Contextualize big-thin Data by Experiencing Prototyping

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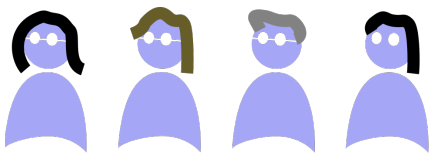
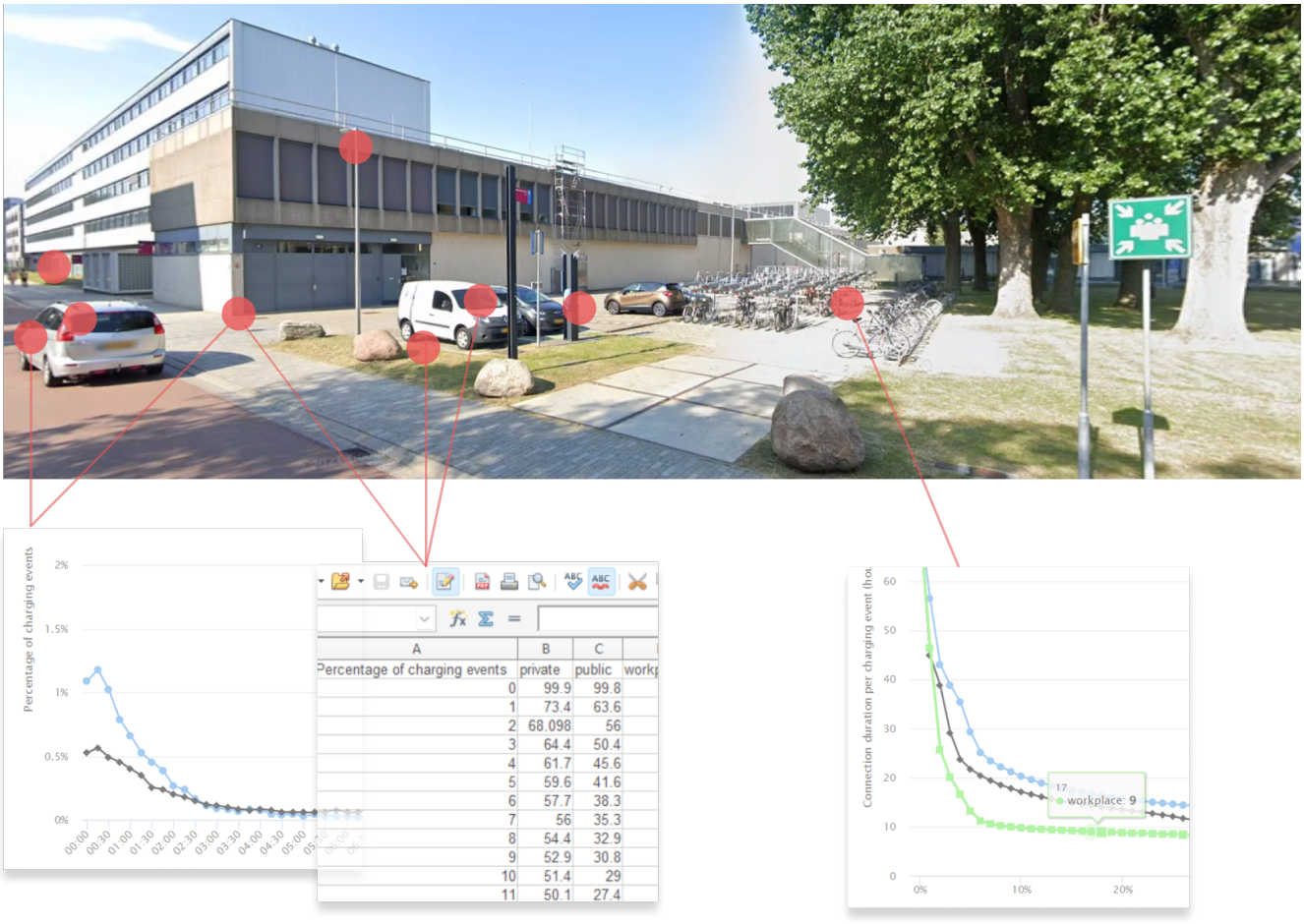


Abstract

Designing with data helps the service providers to monitor and gain deeper insights from users. However, there are not many design methods of data-enabled design for most design teams to rely on. This research focuses on the early exploratory phase of the design process. The goal was to find a solution that could assist in contextualizing the big-thin data by using experiencing prototyping approach for exploratory purposes. A design tool, data-contextualizing canvas, was designed and iterated by three studies (including seven sessions with eight participants in total) in this project. It assisted designers to prototyping the simulated user scenario in a structured way. And designers could extract insights and relevant data points by using it. The tool was a representation of the new data-exploration process proposed in the end of this research.

The design process of data-value-data described a sequence of creative data exploration for establishing the design hypothesis in early design phase. The data-contextualizing canvas was considered to have benefit in 1.offering a constructive way to explore the data and help in inner communication, 2.proposing a different perspectinve in using the big-thin data as design materials, and 3.raising the awareness of user value.



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1. Introduction

1.1 Project background : A prototyping approach for data-enabled design

Today, data-enabled design has become essential for many design teams in the industry. Designing with data helps the service providers to monitor and gain deeper insights from users. However, there are not many design methods of data-enabled design for most design teams to rely on. Therefore, companies continuously enhance their ability in data, developing new design methods to build more competitive services and products for users.

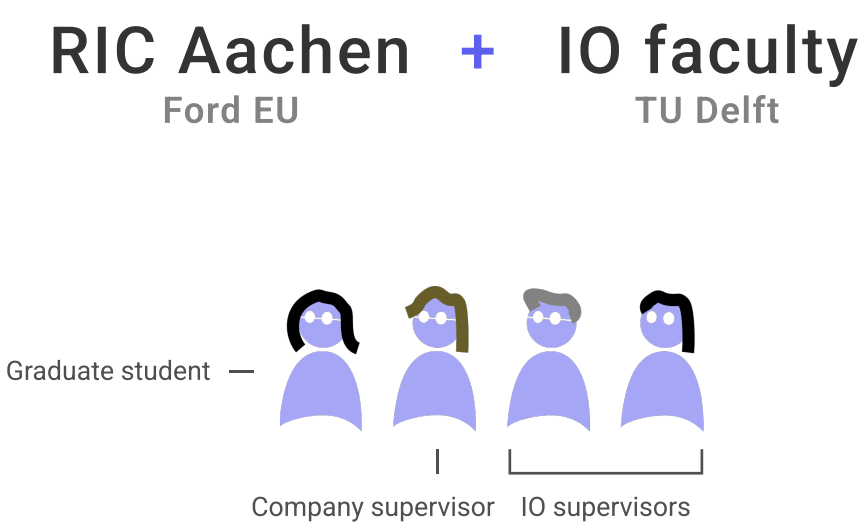
The research was initiated from the cooperation between the Ford Research and Innovation Center Aachen (RIC) and the Faculty of Industrial Design at the Delft University of Technology (TUD). The two organizations have together researched many projects that relate to data-enabled design. This graduation was one of the projects within. I researched this project as a graduate student of TUD, and was supervised by a research team composed of two supervisors from TUD and one from RIC.

This project was about using a prototyping approach for data-enabled design. To be precise, the original project brief was to explore

'How can early prototyping techniques support Ford internal design teams in using data from multiple sources to generate creative and innovative mobility solutions?'

And it also indicated the ultimate goal of the design process was to generate desirable solutions for the users.

At first glance, the components of the research direction were: data-driven and early prototyping techniques. And it was more a new-value-oriented project rather than a solution-orientated project. However, the details of the research question were not defined thoroughly, and it left some room to specify further and explore possible research directions.



1.2 Research introduction

1.2.1 Different kinds of data

One definition of data is ‘any representations of the phenomenon' (Sanders & Stappers, 2012). In this definition, data could be both qualitative and quantitative, depending on its form. Qualitative data is usually generated from interviews, observation, or other qualitative research approaches. It usually contains many aspects of the phenomenon and is more individual, context-oriented, and case-by-case; it is considered to have ‘rich information.’ On the other hand, quantitative data is usually collected via questionnaires, sensors, or specific measurements. It requires more significant sample numbers than qualitative to be effective.

Another framework, a four-quadrant coordinate, splits the data universe into two axes, thin/thick and extensive/small (Bornakke & Due, 2018). shown in Figure 1. The thin/thick axis of the data is referring the information richness. A thick data means the data describe many aspects of the phenomenon and include many contexts (behaviors, environments, or user intention). While thin data can represent little facts of the real world, it requires much interpretation to make sense. In general, the qualitative data is seen as thick data and the quantitative data as thin data. Then, the extensive/small axis refers to the sample numbers. The term "big data," for example, is mainly referring to thin-extensive data. This is because it includes many samples, while it usually lacks context.

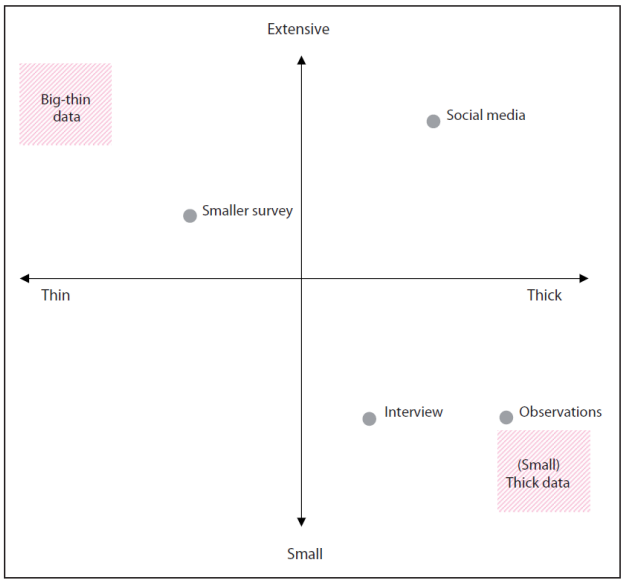


Figure 1. Matrix of thin/thick–extensive(big)/small data

According to the research results from another graduation project (Cruz, 2021), data categories used in the Ford design team now are mainly from the two quadrants: top-left and bottom-right, that is, the thin-extensive data and the small-rich data, respectively. The thin-extensive data were collected from the actual sensors or service systems. On the other hand, the small-rich data were collected through different conventional design research approaches, such as interviewing, observing, or usability test.

Qualitative ‘rich-data’ is more commonly used in the early design process because they include more context and aspects to find rich insights into user behavior. On the other hand, though the quantitative data is used to verify the assumptions of the design research, there are fewer strategies for using thin-extensive data in the early stage of design.

1.2.2 Ford design thinking cycle

Ford has adopted a framework to implement a design thinking process with a human-centered approach. The framework is based on a four-phase process that iterates the human-centered methods, as shown in Figure 2. In the process, the Ford Design team is experienced in using qualitative data at the first stage, Gather Research and Inspiration. However, as mentioned in the previous paragraph, the usage of quantitative data is limited. It is used to confirm the design decisions or verify the assumptions in most conditions. Nevertheless, since the quantitative data represent a part of a phenomenon in the real-world context, it is still possible to be interpreted into valuable insights for design by proper approaches.

Since most of the big-thin data is used to verify the ideas and assumptions, which is Test and Refine Concepts, the other three phases of the cycle have the potential to develop the design approaches. I initiated the research in the exploration phase, which is Gather Research and Inspiration on Ford's design thinking cycle.

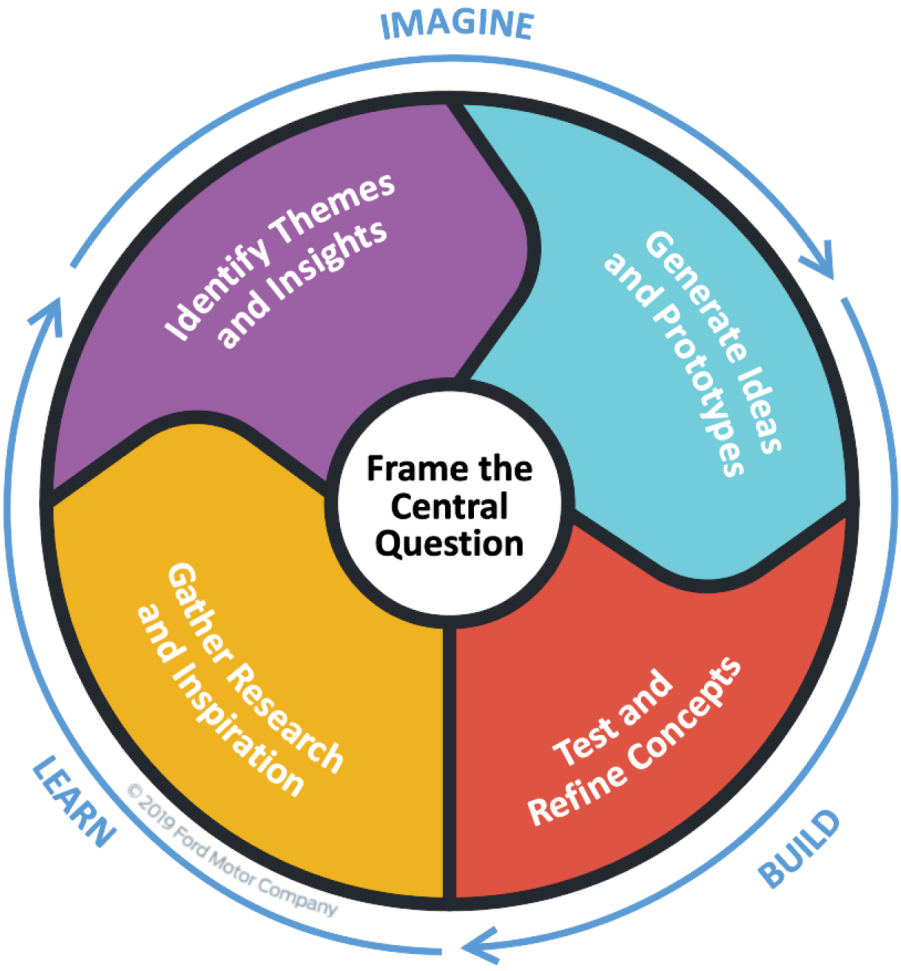
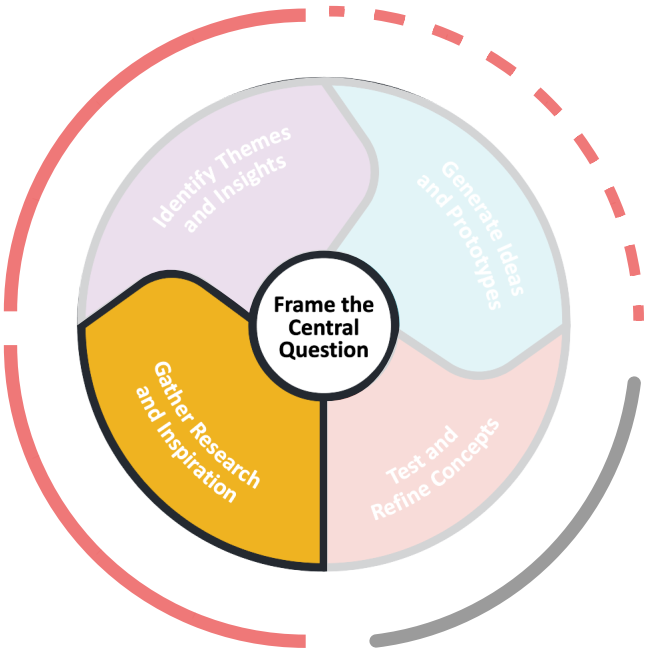


Figure 2. Ford's design thinking process

1.2.3 Big-thin data for early exploration

The design thinking cycle in Figure 2. has similar characteristics to the double diamond design process, Figure 3. In this research, I targeted but was not limited to the early framing phase, trying to use big-thin as materials to inspire the design directions. When exploring the design directions with data, valuable new ideas came to mind quite often. Although they were not the focus of this research, the ideas were also collected and analyzed to optimize the research's final results. After all, the boundaries among different design phases were often vague, and those from other phases highly influenced the outcomes.

This research focuses on the early exploratory phase. The goal was to find a solution that could extend the usage of big-thin data in the design process aside from only validating the assumptions.



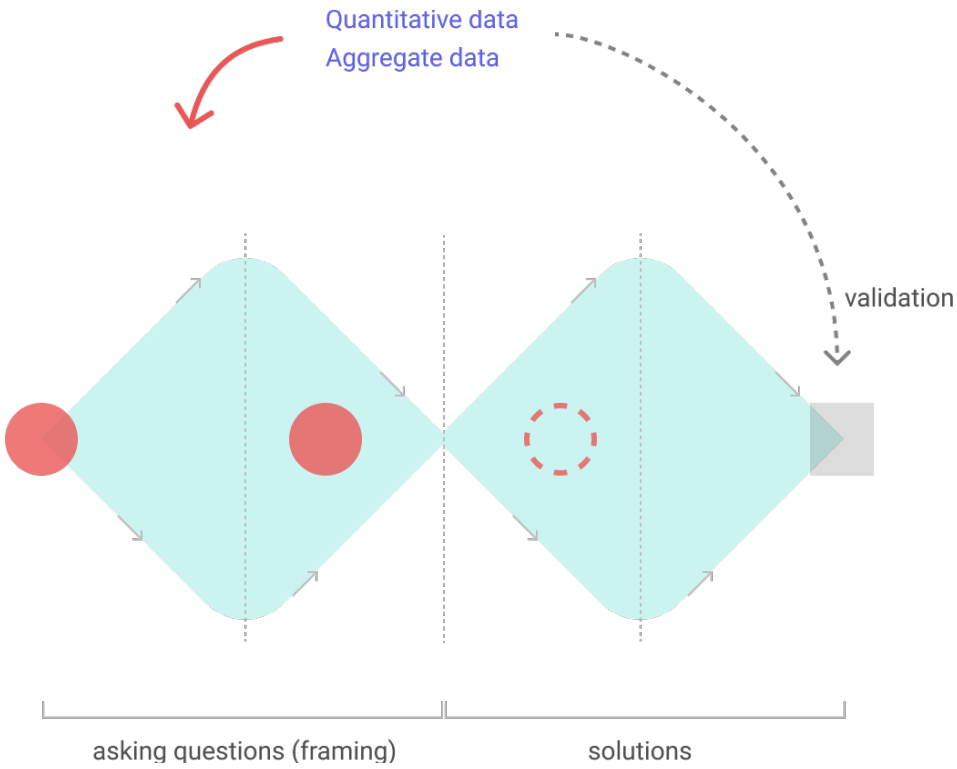


Figure 3. The focus of this research is on double diamonds design process

A successful translation of big-thin data can help obtain more profound insights from users and discover new values. Although contextualizing big-thin data is difficult because the complexity of data is relatively high, there is an opportunity to bridge the gap by applying proper design methods.

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The data collected from the sensors is the consequence of complex factors, reasons, and stories. These contexts are usually not shown or are hard to be identified in the “just number” big-thin data. However, the insights from these contexts are valuable for design works, and extracting meaningful insights is one of the main design objectives. Therefore, designers also explore what it can be and what questions should be asked in the fuzzy front end when designing with big data.

The early questions of design are usually uncertain, dynamic, and continuously changed. It’s even hard to know if they are worth to be answered. This explains why it is challenging for designers to either collaborate with data experts or explore context-less big data. In addition, it takes more time than expected to explore, define and test what information is likely more important to different aspects of the project.

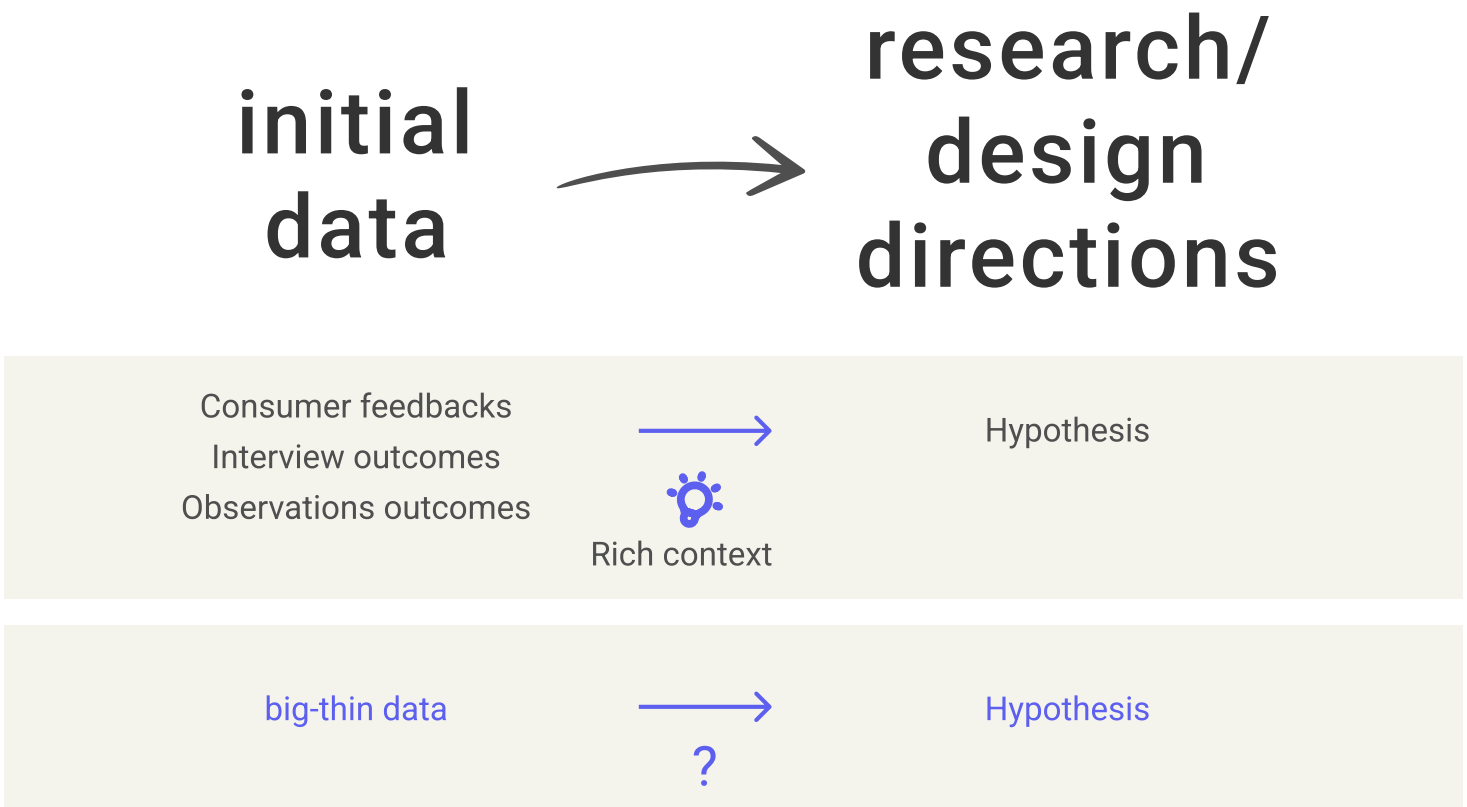


Figure 4. The opportunity in using big-thin data to initiate the research/design directions

1.2.4 Contextualizing big-thin data

Compared to the qualitative data often used in the early design phases to inspire the design/research direction, the big-thin data doesn't include many aspects of the information from the real world. Since the goal was to expand the usage of big-thin data to the exploratory phase, adding the information to the big-thin data might let designers use big-thin data as the initial materials for exploration, like qualitative data. The info added should be coherent to the original data, and it should be related to the ultimate design goal: generating desirable solutions for the users. Following the two objectives, the term 'contextualize the data' in this research was to include more facts that make sense of big-thin data and unfold the users' context in the data.

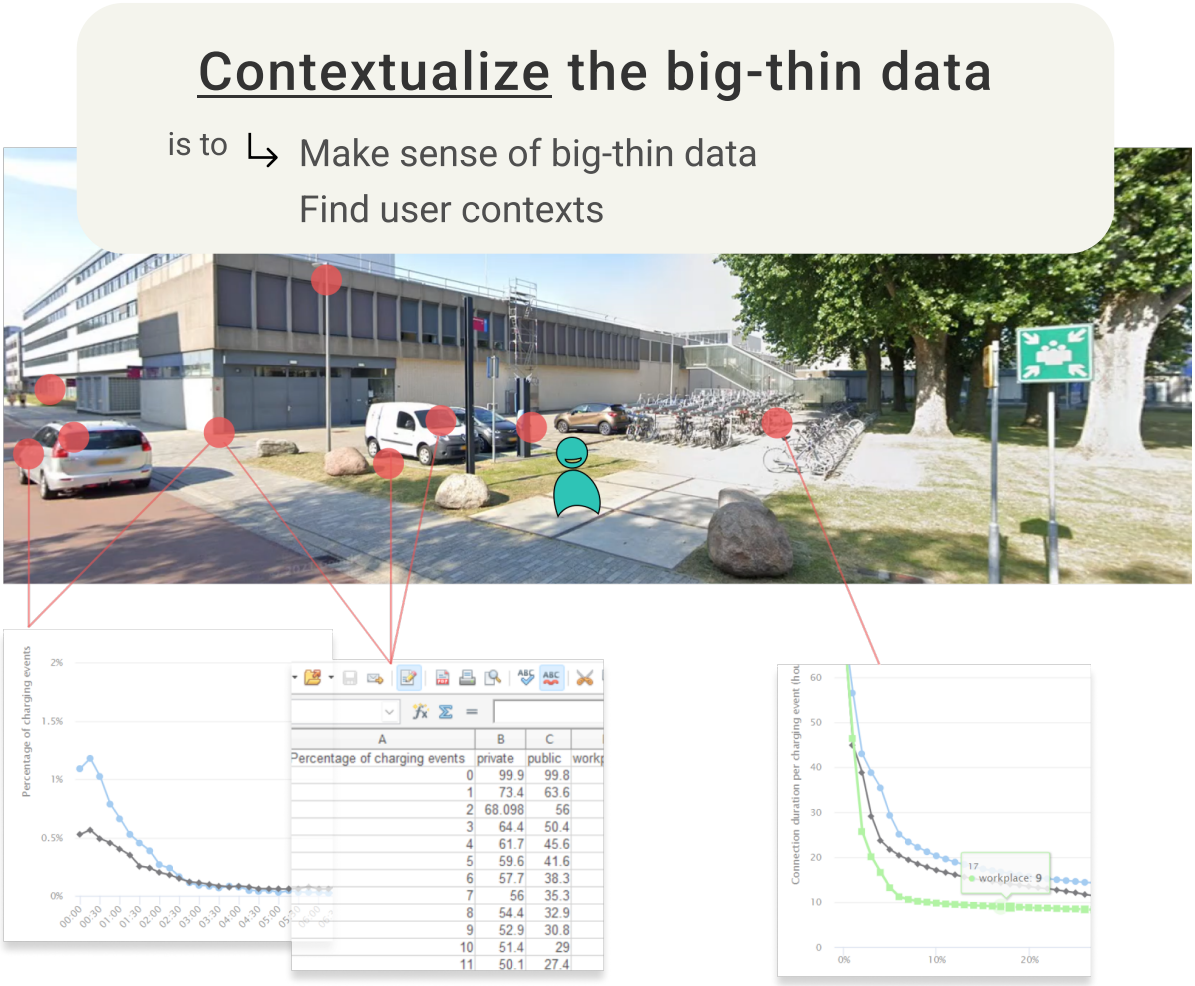


Figure 5. The data were generated from the contexts

1.2.5 Challenges for Ford design team

In the early exploration phase, the mission is to figure out a proper research direction to dive in. However, there usually existed many uncertainties to explore with data. For instance, what direction is valuable, what is the scope should be focused on, or what are the critical variables to study. Moreover, according to the stakeholder of Ford's design team, there was no particular design approach to initiate the design process by using the big-thin data.

There were some challenges in using these data for early exploration. First, being regulated by the General Data Protection Regulation (GDPR), which is the rule for protecting personal data, using the data needs to follow the very strict rules. The process of asking for data sets also requires a formal application, which usually takes time. When there are still many unanswered questions, it is relatively hard to formulate clear and concrete direction and hard to require more research resources, such as other data sets, budgets, or recruiting users.

On the other hand, developing more usage of the big-thin data is an objective of the design team. 'How to make sense of the data' is a way to describe the goal of developing the new design approach. The big-thin data of users' behavior has the potential to benefit the design solutions. Therefore, finding a way to interpret and connect numerous datasets to generate design insights is the desired direction for the design team.

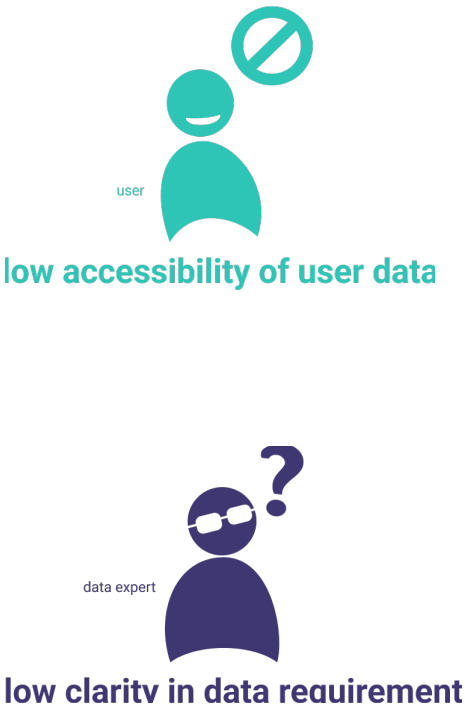


Figure 6. Challenge for Ford when using big-thin data in the early design phase

1.2.6 Experiencing prototyping

In the conventional design process, prototypes and prototyping are used broadly. The most common fundamental usage is testing the functions and detecting unanticipated errors to save time and cost before the production or the product launch (Houde & Hill, 1997). Besides the financial purpose, the prototypes are also built to test if the idea can achieve the expected results before making the final products. For instance, is it valuable or desirable for the target market to reach the business success. Prototypes for these purposes are typical for both physical products and digital products. The prototypes are built to simulate the final products to test their feasibility and viability.

Another function of a prototype is to concretize vague or complicated ideas for communication purposes (Buchenau & Suri, 2000). Because designing a new product is creating something that doesn't exist, it needs a shared representative for all team members to align their thoughts. There are usually experts in different areas to take care of various aspects of the new products. The prototypes can act as a common language among the team for good communication.

Besides the conventional prototypes, another design approach expanded the meaning of prototypes to a more general definition when the service design became more popular than ever. The idea of the prototype transformed from simulating a product into simulating any form that can represent the key experiences. It was named Experiencing Prototyping. (Buchenau & Suri, 2000) The definition is that "Experiencing Prototyping simulates the important aspects of the whole or the parts of the relationships between people, places, and objects as they unfold over time ."

Figure7. Bodystorming layouts for an airplane interior (Buchenau & Suri, 2000)

PROTOTYPING

= ANY REPRESENTATION OF A DESIGN IDEA

EXPERIENCING PROTOTYPING

= SIMULATES THE IMPORTANT ASPECTS OF THE WHOLE OR THE PARTS OF THE RELATIONSHIPS BETWEEN PEOPLE, PLACES, AND OBJECTS AS THEY UNFOLD OVER TIME.

1.2.7 Contextualizing by prototyping user scenario

The first objective of this project was to propose a solution that would assist the Ford design team in utilizing the big-thin data to explore the early design and research direction. The solution was expected to be a design tool that could help the design team in both 'make sense of data' and 'identify essential data points.' The data points are referring to the sensors or connected facilities that can record the phenomenon and generate the data. Identifying the essential data points would help the team overcome the challenge of can't request the datasets without clear needs, as mentioned before.

The big-thin data, which lacks context, needs to be interpreted into meaningful insights to inspire the coming design process. The interpretation can be considered 'telling the story about why or what led to the phenomenon that the data showed.' Since the data pattern was generated because of some context invisible from the big-thin data, it is possible to assume and simulate the context by interpreting the data.

Considering the difficulties of recruiting users, the design tool would be organized as a user-free tool that doesn't include users as the essential actors for using the tool. Instead, the tool would guide the designers to explore the early stage of design by experiencing prototyping.

To conclude the design direction, the main challenge of the design tool is figuring out:

How to assist data-enabled design for exploratory purposes by prototyping user scenarios?

Figure 8. illustrates the idea of the design tool. It would assist designers in prototyping the simulated context of data and iterating the context. The criteria of iteration would be generated and analyzed from the prototyping activities. It was expected to create the ideas, insights, and relevant data points during the process to initiate the coming design process.

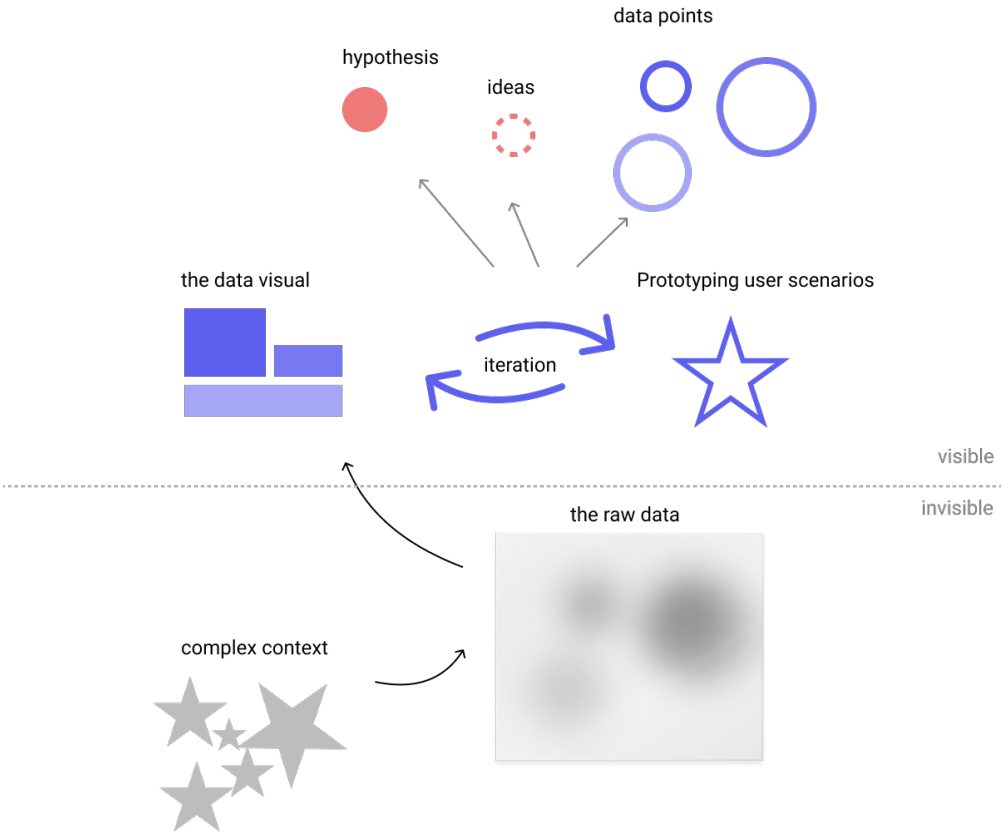
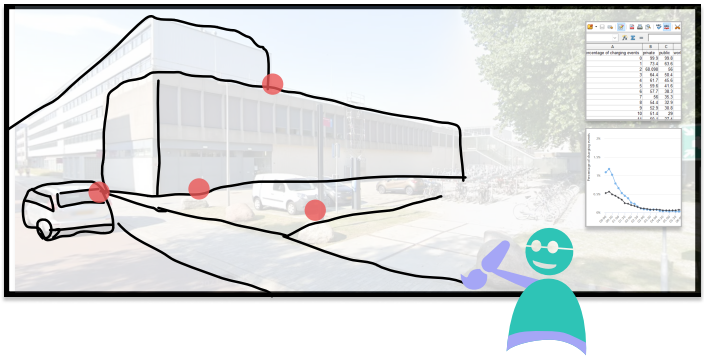


Figure 8. The idea of contextualizing data by prototyping user scenarios

Following the objectives of the design tool, a new scenario of the design process was generated. The design tool aims to help designers overcome the gap of an unstructured research direction initiated from big-thin data. The assumption was that with the early experiencing prototyping approach, the designers could contextualize the big-thin data and initiate the design/research directions. In this new design scenario, this research would focus on:

How can experiencing the prototyping approach assist data-enabled design for exploratory purposes?

The goal is to find out: how designers perceive the approach to 'exploring the design directions by applying big-thin data to the early prototyping activity.' Also, what the role of the big-thin data



is in the prototyping activity. The direction of the design tool is to extend the information from big-thin data with a very designary approach, experiencing prototyping, which is very different from the conventional data analysis technique. As a result, how designers would perceive this approach and the factors can be an important aspect in the area of data-enabled design.

How can an experiencing prototyping approach assist data-enabled design for exploratory purposes?

2. Methodology

2.1 Overview

This research had two missions; the first was to build a design tool for the Ford design team to explore big-thin data by prototyping user scenarios. Another was the research on how this approach can assist designers in doing the exploration and what are the differences between using this tool compared to their normal approach.

The goal of the literature review was to find some theories and definitions about prototyping and data. Such as how to prototype, what is prototyping, and what is data-enabled design. Also, from the literature, I collected some insights about the challenges in including data in Ford's design process and what the design team needs about data to facilitate the design process.

There were three studies in this research. The design tool was built in Study 1 and was iterated in both Study 2 & 3. In Study 1, I built a draft version of the tool as the representation of the idea of exploring data by prototyping. Based on this tool, I planned the prototyping sessions of Study 2. In Study 2, there were three workshops. The participants tested the prototyping session to learn the idea of prototyping with data for exploration, providing their opinion on the tool and the approach. The outcomes from Study 2 were collected and analyzed into design criteria to iterate the tool for coming Study 3. The canvas used in Study 3 was the iteration of the prototyping session in Study 2, according to the feedback from participants. Besides the major iteration between Study 2 & 3, there was one minor iteration each in Study 2 & 3.

The results of all the studies were used to improve the design tool, and they were analyzed and interpreted with the theories from the literature to answer the research question.

Figure 10 shows the process of the research. Six main steps (marked in blue) were taken to research and design the tool that assists designers in exploring data insights. Next to the blue line of main steps is the development process of the design tool; it can also be seen as the iteration of stimuli of the research. The row at the right is informing the layer of research. The research sequence is not following the main step because the research directions were modified over time. The research aims to propose new values rather than solving a particular problem. The more information collected from the sessions, the more chaotic the research focus would be. The final research question was defined at the end of the Study 2, so the data collection and analysis of the personal draft session was after the Study 2.

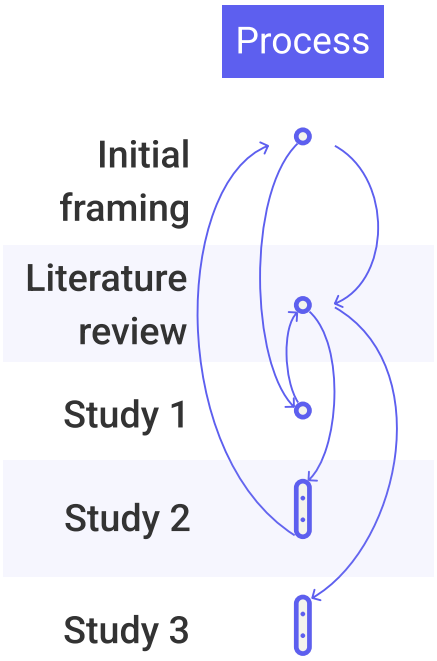


Figure 9. The actual execution process was more chaotic. The research direction was not clear at first, and I repeated the “framing” step several times.

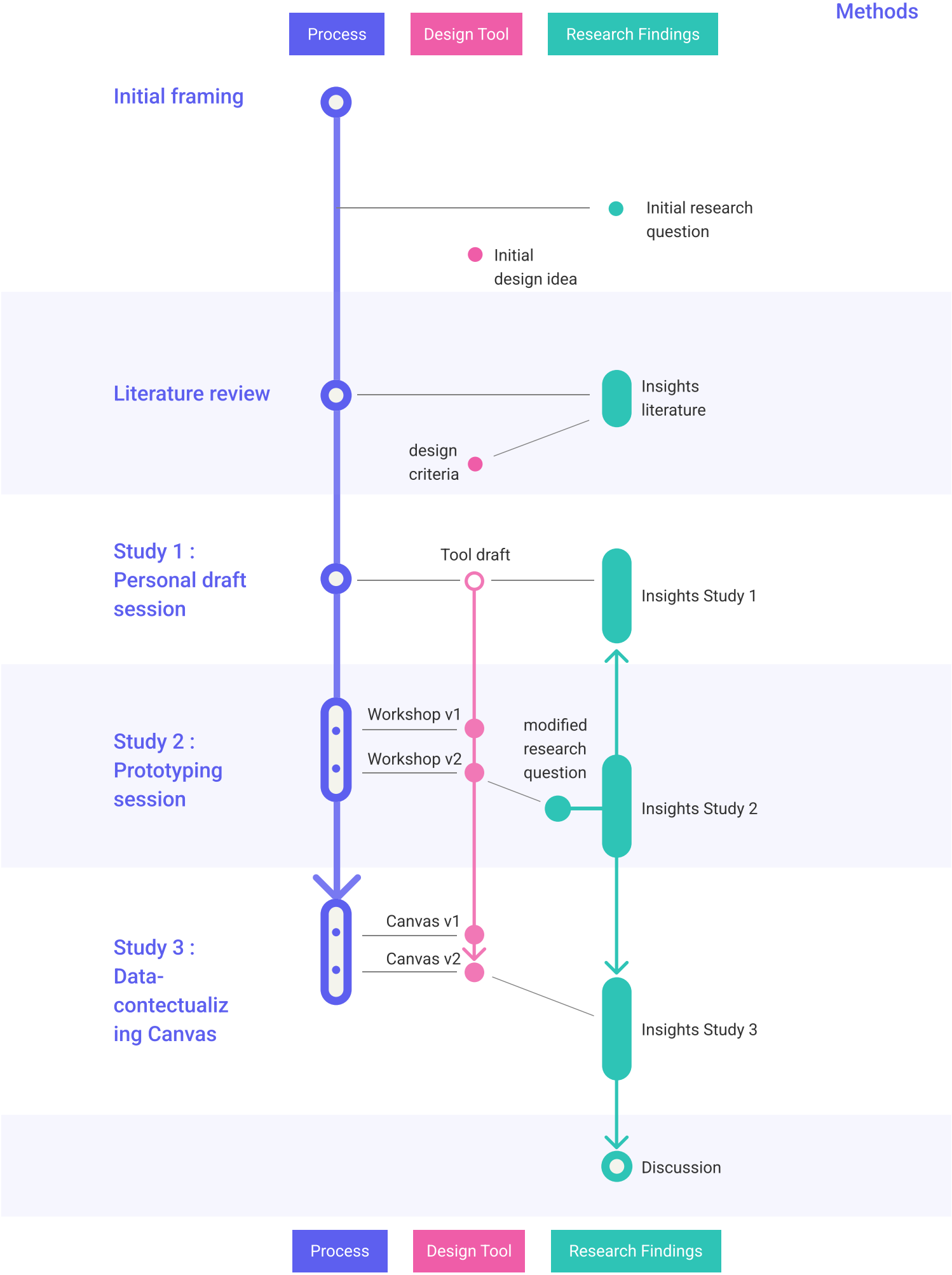


Figure 10. The overall research methods

In Initial framing, the mission is to understand the project requirements' scope, context, and definition. Several meetings were held with stakeholders to clarify the requirements and desired directions. Besides meetings, I also read literature to specify the terms and scope of the project, looking for a potential research topic. According to the supervisor from Ford, since the research on the working flow and design challenges were conducted many times with the same group of people, it would be better to avoid repeated research. Since previous projects have researched on design team's context and checked with the supervisor from Ford, most of the company insights in this research were collected from them. The outcome of the initial framing was the initial research question, which indicated the direction of research would go with' how can Ford designers contextualize the thin-extensive data by prototyping for exploratory purposes?' Meanwhile, it also informed the objective of design, which was 'formulating a prototyping approach to assist designers contextualizing the data.'

Except for Study 1: personal draft session, which was executed and reflected by myself, seven other participants were included in this research. Four for Study 2: prototyping session, and four for Study 3: Data-exploratory prototyping. (One participant from Ford had joined both Study 2 & 3.) The participants' details, such as careers and background, are introduced in the coming chapter.

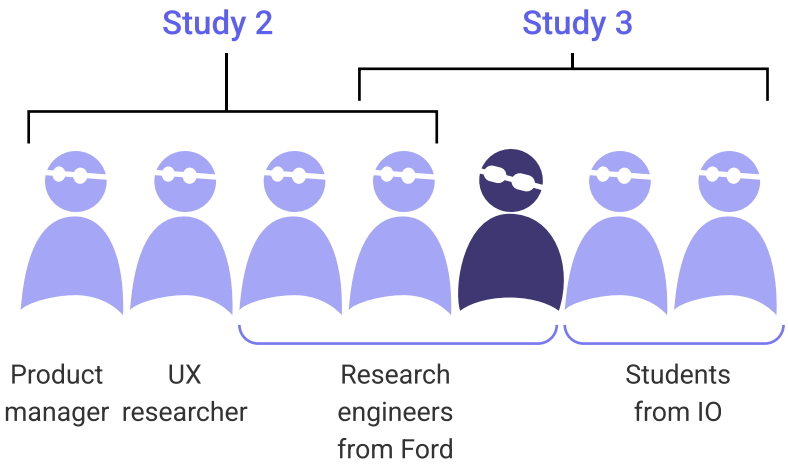


Figure 11. Participants overview

2.2 The case

This research used the open dataset called 'Elaad,' which the researcher in Ford suggested, as the original extensive-thin data. Elaad is an online database offering data and information packages regarding electric vehicle (EV) charging patterns (ElaadNL, 2020). The data are demonstrated in the form of visualized diagrams.

The dataset was combined with various varients that were collected from the sensors in charging facilities operated

by EVnetNL in the Netherlands.

The followings are some examples of the variants:

TRANSACTION ID - The unique transaction code

CONNECTOR ID - The moment the transaction was

started (logged in locale time zone).

CONNECTED TIME - Time difference between the start and end of a transaction.

Since the focus of the research was not the charging behavior but the design approach, the content of the data was not discussed in this project. Instead, it would focus on designers' methods of using data.

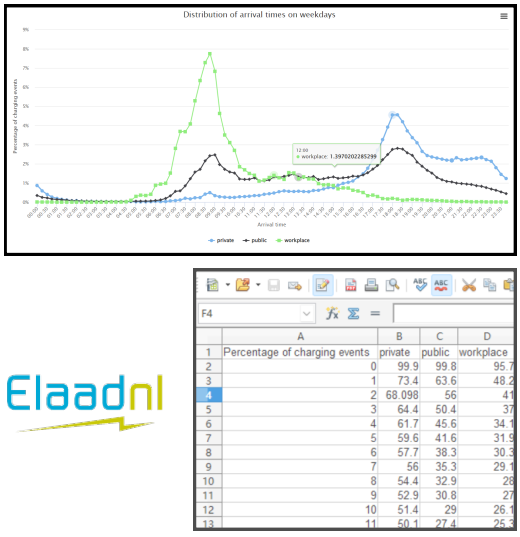


Figure 12. The example of Elaad database

3. Literature

Literature would assist in building up the theoretical foundation of the design tool. Some subjects were relevant but not included in this research, such as design tools, design facilitation, or organizational design development. In this research, the focus was on the combination of big-thin data and the prototyping approach. A design tool was one of the deliverables, and it was also used as the props to test how prototyping assists the early exploration of data-enabled design.

3.1 Prototyping

3.1.1 Dimension of Prototype

Prototyping techniques can be analyzed along four dimensions: Representation, Precision, Interactivity, Evolution (Beaudouin-Lafon & Mackay, 2009). They describe the form, fidelity, usage, and the life cycle of the prototypes. In Beaudouin-Lafon & Mackay's research, they mainly discuss the physical and digital product prototypes. Since the dimensions are limited to the tangible products, the experiencing prototyping also has the potential to be analyzed by the dimensions. In this research, I implemented the four dimensions of prototyping reversely, using them for composing the prototyping plan instead of analyzing.

The form of prototype and prototyping has been discussed for a long time, and everyone has different expectations of what the prototype is (Haude & Hill, 1997). It could be a model form in industrial design or a screen appearance for interaction design. And, in the user study field, they saw a storyboard or scenario being used as a prototype. The dimension Representation had no necessary strict rules, but they just followed the basic principle about what is used to explore or demonstrate some aspects of the future artifact.

Interactivity was about how to interact with the prototype. For instance, watch it, operate it, or place it somewhere. This dimension is also flexible and would change according to what aspects the prototyping wants to simulate.

The evolution of prototypes is about different life spans. "Rapid prototypes are created for a specific purpose and then thrown away. Iterative prototypes evolve either to work out some details (increasing their precision) or to explore various alternatives. Evolutionary prototypes are designed to become part of the final system. (Beaudouin-Lafon & Mackay, 2009)"

The precision, also named 'fidelity' in literature, refers to the relevance of details with respect to the purpose of the prototype.

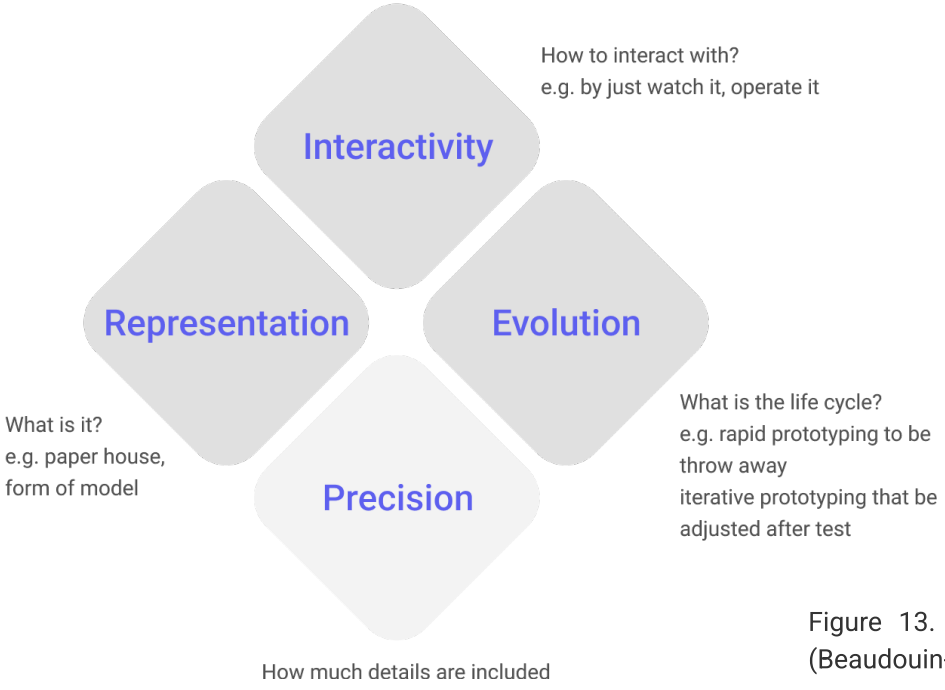


Figure 13. Four dimensions of the prototype (Beaudouin-Lafon & Mackay, 2009)

3.1.1 Prototype fidelity

The fidelity of prototyping could be explained as to how many details are included in the representation. A high-fidelity (high-fi) prototype simulated many characteristics of the target object or scenario. In opposite, a low-fidelity (low-fi) prototype simulates only partial or little features as the reality (or desired design). The level of fidelity was related to the building resource, and it would influence the function of prototyping in design works.

Prototyping was usually used to understand existing user experiences and context, explore and evaluate design ideas, and communicate ideas to an audience (Buchenau & Suri, 2000). Building a high-fi prototype took time and cost, and it could include many aspects and details that might have a certain relation to each other, which influence the final design decisions. However, when learning the users' scenario, the literature found that "low-tech solutions seem to promote the attitude that it is the design question that is important, not the tools and techniques that can be brought to bear (Buchenau & Suri, 2000)." The fidelity influenced the testing focus, and from their results, low-fi prototyping was more suitable for the exploration phase of design.

On the other hand, when using prototyping to communicate ideas to an audience, low-fi prototyping leaves more aspects of design open. The conversation would be easier to focus on the value and some abstract factors. The iteration of low-fi prototyping could also be fast because it was simpler than high-fi prototyping. However, if the level of fidelity was too low, the communication could be too abstract since there wasn't enough representation to relate the idea to reality. In opposite, a too high level might establish too many constraints, and it leads the space of creativity to become too small to explore more possible solutions to the design questions.

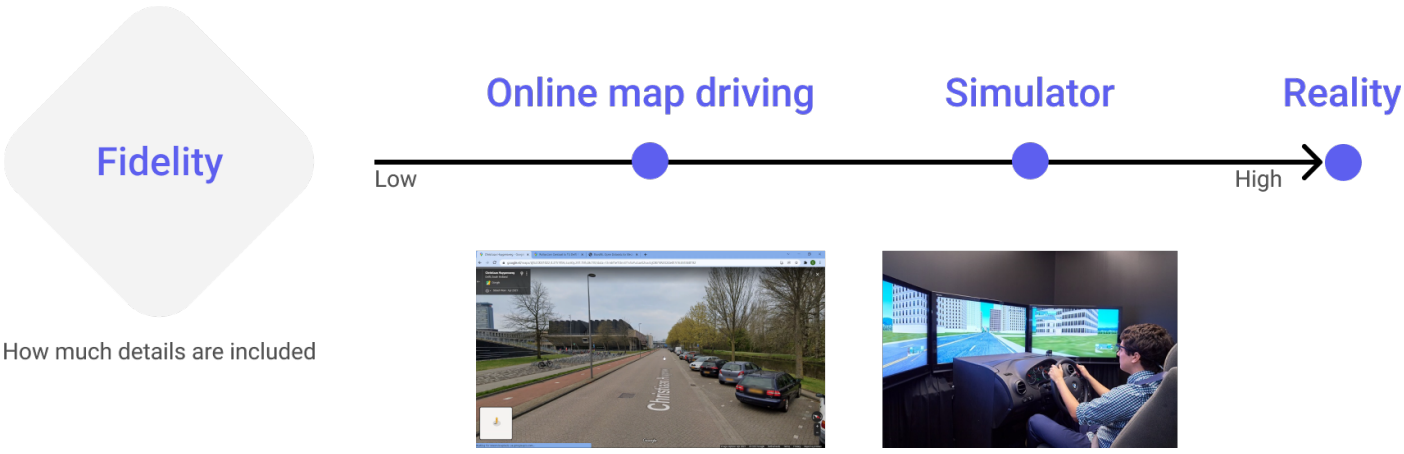


Figure 14. Scale of fidelity and examples

3.1.3 Concept of the design space

Beaudouin-Lafon & Mackay proposed the concept of the design space. The description of the design space is below:

"...the concept of a design space, which constrains

design possibilities along some dimensions while leaving

others open for creative exploration (Beaudouin-Lafon & Mackay, 2009)."

It described the creativity and choices process as the combination of expanding and contracting the design space when it adds or eliminates the ideas. When proposing new ideas, the idea was placed in the open part of the design space. The broader ideas may let designers consider the more undiscovered area in the design space. And, when eliminating the ideas, there may be some reasons which weren't meet the design needs. These decisions were changed to the constraints in the design space, clarifying the design directions.

The prototypes, as representations of a design idea, aid designers in both generating concrete representations of new

ideas and clarifying specific design directions.

I illustrated a grey area with some black lines to visualize the concept of design space, shown in Figure 15. And, I marked the two functions of prototyping to indicate how they aid design work. Figure 16. showed that prototypes could either build new constraints to clarify design direction or generate representations of ideas to expand design space. The colored dots were the ideas that the prototypes represent, the blue arc was the new constraints, and the pink arrows were the expansion of the design space.

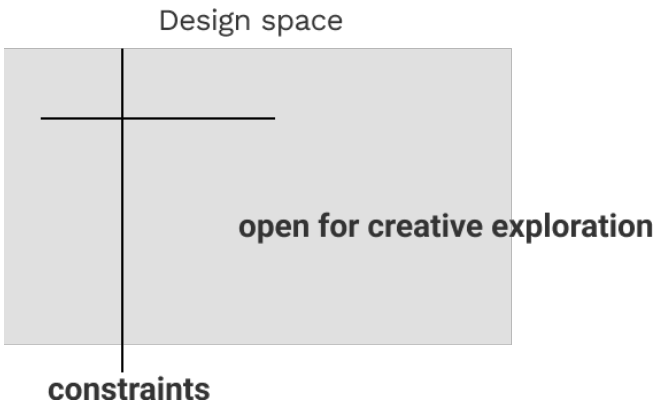


Figure 15. Visualizing the concept of design space

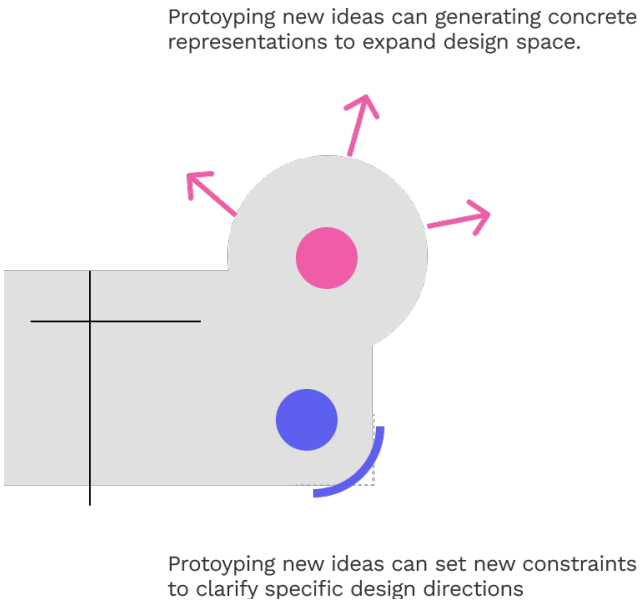


Figure 16. Prototyping functions in design space

3.2 Data-enabled design

3.2.1 Relation between data and design

There are two common taxonomies describing various perspectives of applying the data in the design process. 'Design from, with, by data,' and 'data-driven, data-enabled, data-informed design' (Kollenburg & Bogers, 2019). Note that most of the discussion around data in this area refers to the thin data, which is mostly quantitative and has less user context.

The 'Design from, with, by data,' describes the different roles of data in the design process. 'Design from data' sees the data as the initiatives of design. The data analysis outcomes should be tackled by designing solutions or deciding the design directions. 'Design with data' treats data as the design materials; it can be used as the tools or outcomes to assist the design process. Data's role in 'Design by data' is the most proactive. Data is authorized to generate the design outcomes during the design process. The algorithm can calculate and verify an enormous number of possibilities according to the desired criteria. For example, the digital generative design can provide the best combination of structure and material to meet the desired properties of mechanical elements.

Another taxonomy of data and design, 'data-driven, data-enabled, data-informed design,' introduces the different levels of interferences of data to the design. In data-driven design, the data is the core of the new solutions. The design follows the criteria generated from the outcomes of the data analysis.

The various definitions of the relationship between data and design provide a map for positioning the project direction and the scope. A clear understanding of the role of data may also allow designers to apply the data properly in the design process without too much confusion. This research aims to know the performance and perception of the designer when including data in the design exploration process. I see data as the materials to be used, combining the information from the data with the design approaches to generate meaningful outcomes. The focus is more related to the subjects of ‘data-enabled design’ and ‘design with data.’

3.2.1 Situated prototyping research

Most of the literature on topic of the prototype focus on the prototypes of tangible physical and digital products. Some research also focuses on prototyping for service and experience (Buchenau & Suri, 2000). The combination of data and prototyping is still a new topic. Although the idea of enhancing the strength of data to obtain a business advantage has already existed for decades, there are not many data-enabled design methods or research that could be found in the literature.

There is a data-enabled design research study at Eindhoven University (Kollenburg & Bogers, 2019). They explored how to effectively facilitate innovation area with the approach of 'situated prototyping,' which is a way to combine data and prototyping as a design method. The concepts of 'prototyping' in this research are the process of collecting data and the products, whether digital or physical. They are prototyping by placing the product prototypes that can generate data into the actual environments and asking the real users to use the products in their context. Using the connected prototypes, design questions driven by data, and some conventional research approaches, interviews, and observation, for instance, they explored the different roles of data in the innovation area.

Figure 17. The family toolkit used in the situated prototyping research (Van Kollenburg & Bogers, 2019)

The work of Kollenburg & Bogers inspired me to define the research in data-enabled design. It informed what dimensions can operated from various frameworks described in the study. For instance, the different priorities of data (regard data as references or specific rules), are used in different design stages (exploration, framing, ideation, verification). The scope of data-enabled design is much clearer and more rigid from these frameworks.

3.3 Conclusion

In order to help the designers concentrate on the design challenges, the design tool would provide a series of steps for designers to follow. The steps would be structured along the dimensions of the prototyping to gain clarity when planning.

Among the four dimensions, Evolution was considered pre-defined as the rapid prototyping for this exploratory design tool. Because the goal of this design phase wasn't to generate a new product or service but to form the design hypothesis. Also, the Precision of the prototyping would be planned in a low-fidelity direction. It was because a more abstract representation of design would build fewer constraints, which created more opportunities to explore the unknown open area in the design space.

Defining the representation and interactivity would be the main mission of the designs. The flexibility of these two dimensions allowed designers to decide the prototyping with the resources or materials in hand. Also, they could determine these two to fit better their design tasks, one for tangible and the other for intangible.

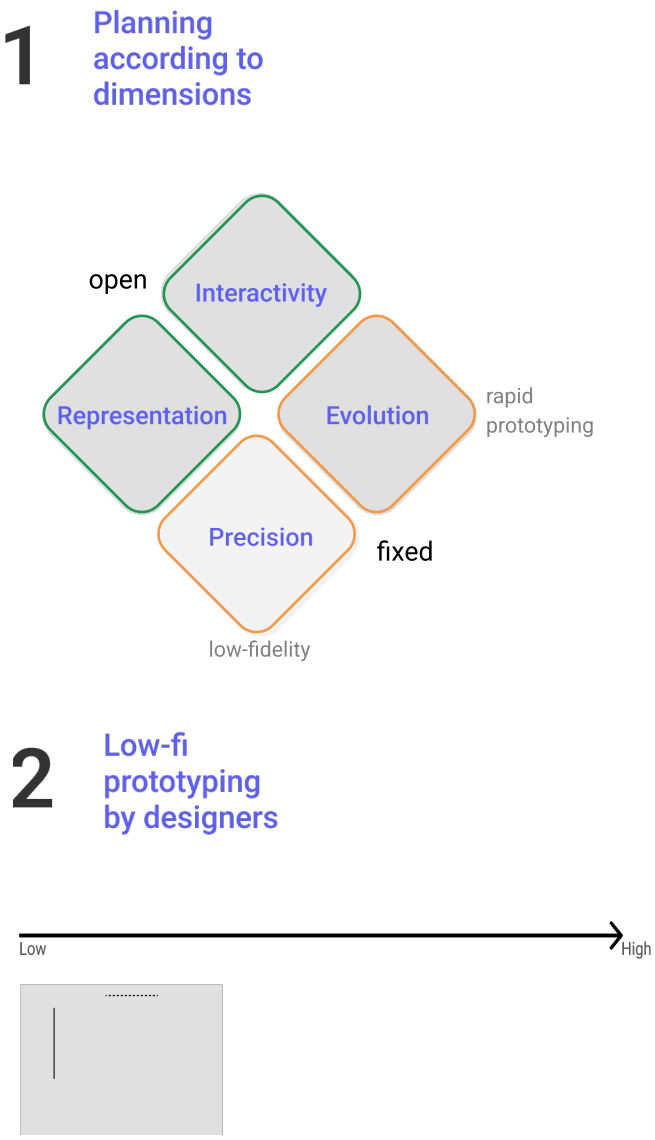
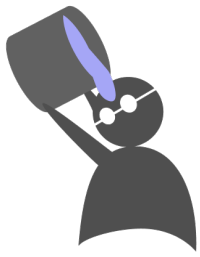


Figure 18. The criteria for the design tool

4. Study 1 : personal draft session

4.1 Setup & goal

A representative that can convey the abstract idea is needed to experiment with how people perceive the concept of contextualizing data by prototyping. A shared benchmark can stimulate the discussion, and the draft setup could evolve to the final solution. The idea was to plan a series of steps to guide people to explore the data by prototyping. However, planning a design approach for exploration is like sailing in the fog. Without a specific goal, there is no clue about what to base on, what to research, and where to go. To overcome the challenge, I first put myself in designers' shoes by asking myself: what would I do if I were asked to extract insights from thin-extensive data by prototyping. From my perspective, the answer to the question is one version of the solution. This version of the solution is regarded as the draft setup of contextualizing data approach, which will iterate in other sessions with participants.



Play the role of designers to build the tool

4.1.1 Method of building the first tool

I took different stages to construct the first version of the design approach, shown in Figure 19. The first stage was playing a role which is trying to contextualize data by using prototyping techniques. In this stage, I took the actions as the designers did, writing down the questions, findings, and other ideas to facilitate the design process. The second stage was observing the results and outcomes from the first stage and then reflecting on them. The goal of the reflection is to specify what were I doing in each step of the first stage. The outcomes of this stage will be used to formulate the next version of the contextualizing-data approach. Finally, in the third stage, the goal was to reflect on the result of the second stage, identifying the critical subjects. They might be either the difficulties during the activity of the first stage or the ideas that might be helpful to facilitate designers/researchers. The outcomes from the third stage were the assumptions of the contextualize-data approach, and they were tested in the following experiment.

1 Outcomes of the exploration
2 Defining the design steps
3 Reflection on the steps

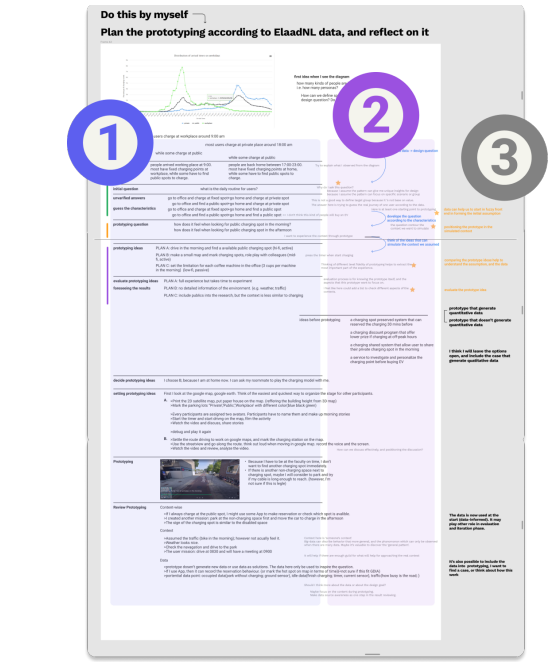


Figure 19. The overview of the Study 1 results.

4.2 Results

4.2.1 Stage 1: To contextualize data by prototyping

Initially, it started with a relatively simple request: how does the designer decide on the prototyping process? I began to work on it according to my personal design experiences.

The first step was observing the data visually and trying to understand what information could be found from the diagram. Then, cluster the notes by the truth I discovered from the diagram and the assumptions or interpretations of the data. The speculative questions and opinions were, at the moment, more useful for exploring the context of how data was generated. As a result, I picked one note describing what might happen when a user interacts with the facility that collected data. Then, transferred the picked note into a design question that may contribute insights into new products, services, or system opportunities.

Since it already had a design question, the next step I took was to develop a scenario that might answer the question. The scenario was developed according to the original data pattern, combined with the assumptions from the designer's(my) experience. Then, thinking of the easiest but most effective prototyping way for myself to experience the simulated scenario to see if I could find new insights from the prototyping of users' journeys.

The prototyping I made is a virtual driving scenario about one driver who wants to drive to his workplace and charges his car at the charging point nearby. I used the street view of Google Maps to simulate the scene of the driver and record my improvising drive with a screen record. After the first round of prototyping, there were many ideas in my mind. I wrote them down into three categories: content, context, and data. The information in 'content' is the insights that can answer the initial design questions. For instance, I found that 'the sign of the charging spot is similar to the disabled space' during the prototyping activity. 'Context' includes the factors that may influence my decision during prototyping. 'Weather' and 'traffic' were in this category. In the last category 'data,' I wrote down the data that can help to prove or provide more information about the scenario I simulated. Besides the ideas in mind, I made a timeline of my first prototyping record, marking what happened and my decisions during the prototyping. Then, I prototyped again with the alternate decision for each decision mark, generating another scenario.

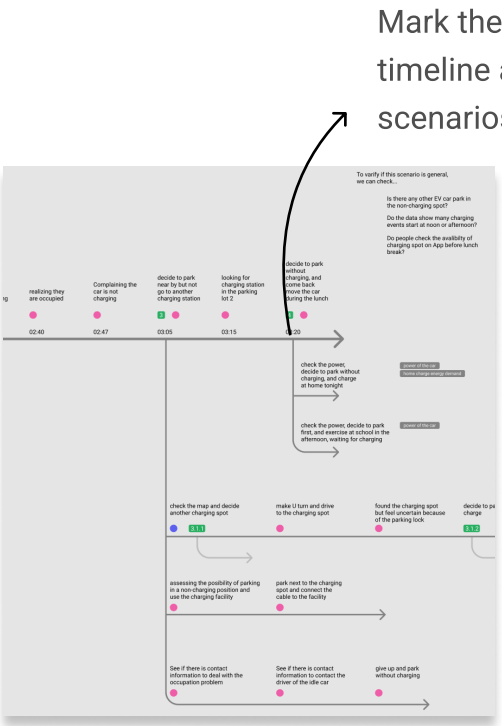


Figure 20. The example of the prototyping in Study 1

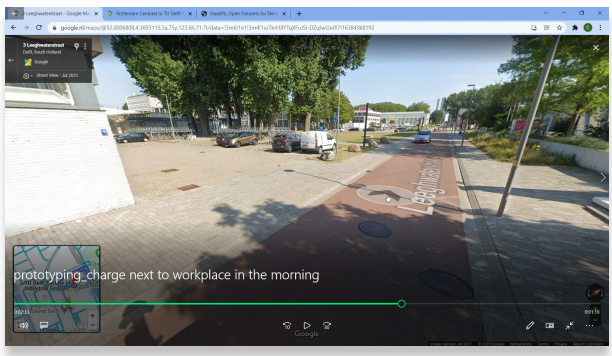


Figure 21. The example of the prototyping in Study 1

4.2.2 Stage 2: Defining the design steps

I defined the steps in Stage 1 as a complete cycle of 'contextualizing the extensive-thin data by prototyping.' It included 1.make assumptions, 2.decide the prototype, 3.prototyping, 4.evaluate the outcomes, and 5.adjust assumptions.

After my first sketchy trial cycle, I went into the next stage to identify my process. I observed the whole process I took when I played the designer role and reflected on it, writing down what I am doing in each step. In other words, I identified what steps I had taken intuitively if I wanted to extract the insights from data by prototyping.

The reflection is noted with several directions, what am I doing, why I want to do it, or what steps are struggling. Here is an example. On one sticky note I made when observing the data visual, I wrote, 'People arrived at working place at 9:00. Most have fixed charging points at the workplace, while some have to find a public spot to charge.' For this note, my reflection on it is 'Try to explain what I observed from the visual because I assume the pattern can give me unique insights for design.'

The purpose of the reflection was to define the actions with a more general and holistic point of view. The reason why this was important is also that all the cases are different in their data, context, goals, etc. Designers should be able to adjust and utilize the tool if they could know the 'why' than 'what' of the design approaches.

4.2.3 Stage 3: Identifying the critical points in steps

At the time when executed Study 1, the design & research direction were not yet clear. As a result, in the last stage of Study 1, I reflected again on the design steps and my personal experience of the private draft session to find some problematic steps when I tried prototyping and found insight from the original data visual.

The first was a question from the beginning of the session: how does the data assist the design process? There were many opportunities that I could check or include more information from the original data. However, it was hard to decide or tell when was the good moment to include it to get ideal results. Also, how to include them was uncertain. It would be helpful if the tool could assist in informing the data roles and usages during the exploratory process.

Then, thinking of prototyping ideas was harder than expected. There were too many things to consider, and all of them had certain relations. A clear mind map or steps to follow would reduce the workload of the mind at the moment. A structured process might assist designers in concentrating on their design tasks, not the 'how to' questions.

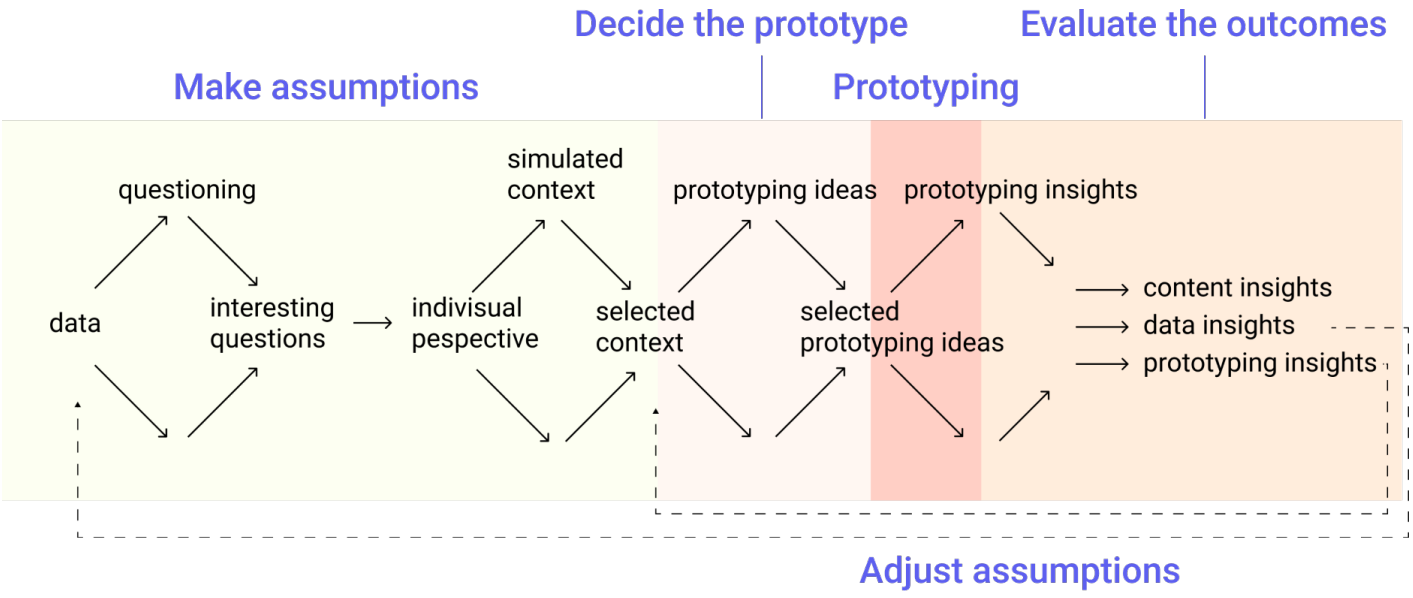


Figure 22. The design process of the first version design tool that was generated in Stage 2

4.3 Key findings & decisions

Through the reflection of the draft setup, I found that the data role, framing of prototyping, and outcome evaluation demonstrate the good value of the approach, while they were also challenging.

4.3.1 Data as initiatives and verifying tools

Visualized data is used to initiate the design exploration. When observing and asking speculative questions about the data, I can quickly figure out the known constraints to follow, and the other dimensions are open to exploring. However, in the same step, it also needs to specify a good question for facilitating the future prototyping plan. The challenge here is identifying which question or description I wrote is insightful and can help explore the user scenario behind the data. There are several frameworks of inquiring data mentioned in Deborah's research. The frameworks help categorize different types of questions by their purpose, usage, or characteristics. To tackle the challenge of identifying proper questions in the early stage, I apply one of the frameworks from Eris (Eris, 2004). It divides the questions into three categories: low-level questions, deep reasoning questions, and generative design questions. Because the goal of contextualizing the data is to simulate the possible user behaviors behind the data, the category 'deep reasoning question' is the one that can lead the mind flow to explore the scenario. This framework can help designers focus on the track of exploring user context without being distracted by unclear data visuals or fancy ideas.

4.3.2 Iterative rapid prototyping

The second design challenge is formulating a precise and efficient prototyping plan. Prototyping is usually used to verify the ideas or test the feasibility of the design process. On the other hand, prototyping for experimental purposes is harder to decide what to focus on and what to try. The prototyping defined in this research is to experience the scenario in any way and with tools that simulate a part or whole context. The idea of experiencing prototyping is from Buchenau & Suri's work in 2000. "Experiencing Prototyping simulates the important aspects of the whole or the parts of the relationships between people, places, and objects as they unfold over time." Adopting experiencing prototyping can create a concrete representation of the stories we are interested in from a specific perspective. The quick and dirty prototyping approach is named rapid prototyping. Its focus on only an essential part of the scenario also leaves more space open and can be iterated easily. The main goal and mission I want to achieve in this subject, prototyping to contextualize the data, is to facilitate the design process. Finding new insights and solutions are the second priority, though they still frequently appear during the exploration. As a result, rapid prototyping is a suitable way to explore the scenarios behind the data.

4.3.3 Formulating low-fı rapid prototyping plan

In another aspect of prototyping, formulating a low-fidelity prototyping plan can also help you specify the most critical parts we want to experiment with. High fidelity prototyping requires designers to be aware of many details to ensure it 'feels real.' However, when there is no clear focus at the early exploratory stage, it means that it has to make everything real to capture the in-depth insights, which is not sufficient for the design process. With the process of coming up with a low-fidelity prototyping plan, designers are able to concentrate on the question and the constraints, specifying what their primary focus is and what is not at the moment. For this approach, we do not aim to find robust solutions or pain points; instead, opening up a broad space of design/research direction from data is the goal. And because it is fast, designers can iterate prototyping without a high cost or much time. If the initial prototyping feels incorrect or irrelevant to the subject, designers can adjust immediately in the next round of prototyping.

4.3.4 Evaluating the outcomes according to initial goal

'What to do with the outcomes of prototyping?' is the third challenge. After finishing prototyping and reflecting to the prototyping, there are many notes regarding content, context, and data, as mentioned in the previous chapter. To transfer and deliver these outcomes, I start by asking what I need at the end of the approach. Looking back at the original direction of Ford's case, the tool should help designers explore the design insights and essential data points by prototyping. For those that contain rich and interesting insights, it is possible to directly deliver them to any other design phase of the whole design process of the design team. Except for these notes, there are different opinions about prototyping methods, additional data points, and new questions. How can they be used to improve the prototyping plan and, on the other hand, indicate the relevant data points to the scenarios? To specify the different purposes of the outcomes more clearly in the last steps, I changed the original three categories. I combined context with content to 'case' and change data into 'data points.' Finally, add in a new category, 'prototyping.'

5. Study 2 : Prototyping session

5.1 Introduction

The Prototyping session was formulated according to the results of reflection in the draft setup, the 'what am I doing' part. By specifying all steps, I am able to communicate with others about how I explore the data and extract design insights by prototyping the user scenario. I also expected it could trigger other designers to easily convey their opinions or knowledge about exploring data-enabled design directions and prototyping.

In Study 2 were three workshops, and the workshop was composed of three parts. The first part introduced the background knowledge of the workshop and the participants' mission. Then, the participants started testing the prototyping session. Finally, the last part of the workshop was an open discussion for participants to express their opinions on the workshop's setup, methods, and other relevant ideas.

Four participants in total were included in the workshops. They all have a background of academic education in design. They worked as a user experience (UX) researcher in the financial industry, a product specialist in the fashion industry, and two research engineers from Ford in the mobility industry. Though participants were not working in the same position in the organization, they were all familiar with some design skills, such as brainstorming, user scenario, and prototyping. Since the research is related to the design approach, it was important to have certain skills in design work.

There was one minor iteration in Study 2. The first and the second workshops followed the same prototyping session setup, named v1. The third workshop utilized the setup named v2, in which more descriptions and characteristics were added to assist the participants in following the steps. The details of the iteration and their reasons will be explained in the coming paragraph.

Figure 23. The setup & participants of Study 2

5.2 Session setup

Some decisions were made to formulate the prototyping session setup of Study 2.

In Study 1, the personal draft session, I concluded my approach into five steps: 1.make assumptions, 2.decide the prototype, 3.prototyping, 4. evaluate the outcomes, and 5. adjust assumptions. Then, I also included the insights from the reflection of the personal draft approach into the steps and formulated a prototyping session for Study 2.

Step 1, making assumptions, was divided into three steps. Firstly, select a data visual as the original starting point of the prototyping session. The second was to ask questions to the input visual and analyze the questions to find more user context. Finally, transfer the perspective of the selected question.

In opposite, step 4 and 5, 'evaluate the outcomes' and 'adjust assumptions,' were combined to be 'Reflecting on Prototyping' because there was no clear mission to complete in step 5.

The steps in the new prototyping session setup in Study 2 were:

1. From Data to Information
2. Analyze Questions
3. Define the Scenario
4. Prototyping Plan
5. Prototyping
6. Reflect on Prototyping

In the following paragraph, I elaborated on some important session processes to clarify the design tool's main functions. Some steps were skipped in this chapter because they were just small moves for participants that were easier to follow but not critical. The complete prototyping session setup was shown in the Appendix chapter.

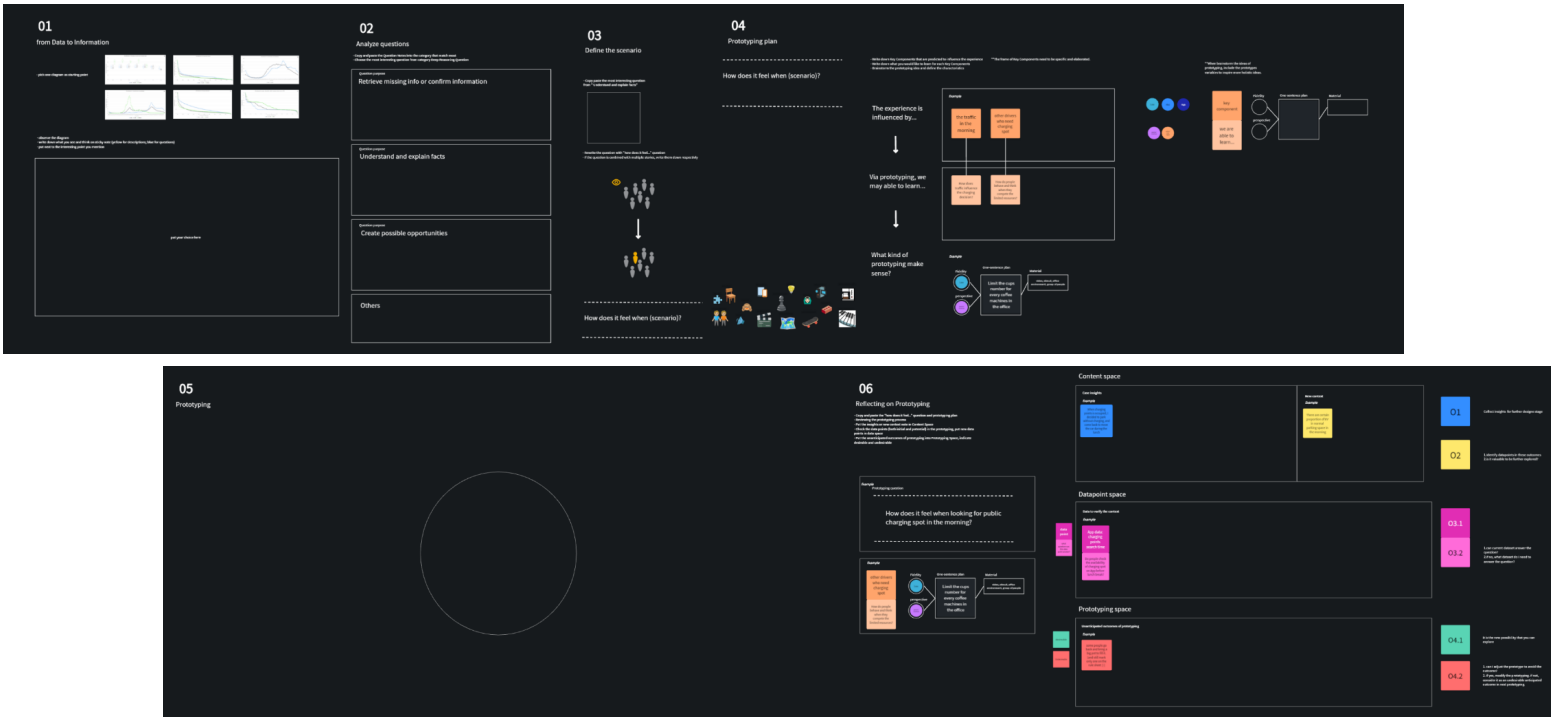


Figure 24. The overview of the prototyping session

5.2.1 Data inquiry

As mentioned in the previous chapter, Eris frameworks for categorizing questions were applied to help designers distinguish different questions from their observation of the data visual.

There were four blocks shown in the layout of the prototyping session. They were not marked with the name of the question types (low level, deep reasoning, speculative). Instead, it used the 'purpose of the question' to let participant easily categorize their questions. The 'low-level questions' is for 'retrieving missing information or confirming information.' And asking 'Deep reasoning question' was for 'understand and explain facts.' Finally, 'speculative questions' were for 'creating possible opportunities.' If it wasn't any of the above categories, the participants could put it into the 'other.' After all, the purpose of these steps was to recognize the 'Deep reasoning question,' and the other setup was preventing participants from being stocked at this step.

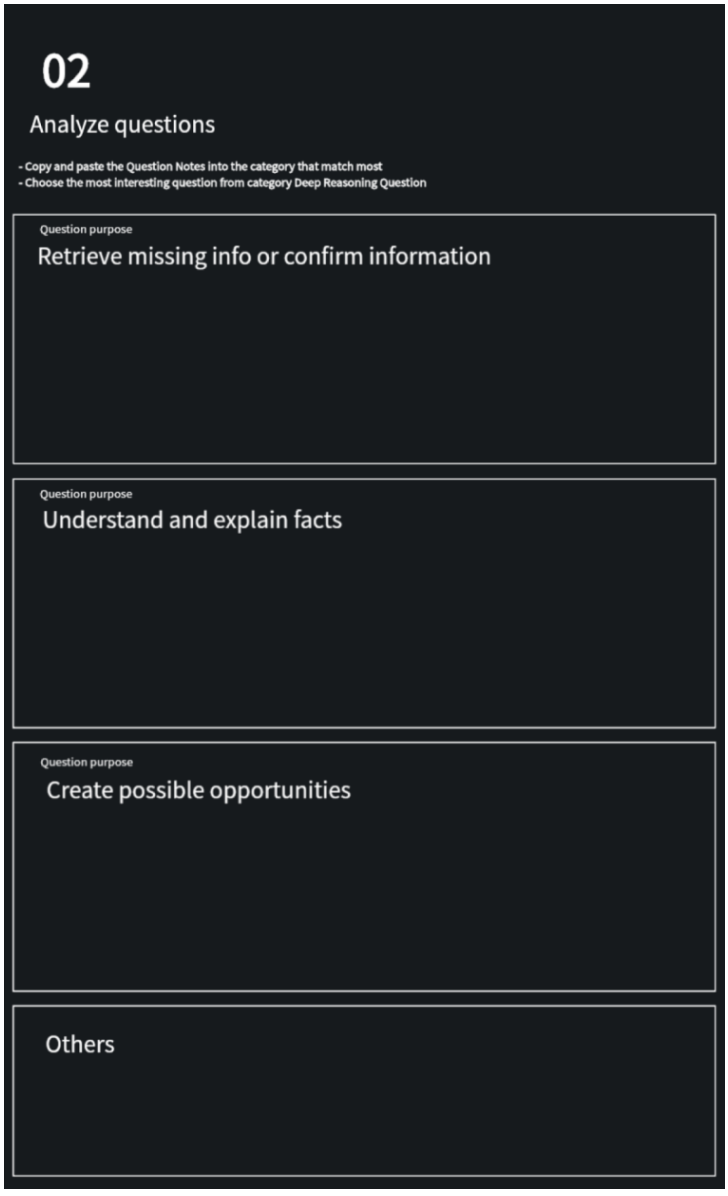


Figure 25. Setup of data inquiry in Prototyping session

5.2.2 Step in the users' shoes to see the question

After participants pick the design question, the next step was to step in the users' shoes to see the question. Since the approach was to let designers play the role of users to experience the scenario that users might have experienced, it has to change the perspectives from an observer to one of the users.

Most of the deep reasoning questions described the facts according to their definition, and they represented a part of the phenomenon in users' journey. The participants would rephrase the question they chose from the previous step in an experiencing-orientated way, with the format 'How does it feel when (scenario)?' The format more or less forced participants to come up with a scenario and put themselves into users' shoes by considering their feelings.

By asking this kind of question, it twisted the perspective from objective to subjective. The change was expected to help participants learn more in-depth insights and interpret the data more reasonably.

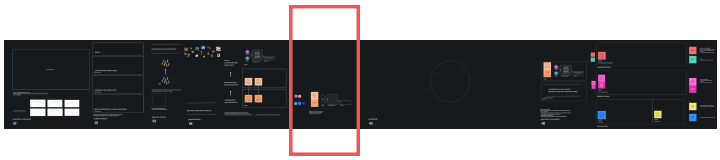
Figure 26. Setup of Objective to subjective question in Prototyping session

5.2.3 Protoyping plan

To initiate the prototyping activity, it needed a clear plan. A prototyping plan was to represent what and how was the prototyping activity. Formulating a plan could also help designers clarify their thoughts, identifying what was important in the experience and what was not. They had to decide where to focus before they started prototyping. And, it would make the critical part of the scenario more obvious. In other words, making a prototyping plan could help in not only deciding what and how to prototype, but also designers' understanding of the scenarios, questions, and the data.

In the prototyping session, I illustrated a template for participants to organize their prototyping plan, as shown in Figure 27. They could propose more than one prototyping plan and compare which was more efficient and effective to generate essential insights. Firstly, deciding what the components that may influence the user experience were, called key components. Next to the key components were the things to learn. Participants had to write down what they wanted to learn from the prototyping about these components. Then, according to these key components and what things to learn, participants could come up with some prototyping ways. Writing them in the form of one sentence was expected to be easier to compare the multiple ideas. Also, participants could write down the materials they want to use for prototyping, either tangible or intangible. For example, it could be paper, the form of a model, or an activity.

On the left side of the prototyping plan template was the 'fidelity' and 'perspective.' Participants could assess the fidelity of the prototyping. From Study 1, evaluating the prototyping fidelity might allow designers to deconstruct the questions and determine the focus of the scenarios. And, the two prototyping perspectives, active and passive (Buchenau & Suri, 2000), might allow participants to specify the way of interaction, which was mentioned in the literature chapter.



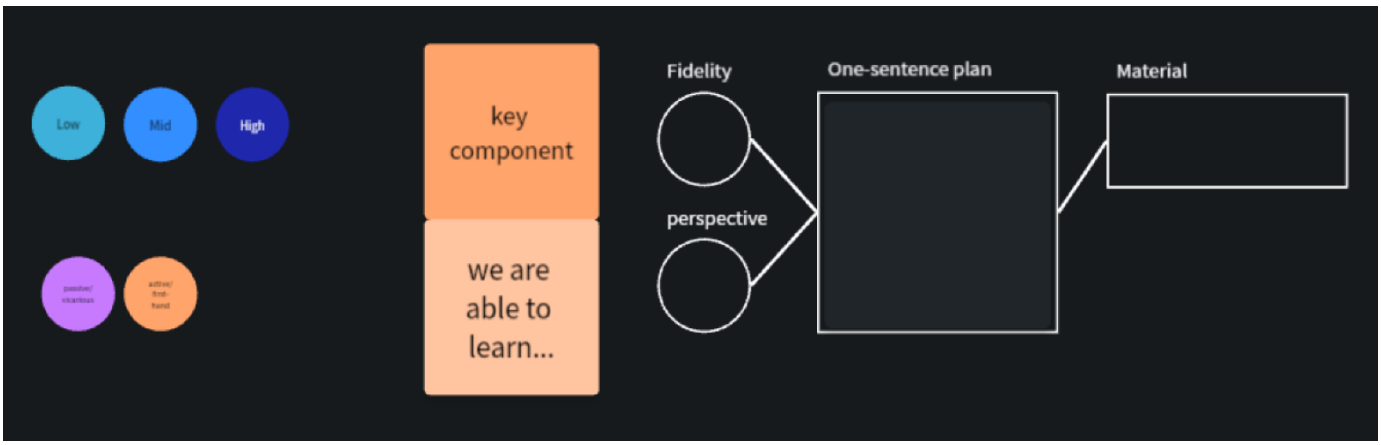


Figure 27. Setup of Protoyping plan in Prototyping session

5.2.4 Reflection categories

One takeaway from Study 1 was that a lot of information popped into my mind when prototyping. Some of those were related to the case, n this research is the charging behavior. And, some were related to datasets that needed to prove more insights. The rest were some thoughts about the way we do the prototyping. For example, there might be something you want to improve or something you did feel like 'Yes, it helps in this way' to do the prototyping.

As a result, in the last part of the prototyping session, three blocks were arranged to help designers categorize their thoughts: content space, data points space, and prototyping space.

There were also further setups in the data points and prototyping category. In data points, participants could write down the name of the data points with pink sticky notes and how this could help generate insights with light pink sticky notes. The arrangement was for designers to identify only the essential data points rather than all data points. Another arrangement was two other sub-categories in block prototyping space: desirable reflections in green sticky notes and undesirables in orange. Participants could iterate their prototyping by including the desirable part and eliminating the undesirable element.

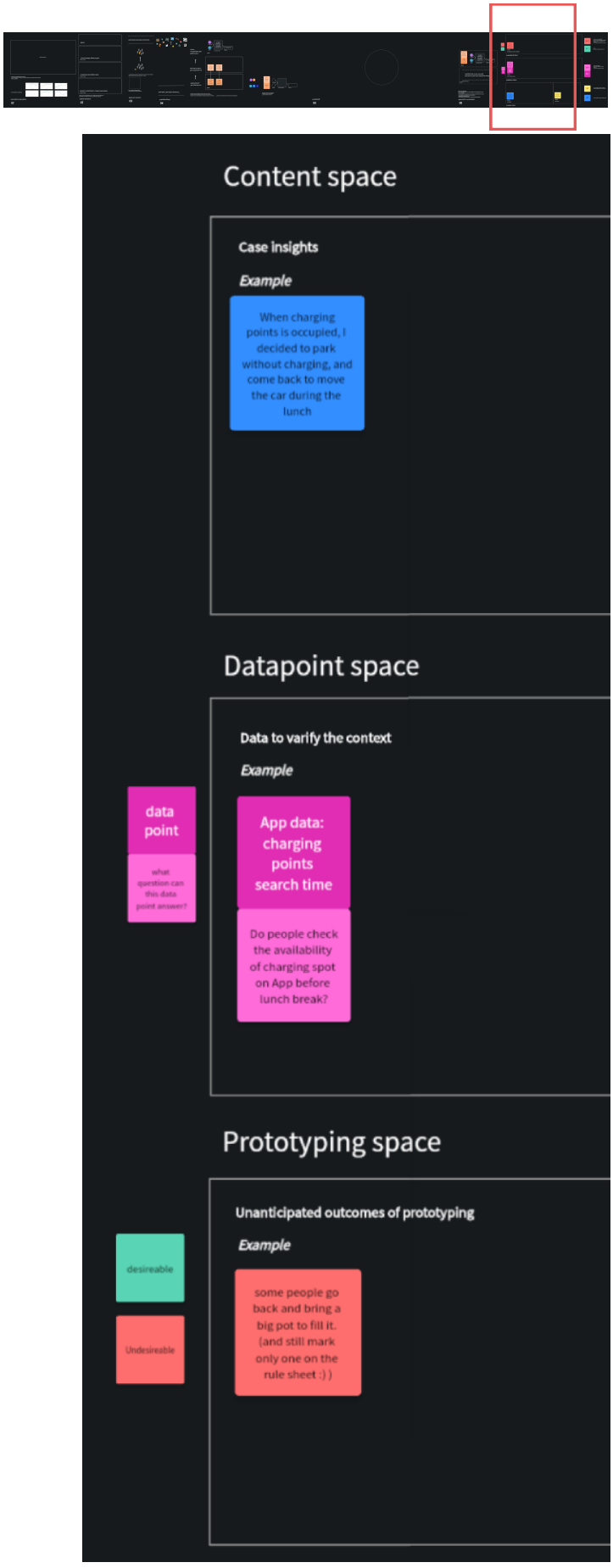


Figure 28. Setup of Reflection categories in Prototyping session

5.3 Analysis approach

The Prototyping session was tested with designers and researchers with the workshop. There were three layers of goals for the workshop: assessing its value for the Ford design team, evaluating the functionalities, and testing the usability.

The top layer, assessing its value for the Ford design team, is related to the main research direction: understanding how contextualizing data by prototyping can help design and research work in Ford. Since the data-enabled design process in thin-extensive data is still new for the Ford design team, the Prototyping session could initiate the awareness of using data for the exploratory purpose. This role of data is innovative and relatively abstract. By introducing the idea of the Prototyping session, it is expected to construct a shared conception and raise the awareness of using data in the 'Gather Research and Inspiration' phase of the Ford Design Thinking Model. Based on the Prototyping session, designers and researchers can identify different aspects of the approach and give their opinions on how does and doesn't the tool works.

The second layer is to evaluate how people perceive the Prototyping session and if the functions of the Prototyping session are helpful for them.

This layer could be seen as the practice of the theories and the core idea of contextualizing the data. There could be the various way to achieve 'contextualizing data for exploration.' The decisions in this layer were like the feature of physical products. Use different ways to achieve the goal and improve the features to find the best solution.

The last layer, The Guide, referred to the writings, visuals, or layout of the design tool. Sometimes, it wasn't the process wrong, but participants just couldn't understand what the instruction meant. A better presentation of the design tool was needed to let the tool become handy and, most importantly, self-spoken.

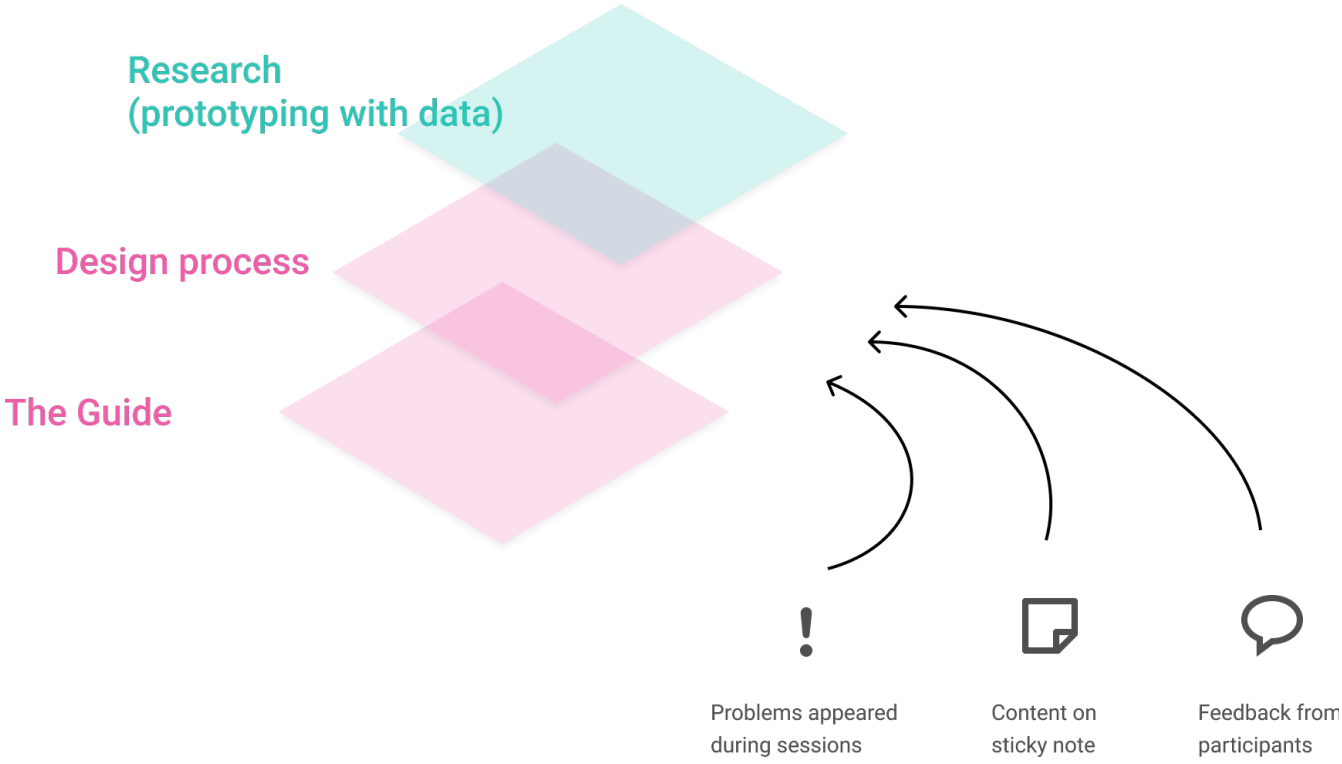


Figure 29. Analyzing the results by three layers to iterate the tool and research at the same time

5.4 Results

5.4.1 Workshop v1

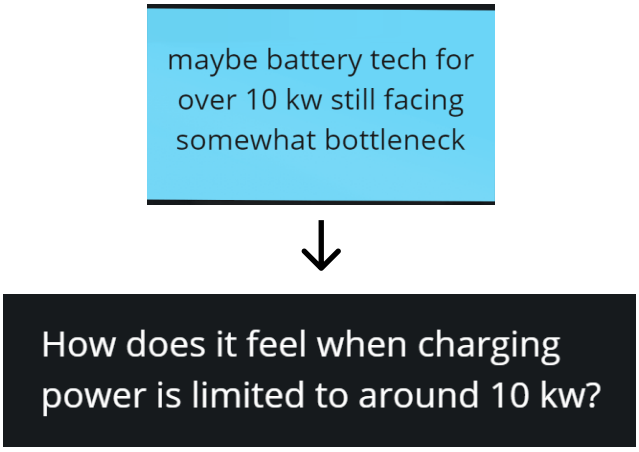
A UX researcher, who worked in a fintech company, participated in the first workshop of Study 1. I facilitated the workshop, introducing the missions and the background of the prototyping session to him and guiding him to operate the tasks in the prototyping session.

1

UX Researcher

Duration:

1.5 hrs



The chosen question and the 'How does it feel' question

In almost all the steps, the participant spent more time than scheduled at the beginning. The clarity of the tasks was too low for him to understand.

"Am I acting a designer? Why I have to observe the diagram? ... Can I interview the users?" — participant 1 of the Study 2

Besides the overall goal was not clear to him, in the step 'Define the scenario,' he had a hard time transforming the original question into the 'How does it feel' question. The question he wrote down from the original diagram was not directly related to the users' behavior. (The data used in this session was not even generated by users' behaviors. The variety of the data was another challenge to do the experiencing prototyping.)

Finally, the template of the prototyping plan, as shown in Figure 27, was not helpful but leading to more confusion for the participant. During the workshop, the participant could verbally describe the plan in mind but was confused about filling the template, so he kept asking questions to the facilitator. It meant he struggled with the session's layout but was not stocked by coming up with the prototyping plan.

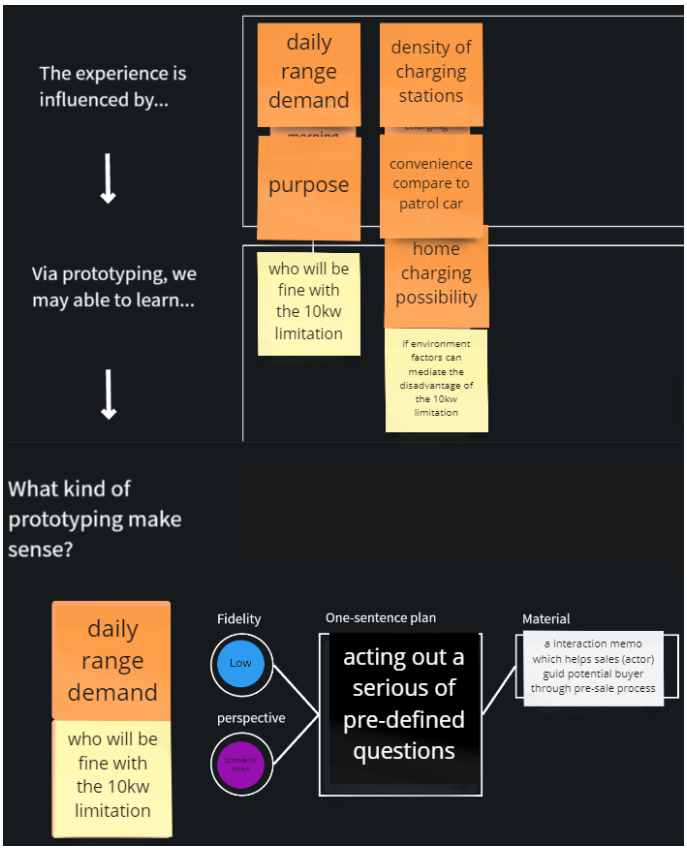


Figure 30. A finished Prototyping session of the online workshop

The participant of the second session was a Product Specialist who worked in a fashion brand company. A similar process as the first session was taken, while another add-on part was used to finish the complete prototyping session.

2

Product Specialist

Duration:

1.5 hrs + 2 hrs

How do people use their cars at nights on weekdays?

↓

How does it feel when my car runs out of power at nights on weekdays ?

The chosen question (objective) and the 'How does it feel' question (subjective)

The second participant generated more ideas in general. He proposed many questions, key components, and prototyping plans. In this session, it highlighted the problem that there weren't clear criteria or goals for participants to make decisions. Although the facilitator introduced the session functions and the usage at the beginning, the Prototyping session was not self-explained enough. It took one and half hours to progress to the step of the prototyping plan.

Since the research needed a more holistic view of the design tool, I extended the workshop to another time slot with the same participant to finish the Prototyping session. The prototyping progress was smooth, and so was the step 'Reflecting on Prototyping.' The participant invited me together to do the prototyping and then used the three categories of the last step to reflect on the prototyping successfully. He could learn new insights from the prototyping and clarify various aspects of the results with the three blocks of reflection. One important takeaway shown in Figure XX was that the prototyping approach's reflection could help obtain more in-depth user insights and clarify the exploration's directions.

"The first part of the workshop is framing. it needs more in-depth understanding of the design background. The second is design, it's easier because you can follow the steps and play." — participant 2 of the Study 2

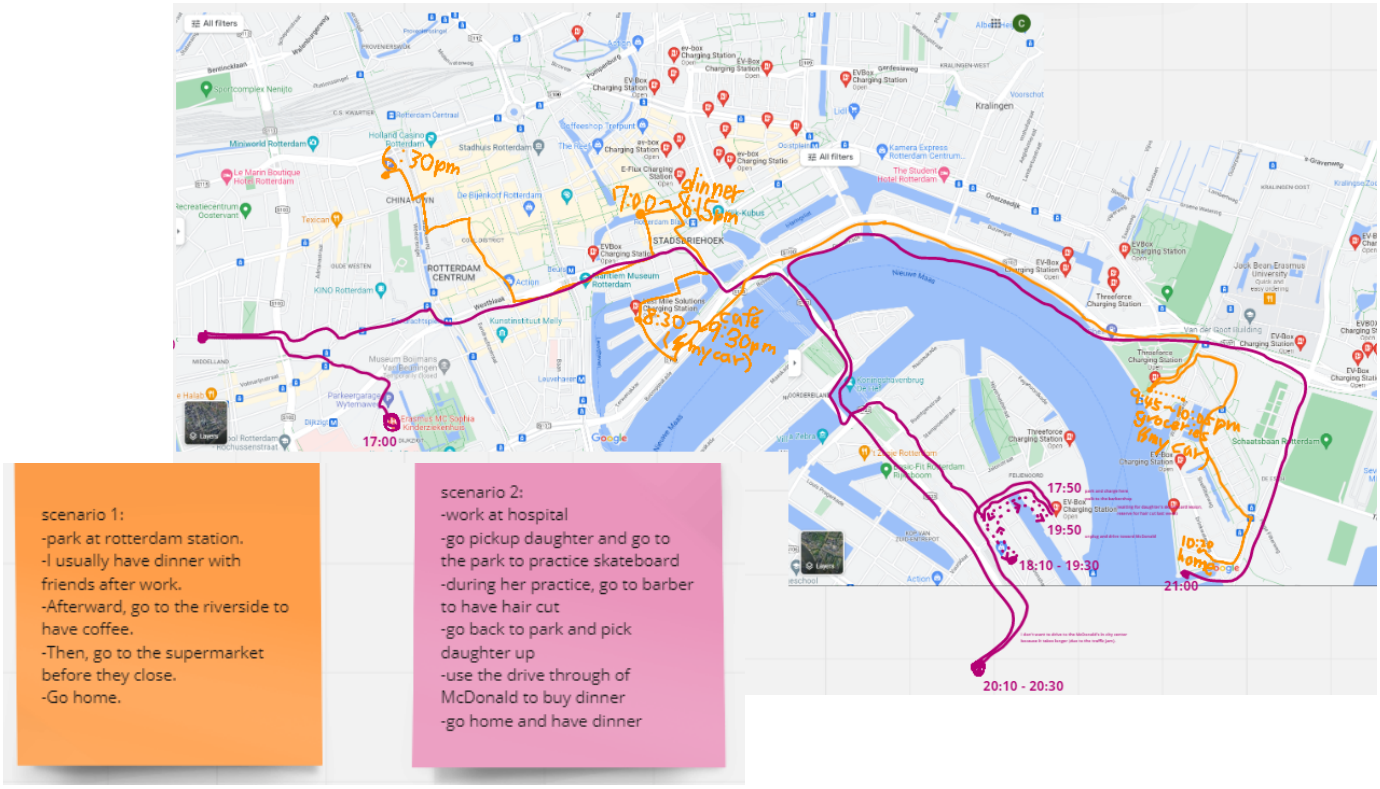


Figure 31. A prototype done by the participant, which involved drawing routes on an online map

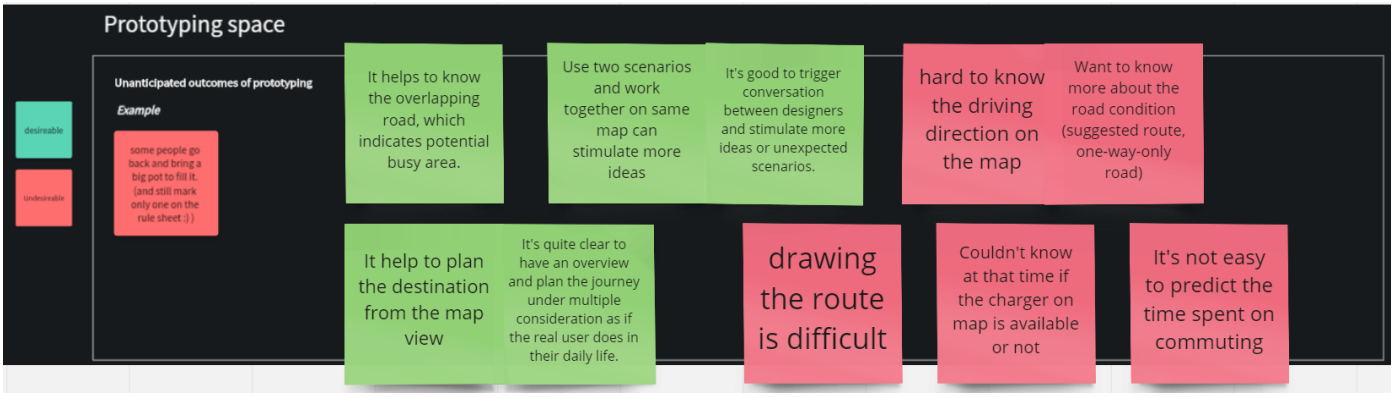


Figure 32. The unanticipated outcomes of prototyping for the participant. Greens for desirable, Reds for undesirable.

5.4.2 Iteration

There was a time limitation in each step of the prototyping session. Both participants were too confused about the description to complete the steps in time. Without the overall understanding, it was hard to follow all the steps and figure out the purpose of the session. As a result, I prepared slides for a better description of the design tool's overall idea to increase the prototyping session's clarity.

Besides the overall problem, for those parts that they had completed (till proposing the prototyping plan), they were stocked at the similar steps: asking the' How does it feel' question and proposing the prototyping plan.

I made some adjustments after the second session of Study 2. Since the information and the problems were not clear when the first time shared the design tool with others, only some small characteristics were adjusted to make the prototyping session easier to follow. For the hardest step, asking the' How does it feel' question, an illustration that visualizes the abstract concept was added, as shown in Figure 34. Then, for another challenging step, proposing a prototyping plan, a series of icons and the short videos of prototyping was added as the stimuli to trigger the participants' mind to come up with more diverse prototyping plans, as shown in Figure 35.

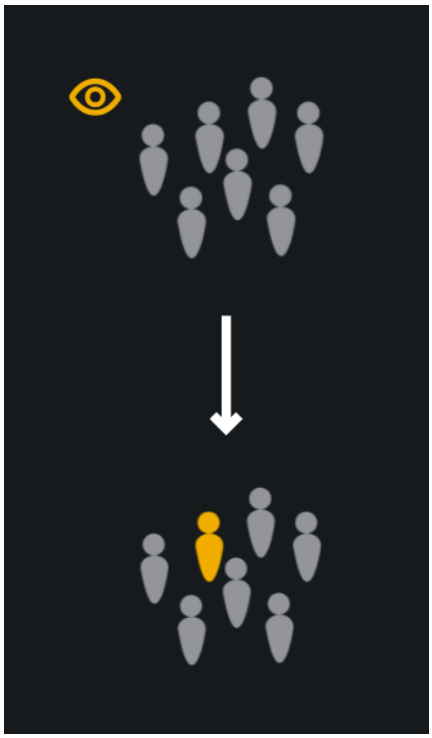


Figure 34. Adding illustration of the idea of 'step into users' shoes' to rephrase the question

Figure 33. The session iteration basically fixed the third layer's problems: the guide's issue.

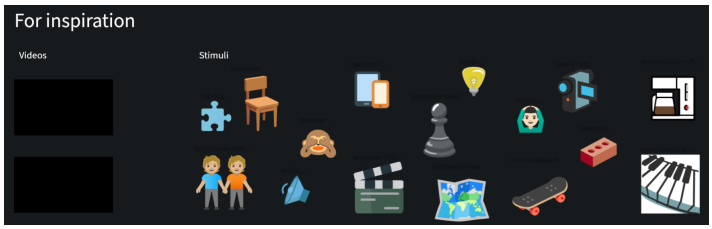


Figure 35. More illustrations were added to assist participants coming up with prototyping plans.

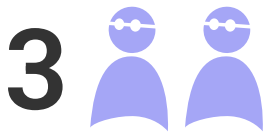
5.4.3 Workshop v2

Two Research Engineers, one was the Human-Centered Design Expert and another was the Innovation Project Lead, participated in the last session of Study 2 with the iterated version of the Prototyping session. In the end, although the description slides were added, they could not finish the entire workshop in two hours. It was out of time before proposing any prototyping ideas. The possible reason for that might be the whole idea of contextualizing the data by experiencing prototyping was not perceived well by the participants.

"We should always be able to connect to the overall goal. and I think the overall goal is at the moment a little bit missing." — participant 3 of Study 2

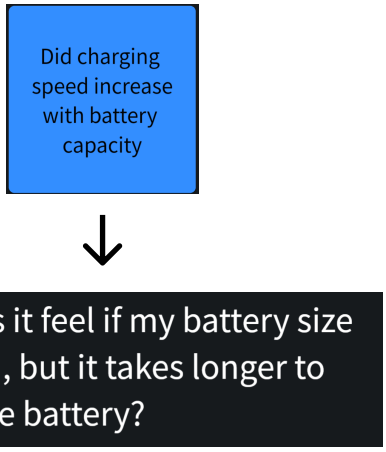
In the third session, though new features were added, participants were stocked by the steps of transforming the questions and coming up with the prototyping plans. During the prototyping session, they suggested using a scenario rather than a question as to the foundation of the prototyping plan. The scenario was a more concrete representation of the assumption, and it was easier to generate the variants.

"But you also saw that we need a scenario before we think of the right prototype. Therefore, I would say it's good if you are not just blindly fill in the boxes but also raise concerns. And see the deck as a good assistant or process." — participant 3 of Study 2



2 Research Engineer
(from Ford)

Duration:
2 hrs



The chosen question (objective) and the 'How does it feel' question (subjective)

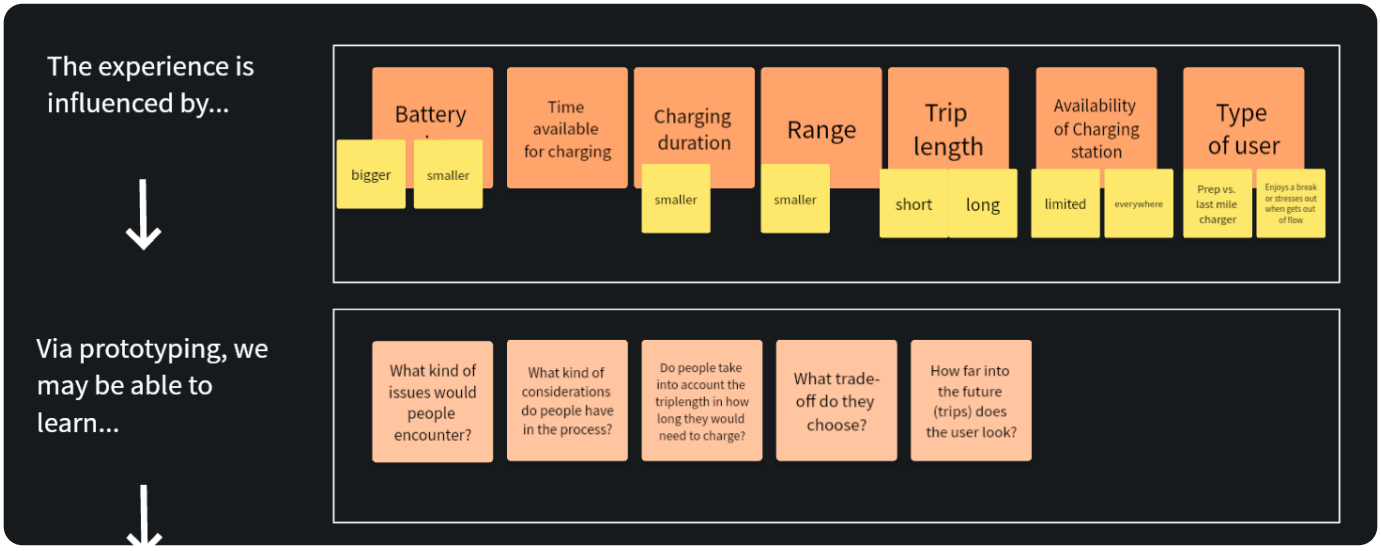


Figure 36. Participants spent much time in the step of "Identifying the critical components."

5.5 Key findings & decisions

1 Compared to the context (or factors), simulated scenarios are relatively easier for designers to come up with.

At first, the setup of the design tool targeted the context factors behind the input data. It aimed to find out the influential elements and prototyping around that specific subject. After the session, it showed that the scenario (story) made more sense to the participants. A scenario was also easier to conceptualize or concretize than key elements by designers when creating a simulated future. So, the coming design changed the mission into coming up with a scenario and formulating the prototyping plan according to the simulated scenario.

2 It ass not necessary to guide hand-by-hand. Instead, communicating an overview or a goal of the process allows designers to solve the tasks in their way.

All participants were confused about the many-steps session. Although it included a description part at the beginning of the session, participants could not understand the tool's overall goal and the minor goals in each step. Since the tool was designed for design experts, it should use a more principle-to-details way to guide the designers. The introduction should be clear but not necessarily explicit at the beginning, then introduce the details to follow as the practical operation of the overall contextualizing-data concept.

6. Study 3 : Data-contextualizing Canvas

6.1 Introduction

The goal of Study 3 is to assess the viability of the Contextualizing-data Prototyping Canvas. In other words, test whether the canvas can assist designers/ researchers in their daily work. Another purpose of the session is to collect more opinions from participants about using the prototyping approach in exploring the data.

Study 3 is also the iteration of Study 2. In Study 2, the schedule is introducing the tool first, and then participants follow the steps to use the tool. After they finished using the tool, they started discussing it. However, it turned out to lack time, and also, the introduction at the beginning was not descriptive enough to understand. As a result, the assessment of Study 3 includes the tool, setup, and introduction. The new setup and introduction also provide a benchmark that has the potential to determine the form of the tool.

The most apparent change from Study 2 to Study 3 is transforming a 'series of steps' into 'a canvas.' Because in Study 2, participants were confused about the steps. Not because of any uncleared indication, but because the lack of a holistic overview led participants to be unable to solve the problem themselves. So, they were stuck when the steps were hard to finish.

Another reason to change from steps to canvas is that the sequence is not the 'must be' rule for the function of the tool. The primary function is to explore the data in a prototyping way. There could be various combinations of design approaches to fulfill the needs of early research. As a result, a canvas that reminds different aspects of prototyping and data is expected to be handier than a series of steps that indicate every 'next move.'

As mentioned before, Study 3 tests the actual usage of researchers/designers and how they perceive this tool in their workflow. Study 3 comprised of Warming up, canvas overview, canvas testing, and Feedback four parts. Following the 3-30-300 seconds rule mentioned in the previous paragraph, the first three parts introduce the rules thoroughly with activities. And the Feedback part is to collect the participants' opinions and identify the tool's role in the design practices. It takes one hour to warm up and try the canvas and thirty minutes for the feedback (one and half hours in total.)

Due to the corona measures at the time, the session was planned to be a remote version. The main meeting was online, with the virtual call via Webex and Zoom, and the virtual workshop spaces were planned on Bluescape and Miro. There were three rounds for Study 3. The participants of the first two rounds were two design students of TU Delft, and the third round was tested with two employees from Ford.

Figure 37. The setup of Study 3

6.1.1 Warming up

In Warming up, participants are asked to observe the data visual shown in Figure 38. and make a plan with the virtual sticky notes to answer the question 'what would your plan be if you are asked to extract insights or facilitate the design process from the diagram?' The Warming up part takes about 10 minutes to finish. First, the facilitator (me) describes the rule of Warming up to the participants, guiding them to think aloud and write down the steps they would take. Then, the whole Warming up part ran communicatively, that the participants share their working flow with others.

The Warming up aims to familiarize the participants with the tasks that the tool can assist. They may quickly realize what kind of missions this session is targetting. Also, starting with a personal perspective may help participants notice the intuitive solutions from their experiences. On the other hand, for the research on how prototyping assists exploration, it can enable collect the original behaviors' data. The early test by Warming up can indicate the before-after differences in the design process.

6.1.2 Feedback question

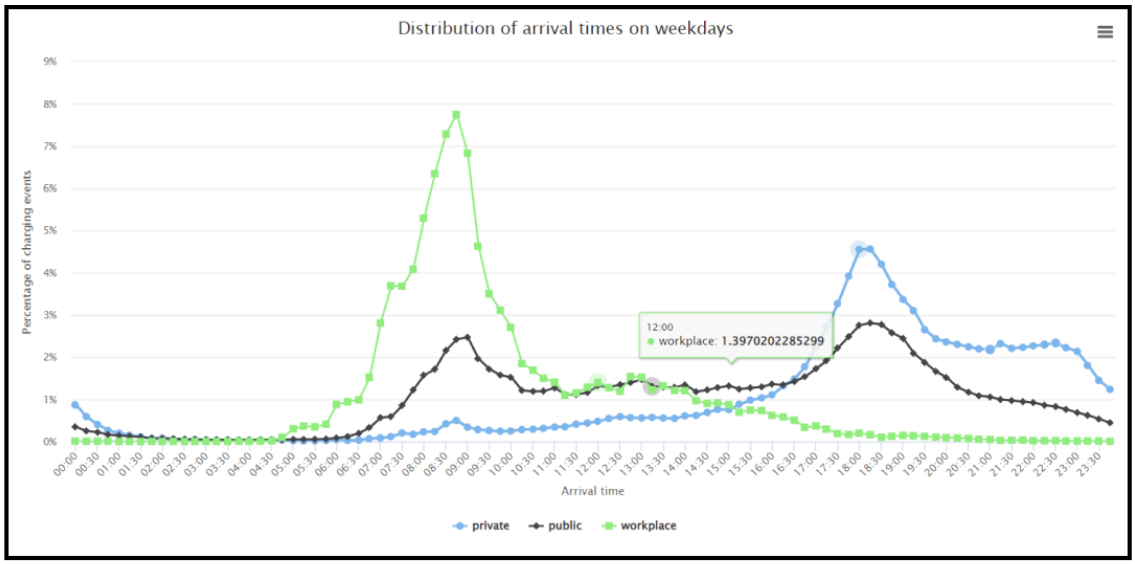
After testing the canvas, the final step was asking the feedback from the participants. It was formulated as a semi-structured interview, composed of several fixed questions and some relevant follow-up questions according to what participants said when needed. The fixed questions are listed as follows:

Q1. How do you feel the differences between the original research plan in the warming up activity and the canvas instruction?

Q2. What parts of the tool do you like the most? And what parts do you not like? Why?

Q3. How would you position the tool in your daily work?

Besides asking for feedback, the part includes a more open discussion to collect more ideas and thoughts from the participants. It takes about 30 minutes for this part and the closing of the v2 session.



What is your plan to learn new things from the data visual like this?

Figure 38. The stimuli used in warming up

6.2 Canvas

6.2.1 Overview

After the Warming up part was introducing overview of design approach. This part was the introduction of the design approach. The overview of the approach, shown in Figure 39., was displayed to the participants, and the facilitator introduces the figure to them. The overview part took about five minutes.

The overview was arranged with a loop-like layout to convey that the it was iterative. At the bottom of the canvas was a blue arrow that indicates the inputs, which was the data visual. And the orange one at the right indicates the outcomes, which were scenarios for design and essential data points. Users of the canvas could expect an iterative process that can help them transform data into scenarios and find out more data points to initiate the next loop or other design phases. A circle-like block, 'Rapid prototyping,' was placed in the middle top, which was the core of the canvas. The message from this arrangement was that the rest of the three blocks support the main character 'Rapid prototyping' happen. The reader may get a sense of what was the most important thing about the tool and what was minor.

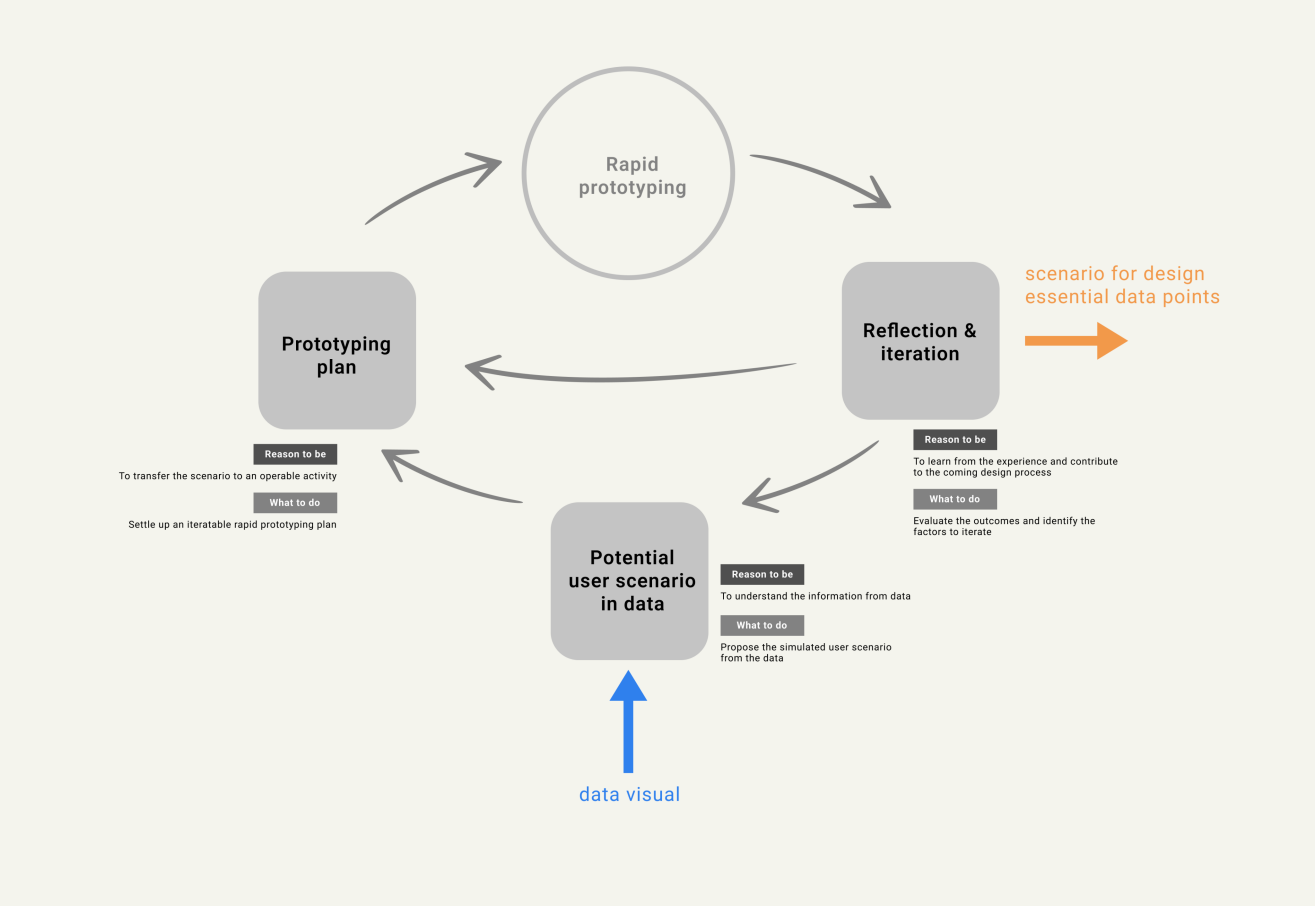


Figure 39. The overview of the approach

Four blocks represent four main missions that assist designers/researchers in exploring data. 'Potential user scenario in data' at the bottom helps designers/researchers to propose a simulated scenario by stepping in the users' shoes. It indicates a clear direction that interprets the data visually from users' perspectives to open up the opportunity for prototyping. In this block, it is also necessary to more or less understand the message from the data.

'Prototyping plan' is for designers/researchers to formulate a clear and realistic plan for prototyping the important parts in the scenario. A practical activity plan that can be executed immediately would help to ground and analyze the imaginary scenario. Meanwhile, making a prototyping plan would let designers/researchers know their scenarios better and think of the influential issues in the scenarios.

'Rapid prototyping' at the top is the core activity of the canvas. This Rapid prototyping block represents the execution of the prototyping plan. There is no indication or limitation for this block because the way of prototyping and flowing assessment are in other blocks. In this part, the canvas users should focus on experiencing the prototyping activity they have planned.

At the right is 'Reflection & iteration,' which is also connected with the orange outcomes arrow. In this block, the goal is to review and reflect on the prototyping activity to acquire the insights and the ideas for prototyping iteration. The mission of Reflection & iteration is summarizing the scenarios, plans, and prototyping in other blocks, collecting the insights, and moving-on strategy.

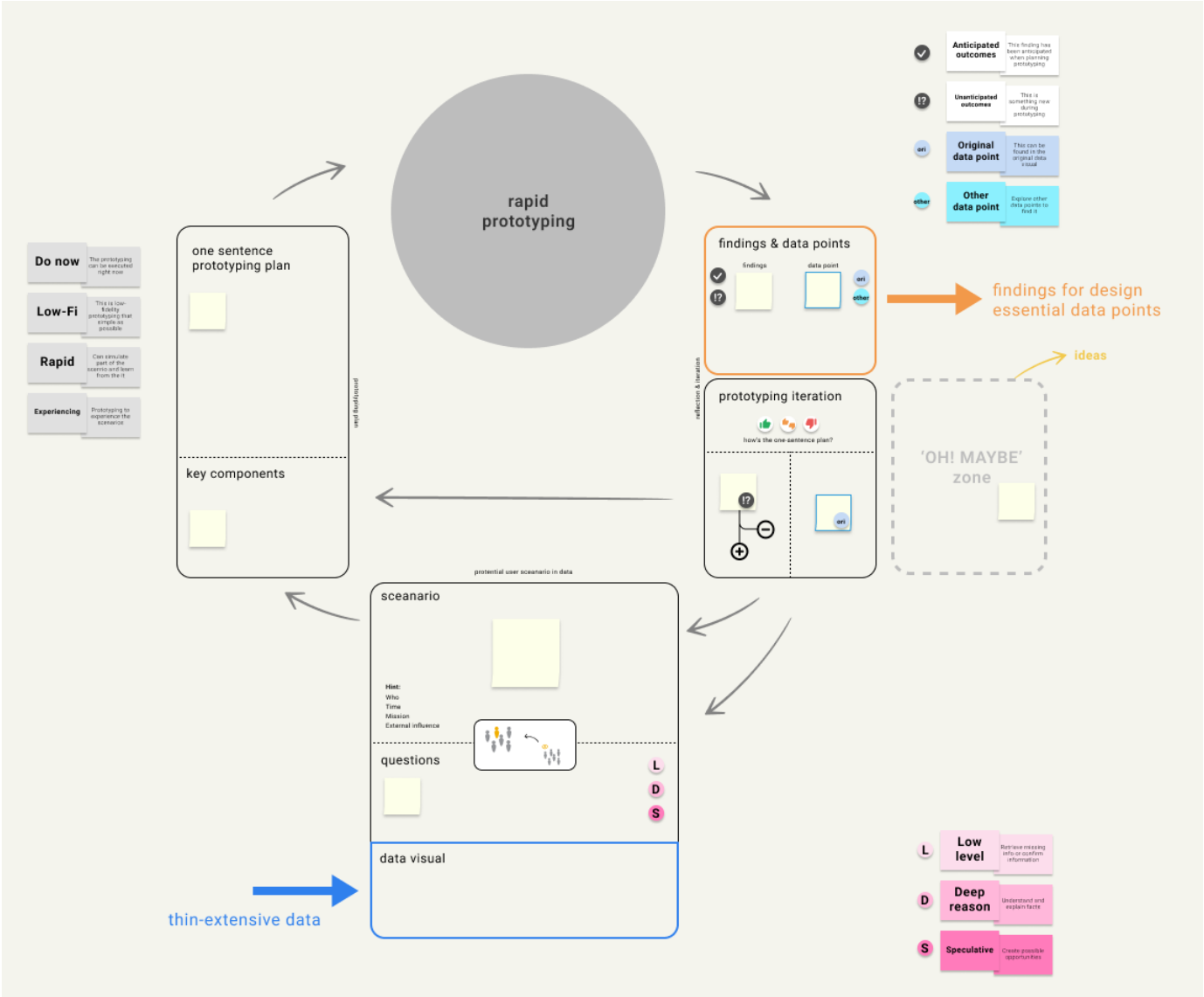


Figure 40. The Data-contextualizing Canvas v1

Data-contextualizing Canvas-details

The detailed canvas was introduced in the third step of the session, shown in Figure 40. In this step, participants were asked to test the canvas by themselves. The canvas retains the form of a 4-blocks loop and further showed the detailed content of each block. Following the indication on the canvas, participants prototyped in the their ways and extracted the insights. Some hints and tokens could help participants so execute the prototyping according to the original data visual. This part of the session took about 45 minutes to finish, the time would vary because of the different prototyping ways.

In Potential user scenario block, shown in Figure 41, there are three areas from bottom to top: data visual, questions, and scenario. Firstly, place and kind of thin-extensive data that needed to research in the blue area. Then, start to observe the input data and write down any question in mind in the area 'questions.' After collecting the initial questions, put three kinds of stickers on the question to differentiate the questions. Assign one question with a D sticker, which means it is a deep reasoning question, as the direction for this round. After the questioning, the canvas indicated shifting the role from a high-level observer to one of the users. In other words, step into users' shoes to simulate what scenario they might have experienced. There include some hints in this area to assist the participants to writing down the description of the scenario.

By the end of the first block, it would generate a simulated scenario that one user might experience according to the clues provided by the original data input.

The next move was formulating a prototyping plan to experience the important part of the simulated scenario. In this block, it contained 'key components' and 'one-sentence prototyping plan.' To further explore the simulated scenario by prototyping, participants could choose the specific moment, action, or factor to focus. These moments, actions, and factors were named 'key components' in the canvas. More details and perspectives would be discovered when focusing on the 'key components' of the simulated scenario. Also, identifying the 'key components' helps designers/researchers justify how and what to prototype can facilitate the exploration toward the desired direction. In other words, participants can also understand the 'key components' as the influential things in the simulated scenario. The intuitive choice will be tested and verified immediately in the coming prototyping activity. On the other side of the block was a 'one-sentence prototyping plan.' This area is to collect the potential prototyping ideas that designers/researchers will execute for exploring the insights. When ideating the prototyping plans, there are four criteria to follow. The first one is 'Do now,' which means the prototyping activity can be executed immediately. The second instruction is 'Low-fi,' which represents trying to think of the low-fidelity prototyping activity.

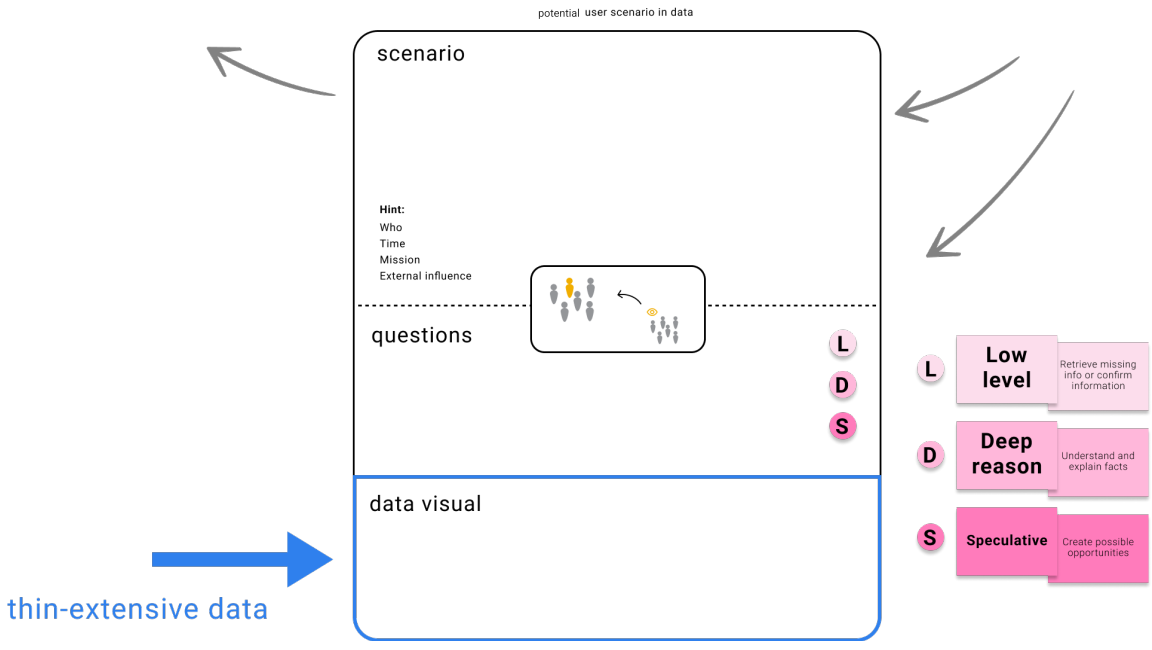


Figure 41. Potential user scenario block

A low-fidelity prototype allowed us to explore a wider range of topics, keeping the focus on a relatively abstract level to trigger creativity. Then, it suggested doing rapid prototyping that simulates the essential part to test and can be thrown away after the test. The rapid prototype helped in emphasizing the ‘key components’ we focused on and avoiding distraction from less relevant details. The last recommendation is ‘Experiencing.’ In this tool, designers should step into users’ shoes to experience what users may have experienced. The planned prototyping should let designers/researchers perform as a user rather than an outside observers. There can be many prototyping plans targeting the same key component, or one plan includes multiple key components.

By filling this block, participants can convert the simulated scenario into realistic prototyping plans. The comparison between the plans will assist the designers/researchers gain a deeper understanding of their assumptions. Finally, one or more plans would be chosen and be executed at the ‘Rapid prototyping’ block in the middle of the canvas.

In block 'Reflection & Iteration,' there were two areas assisting designers in collecting and assessing the outcomes. The area' findings & data points,' marked with an orange border, collected the outcomes generated in the prototyping activity. Designers/ researchers wrote down the insights and findings from their prototyping experiences and put them into the orange area. Besides the findings, the sticky notes of some essential data points, which might prove or support the findings, were also written and placed in this area. The orange area's content was the whole canvas's main output.

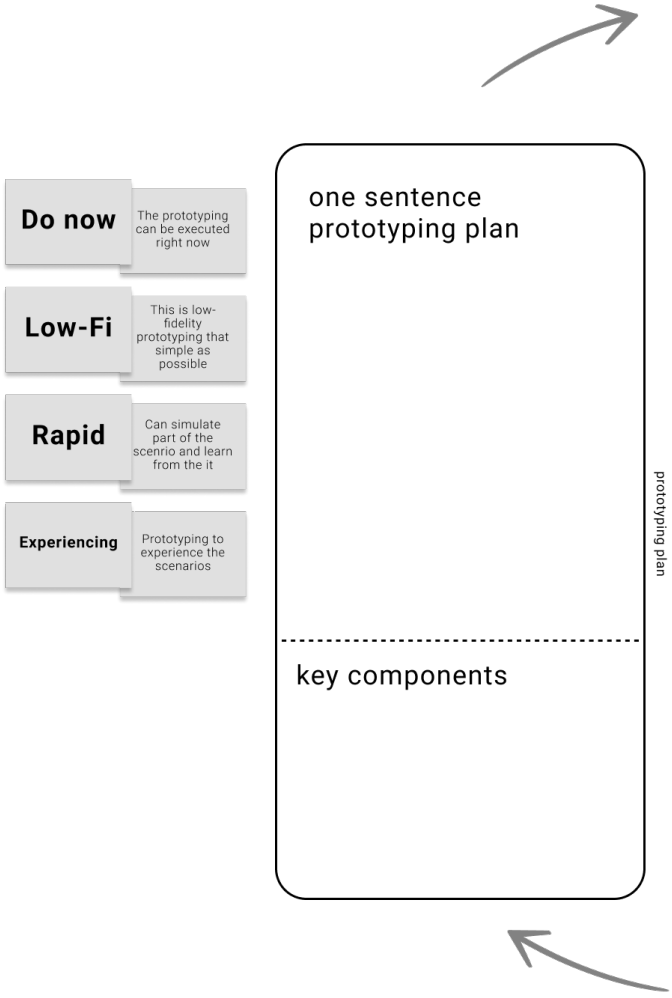


Figure 42. Prototyping plan block

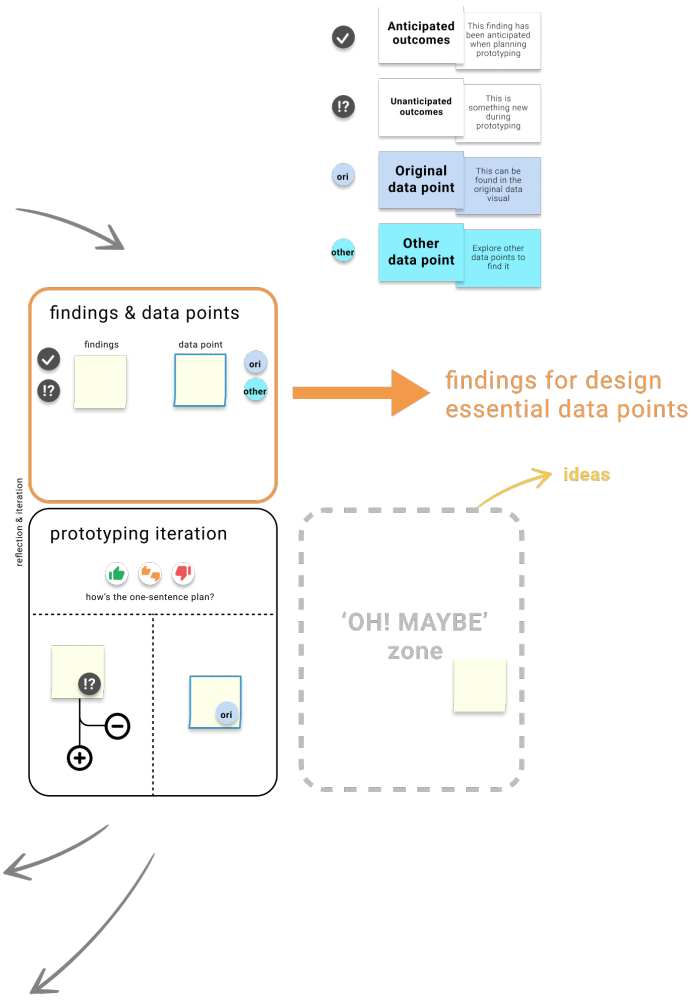


Figure 43. Reflection & iteration block

Next, there were two sets of stickers to mark the outcomes in the orange area for prototyping iteration. The first set is to justify if the finding is anticipated when planning the prototyping. If the finding was something that meets the expectation in the planning block, then put on a check sticker. Opposite that, put 'I?' sticker on the sticky note if the finding is something unexpected at the beginning. For the data points sticky notes, there prepared another set of stickers. If the data point mentioned on the sticky note could be found from the data visual, which was input at the 'data visual' area of the canvas, put an 'ori' sticker on it. Except for those with 'ori,' put 'other' on the data point sticky notes to inform what relevant data sets could be further explored according to the simulated scenario and insights.

Three strategies to reflect and iterate the prototyping plan were suggested in the area' prototyping iteration.' On the top was the overall reflection by the red-orange-green lights. Giving light to the plan allowed people to jump out of the content and reflect on the approach they prototype. The green light meant they could keep using the same way to prototype. The orange represented that the plan was generally acceptable but needed adjustments. The red meant it didn't help with the desired exploration, and should change a way to prototype. On the bottom left introduced another iteration strategy by assessing the findings notes with '!?' sticker. The note with '!?' sticker on it means this was something unanticipated when formulating a scenario and prototyping plan. Then, assess if these new findings are desirable outcomes that are worth to further exploring. If it was desirable, it was possible to add the findings to the scenario, or it could be treated as another key component of the prototyping plan. On the bottom right of the area, ' prototyping iteration' is the last iteration strategy driven by the proposed data points. The data point note with 'ori' sticker on it means the data pattern of the finding can be found in the original input (data visual). Designers/ researchers could highlight the relevant part and iterate the potential user scenario in the next round of prototyping.

Finally, there was a special area named “‘OH! MAYBE’ zone” on the canvas. This area was like a parking lot of ideas. Whenever it pops out new design solutions in mind during the whole exploratory activity, write them down immediately in the ‘OH! MAYBE’ zone. The area could store the creative ideas and yet keep the exploration process on track without being distracted. When designers finish one cycle of exploration, evaluating the solutions in the ‘OH! MAYBE’ zone might also contribute to the prototyping iteration or the other coming design process.

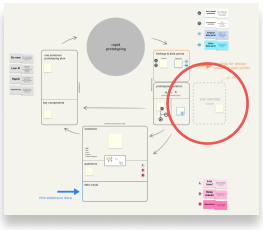


Figure 44. OH MAYBE Zone

6.3 Results

6.3.1 Results of canvas v1

Two sessions that used the first version of the canvas was included with TUD students in Study 3. The participants successfully used the canvas to formulate plans, prototyping, and extract insights.

Besides the pros, some key outcomes influenced the future iteration of the canvas. They were analyzed according to the topic of 'Design process' and 'The guide,' which were mentioned in the previous chapter.

1

TUD design student
Duration:
2 hrs

2

TUD design student
Duration:
2 hrs

v1

Problems about Design process:

- **The participant had no clue about picking only one question**

"I had so many questions in the first step, then I have to choose one and head far...maybe I can find the answer for multiple quesitions." - participant 1 of the Study 3

- **The understanding of the three types of questions consumed more concentration and energy than expected.**

"You ask me to choose only one deep resioning question, but I have so many othe questions that so interesting for me... I can do another cycle, but that cost me another half hour." - participant 1 of the Study 3

This point is also from my observation during the session. I observed the reaction of participants while introducing the questioning framework. It took some time to understand and categorize the questions, but only little effect (use only deep reasoning questions).

- **'Prototyping the scenario' is not clear at the first moment**

"I was confused when you mentioned prototyping, I thought it wants to test something, but no, it is just prototyping the scenario. Maybe phrase it as 'Simulation' would be better." - participant 2 of the Study 3

Figure 45. Participants prototyping with YouTube video and the cart in his room

Problems about the Guides:

- **The titles are not descriptive enough. Need a lot of faciltation to know what to do**

"I would like to have some small texts that can reemind me what am I looking for for this step...if I have some doubt, I can go back and check." - participant 1 of the Study 3

- **The description next to the canvas is very confusing**

"I see these four things in order, but something is more important than other, right?." - participant 1 of the Study 3

6.3.2 Canvas iteration

Remove inqiury

Asking questions when observing the data seemed to be intuitive and an easy step to start with. However, participants spent time rephasing and categorizing their inquiries, yet they had to generate the users' scenario afterward. The efforts were considerable, and the outcomes were not as important as the time invested. Additionally, participants were confused with the usage of the questions. It felt like you made an assumption base on another assumption. The problem could also be found in Study 2. That was, participants found it hard to ask the 'How does it feel' question, and they struggled in thinking of the key components they desired for the prototyping.

To tackle the problem, I first reviewed the overall goal of the approach, which was finding the design/ research directions. Also, I reviewed the smaller objective of the bottom block, which was generating a simulated scenario from data. It seemed that asking questions was not a necessary steps for both in-canvas and beyond-canvas goals. What was important was anticipating the scenario that users experienced by observing the original data. Since the questioning step adds more complexity to the design approach, the decision was to remove the inquiry steps and generate the simulated scenario directly from the original data visual.

In the new version of the canvas, designers were asked to observe the input data and directly come up with some ideas by thinking of 'what might the users have experienced?' Then, writing or drawing the simulated user's scenario. By doing this, it prevented designers fall into the mindset of asking a good or proper question. Instead, they could focus on only one single task, which was to think of a simulated scenario from the data.

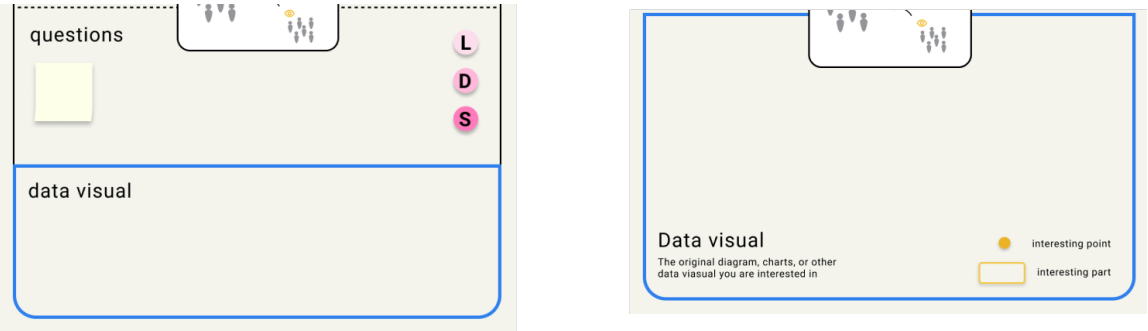


Figure 46. Remove the Inquiry part to simplify the canvas and reduce the confusion

In the first two sessions, I facilitated the participants using the canvas. They followed the instructions to finish the canvas. While the designers should use a canvas without any facilitation, it should provide specific information to let designers understand the missions and functions of each part.

Firstly, the potential user scenario block added the marking tools in the Data visual. The orange dot and adjustable orange area could let designers highlight the patterns or characteristics they found informative in the data visual. And in the Simulated scenario, the hint for designers to come up with the scenario was added. It aimed to assist designers in building the scenario with some specific details.

Secondly, in the prototyping plan block, I moved the descriptions into the canvas in the view flow to solve the problem in the previous session, which was the sticky notes were placed at the side and not being awarded by the participant at the first moment.

The last adjustment of the small tools was the stickers that mark something new and the data source. Since the last step, reflection used only the 'Unanticipated outcomes' and 'Original data point' to assess the prototyping approach for iteration, I removed the 'Anticipated outcomes' and 'Other data point' to simplify the information on canvas. Like the instruction in the prototyping plan block, the marks were moved closer to the sight flow.

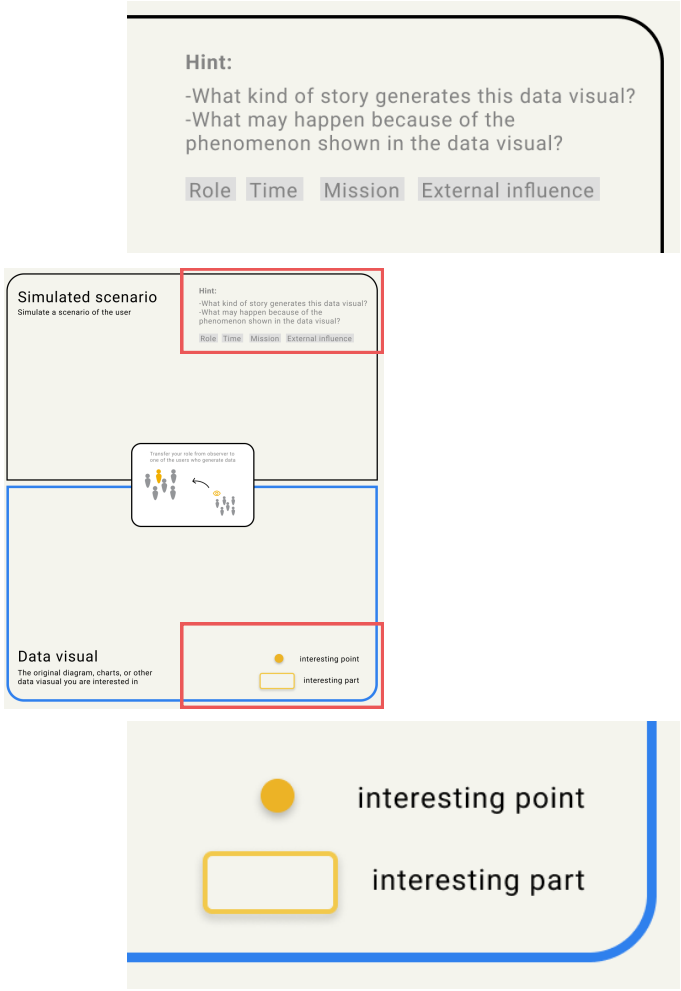


Figure 47. Adding the description of each area and adding the yellow marks to mark the critical points/ area in the data visual

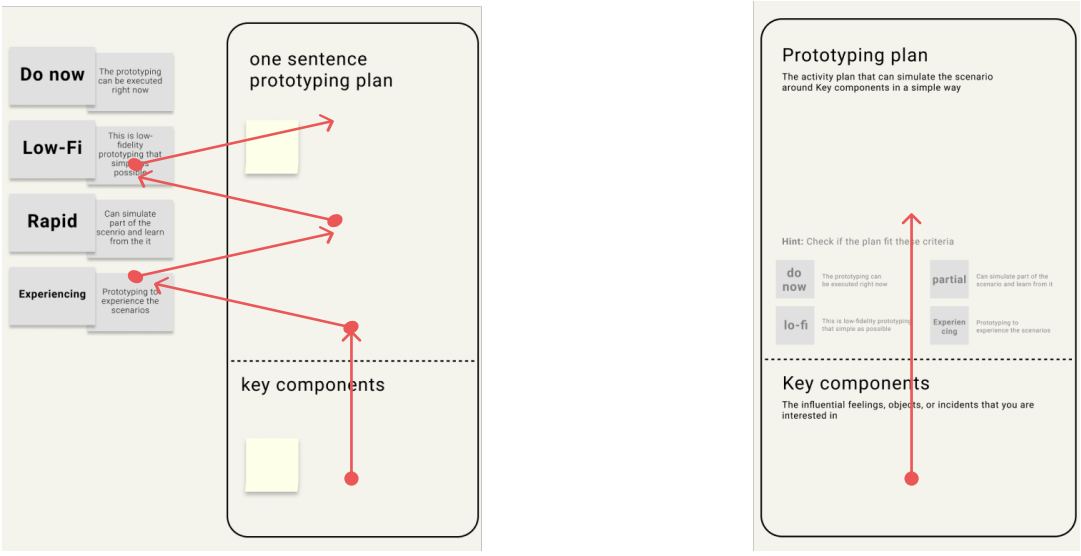


Figure 48. Integrating the assisting descriptions into the eye flow

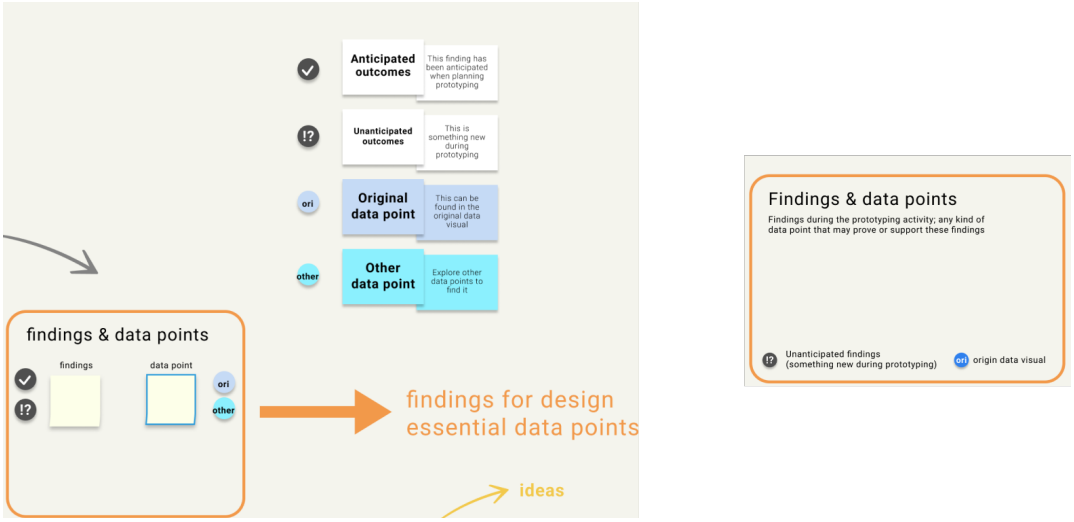


Figure 49. Simplifying the description next to the canvas

Reposition OH MAYBE Zone

The position of OH MAYBE Zone was moved from the space of outcomes to the canvas' center. New design ideas popped up in all four blocks during the first and the second sessions. One participant was unaware of the OH MAYBE Zone at the beginning, and he suggested having an idea parking lot.

Although the new design ideas weren't the priority of the outcomes we expected from this canvas, they were precious materials for the whole design work. Placing it in the middle might make designers aware of it and feel released because the sudden ideas would be recorded immediately.

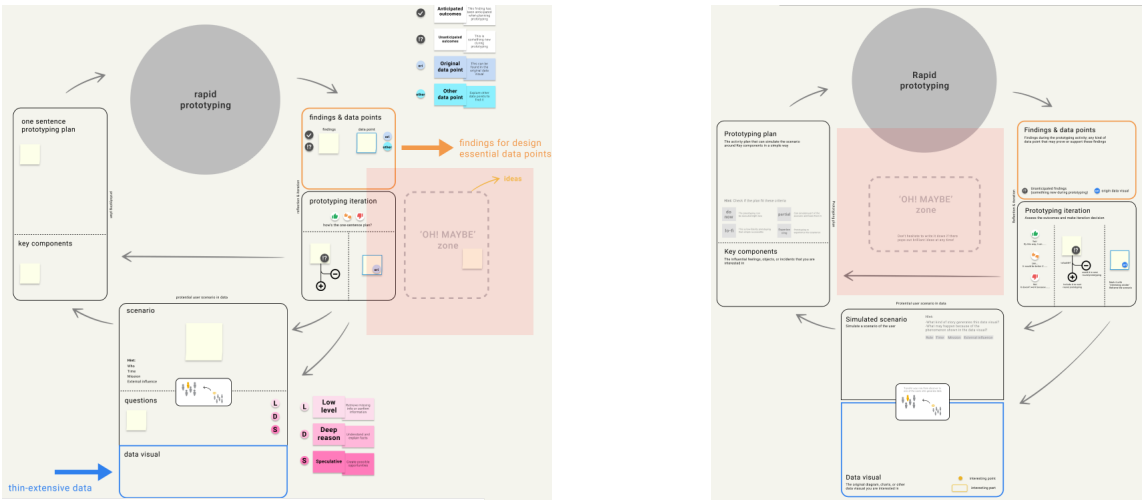
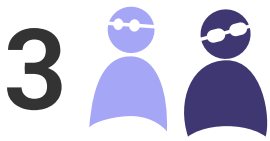


Figure 50. Change OH MAYBE Zone to center of the canvas

6.3.3 Results of canvas v2

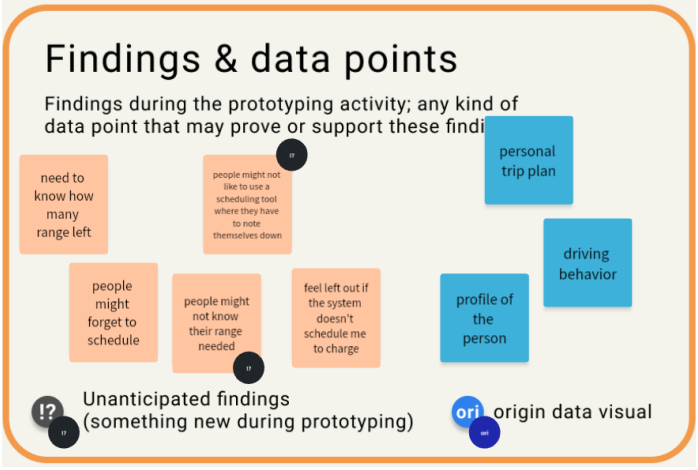
Two Research engineers from Ford joined the third session of Study 3. One participant was the Innovation Project Lead, who had participated in Study 2 as well. Another was the Intelligent Digital & Tophat Systems Expert, who generally develops products, services or technology for smart vehicles with a focus on the technical content, testing & implementation. He had a different background from all other participants in this research. He was trained as a more technical engineer rather than a designer.



2 Research Engineer
(from Ford)

Duration:
2 hrs

Results about Research:



Participants spend two hours in total finishing the session, including the prototyping activities. After the canvas iteration, most of the features were clear to the participants, who successfully learned the functions and purpose of the canvas. They generated the insights and the relevant data points which were meaningful for the future design and research.

"I think creating a story around a dataset helps, and (so as) get into the perspective of users."- participant 3 of Study 3

The participants also highlighted the core goal of this design approach: doing an essential pre-research before investing too many resources into formal research.

"You can not go out and observe or collect more data if you have no clue what to observe and what to learn." - participant 3 of Study 3

Last, the design approach was not a groundbreaking new solution, but the canvas helped visualize the abstract process in the designers' minds to benefit the team cooperation.

"It is definitely good to make it transparent what you are thinking...We walk through these together and make this abstract thinking more concrete, and we can share thoughts and also communicate about it." - participant 3 of Study 3

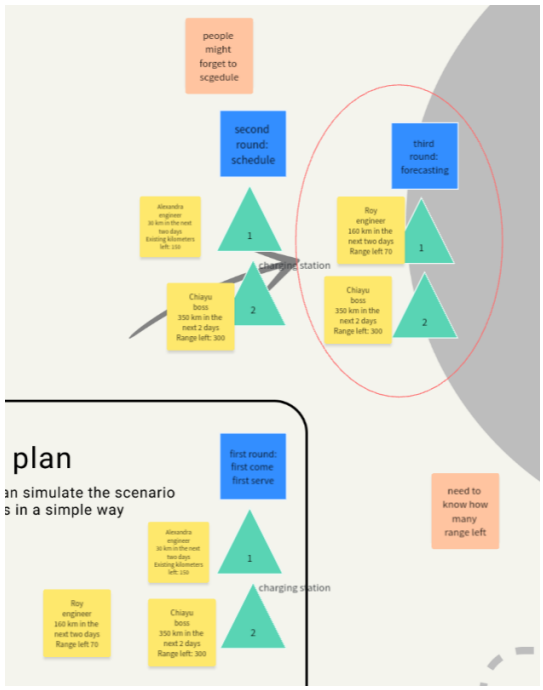


Figure 51. Participants prototyping with online white board, doing a instant-charger-occupied game with simple geometry.

6.3 Key findings

From looking for more datasets to diving deeper into user scenario

When trying to initiate the design process or research direction from the data diagram, it is easy to fall into the mind of 'only numbers.' All participants had mentioned the significant differences in their way of thinking. During the warm-up activity, they made a plan to explore the data, and in the meanwhile, they had several potential directions and actions in mind. These thoughts came out when they observed the data diagram, and they led their mind into a status that concentrated on 'numbers.' They keep focusing on the diagram to understand the meaning of the data, leading them to be stuck in a quantitative mind. Even the ideas or solutions are related to quantitative data.

When they use the Data-contextualizing Canvas to assist their exploration, they are forced to think in a qualitative-oriented way. As a result, they began to consider more about the qualitative stories and more aspects that were hard to discover from the quantitative data. The participants treat this as a positive influence because it does help to explore broader directions and find more opportunities.

The canvas offered a structured way to process the design exploration

Another positive feedback from the participants is that the canvas helped formulate the research/design direction in a relatively structured way. Though the potential scenario part of the canvas is also proposing the scenario intuitively, the following analysis of prototyping makes participants feel they explore the directions in an organized way. The canvas guides them to deconstruct the initial intuition from different perspectives, figuring out what exactly they are going to explore. It is also important to know and review what is included in the assumption. When it requires more data sets to support the hypothesis, what data sets are essential and reasonable to connect.

Introduce the principles first made designers apply their expertise easier

Layering the instruction in different levels is effective for people to understand the principles and usage of the tool. The function of the tool is to assist people educated in design in conducting design exploration and research. Therefore, hand-by-hand navigation is too limited since the users are design experts, who prepare the ability to learn abstract tools and use them. In addition, the constraints of steps-to-do limit the design skills and lead to more confusion.

Hence, after the learning from the experience of v1 session, the tools are layered into three levels. For the highest level, participants are told: what are the inputs, outputs, and requirements of using the tool. The description is formulated along with the core of what it is. In the next level, how the tool functions are the main message to communicate and introduce the four big steps. If users can understand the definition and complete the mission of each big step by learning their purpose, then they don't need to go to more details. Finally, the last layer introduces the details of what to do. The tool can assist users if they don't know how to think and how to transfer between different design materials.

Designers did not always assess the approach they used for research

The Outcomes & Reflection part of the canvas (blocks on the right) shows an area to guide users to reflect on the outcomes of prototyping and on their way of prototyping. The participant from Ford mentioned that she assessed only the results in her daily research job, but not the methods she took for research. Keeping reflecting on the approach is not a very efficient way in practice. The purpose of approach is allowing you to transform the inputs into the outputs. While the outcomes still need to be verified, it is unnecessary to reflect on the approach.

However, there is still some room to discuss. For instance, when the experiment has to be executed many times, then the adjustments of each round can be much more valuable for obtaining better outcomes. On the other hand, it still makes sense that tools may be simplified in the organizational design environment to be more effective.

Structure the process benefit the inner communication

The exploratory activity in early stage of research is usually execicuted by only one person because it is hard to cooperate or communicate with others when the concepts and ideas are still abstract and unsured . With the assistance from canvas, as mentioned before, it provides a more structured way to conduct the exploratory activity. To a design team, it will be easier to share and communicate what others are doing. In the v2.1 session, there were two participants testing the canvas at the same time, and one of them is not in background of design. They mentioned that not everyone is able to think or facilitate the process in such fast and creative way. However, in this structured way, it is possible to understand and further learn the process of thinking.

Need people with design expertise in the design team

Same point but another side of previous insight, the tool can be used by a well-trained person, but everyone. It requires a person who is able to generate many ideas, think of the scenarios, and propose the prototyping ideas. This is one of the criteria to the tool: it is made to assist people with design trains. Indeed, in the canvas, users are asked to use many design skills ,such as scenario, ideation, and planning a feasible prototyping methods. They are more design-orientated approched that need more experience to master all of them.

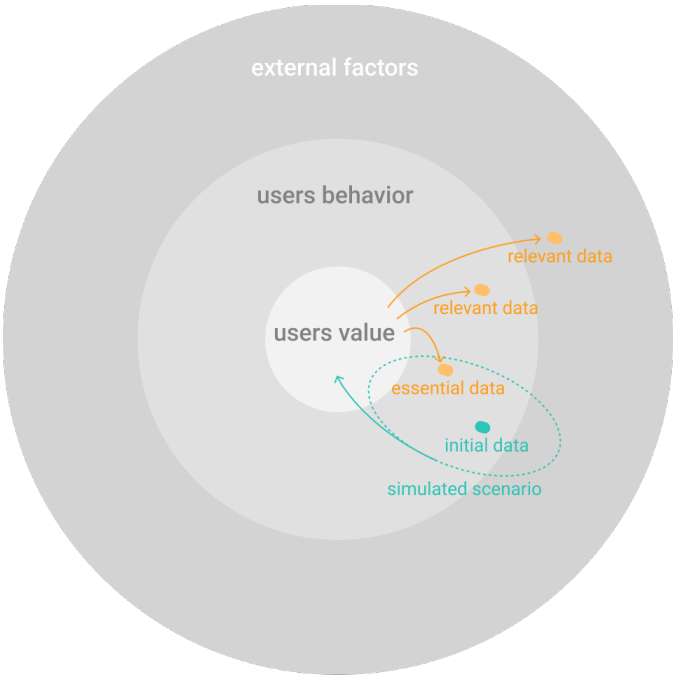
7. Discussion & Conclusion

7.1 Discussion & Limitations

After the experiment, we first answer the research question: how can we contextualize the initial data to facilitate the design/research directions? The outcome is the canvas. With the canvas we can translate the initial input data, big-thin data, into some design direction and related datapoints by simulating the users scenarios.

By analyzing the canvas and the studies, I am able to answer the another design question: How can Ford designers contextualize the thin-extensive data by prototyping for exploratory purposes?

The figure shows the concentric circles representing multiple user context layers. In the middle is the users' value which is the intention that drives users to do something. The middle ring is users' behavior, which sensors can detect and record as data, such as plug-in time, parking time, and in-app reservation. Finally, external factors represent those that are not directly caused by users' behavior but may influence users' decisions. For instance, the weather, traffic condition, and electricity fee.



Circle represent real user journey

The canvas contextualizes the data by leading the designers to find the users' value. In the beginning, the canvas guided the designers to generate a simulated scenario according to the initial data (either users' behavior or external factors) and emphasize the interesting/important components in the scenario. The process help designers focus on what's happening in the real world rather than just the numerical information from big-thin data. Then, the canvas leads designers to experience the scenario by prototyping, discovering the insights and opportunities for coming design or research. At the final stage, the designers documented the findings and were asked to mention the relevant data points. This step brings designers from the exploration back to the practical validation status to check the fact behind the data. The canvas then helped raise the data awareness again, and it suggested the following actions to take.

Through elaborating the last back-to-data step, designers can find essential data points which can potentially prove the proposed scenario from initial data. And other relevant data points can indicate the users' behaviors and external factors to understand the contexts better.

To conclude the process of contextualizing the data, the canvas facilitated the designers to explore user insights with the mind flow of 'data to value to data.' It raises the awareness of users' value when designers dive into the data and raises the awareness of data again when designers dive into the scenarios.

Figure 52. Data to value to data : By prototyping the experience of simulated scenario, designers can identify the potential user value and further link to essential data points.

Prototyping in a Structured Way

One function of the canvas is to assist designers in structuring the prototyping activity for exploratory purposes. Besides the features that include data in the canvas, the design of the canvas helps designers analyze their ideas of prototyping in a structured way. The canvas was designed according to the analysis of previous studies (Study 1 & 2). The four main blocks of the canvas indicate the different sessions of prototyping activities. The first block guides designers to generate a scenario that informs what to prototype, and it also suggests the way of interaction as 'experiencing it.' Then, the result of the second block is the prototyping plans. They are the representation which means the form (way) to do the prototyping. Also, designers can define which and how many details will be simulated in the prototyping plan. Finally, after executing the prototyping plan, there are steps to extract the essential results, such as findings, data points, and new ideas. In the last step, also suggest concrete approaches to iterate the prototyping. By structuring the different aspects for exploring with prototyping, designers are able to concentrate on the design challenges without being bothered by messy and explosive information in mind.

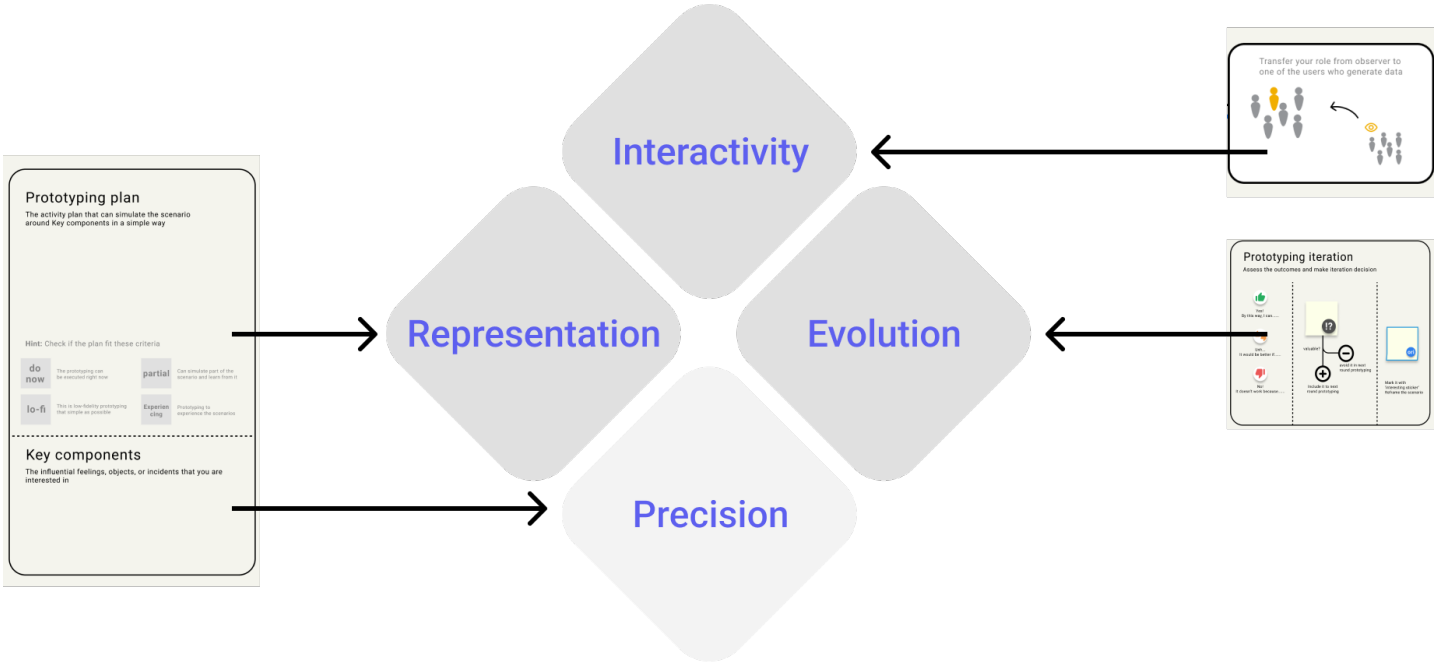


Figure 53. Match the charactoristics of canvas to four dimensions

The role of prototyping and data in exploring the design space

In the concept of design space, the action of exploration is to identify what are the constraints and what is still open to creation. It also mentioned that prototyping could expand design space and clarify design directions.

From the previous studies, participants found new directions to explore when prototyping the simulated scenario. For example, a participant said, "Then, if we want this work, we need to know how many milages he drives every day. Maybe just every weekday." The simulated scenario has set a concrete representation that designers can understand and then start to explore along with a more specific direction.

On the other hand, designers can also use prototyping to identify the relevant data that provides more facts to frame the design directions. For example, a participant said, "...because the wall boxes are not enough, we can develop a cool scheduling system." The participant found a factor that could influence the design direction from the simulated scenario and saw it as an influential component when exploring the opportunities.

The two examples show that prototyping a simulating scenario can also be relevant to the concept of design space. The data represents a part of the reality, and it can play the role of the constraints in the concept of design space. Designers frame the simulated scenario according to these data, and these scenarios can indicate both constraints and space to explore. In this way, designers are able to facilitate the exploration of more design opportunities by keeping discovering more constraints and open space.

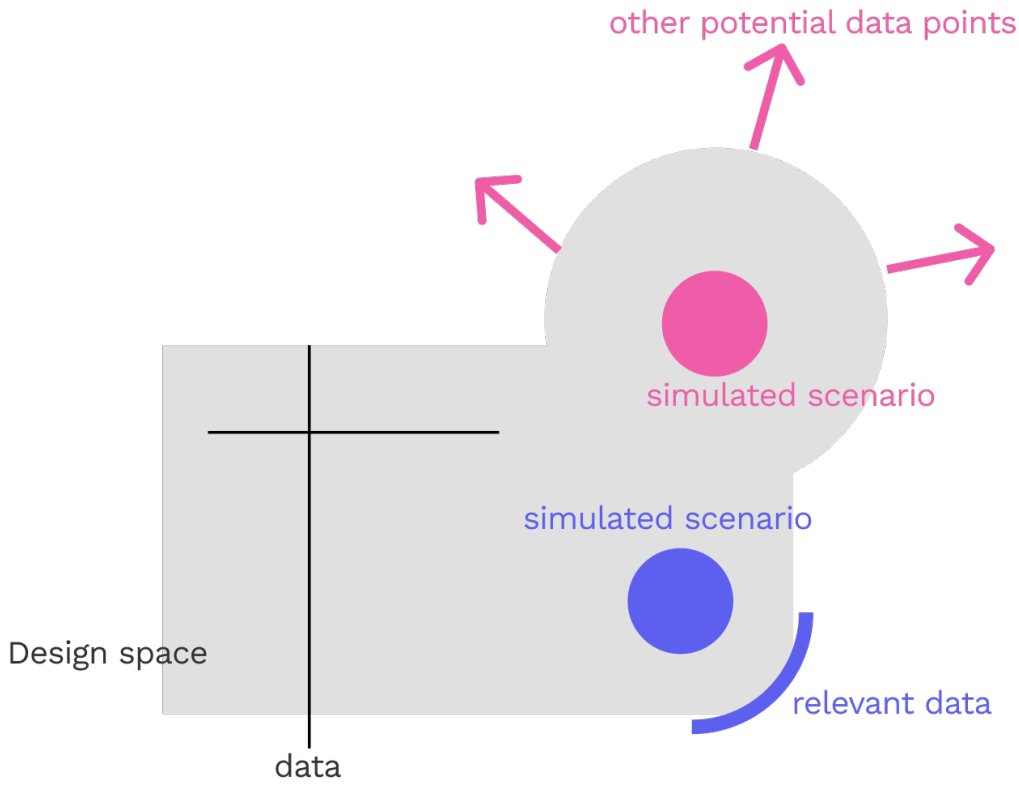


Figure 54. The data played the role of constraints in design space; the simulated scenario helped expand the design space and establish new constraints.

Low-fi prototyping works

There are two categories of reasons for applying low-fi prototyping. One is related to creativity (Buchenau & Suri, 2000), and another is related to the design practices in the industry.

On the subject of creativity, low-fidelity prototyping is effective. The participants successfully found the new insights they were satisfied with by executing low-fidelity prototyping plans. The participants were not distracted by building a 'proper' representation of single objects in their simulated scenarios. Instead, they were focused on the components they proposed and used some easy representations to simulate the scenario.

From the studies, we can only know that low-fi prototyping can effectively obtain new findings (and the relevant data). However, since the influence of the fidelity was not the core of this research, I did not test the effects of using the high fidelity prototyping.

Another beneficial reason to apply low-fi prototyping is practicality. Low-fi prototyping can save cost and time because it doesn't need to include authentic objects with many details. Low fidelity prototyping uses simple materials, such as paper or clay, and simple actions to simulate the essential part of the scenario. The most important thing is to precisely choose the critical aspects to simulate, but not how real it could be. Also, the prototyping is used or experienced by only designers for exploratory purposes. As a result, designers can build low-fidelity prototyping in very short time and cost but still effective.

The iteration of prototypig activity was not always considered

In the last iteration step of the prototyping cycle, designers can again review the simulated scenario, prototyping plan, and prototyping process according to the quick analysis of the results. In study 3, participants were unsure or confused about what they were doing with the canvas in the first round. However, when they finished the first round of the prototyping cycle and started to review the prototyping again, they were able to point out what they did and how it would be better to do the next round of prototyping, either in a new way or adjust the focus.

"Ya, I would do it again, but I will use better devices that can really show the status of charging and the percentage of the power."

In another test of study 3, participants from Ford showed a different attitude to the iteration session.

Since the participant already got many new ideas and directions to test, how to move forward and verify the findings were more important than doing another round of exploratory prototyping.

"In my practical work, I would not reflect on the methodology, but the outcome...I would not be interested in how to redo the experiment that I just did, but to find the points need to be tested."

The opposite opinions show the different strategies to process the design progress. Redoing the prototyping means exploring more opportunities from the data and increasing the diversity of the design directions. By iterating the prototyping approach, designers may eliminate the bias and notice the neglected aspects of certain scenarios.

On the other hand, diving into the findings to test the assumptions means closing the exploration phase and starting to verify the directions that they received from the prototyping. The two situations will both happen if designers want to process the progress (It must be a moment to quit the exploratory prototyping cycle). However, this research needs broader study and discussion if the iteration is a necessary step.

Note that the discussion about iteration need to be further proved and justified since the iteration round was not tested in this research.

Value awareness

Then, how does this canvas make a difference in designers' design process?

The original situation is that designers observe and understand the data, interpret them into assumptions, and then test them in the next design phase. Though the outcomes of using the canvas are still the design assumptions, there are some differences in their characteristics.

First, the awareness of user value is emphasized when using the canvas. Participants compared the outcomes of the warming up session and canvas session themselves, mentioning they concentrated on understanding data and knowing more about it. After collecting enough data, they try to propose an hypothesis according to the facts they learned from the data.

Conversely, using the canvas provided a sure way to raise the awareness of user scenarios and value in the early exploration phase.

Let's put the two ways of thinking on the concentric circle of users' context proposed before. The Figure 55. illustrates the two different ways of exploring data. The original way, the purple color, starts with the data and understanding the data better by finding more datasets that may have relations to the initial data. In this way, it is like finding a piece of a puzzle that can match the original piece. Different from the original way, with the approach of experiencing the simulated scenario, designers form a story according to the original data and recognize the potential user value during prototyping. Then, looking back to find if there are proper datasets that can support the assumptions. This approach is more like using the original puzzle piece to guess what the complete picture looked like, then finding the key pattern in the pool of puzzle pieces to test if the picture exists.

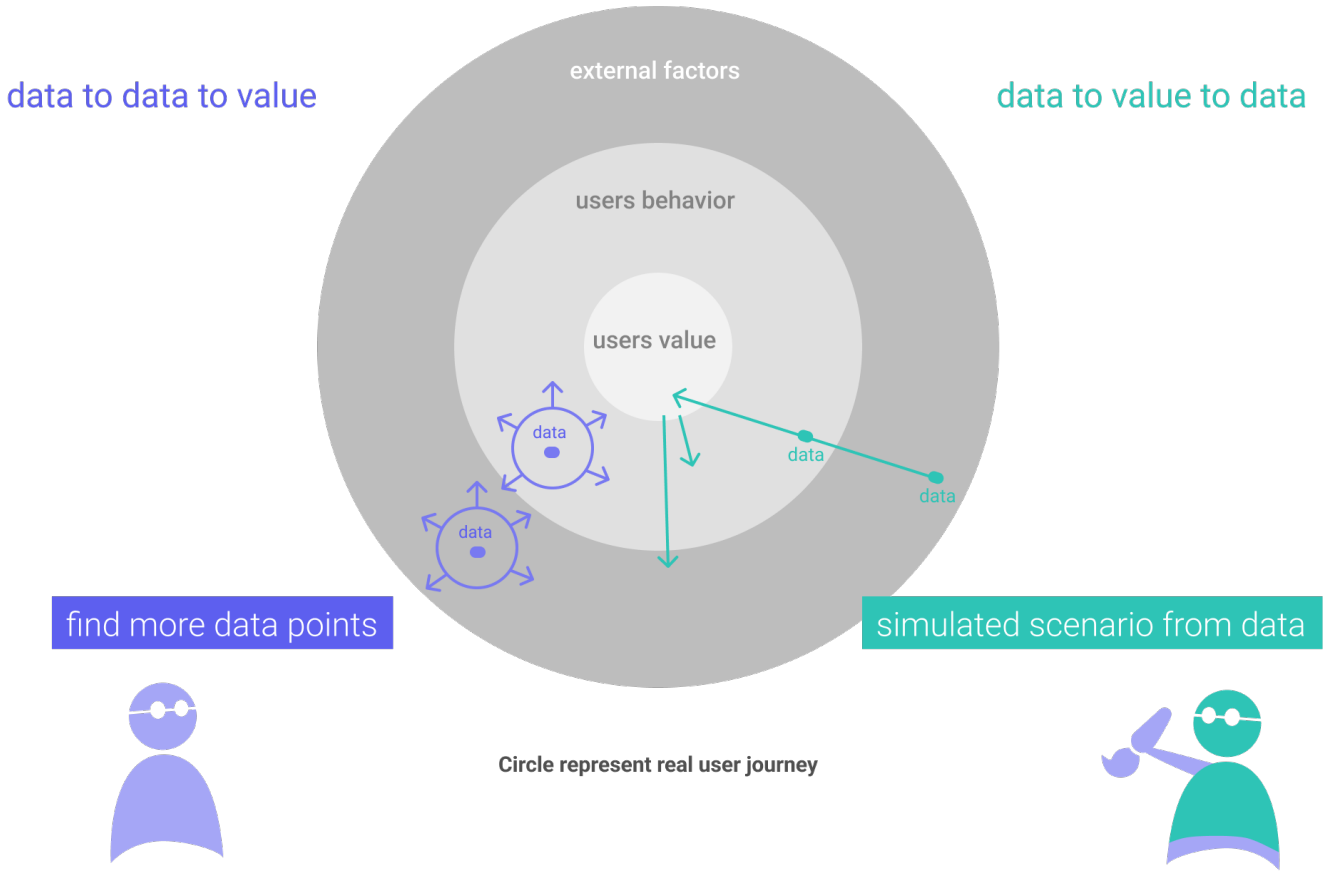
According to the sequence of actions, I named the method in purple 'data to data to value,' which is more common in current working practice. The new method proposed in this research is named 'data to value to data,' which is another option to explore data to make sense of data.

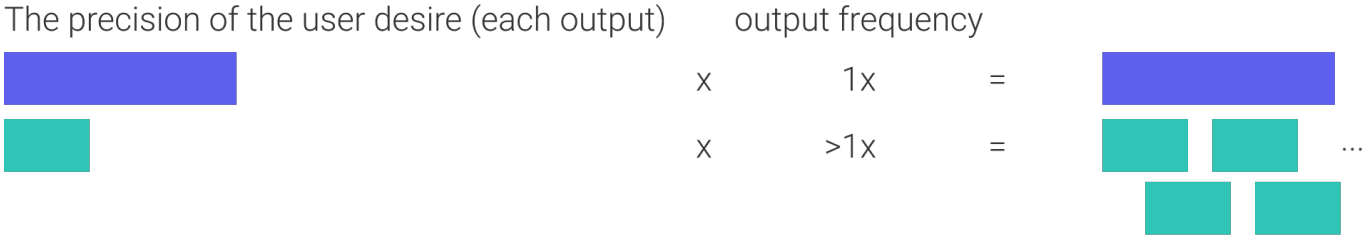
'Data to value to data' is a mindset about implementing the awareness of user value into the early data exploration. In Ford's design team case, understanding the data and using more datasets are sometimes challenging. Instead of directly diving and exploring the big-thin data, designers can explore the directions with a more designerly approach, which is proposing the simulated scenario before collecting 'enough' information from the data. The approach relies on designers' logic and understanding of user value to bridge the gap of the lacking information (from data). The outcomes may be less convincing than those from 'data to data to value.' So, using the 'data to value to data' approach is important to validate with the actual users because it includes fewer facts(data) at the phase of forming the assumptions.

In the context of Ford's design team, sometimes similar to other design teams, the effort to access the data and use it in the early stages is high. It is like a big bet in design practice: high-risk, high pay. However, though the accuracy of the approach' data to value to data' is lower, the low-cost characteristics allow designers to do it many times to clarify the research directions.

Another way to differentiate 'data to data to value' and 'data to value to data' is the requirement of different expertise. Previous research mentioned the ability gap between data analytics and designers/ researchers (Jansen, 2021). The cooperation between user (design) experts and data experts were critical because it needs the first demonstration of more pattern for designers to understand data and then interpret the data to users' value with a user-center mindset. We can see this process as 'data to data to value.' On another side, 'data to value to data' is first proposing the user value by design experts and then requiring the data to iterate the directions.

It is possible that the 'data to data to value' approach can detect more pain points because it gathers more data in the first stage, which focuses more on current situations. While with 'data to value to data,' there may be more directions related to new value prepositions because the simulated scenario allows designers to highlight more exciting ideas. These assumptions haven't been tested yet but are worth discussing here. The influences on design outcomes by using two approaches can be studied in future research.





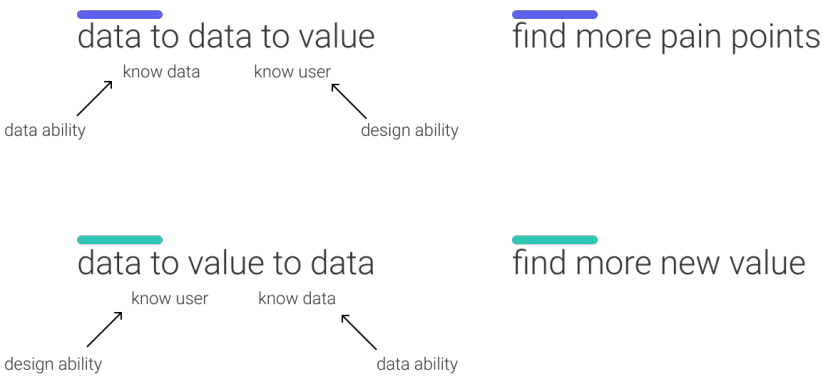


Figure 55. Two different ways of exploring data, and their characteristics (precision of user desire, time distribution, functions)

Limitations

This research has some limitations due to time, researcher, and current situation.

Firstly, the research was conducted from 2021 to 2022, which is the period influenced by the Covid-19 pandemic. Most of the materials and approaches used for prototyping in this research are digital. Only one participant used a physical cart in his room to prototype. However, it is hard to discuss the differences between using digital materials and physical when exploring data in this research.

Secondly, most of the data visuals used in this research were from the same source, Elaad, and the same topic, electrical vehicle charging. Only one participant used his own data visual as the starting point. Since the research was not focused on the content of the data, the influence of data input might not be critical to the results. However, it needs to mention that the quality or the subject of the input data may have the possibility to influence the outcome. Also, the data input in this research were all data visuals, and they were with only one picture for every exploration cycle. The diversity of input data forms was low. It will be necessary to include more kinds of input data to generalize the use of canvas if there will be more experiments.

Then, the process of forming the canvas was a trial-and-error process. Not until study 3 were the sequence and the instruction of steps/stages clear. As a result, all the studies, including study 3, were facilitated by me. The instructions on the final canvas or workshop setup were just the role of assistance. It didn't test if the designers could understand and successfully use the canvas without facilitation. The design of canvas can be further optimized to increase usability.

Finally, as mentioned in the previous chapter, only the sessions in study 3 were finished by participants in time. However, no session had gone to the iteration stage(another prototyping cycle). 'How iteration can influence the results' was not tested in this research. This may be a critical aspect since participants had a significant change in their reaction to the prototyping plan and simulated scenario.

7.1 Recommendations

Many ideas and directions were generated from each cycle. This research focuses on proposing the directions and data points but doesn't include the evaluation part to converge the ideas and directions. For designers who want to use the tool offered in this research, it is suggested to do an additional evaluation to collect the outcomes and give a hierarchy to the result. The canvas was designed in a certain structure, and it clarifies the different aspects of the prototyping and scenario. An evaluation approach can be planned by referring to the structure of the canvas. The sequence of outcomes in the canvas was data, scenario, key components, prototyping plan, findings, then data points. The evaluation can assess the problems or the opportunities for different subjects. For example, if there is a problem in the prototyping plan, it can keep the same key components and generate another plan. A structured approach can help in assessing the outcomes more efficiently.

Simulate the scenario from more general contexts, not only one user's perspective

In the canvas, I assigned the way of 'experiencing the simulated scenario.' The decision was made because I believed it was easier for designers to empathize with users. However, some data related to external factors did not directly show the users' behavior. Via this kind of data, generating a simulated scenario that is experienceable didn't make much sense and was not very intuitive for designers to do. There was a possibility to execute the 'data to value to data' by a more general approach than experiencing the simulated user scenario. An extended tool that assists designers in generating simulated scenarios from 'non-behavior' data is also possible. After all, the development and the use of design tools are usually adaptive in various situations.

Research on how the level of prototyping fidelity influence the data exploration

Besides the dimension of Interaction, Precision is another critical aspect that may influence the experiment results. The canvas suggests that the designers should use a low-fidelity way to prototype the critical parts of the simulated scenario for exploration purposes. The reasons are mainly about saving resources, enhancing creativity, and discovering more opportunities, as described in the previous chapters. However, the discussion around collecting more details of the facts as the foundation to propose design direction brings the high-fidelity prototyping back on stage again. More details of the facts may help discover the pain points, and it means high-fidelity prototyping could help uncover more information in the scenario. The effect of high-fidelity prototyping was not tested in this research. It is possible to find more insights or highlight more characteristics by comparing the outcome of low-fidelity prototyping.

Research on designers' mind flow when exploring from a data visual

There was a phenomenon that most of the participants were asking for more datasets intuitively when they were asked to make their own plan to extract insights from data. This was attributed to the 'data to data to value' process in the research. Though most designers were trained to be more user-center when detecting the question, they concentrated on finding more data. The mind flow of how designers perceive the big-thin data may be a topic to research. Why does it need more data(information) to facilitate the design process, and what is the strategy in mind to explore data may be helpful to develop more tools to assist the design work.

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9. Appendix