesis and how it has been conducted in combina-

tion with The Company. The process and results, such as prototypes and guidelines, have been affected by the collaboration. This can be argued both negative and positive since an analytic software has significantly influenced the result. However, by solely being affected by one, the generalisation of the result is arguable. Due to that, it would have been good to evaluate the result further with another analytic software to ensure the generalisation and validity.

8.3 Ethical Issues

During the Pre-study of the project, ethical aspects were explored, see Section 1.2. Some of the aspects brought up were privacy, representation of filters and an accessible design. The ease of use of the design has been in mind to some extent throughout the project since the goal has been to define guidelines to help when designing filters for an analytic software. *G2. Provide a well-designed UI with carefully crafted micro interactions*, *G3. Indicate possible interactions* and *G4. Provide resettable filters* are both guidelines that take the design and ease of use in mind to empathise the importance of creating an intuitive UI that is accessible. The final set of guidelines can be seen as complementary to general UI guidelines, meaning guidelines referring to for example using colours or sizes that are accessible for people with visual impairment is implied.

There has been communication and transparency with the participants throughout the project about how the gained insights will be used. This was to ensure that the participants knew what their insights were leading to and so that they would feel more comfortable attending. All participants were also informed of their rights to leave and stop whenever they wanted to not feel forced to participate in the activity. Transparency is essential in the process as well as in the product. Due to that, it is crucial to keep in mind when designing filters for an analytic software. Especially it is essential to have in mind if any specific filters are recommended or somehow highlighted. There are primarily two guidelines that refer to guiding the user forward and giving suggestions; *G9. Suggest relevant ways forward* and *G11. Provide shortcuts for common selections*. By providing ways forward and shortcuts, there is a possibility to mislead the user and create and skew the user's use of filters. This is a crucial aspect to consider when designing filters to prohibit the possibility of companies hiding information by misleading the user. If a design allows this, the user could be led in different directions, so they do not immediately think of other ways to filter the data, revealing essential insights and information. Thereby the guidelines can be interpreted and applied in a way that might negatively affect the user. Therefore, it is crucial to consider the meaning of the guideline and how it could negatively affect the user if interpreted and poorly implemented. This aspect has been in mind during the project but should be kept in mind in future work as well.

8.4 Future Work

The guidelines and design were developed simultaneously, meaning that the guidelines had the same focus depending on the scope and orientation the design process headed towards. This meant that some exciting concepts regarding filters were identified but were not always investigated in further detail. However, it is essential to remember that they are still of relevance and should be considered when designing filters for future work.

One area that was not covered in this thesis but that was mentioned by a few of the interviewees when conducting the internal stakeholders' interviews was the importance of being able to quickly indicate to the user what filters are applied, see Section 6.2.1. This scope was not ideated upon further during the project since in iteration one when the scope was narrowed down, it was decided to be outside of the scope of the rest of the project, see Section 6.1.4 for more information. However, this area is highly relevant and should be investigated further. Similarly, incorporating AI into the filter experience is another possible direction brought up during the process that was not examined. It would have been interesting to investigate further how AI can be used to suggest suitable filters and filter combinations for the current data to guide the user towards relevant and wished information. Except for exploring other areas that were not covered during the thesis, future work should additionally focus on developing the current designs and guidelines further. For example, creating a higher-fidelity prototype for Filters' Relations should be created, and this is to be able to evaluate and improve the solution further. Additionally, investigating how multiple time ranges should relate to each other, and be visualised, in the Date Picker should be considered.

As previously mentioned, the guidelines could be iterated on further. An evaluation of the guidelines can be relevant to ensure that they are clear and present the intended purpose. Some guidelines overlap to some extent, and those could be considered to be merged or distinguished further, such as, e.g. *G9. Suggest relevant ways forward* and *G10. Indicate filters' relationship*. The guidelines' validation could also be confirmed to a greater extent by confirming the guidelines with additional sources. However, in general, more evaluations of both the designs and guidelines should be performed since the number of evaluations and user tests performed in this thesis is not enough for drawing reliable conclusions.

9
Conclusion

This thesis' purpose has been to explore three different contexts related to filtering analytic software to support the analysis of data effectively. The following research question has been aimed to answer:

What should be considered when designing filtering for an analytic software?

The thesis followed the research through design approach to answer the research question, including an iterative design process. The process consisted of four weeks of Pre-study, followed by three design iterations. The goal was to answer the research question by developing a set of defined guidelines while simultaneously designing an improved concept and conducting research within the field. The project's improved concept resulted in three prototypes: Date Picker, Search & Filter and Filters' Relation. The final set of guidelines was sorted into two categories, *Filter Functionality and Design Guidelines* and *Scope Specific Guidelines*, and are stated as follows:

Filter Functionality and Design Guidelines

G1. Provide an overview of the distribution.

G2. Provide a well designed UI with carefully crafted micro interactions.

G3. Indicate possible interactions.

G4. Provide resettable filters.

G5. Provide the possibility to filter iteratively.

G6. Provide direct manipulation with instant feedback.

Scope Specific Guidelines

G7. Provide precise endpoint selection.

G8. Allow a non-technical vocabulary.

G9. Suggest relevant ways forward.

G10. Indicate filters' relationship.

G11. Provide shortcuts for common selections.

Future work should focus on generating more user tests as well as elaborating further on other areas of filtering that were excluded from this thesis. To conclude, the design and guidelines created serve as a concept aiming to support the design of filtering in an analytic software. This thesis has answered the research question by providing guidelines defined while designing improved concepts simultaneously and conducting research within the field.

References

[1] Intellipaat, "What is spotfire?" 10 Nov 2021. [Online]., availiable: https://intellipaat.com/blog/what-is-spotfire/, Accessed on: 2021-10-11.

[2] C.Ahlberg & B.Schneiderman, "Visual information seekin: Tigh coupling of dynamic query filters with starfield displays," 24-28 April 1994. [Online]., availiable: https://doi.org/10.1145/191666.191775, Accessed on: 2021-12-03.

[3] J. J. Thomas, "Illuminating the path:[the research and development agenda for visual analytics," 2005. [Online].

[4] Enlyft, "Companies using tibco spotfire," 2020. [Online]., accessed: https://enlyft.com/tech/products/tibco-spotfire, Accessed: 2021-12-03.

[5] SAS, "Big data. what it is and why it matters," 10 Nov 2021. [Online]., availiable: https://www.sas.com/en_us/insights/big-data/what-is-big-data.html, Accessed on: 2021-10-11.

[6] R. Chang, C. Ziemkiewicz, T. M. Green, and W. Ribarsky, ""defining insight for visual analytics"," 2009. [Online].

[7] F. Vassilatos & C. Crawshaw, "Ux pattern analysis: Enterprise filtering," 24 March 2021. [Online]., available: https://pencilandpaper.io/articles/user-experience/ux-pattern-analysis-enterprise-filtering/, Accessed on: 2021-10-11.

[8] W. Cui, "Visual analytics: A comprehensive overview„" *in IEEE Access*, vol. 7, 2019, pp. 81555-81573.

[9] N. Steele, "Maintaining your online privacy," May, 28, 2021. [Online], Available: https://www.nist.gov/blogs/manufacturing-innovation-blog/maintaining-your-online-privacy, Accessed on: 2022-02-08.

[10] J. Heer & B. Shneiderman, "Interactive dynamics for visual analysis," vol. 10, 2012.

[11] enlyft, "Companies using tibco spotfire," 2020. [Online]., accessed: https://enlyft.com/tech/business-intelligence, Accessed: 2021-02-11.

[12] M. Sparkman, D. Mabee, T. Sherer & K. Sharkey, "Types of filters in power bi reports," *Microsoft*, [Online]. April 2021., available: https://docs.microsoft.com/en-us/power-bi/create-reports/power-bi-report-filter-types, Accessed on: 2022-01-24.

[13] Microsoft, "What is power bi?" Jan, 29, 2022. [Online], Available: https://docs.microsoft.com/en-us/power-bi/fundamentals/power-bi-overview, Accessed on: 2022-01-18.

[14] Data Flair, "Filter pane in qlik sense – properties, pros, & cons," [Online]. April 2021., available:

https://data-flair.training/blogs/filter-pane-in-qlik-sense/, Accessed on: 2022-01-24.
[15] QlikTech International AB, "Qlik sense," 2022. [Online], Available: https://www.qlik.com/us/lp/ppc/qlik-sense-business/brand?, Accessed on: 2022-01-29.
[16] Qlik Help, "Filter pane - qlik sense," [Video]. Youtube, Aug. 2019. Available: https://www.youtube.com/watch?v=Qyzoat9EtRQ.
[17] Tableau, "Filter data from your views," [Online]. April 2021., available: https://help.tableau.com/current/pro/desktop/en-us/filtering.htm, Accessed on: 2022-01-24.
[18] Tableau Software, "What is tableau?" 2022. [Online], Available: https://www.tableau.com/why-tableau/what-is-tableau, Accessed on: 2022-01-1X.
[19] N. Yau, "Visualize this: The flowingdata guide to design, visualization, and statistics," 2015.
[20] Thomas, J. & Cook, K., "Illuminating the path: Research and development agenda for visual analytics," *IEEE-Press*, 2005.
[21] Lonsdale, M. D. S., & Lonsdale, D, "This is a repository copy of design2inform: Information visualisation," . *The Office of the Chief Scientific Advisor*, 2019.
[22] T. J. Brigham, "Feast for the eyes: An introduction to data visualization," *Medical Reference Services Quarterly*, vol. 35, pp. 215–223, 2016.
[23] Bursi-Amba, A., Gaullier, A. & Santidrian, M. , "Infographics: A toolbox for technical writers?" 2016, Paris: Diderot University.
[24] S. Negash & P. Gray, "Business intelligence," *in Handbook on Decision Support Systems 2*, Springer, 2008, pp. 175–193.
[25] D. Loshin, "Business intelligence : The savvy manager's guide," san Francisco, CA: Elsevier Science & Technology, 2012.
[26] D. Seminar, "User experience white paper," *All About UX*, Jan, 11, 2011. [Online], Available: http://www.allaboutux.org/files/UX-WhitePaper.pdf, Accessed on: 2022-01-27.
[27] Interaction Design Foundation, "User experience (ux) design," (n.d). [Online], Available: https://www.interaction-design.org/literature/topics/ux-design, Accessed on: 2022-02-05.
[28] L. Alben, "Quality of experience: Defining the criteria for effective interaction design," *Interactions*, vol. 3, p. 11–15, May, 1996. [Online], Available: https://dl.acm.org/doi/10.1145/235008.235010, Accessed on: 2022-01-28.
[29] Usability Professionals Association, "Glossary," 2010. [Online], Available: http://www.usabilitybok.org/glossary, Accessed on: 2022-01-26.
[30] D. Norman & J. Nielsen, "The definition of user experience (ux)," *Nielsen Norman Group*, [Online]. Dec 2017, available: https://www.nngroup.com/articles/definition-user-experience/, Accessed on: 2022-01-27.
[31] K. Moran, "Defining helpful filter categories and values for better ux," *Nielsen Norman Group*, July, 15, 2018. [Online], Available:

https://www.nngroup.com/articles/filter-categories-values/, Accessed on: 2022-01-27.

[32] Baymard Institute, "How do users scan, filter and browse your search results and category pages?" *Baymard Institute*, (n.d). [Online], available: https://baymard.com/research/ecommerce-product-lists, Accessed on: 2022-01-29.

[33] K. Shokurova, "9 filtering design best practices to improve e-commerce ux," *UX Planet*, Mar, 11, 2020. [Online], Available: https://uxplanet.org/9-filtering-design-best-practices-to-improve-e-commerce-ux-edac50560f94, Accessed on: 2022-01-27.

[34] Asos, 2022. [Online], Available: https://www.asos.com/, Accessed on: 2022-02-14.

[35] L. Cuncha, "How to craft a kickass filtering ux," *UX Collective*, Mar, 2, 2017. [Online], available: https://uxdesign.cc/crafting-a-kickass-filtering-ux-beea1798d64b, Accessed on: 2022-01-29.

[36] Momondo, "Välkommen! hitta ett flexibelt flyg för din nästa resa." *Momondo*, 2022. [Online], Available: https://www.momondo.se/, Accessed on: 2022-02-14.

[37] C. Holst, "The current state of e-commerce filtering." *Smashing Magazine*, Apr, 20, 2020, [Online]. Available: https://www.smashingmagazine.com/2015/04/the-current-state-of-e-commerce-filtering/, Accessed on: 2022-01-26.

[38] ——, "Filter ui design: A horizontal toolbar can outperform the traditional sidebar," *Baymard Institute*, May, 5, 2015. [Online], available: https://baymard.com/blog/horizontal-filtering-sorting-design, Accessed on: 2022-01-29.

[39] L. Vollaire A. & Prakhorova, "Search filters: 5 best practices for a great ux," Mar, 27, 2020. [Online], available: https://www.algolia.com/blog/ux/search-filter-ux-best-practices/, Accessed on: 2022-01-29.

[40] V. Friedman, "Frustrating design patterns: Broken filters," *Smashing Magazine*, Jul, 14, 2021. [Online], available: https://www.smashingmagazine.com/2021/07/frustrating-design-patterns-broken-frozen-filters/, Accessed on: 2022-01-29.

[41] C. Frayling, "Research in art and design," *in Royal College of Art Research Papers*, vol. 1, Royal College of Art, 1993.

[42] W. W. Gaver, "What should we expect from research through design?" *Confer- ence on Human Factors in Computing Systems - Proceedings,*, May. 2012.

[43] J. Zimmerman, J. Forlizzi, & Shelley Evenson, "Research through design as a method for interaction design research in hci." *in Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, san Jose, California, USA. April 2007, pp.493-502.

[44] H. Rittel & M. M. Webber, "Dilemmas in a general theory of planning," *Policy Sciences*, vol. 4, no. 2, 1973. pp. 155-169.

[45] Interaction Design Foundation, "What are wicked problems?" 2022, [Online]. Available: https://www.interaction-design.org/literature/topics/wicked-problems, (Accessed on: 2022-01-26).
[46] R. Buchanan, "Wicked problems in design thinking." *Design Issues*, vol. 8, 1992. pp. 5-21.
[47] J. C. Jones, "Design methods." *John Wiley & Sons, Inc*, 1992.
[48] E. Wong, "What is a wicked problem and how can you solve it?" *Interaction Design Foundation*, 2021. [Online], available: https://www.interaction-design.org/literature/article/wicked-problems-5-steps-to-help-you-tackle-wicked-problems-by-combining-systems-thinking-w Accessed on: 2022-01-29.
[49] Interaction Design Foundation, "Design iteration brings powerful results. so, do it again designer!" 2021, [Online]. Available: https://www.interaction-design.org/literature/article/design-iteration-brings-powerful-results-so-do-it-again-designer, (Accessed on: 2022-01-29).
[50] J. Nielsen, "Agile development projects and usability," *Nielsen Norman Group*, Nov, 16, 2008. [Online], Available: https://www.nngroup.com/articles/agile-development-and-usability/, Accessed on: 2022-02-05.
[51] A. Cooper, R. Reimann, D. Cronin & C. Noessel, "About face : The essentials of interaction design," 4th ed. John Wiley & Sons, Incorporated, 2014.
[52] Design Council, "What is the framework for innovation? design council's evolved double diamond," (n.d). [Online], Available: https://www.designcouncil.org.uk/news-opinion/what-framework-innovation-design-councils-evolved-double-diamond, Accessed on: 2022-02-05.
[53] Interaction Design Foundation, "What is design thinking?" 2022, [Online]. Available: https://www.interaction-design.org/literature/topics/design-thinking, (Accessed on: 2022-01-29).
[54] R. F. Dam, "5 stages in the design thinking process," *Interaction Design Foundation*, 2021, [Online]. Available: https://www.interaction-design.org/literature/article/5-stages-in-the-design-thinking-process, (Accessed on: 2022-01-29).
[55] S. Gibbons, "Design thinking 101," *Nielsen Norman Group*, [Online]. July 2016., available: https://www.nngroup.com/articles/design-thinking/, Accessed on: 2022-01-19.
[56] S. Gupta, "What are the 5 stages of design thinking?" *Springboard*, July 2020. [Online], Available: https://www.springboard.com/blog/design/design-thinking-process/, Accessed on: 2022-01-26.
[57] S. Gibbons, "Empathy mapping: The first step in design thinking," *Nielsen Norman Group*, [Online]. Jan 2018., available:

https://www.nngroup.com/articles/empathy-mapping/, Accessed on: 2022-01-19.

[58] B. Martin & B. M. Hanington, "Universal methods of design : 100 ways to research complex problems, develop innovative ideas, and design effective solutions„" *Quarto Publishing Group USA*, 2012.

[59] J. DaSilva, "A guide to competitive analysis for ux design," *Adobe*, Jun, 12, 2020. [Online], Available: https://xd.adobe.com/ideas/process/user-research/guide-to-competitive-analysis-ux-design/, Accessed on: 2022-02-07.

[60] S. Gibbons, "User need statements: The 'define' stage in design thinking," *Nielsen Norman Group*, [Online]. March 2019., available: https://www.nngroup.com/articles/user-need-statements/, Accessed on: 2022-01-19.

[61] LUMA Institute, "Rose, thorn, bud," *Google Design Sprints*, (n.d). [Online], Available: https://designsprintkit.withgoogle.com/methodology/phase1-understand/rose-thorn-bud, Accessed on: 2022-03-02.

[62] M. Christensen, "Impact mapping," *Agile UX Impacts*, Dec, 13, 2016. [Online], Available: https://agileux.se/impact-mapping/, Accessed on: 2022-03-02.

[63] A. Harley, "Ideation in practice: How effective ux teams generate ideas," *Nielsen Norman Group*, [Online]. Oct 2017, available: https://www.nngroup.com/articles/ideation-in-practice/, Accessed on: 2022-01-27.

[64] R. F. Dam & T. Y. Siang, "Introduction to the essential ideation techniques which are the heart of design thinking," *Interaction Design Foundation*, [Online]. Jan 2022, available: https://www.interaction-design.org/literature/article/introduction-to-the-essential-ideation-techniques-which-are-the-heart-of-design-thinking, Accessed on: 2022-01-16.

[65] M. Weprin, "10x10 sketch method," *Medium*, 2022, [Online]. Available: https://mweprin.medium.com/10x10-sketch-method-9c662656d67d, (Accessed on: 2022-03-02).

[66] E. Chung, "Generate crazy ideas with this design sprint method," *UX Planet*, Jul, 30, 2020. [Online], available: https://uxplanet.org/generate-crazy-ideas-with-this-design-sprint-method-c6a36a16c3d5, (Accessed on: 2022-03-02).

[67] Google, "Solution sketch," *Google Design Sprints*, (n.d), [Online]. Available: https://designsprintkit.withgoogle.com/methodology/phase3-sketch/solution-sketch, (Accessed on: 2022-03-02).

[68] R. F. Dam & T. Y. Siang, "Stage 4 in the design thinking process: Prototype," *Interaction Design Foundation*, [Online]. Jan 2022, available: https://www.interaction-design.org/literature/article/stage-4-in-the-design-thinking-process-prototype, Accessed on: 2022-01-16.

[69] R. Krause, "Storyboards help visualize ux ideas," *Nielsen Norman Group*, [Online]. July 2018, available: https://www.nngroup.com/articles/storyboards-visualize-ideas/, Accessed on: 2022-01-30.

[70] UserTesting, "Usertesting," 2022. [Online], Available: https://www.usertesting.com/, Accessed on: 2022-03-15.
[71] R. F. Dam & T. Y. Siang, "Stage 5 in the design thinking process: Test," *Interaction Design Foundation*, [Online]. Jan 2022, available: https://www.interaction-design.org/literature/article/stage-5-in-the-design-thinking-process-test, Accessed on: 2022-01-17.
[72] Hartson et. al, "Chapter 13: Rapid evaluation methods," *in UX Book - Process and Guidelines for Ensuring a Quality User Experience.*, Elsevier, 2012, 467–503.
[73] Miro, "Miro," 2022. [Online], Available: https://miro.com/, Accessed on: 2022-01-29.
[74] Figma, "Nothing great is made alone," 2022. [Online], Available: https://www.figma.com/?fuid=, Accessed on: 2022-01-29.
[75] Axure Software Solutions, Inc, "Axure," 2022. [Online], Available: https://www.axure.com/, Accessed on: 2022-01-20.
[76] B. Kopf, "Figma vs. sketch vs. axure – a task-based review," *Toptal*, 2019. [Online], Available: https://www.toptal.com/designers/ux/figma-vs-sketch, Accessed on: 2022-01-20.
[77] ACM, Inc., "Acm digital library," 2022. [Online], Available: https://dl.acm.org/, Accessed on: 2022-02-28.
[78] Chalmers, "Chalmers library," 2022. [Online], Available: https://www.lib.chalmers.se/en/, Accessed on: 2022-02-22.
[79] Google LLC, "Google," 2022. [Online], Available: https://google.com/, Accessed on: 2022-02-28.
[80] YouTube, "Youtube," 2022. [Online], Available: https://www.youtube.com/, Accessed on: 2022-03-01.
[81] Markinblog, "List of largest ecommerce companies in the world in 2021 (ranked by revenue)," Sep 2021. [Online], Available: https://www.markinblog.com/largest-ecommerce-companies/, Accessed on: 2022-02-09.
[82] Amazon, 2022. [Online], Available: https://www.amazon.com/, Accessed on: 2022-02-15.
[83] Alibaba, 2022. [Online], Available: https://www.alibaba.com/, Accessed on: 2022-02-15.
[84] C. Zorzini, "60 amazing online fashion stores and their ux tricks you should steal," *Ecommerce platforms*, Sep 2021. [Online], Available: https://ecommerce-platforms.com/ecommerce-websites/independent-fashion-stores, Accessed on: 2022-02-09.
[85] K. Seemann, "The 13 best websites for booking flights at the cheapest prices [2021]," *Upgraded Points*, July 2021. [Online], Available: https://upgradedpoints.com/travel/best-websites-for-booking-cheap-flights/, Accessed on: 2022-02-09.
[86] D. J. Bland, "Assumtuons mapping," [Online], Available: https://designsprintkit.withgoogle.com/methodology/phase2-define/assumptions-mapping, Accessed on: 2022-02-08.

[87] L. Björk, M.Björk & C. Räisänen, “Academic writing: A university course,” vol. 3, 1996. [Online], Available: https://www.studentlitteratur.se/kurslitteratur/sprakvetenskap-och-sprakdidaktik/engelska/academic-writing/, Accessed on: 2022-02-07.

[88] Zara, 2022. [Online], Available: https://www.zara.com/se/en/, Accessed on: 2022-02-15.

[89] Ebay, 2022. [Online], Available: https://www.ebay.com/b/Camera-Drones/179697/bn_89951, Accessed on: 2022-02-15.

[90] Flygresor, 2022. [Online], Available: https://www.flygresor.se/showresult.php?id=691452673, Accessed on: 2022-02-15.

A

How to Conduct Interviews

How to conduct interviews

This document presents information about what to have in mind before, during, and after conducting an interview. The document includes information gathered first from the Nielsen and Norman Group than the Interaction Design Foundation before finally presenting a conclusion of compressed information from both sources.

1. Nielsen and Norman group

Below, some general information on how to conduct an interview and what to have in mind according to the Nielsen and Norman Group is presented [1].

GENERAL

- Give insights into what users think.
- Reflects users' perceptions and feelings about a process
- Interviews are a quick and easy way to get a sense of how users feel, think, and what they perceive to be true.
- Questions about a topic of interest → Filters

DURING

The user should be comfortable:

1. In the start explain the reason for the interview
2. Let users finish their thoughts. Do not interrupt them.
3. Don't rush the user.
4. Start with questions that are easy to answer and that are unlikely to be interpreted as personal or judgmental.
5. Show some empathy by asking related questions and recall to previous mentioned matters

PREPARATION

1. Prepare questions before the interview.
    a. This to ensure that
        i. Your questions will be answered
        ii. Your able to construct better non-leading (meaning open) questions
        iii. Overcome stress
2. Write dialog-provoking interview questions.
3. Avoid leading, closed, or vague questions.
4. Jog the memory by asking about **specific events** rather than about general processes
5. Prepare more questions than you believe you will have time to ask.
6. Set a **goal** for the interview.
    - *Learn about users* is to broad

- Example of good: *Find out how bicycle couriers get the best route directions, and what they feel works well, where they think there are issues, and how they think things could be improved*

KEEP IN MIND
Remember that humans memory is flawed
Participants don't know exactly what is relevant for the interviewer,
Not everybody are comfortable with sharing details

2. The Interaction Design Foundation

Below, some general information on how to conduct an interview and what to have in mind according to the Interaction Design Foundation is presented [2]. They mention how user interviews can be a great way to extract information from users for user experience understanding, usability understanding and ideation.

GENERAL
- Interviews tend to give insights into what people say they will do and this is sometimes (often even) not the same as what they actually do.
- Human beings have memory issues.
- Users aren't designers. Interviews should stick to concrete examination of what is happening and how the user feels.

PARTICIPANTS
- Ideal interview takes place with two UX researchers and one user
    - The first UX researcher focuses on asking questions and guiding the interviewee through the interview.
    - The second takes notes
        - If a second can not attend it could be good to record

TYPICAL TOPICS
- Background (such as ethnographic data)
- The use of technology in general
- The use of the product
- The user's main objectives and motivations
- The user's pain points

PREPARATION
- Recruitment
- Create a script
    - Start by explaining the purpose of the interview
    - Explain how the data will be collected
    - Leading questions

    - Keep the manuscript short so you don't read a text longer than 10 min
    - The script is only a guide

DURING

- Make your interviewee comfortable
- Try to focus on the interviewee and not on note making
- Thank the interviewee at the end of the process

3. Conclusion

A conclusion of how an interview should be conducted and what is essential to have in mind is presented. The conclusion is based on the previous information presented in sections one and two, Nielsen and Norman Group [1] and The Interaction Design Foundation [2].

PREPARATION

- Recruit participants
- Set a **goal** for the interview.
- Create a script. This to ensure that your questions will be answered.
    - Start by explaining the purpose of the interview
    - Explain how the data will be collected
    - Leading questions
    - Keep the manuscript short so you don't read a text longer than 10 min
    - The script is only a guide
    - Jog the memory by asking about **specific events** rather than about general processes
    - Prepare more questions than you believe you will have time to ask.

TYPICAL TOPICS

- Background (such as ethnographic data)
- The use of technology in general
- The use of the product
- The user’s main objectives and motivations
- The user’s pain points

DURING

- Make your interviewee comfortable
    - Let users finish their thoughts. Do not interrupt them.
    - Don’t rush the user.
- Try to focus on the interviewee and not on note making

References

[1] K. Pernice, “User Interviews: How, When, and Why to Conduct Them”, *Nielsen and Norman Group*, Oct 7 2018, [Online]. Available: https://www.nngroup.com/articles/user-interviews/, (Accessed on: 2022-02-14)
[2] Interaction Design Foundation, “How to Conduct User Interviews”, 2021, [Online]. Available: https://www.interaction-design.org/literature/article/how-to-conduct-user-interviews, (Accessed on: 2022-02-14)

B

Cognitive Walkthrough

Cognitive Walkthrough

This document presents the tasks and actions that are decided to be performed during an cognitive walkthrough evaluation. “The four questions to be asked during each action of a Cognitive Walkthrough” are retrieved from B. Martin & B. M. Hanington’s book “*Universal methods of design : 100 ways to research complex problems, develop innovative ideas, and design effective solutions*” as a foundation for understanding the user's thoughts and interactions during the evaluation process.

The Four Questions to be Asked during each action of a Cognitive Walkthrough

1. Will the user try and achieve the right outcome?
2. Will the user notice that the correct action is available to them?
3. Will the user associate the correct action with the outcome they expect to achieve?
4. If the correct action is performed; will the user see that progress is being made towards their intended outcome?

Task 1: Filter time range for the data to be between the 2nd of Feb and 2nd of May 2021.

Action 1: Press the filter symbol

Action 2: Press the calendar button

Action 3: Press next month button X times

Action 4: Press 2nd of Feb as start date

Action 5: Press next month button X times

Action 6: Press 2nd of May as end date

Action 2: Press the slider button and drag to 2nd of Feb

Action 3: Press end slider button and drag to 2th of May

Action 2: Press on the dates under the slider button

Action 3: Write start date

Action 4: Press date under end slider button

Action 5: Write end date

Action 1: Press down arrows

Action 2: Press text input area

Action 3: Write expression

Action 4: Select selection

Task 2: Filter the top right visualization further by adding an additional range between 1st of December to 30th December.

Action 1: Press down the date filter done

Action 2: Drag the date filter done to the top right visualization

Action 3: Drop the date filter done on the top right visualization

Action 4: Press the pen/gear button

Action 5: Select the date as in previous task

Task 3: Filter data to December and iPhone with help of the text input filter on the page.

Action 1: Press down arrows

Action 2: Press text input area

Action 3: Write expression: 2010 iPhone & Samsung

Action 4: Select selection (press enter)

Action 3: Write expression: 2010 iPhone

Action 4: Press Samsung with help of the checkbox in drop down menu

Action 5: Select selection (press enter)

Task 4: Add a new date range from 10th to 12th of June 2021.

Action 1: Press the filter symbol or the arrows on top of the page

Action 2: Press the calendar button

Action 3: Press Add Range

Action 4: Press next month button 3 times

Action 5: Press 10th of June as start date

Action 6: Press 12th of June as end date

Action 2: Press on the slider range to create a break point

Action 3: Press the slider button and drag to 10th of June 2021

Action 4: Press end slider button and drag to 12th of June 2021

Action 2: Press on the slider range to create a break point

Action 3: Press on the dates under the slider button

Action 4: Write start date 100621

Action 5: Press date under end slider button

Action 6: Write end date 120621

Action 1: Press down arrows

Action 2: Press text input area

Action 3: Write expression

Action 4: Select selection (press enter)

Task 5: Add a recurring time range of every Saturday.

Action 1: Press the filter symbol or the arrows on top of the page

Action 2: Press the calendar button

Action 3: Press the Repeat button

Action 4: Press the S button

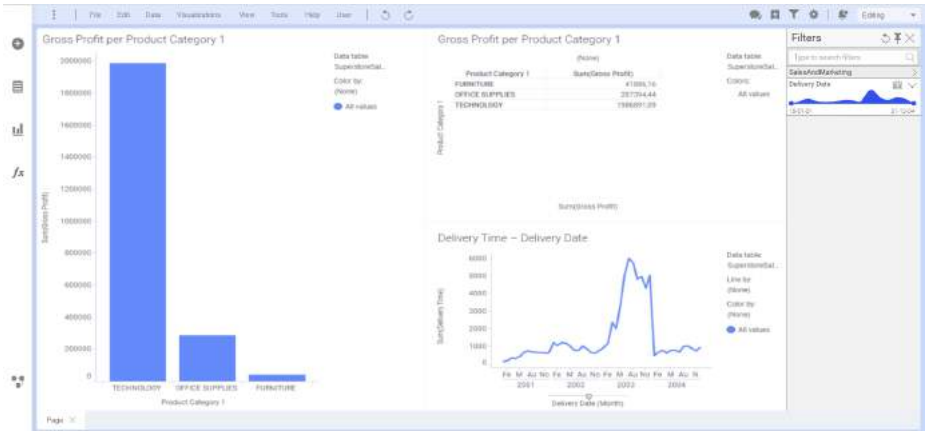
C

Date Picker - User Testing

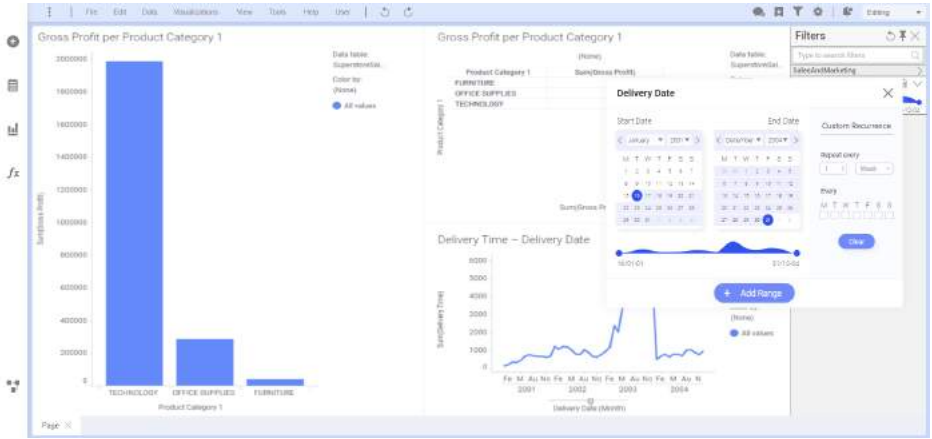
***Usertesing.com*:**This document presents the tasks and actions that are decided to be performed during an evaluation conducted through the platform User Testing used by The Company. Verbal answers are expected for most of the tasks to gain an understanding of the user's thoughts and opinions of the prototype and in general the evaluation.

***Purpose of test*:** See if the users understand how the filter time and add several ranges and with specific selections.

***Scenario*:** You are working at a warehouse that sells Furniture, Technology and Office Supplies. You have received data from the early 2000s with the company's Gross Profit and Delivery Time during that period. Your task is to get an understanding of the data and compare the gross profit between different time ranges.

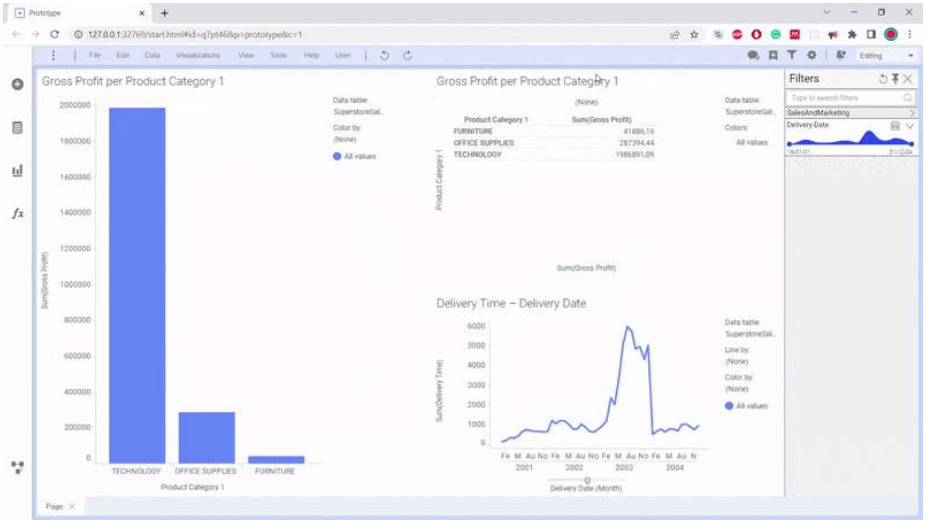


1: Startpage of prototype with open filter pane
Q: Please describe what you see on the screen?
Q: How would you perform the task *“Filter a time range for the data to be between the first of February 2001 to last of December 2001”*?



2: Pop up

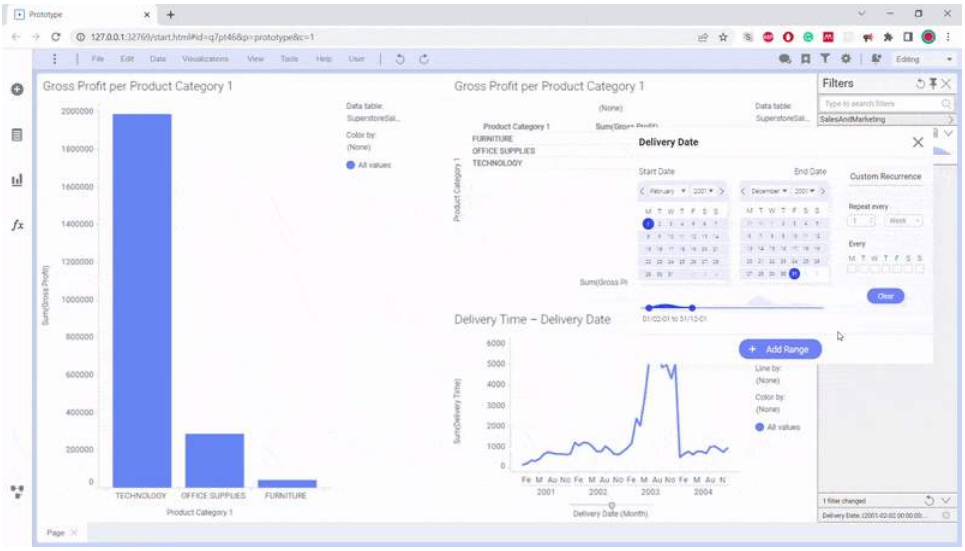
Q: Please describe what sort of interactions you think is possible in the pop-up and elaborate what you think will happen?
Q: If you got the task again to *“Filter a time range for the data to be between the first of February 2001 to last of December 2001”* how would you do it?



Explanation: The video represents one way of selecting the given time range of first of February 2001 to last of December 2001.

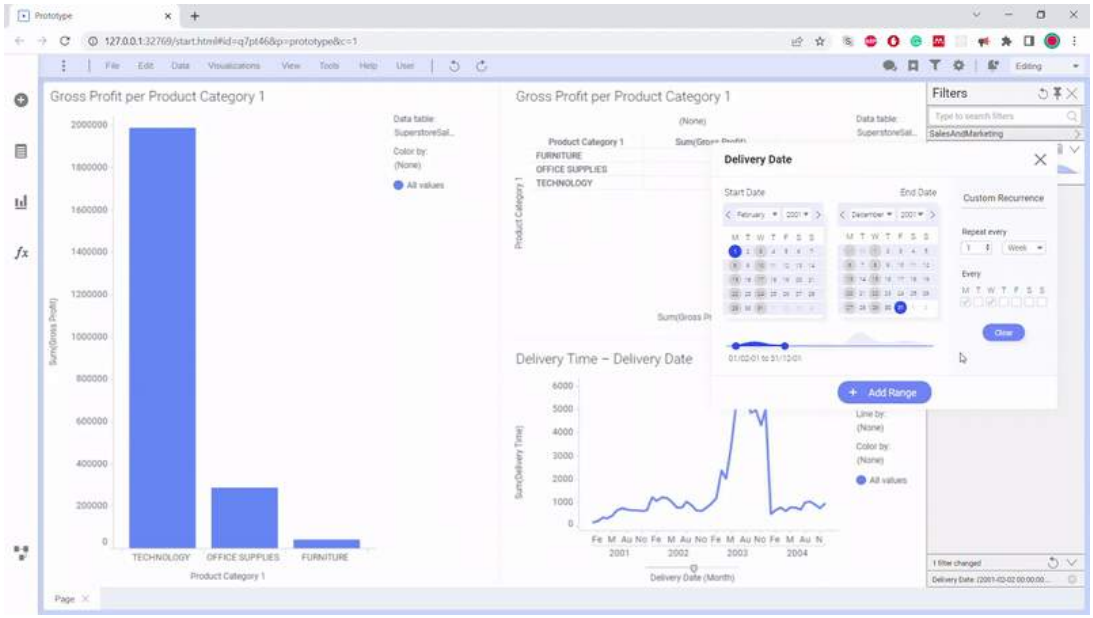
Q: Please describe what you think has happened in the pop-up?
Q: Please describe what you think has happened to your data?
Q: Please describe how you would select only data of specific days within the interval e.g. only Mondays and Wednesdays?

3. Video of selecting Mondays and Wednesdays.



Q: Please describe what has happened and if it was what you expected?
Q: How would you perform the task to select an additional time range?
Q: If you add an additional time range, how would you expect it to affect the data and be shown in the visualisations?

4. Video of adding another time range.



Q: Please describe what you think has happened to your data and if it was what you expected?

5:Likert and final:
Q-Scale-1-5: As a User, how satisfied are you with the possibility to filter a time range using the date picker popup, shown in this test?
Q: If you had a magic wand, what would you change about this solution?
Q: Do you have any other comments you'd like to share with us?

D

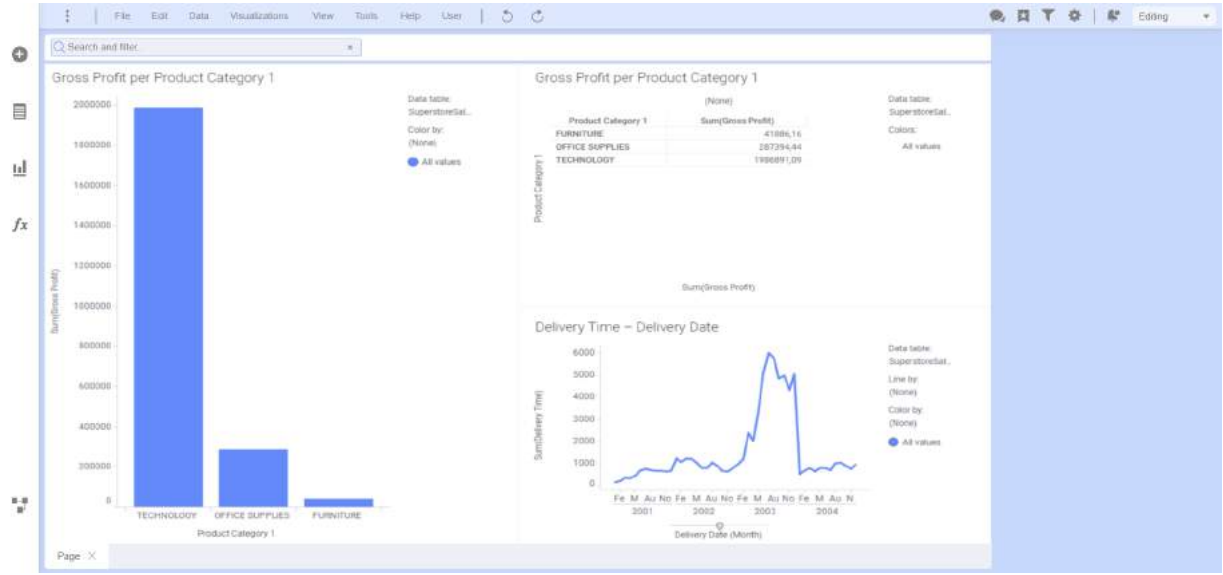
Search & Filter - User Testing

***Usertesing.com*:**This document presents the tasks and actions that are decided to be performed during an evaluation conducted through the platform User Testing used by The Company. Verbal answers are expected for most of the tasks to gain an understanding of the user's thoughts and opinions of the prototype and in general the evaluation.

***Purpose of test*:** See if the users understand how the search and filter works and how it can be used and interacted with.

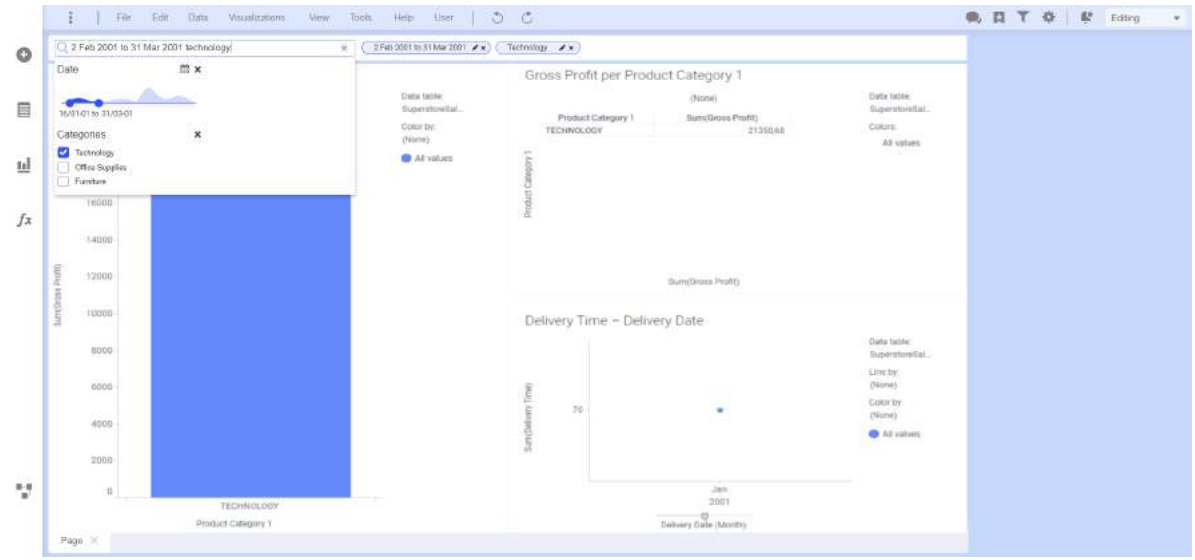
Scenario: You are working at a warehouse that sells Furniture, Technology and Office Supplies. You have received data from the early 2000s and the company's Gross Profit and Delivery Time during that period. Your task is to get an understanding of the data to be able to compare it to today's business.

1: Startpage of prototype

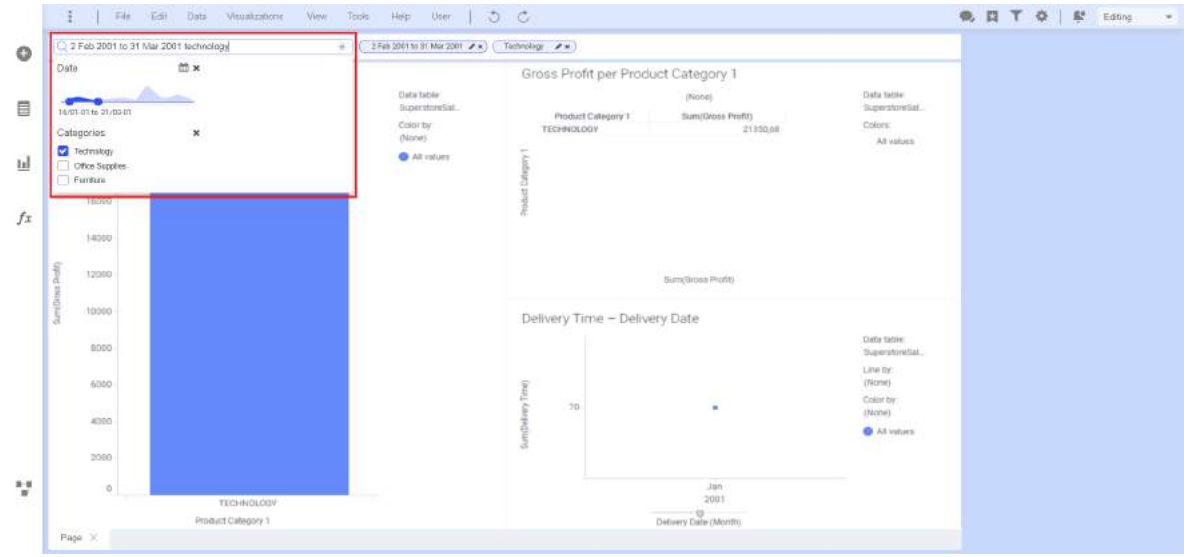


Q: Please describe what you see on the screen
Q: Please describe what you think is possible to do with the “Search and filter…” UI element?
Q: Write explicitly in this text box what you would have used the “Search and filter…” UI element for, to get an improved understanding of the data. E.g write your input text.
Q: What would you have expected as a result of what you wrote in the previous question?
Q: If you would have been asked to filter the time range to be set from “2 Feb 2001 to 31 Mar 2001” and the category to be set to “technology”. How would you use search and filter to perform that action?
Q: What do you think will appear if you write “2 Feb 2001 to 31 Mar 2001 technology” in the “Search and filter..” UI element?

2: Search and filter pressed shows a dropdown

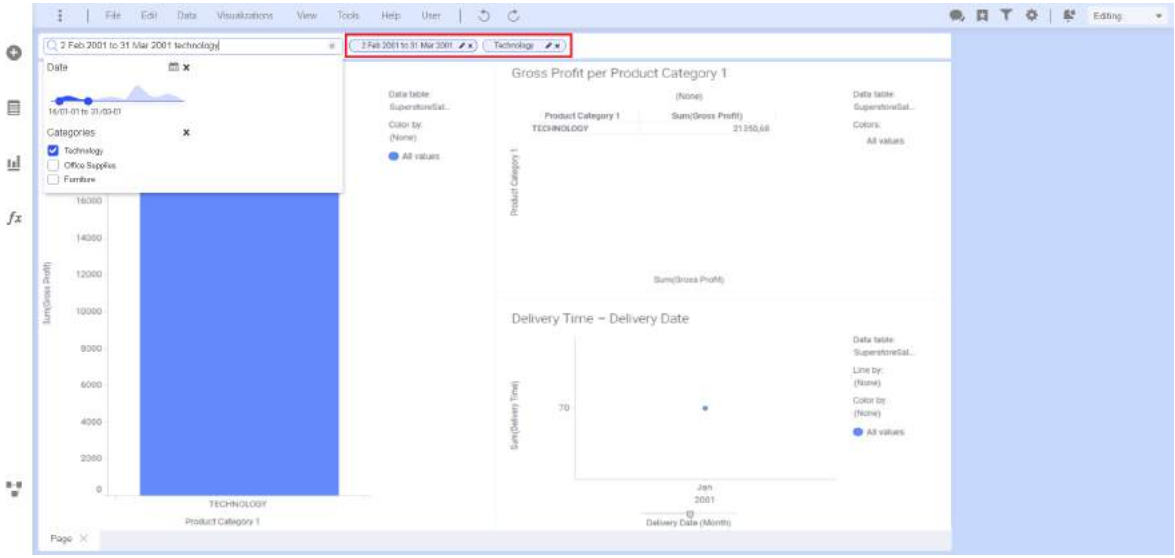


Q: Please describe what you see and what you think happened to the visualisations/data?



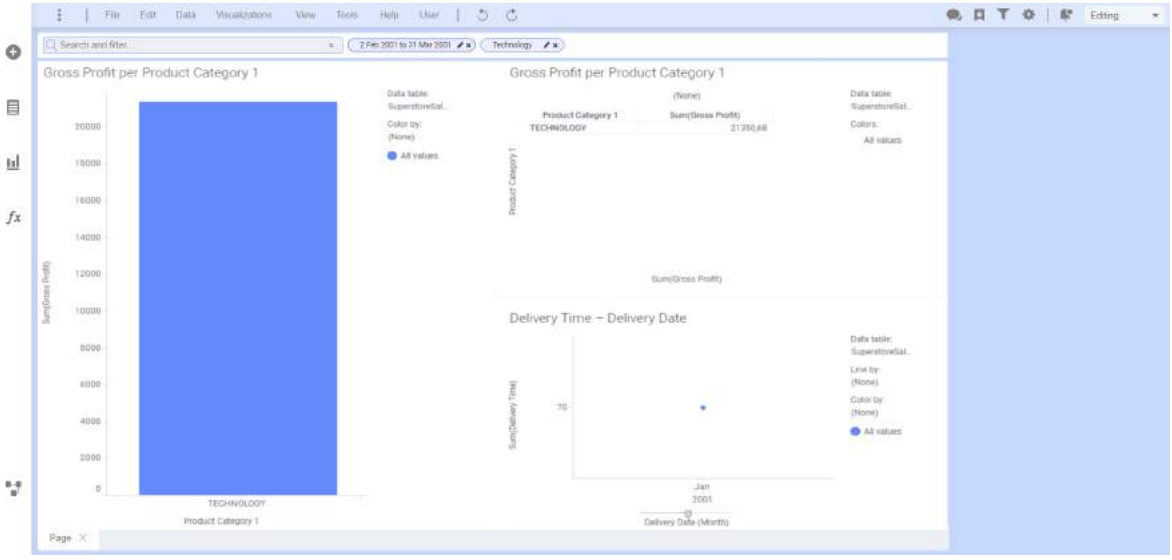
Q: Please describe what sort of interactions you think are possible inside of the red area?

Q: If you were asked to change the time range. Explain how you assume that can be done (hint: there are multiple ways)



Q: What does the pills represent?

4: Pills in search bar with filtered visualisation



Q: Do you think it is possible to interact with the pills? If yes, what sort of interactions do you think is possible?

5:Likert and final:

Q-Scale-1-5: As a User, how satisfied are you with the possibility to filter through text input?

Q-Scale-1-5: As a User, how satisfied are you with the possibility of adjusting a previously chosen filter through interacting with the pills?

Q: If you had a magic wand, what would you change about this solution?

Q: Do you have any other comments you'd like to share with us?

E

Guidelines for Designing Filters for Analytic Software

Guidelines for Designing Filters for Analytic Software

G1. Provide an overview of the distribution. *There should be an overview of the data distribution to give the user a quick, compact insight of what the data looks like, and can guide the user to what she needs to look into (e.g. a gap).*

G2. Provide a well designed UI with carefully crafted micro interactions. *Filters should include relevant information without cramping the functionalities to enhance precision and clarification. Dropdowns and icons should be applied when possible to either clarify or substitute a text/description to avoid overwhelming the user.*

G3. Indicate possible interactions. *It should be possible to re-use filter settings and combinations in different contexts and the filters affordance with help of hints and tooltips, should indicate possible interactions.*

G4. Provide resettable filters. *Filters should easily be reset, meaning a chosen filter should have a clear or undo option.*

G5. Provide the possibility to filter iteratively. *The user should be able to adjust and update filter selections. The user should also be able to apply multiple filters, meaning having several filters active at the same time.*

G6. Provide direct manipulation with instant feedback. *Selections or interactions with filters should be applied immediately and mirror the user's input.*

G7. Provide precise selection. *The user should be provided with multiple possibilities to specify precise selections.*

G8. Allow a non-technical vocabulary. *The user should feel the freedom and flexibility to express queries using a non-technical vocabulary.*

G9. Suggest relevant ways forward. *The user should get autocomplete text suggestions and filter recommendations relevant to the data and input, based on the system's interpretation.*

G10. Provide shortcuts for common selections. *It should be possible to make additional filtering selections to a given data type as well as provide shortcuts for common selections.*

G11. Indicate filters' relationship. *The user should be able to edit the relation between filters, and the relation should be visually represented to facilitate the understanding of the filters' relationship to each other.*