M. Sc. Thesis

Reflecting on Health Data: Exploring Approaches to the Design of Reflection in Interactive User Interfaces for Data Donation in Healthcare

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Summary

Nowadays, mobile devices (e.g., smartphones and wearables) make it easier than ever to track personal health data. By doing so, users can gain insight into their daily movement, heart rate, and blood pressure. This data can also be useful to medical researchers, who can use it to help with recovery or assess disease progression. However, simply collecting data is not enough for users to determine their overall health. For instance, the number of steps taken during the day alone is not meaningful. But compared to the past number of steps, heart rate, and blood pressure, it becomes possible to conclude whether one's health status - is improving or deteriorating. The way this data is presented is crucial in prompting users to conclude and to reflect on their health. Effective visualization and design elements can emphasize meaningful changes in the collected health data.
In this thesis, I aim to investigate how an interactive user interface for donating health data can be designed to support users' reflections on the data disclosed.
The research process will closely follow the human-centered design process. A scoping review will be conducted to obtain insight into the current state of research and aid in the creation of an interactive user interface that supports reflective thinking processes. This review will collect existing knowledge about reflection in interactive user interface design to use in the design process.
In the second part of this thesis, I will create a prototype for an app that supports reflection, specifically in the context of diabetes. The design process outcomes will be evaluated by a diabetes specialist, followed by a qualitative study to assess the prototype's effectiveness in helping users with their reflective processes and its overall usability.
I created a website to explore the concept of reflection in human-centered computing and how it can be used to support reflection. The website includes information about different methods for incorporating reflection support and features an enhanced and redesigned prototype.

Zusammenfassung

Heutzutage machen es mobile Geräte (z. B. Smartphones und Wearables) einfacher denn je, persönliche Gesundheitsdaten zu aufzuzeichnen. Auf diese Weise können die Nutzer Einblicke in ihre tägliche Bewegung, ihre Herzfrequenz und ihren Blutdruck gewinnen. Diese Daten können auch für medizinische Forscher nützlich sein, die sie zur Unterstützung der Genesung oder zur Beurteilung des Krankheitsverlaufs nutzen können. Das bloße Sammeln von Daten reicht jedoch nicht aus, um den allgemeinen Gesundheitszustand einer Person zu bestimmen. So ist beispielsweise die Anzahl der am Tag zurückgelegten Schritte allein nicht aussagekräftig. Vergleicht man sie jedoch mit früheren zurückgelegten Schritten pro Tag, der Herzfrequenz und dem Blutdruck, lässt sich feststellen, ob sich der Gesundheitszustand einer Person verbessert oder verschlechtert. Die Art und Weise, wie diese Daten präsentiert werden, ist entscheidend dafür, dass die Nutzer zum Nachdenken über ihre Gesundheit angeregt werden. Effektive Visualisierungs- und Designelemente können sinnvolle Veränderungen in den gesammelten Gesundheitsdaten hervorheben.
In dieser Arbeit möchte ich untersuchen, wie eine interaktive Benutzeroberfläche für das Spenden von Gesundheitsdaten gestaltet werden kann, um die Reflexion der Nutzer über die offengelegten Daten zu unterstützen.
Der Forschungsprozess wird sich eng an den menschenzentrierten Designprozess anlehnen. Ich möchte mit Nutzern in Kontakt treten, um meinen Designansatz zur Implementierung von Reflexion zu bewerten und Feedback zu meinen erforschten Reflexionsansätzen zu sammeln. Es wird ein Scoping Review durchgeführt, um einen Einblick in den aktuellen Forschungsstand zu erhalten und um die Entwicklung einer interaktiven Benutzeroberfläche zu unterstützen, die reflektierende Denkprozesse fördert.
Im zweiten Teil dieser Arbeit werde ich einen Prototyp für eine App entwickeln, die die Reflexion unterstützt, insbesondere im Zusammenhang mit Diabetes. Die Ergebnisse des Entwurfsprozesses werden von einer Diabetesspezialistin bewertet, gefolgt von einer qualitativen Studie, um die Effektivität des Prototyps bei der Unterstützung von Nutzern bei ihren Reflexionsprozessen und seine allgemeine Benutzerfreundlichkeit zu beurteilen.
Um den Bereich der Reflexion weiter zu erforschen, wurde eine Website erstellt, auf der die Reflexion im Bereich des Human-Centered Computing und die möglichen Methoden zur Unterstützung der Reflexion erläutert werden. Dies wurde durch die Verwendung des erstellten Prototyps erreicht, welcher außerdem für die Webseite erweitert und neu designed wurde.

Contents

1 Introduction

Due to a more sedentary lifestyle, unhealthy diet, and lack of physical activity, health conditions such as obesity and diabetes have become increasingly common [54]. To address this problem, technology has been developed to encourage physical activity and motivate people to adopt healthier lifestyles. Smartphone apps and wearables to track physical activity and health data have become popular. People are paying more attention to their health than ever before [33]. This trend is primarily due to social media platforms, where fitness and healthy lifestyle content has become increasingly popular and engaging [33]. Smartphones have responded to this trend by offering apps such as pedometers and heart rate trackers designed to support this lifestyle. These apps provide charts that display daily, monthly, and yearly data, allowing users to understand their behavior better [43].

Despite the various features and functions of these apps, it is not clear how their design elements, such as bar plots showing daily activity, influence user behavior in relation to data collection and self-reflection [20]. Therefore, this thesis examines the impact of particular design elements in a smartphone app that tracks user health data. The objective is to encourage users to reflect on the data they shared and their physical activity levels, which will increase their self-awareness according to the collected data [20]. As diabetes is a health issue that often arises due to an unhealthy lifestyle [54], an app prototype was developed to assist patients in managing this illness and guide them towards a healthier lifestyle.

In Human-Computer Interaction (HCI), reflection is a complex process involving actively exploring one's experiences to gain new insights and develop a critical perspective [53]. It is a form of problem-solving that helps individuals understand a situation and learn to self-manage [53]. For example, using an app that promotes self-reflection on sharing personal health data may lead one to reconsider the level of information they are sharing [20]. Self-reflection is a powerful tool that can help individuals improve their diet, become more active, and make better choices in various aspects of life, such as choosing a partner or workplace. Reflective learning has been shown to be a great way to improve oneself and increase self-confidence [8]. As a result, reflection has become an important and promising in HCI. While it is widely recognized as a useful tool, the challenge lies in effectively incorporating it into application design [20].

This thesis investigates design approaches for reflective user interfaces (UI) in health donation applications to improve the user's ability to engage in reflection.

1.1 Motivation

Every day, we make decisions influenced by different factors such as changing conditions, needs, and time pressure. It's essential to take some time to reflect on our choices. In

psychology, self-reflection is turning our thoughts inward and focusing on ourselves. This process involves introspection, which is all about questioning our thoughts, feelings, and actions to gain a better understanding of ourselves [8].

Reflection is crucial for learning from our mistakes, identifying our strengths and weaknesses, and building self-confidence. Reflecting on health data can also help users make better choices by assisting them to learn from past mistakes and identify weaknesses [20].
As there is a rise in the number of patients suffering from obesity, there is an urgent need for interventions that encourage healthier lifestyle choices and counteract the adverse effects of sedentary lifestyles on health [43]. Obesity increases the risk of developing diseases such as diabetes or other illnesses caused by an unhealthy lifestyle [54]. To promote a healthier lifestyle, apps that facilitate reflection on health data can be beneficial for individuals who are struggling with obesity and related health problems [43].

1.2 Research Goal

The main objective of this thesis is to explore how different user interface designs can promote self-reflection among users. In this thesis, a prototype app is created to support diabetes patients in their daily lives, encouraging reflection to help them make better choices regarding their diet and activity. To achieve this goal, a scoping review is first conducted to gather information about the current state of research in the field of reflection. Secondly, based on the findings, an interactive prototype is designed. The prototype is intended for diabetes patients who are newly diagnosed and require assistance in adapting to their new life situation. Finally, a qualitative study is conducted to test the interactive prototype. The purpose of this study is to gain insight into whether the prototype design effectively supports users' reflection processes and, if not, to determine why it is ineffective.
Research in HCI focused on reflection can be extremely beneficial for those who wish to improve their lifestyle [20]and those currently facing acute or chronic illnesses and need to monitor their behaviors for a speedy recovery or to maintain their health [60]. Individuals with chronic illnesses can stay on top of their health and prevent further complications by keeping track of their diet, exercise, and other quantifiable factors such as heart rate and blood pressure. This type of research can also be precious for chronically ill people who require a comprehensive overview of their behavior to manage their conditions effectively[43].

1.3 Context of the Project and Problem Description

Reflecting on health data collected through an app can help individuals gain insights about their health and performance. By analyzing this information, users can learn from it and draw conclusions that can aid them in improving their health or enhancing their performance [8].
Reflection on health data can be extremely beneficial when applied in the right context, such as in an app that aids in supporting patients in recovering more efficiently. However, to achieve this, the data must be appropriately prepared and presented to offer patients an accurate representation of their health status. The donated health data can then be used to make informed lifestyle choices. An example of this can be seen in the app *Glucose Buddy* 2. This app is designed to assist patients in monitoring their glucose levels and present the data as a graph that displays the correlation between glucose levels and body weight. This visual representation of health data can help patients reflect on their health status and observe how it relates to their body weight.

Designing for reflection can be challenging since no established guideline exists for creating reflection-supporting interactive user interfaces. This makes it difficult to incorporate reflection into such interfaces, making it a less commonly used tool for self-awareness and learning from one's mistakes[20]. Cho et al. [20] categorize these options into three

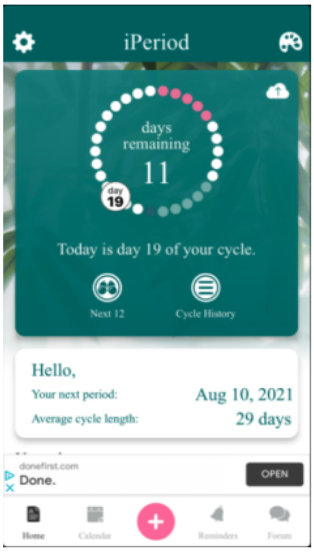

Figure 1: App display shows features that support descriptive reflection in the app *iPeriod Lite Period Tracker* [20].

Figure 2: App display shows features that support descriptive and dialogic reflection in the app *Glucose Buddy* [20].

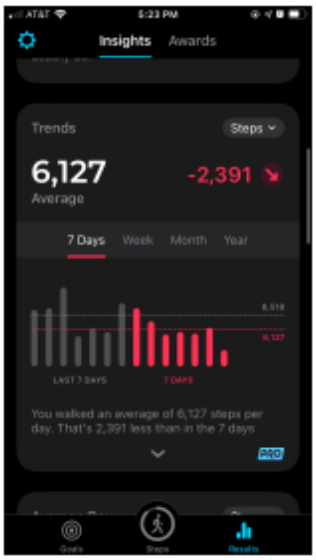

Figure 3: App display shows features that support explanatory and dialogic reflection in the app *StepApp*[20].

possible design components for reflection, all of which support reflection differently. As shown in figures 1, 2, and 3, there are several options to design for reflection.

Figure 1 shows the app *iPeriod*, which is designed to help the user analyze the data, such as the time and duration of the last period, to help monitor their behaviors and feelings [20]. The screen displays a circular visualization representing the user's menstrual cycle. Each day is indicated by a dot on the circle, with a pointer showing the current position in the cycle. The expected upcoming period is indicated by brightly coloring the dots in the cycle circle in bright pink. Inside the circle, there is a text displaying the number of days remaining in the cycle, with the number formatted in a larger text size for emphasis. Below the visual representation, there's a text field providing information about the average cycle duration and the expected date of the next period. This falls under the design component *revisiting*.
Figure 2 shows the app *GlucoseBuddy*, which presents these users with an interpretation and summary of the collected data, helping them better understand their behavior. To achieve this, collecting data not only through self-tracking devices but also manually may be useful. Studies have shown that manual tracking can aid in reflecting on past experiences [20]. The screen displays two graphs. The first graph shows blood sugar levels in mg/dl on the y-axis and time of day on the x-axis. Users can manually mark their blood sugar measurements before or after meals. The second graph displays body weight fluctuations over the last month, with dates on the x-axis and weight in lbs on the y-axis. Each weight measurement is represented by a dot connected to the previous measurement, creating a line graph of weight fluctuations. This falls under the design component of *prompting and providing explanation* [20].
Figure 3 displays the app *StepApp*, which shows relations between two or more data points and determines the causality between their experiences. The insights gained from this design component can be dialogic, but this depends on the data tracking style [20]. The screen displays on the top a single large number representing the average daily step count. There's also a trend indicator in bright red with a downward arrow, signaling that the user's walking activity has decreased. Below the numbers, there's a bar graph depicting the steps taken each day. Taller bars represent more steps. When viewing the last seven days, the graph shows the last fourteen days. The recent seven days are highlighted in red, while the previous seven days are grey. Additionally, the graph includes two lines indicating averages, one red, and one grey. The red line represents the current week's average steps, while the grey line represents the previous week's average steps. As the current average is lower, this visually conveys that the user walked less this week than the week before. Furthermore, the app provides a textual note under the graph, alerting the user to the decrease in activity compared to the previous week. This falls under the design component of *compare and self-diagnosis* [20].

In summary, Cho et al. [20] provide insights into how reflection is viewed in theory and applied in practice. However, the publication does not address how the specific design concepts effectively support reflection, nor does it explain the impact of these design concepts. For example, how does a user interact with an app that uses reflection-supporting design concepts, how would they interact with an app that does not incorporate these concepts, and what other concepts can be applied to designing for reflection? These questions highlight the need for further research.

1.4 Research Questions

The primary objective of this thesis is to create and assess an interactive prototype that aids individuals with diabetes in contemplating their health data. This prototype aims to assist them in managing their lives around their ailment and improving their glucose levels through the use of the reflection-supporting design of the application. This can be accomplished by allowing users to take action, such as monitoring their food intake, or by presenting them with tracked data, such as their glucose levels. The assessment of this prototype will provide valuable insights into which design concepts were effective in supporting the user's reflection process.
To achieve this goal, a series of research inquiries need to be addressed. The first inquiry should focus on designing possibilities that promote reflection during data collection and presentation and analysis of the collected data.
The first research question aims to investigate how health data should be presented and how the design for reflection can be incorporated into interactive user interfaces.

RQ1: "What design components can be used in an interactive user interface that tracks health data to impact the user's ability to reflect on their health status?"

To answer our research question, a scoping review is carried out. This review will provide suggestions on various design approaches, specific design elements, or concepts that can be incorporated into interactive prototypes to promote reflection. The results offer guidance for the design of an interactive user-interface prototype.

The second research question focuses on how to use design concepts best. It involves determining how the findings of the scoping review can be utilized to encourage reflection while also pinpointing scenarios where they should not be applied or how they could better serve the specific needs of individuals. The solution to this query can be obtained by examining the distinctive design of the app with a qualitative study.

RQ2: "How can designing for reflection be incorporated into interactive user interfaces?"

The qualitative study involves the use of the Think-Aloud method. This method is facilitated when participants interact with the interactive user interface prototype. This click dummy includes reflections promoting design possibilities discovered during a scoping review and expressing their thoughts about the app prototype. The information gathered through this technique provides initial insights into when participants reflect on their health data. A semi-structured interview is conducted to gain more insight into why they reflected at that particular time. This interview asks participants to recall the moment they reflected on their health data and explain the reason behind their reflection.

The objective is to assess the findings of the scoping review included in a prototype and to discover design methods that promote reflection. Additionally, it is essential to identify the key factors to take into account when designing for reflection. For example, it is crucial to determine when reflection is needed, as well as to consider the possible adverse effects of reflection and how to mitigate them.

2 Background

Reflection is a crucial activity that enables individuals to gain insights and improve themselves. It is a valuable practice that is recognized across many fields. By reflecting, people can engage in various ways to comprehend and interpret things, become aware of their surroundings, and gain insights to make informed decisions for their well-being and advance societal values such as justice or environmental sustainability [20].
According to Rodgers [10], reflection is a tool for processing experiences, not a goal in itself. It promotes moral growth based on existing theories. She describes reflection as an iterative process that involves moving back and forth between theory and practice.
Piaget [30] argues that individuals learn through intellectual resolution, with each event influenced by previous experiences, individual backgrounds, and critical events that can change ways of thinking. Reflection is a commonly accepted concept among educators, who assume it is a natural response to a dilemma or challenge. However, how an individual reflects has a significant impact on the outcome. Reflective individuals can think about their behaviors and make judgments about them [9].

Schön [55], a well-known educational theorist, emphasized the importance of "reflection-in-action" and "reflection-on-action" in his work, particularly in his book "The Reflective Practitioner: How Professionals Think in Action." Schön [55] discusses how professionals, including architects, engineers, and managers, use reflective processes to solve problems and make decisions in their work. The concept of Schön's [55] reflection-in-action proposes that professionals can reflect and think critically while performing a task or facing a problem. This ability involves adapting, adjusting, and problem-solving using past experiences and knowledge in real-time. [55].
Reflection-on-action occurs after the fact when individuals retrospectively analyze and contemplate their experiences, actions, and outcomes. This form of reflection allows individuals to learn from their experiences, consider alternatives, and improve their future actions [55].
Schön's [55] ideas on reflection have been influential in education and professional development, emphasizing the importance of continuous learning, adaptation, and critical thinking in professional practice.
Approaches to support reflection-on-action can be implemented through various interactions. A widely utilized approach in educational environments is reflective writing. Reflective writing is a method used to cultivate students' reflective abilities and has been proven effective in stimulating reflection. Reflective writing can take various forms, such as diary or online journaling and reflection essays, in which peer group discussions can be complementary [12]. According to Claisse et al. [11], the diary is an effective reflection tool. The study utilized handwriting and pictorial representations to support reflection.
Another method for reflection-on-action is critical incident questioning based on Schön's idea of the reflective practitioner [55], which involves guiding students in making deci-

sions under uncertain conditions. These uncertain conditions are often called critical incidents [55]. A study was carried out by Bruster et al. [9] in which educators were asked to reflect on one incident per week. They were required to document the incidents by providing three details: the context of the incident, the dilemma they experienced or observed, and the resolution of the dilemma.
One method to utilize reflection-in-action is "Think Aloud" proposed by Schnell [13], where participants articulate their thoughts, assumptions, and decision-making processes. This helps bring internal reasoning to the surface, making it easier to analyze and reflect in real-time [13].
In-action reflection can also be supported by intentionally pausing during a task or problem-solving process to assess the actions [55]. Cheng et al. [45] developed an app called PAUSE, which supports reflection by encouraging slow, continuous, and gentle finger touch movements to rethink existing touch gestures, including those used on smartphones, for everyday interactions. The mindful approach to touch involves having a clear intention when performing tasks, fundamentally different from the habitual routine used for simple everyday activities [45].

In summary, self-reflection is a powerful tool for personal growth. It enables individuals to learn from their mistakes, identify their strengths and weaknesses, and make more thoughtful decisions.

2.1 Designing for Reflection in Human-Centered-Computing

Human-centered computing (HCC) is an interdisciplinary field that focuses on designing and developing computer systems, software, and technologies with a primary emphasis on the needs, preferences, and experiences of humans [56]. The goal of HCC is to create systems that are not only technically effective but also usable, accessible, and supportive of how people think, work, and live. HCC was initially aimed at enhancing productivity. However, as the field of HCC progressed, researchers also began to incorporate emotions, experiences, and cultural characteristics. This led to the introduction of reflection as an essential topic for consideration. Reflection offers three main benefits: it enhances education, improves the design process, and helps individuals gain greater self-knowledge. Despite its crucial role in human-centered computing, there is still a need for a consistent definition of reflection and a design guideline to adhere to while designing for reflection in HCC [18].
Rodger [10] defines reflection as a methodical, rigorous, and disciplined form of thinking. She stresses that reflection is not merely a casual, spontaneous thought process but rather an intentional and structured activity. Reflection involves the process of making meaning from experience. It's about interpreting and making sense of what happened to understand it better. Rodger [10] highlights that reflection includes engaging in dialogue with others. This social component helps to broaden one's perspective, enabling a more profound understanding through collaboration and discussion. Reflection is an ongoing process that is essential for learning and development. It is not a one-time occurrence

but rather a continuous cycle that informs future actions and decisions. Reflection involves linking specific experiences to the broader context, encompassing one's beliefs, values, and the broader social and cultural environment [10]. Slovak et al. [46] explain that there is a significant gap in how technology can support the process of reflection. The process of reflection also needs to be carefully guided, as it cannot be assumed that the ability to reflect is a universally available trait that can be stimulated simply by providing data [46].

When designing for reflection, it is crucial to consider the evaluation process. Reflection is a multifaceted and intricate concept that can sometimes be vague, making its evaluation a challenging task. According to a review by Baumer et al. [18], many studies did not directly measure reflection; instead, they measured the outcome variables. They automatically assumed that an improvement in the outcome variables indicated an increase in reflection. After presenting individuals with their data, some studies considered individuals to have reflected on their behaviors but found little evidence of a reflective process [18].
Isaac et al. [16] conducted a study in 2013 where they measured reflection by asking users to re-rate their feelings about past journal entries. Not only did this make the reflection visible, but it also allowed for investigating its effects on overall well-being. Baumer et al. [18] discovered that studies had difficulty in measuring reflection because of unclear or nonexistent definitions of reflection. It is challenging to gauge something that lacks a clear definition.

According to Baumer et al. [18], many studies have investigated reflection to achieve improvement, behavior change, increased self-awareness, or better educational outcomes. However, it is crucial to recognize that this may not be the case for all individuals [18]. Baumer [19] has introduced a concept of so-called "dimensions of reflection" that can aid in developing reflective technologies. These dimensions are not prescriptive, but they offer a set of creative conceptual tools that can inspire and inform the design process.
Baumer's [19] three dimensions of reflection include "Breakdown", "Inquiry", and "Transformation". Refers to a specific aspect of reflective thinking that occurs when normal expectations or routines are disrupted. The "Breakdown" refers to an unexpected event that disrupts habitual thinking or actions, prompting individuals to pause and reevaluate, leading to deeper reflection. The "Inquiry" dimension of reflection involves actively seeking to understand, explore, and question a situation or experience. This type of reflection includes a deliberate and thoughtful investigation aimed at gaining deeper insights and understanding. It goes beyond simply noticing or reacting to events and involves a systematic approach to examining and making sense of experiences. As reflection ultimately involves change, the "Transformation" dimension pertains to the aspect of reflection that leads to significant change or development in an individual's understanding, beliefs, or practices. This dimension focuses on how reflection can deepen understanding and also bring about a fundamental shift in how a person perceives a situation, themselves, or their approach to their work or life. According to Baumer [19],

this is the most challenging dimension to include in designs.
McAlpine et al. [37] proposed a model of reflection, where reflection is formulated as continuous and dynamic interaction with both actions and knowledge in service of learning goals. The model comprises six main components: goals, knowledge, action monitoring, decision-making, and the 'corridor of tolerance'. The first step to achieving goals is identifying and setting them, then constructing a plan based on reflecting on one's knowledge and guiding subsequent actions accordingly. People assess and adjust their behavior by keeping track of their advancement. This means that changes in their actions, such as collecting data more often or adhering to their health and fitness regimen, will be determined by their corridor of tolerance to accomplish their goals. The corridor of tolerance is a close relationship between knowledge and action, generating critical reflection based on set goals [37]. The tolerance corridor determines whether monitoring leads to change in action [37]. Carpenter et al. [15] argued that this model of reflection could provide insights into the dynamic of reflective thinking around specific learning goals.
Bentvelzen et al. [23] also discussed design restrictions aimed at creating environments and structures to facilitate deep, meaningful reflection rather than surface-level or routine responses.
Design restrictions include providing a structured process with prompts and guiding questions, as well as incorporating a specific time for reflection into a framework to ensure that it is not rushed or overlooked. Another design restriction is that reflection should involve active engagement, for example, through dialogue with others or interaction with peers. It should also encourage individuals to actively engage with their experiences rather than just passively recall them. It also includes asking them to connect theory to practice or to challenge their initial assumptions. It is important to recognize that reflection is a highly personal process. Therefore, it is crucial to allow flexibility for individuals to reflect in ways that suit their personal learning styles, experiences, and goals [23].
The user must be able to interpret the collected and visualized data effectively. To ensure effective implementation, it is essential to consider the user's level of knowledge [39]. The needs of users should be considered in addition to their level of knowledge. When users are unable to track the necessary data to understand their progress, they tend to stop tracking and exit the reflection phase. Bentvelzen et al. referred to this as a conceptual mismatch [39].
Cho et al. [20] proposed three design implications that should be followed to design an interface that supports reflection. Users should be free to set their objectives and choose which data they wish to collect. Compulsory information that must be collected can lead to unnecessary stress and incorrect assumptions about what is considered normal or healthy. This can make users feel insecure. Performance is typically assessed through quantitative data, such as the distance covered at a specific time or the weight lifted during a workout. While this data type is easy to interpret and visualize, better insights into performance improvements may exist. As most goals are quantitative, such as losing 20 kg or running 10 km, the performance indicator used should help the user to determine the quantitative goal through why- and how-questions [20].
Cho et al. [20] suggest that personal informatics tools, which are digital systems de-

signed to assist individuals in collecting, tracking, analyzing, and reflecting on personal data related to various aspects of their lives, assume that users should reflect on their data. However, reflection can hinder goal achievement by creating unexpected negative emotions. Human memory naturally fades over time, unlike databases that have perfect recall. Reviewing and reliving old journal entries can negatively impact the mental health of some individuals. Some people tend to focus on adverse life events and use them to justify their current behavior. This can lead to further negative thinking and a cycle of negative behavior [18]. It is advisable to use reflection only when necessary instead of automatically incorporating it into every personal informatics app [20].

In summary, the research on reflection in human-centered computing provides various theoretical instruments for designing reflective technologies. It also highlights the importance of carefully considering where to integrate reflection support in such technologies.

2.2 Designing for Reflection for User Interfaces for Health Data Donation

Over the last decade, the National Institutes of Health have suggested that medicine needs to transition from its outdated approach of providing standardized therapies to a more advanced and personalized system that is predictive, preemptive, and participatory [25]. These changes require networking and information technology advancements as they rely on data. To improve healthcare, it is crucial to understand how to visualize and communicate data for each community of participants [7].
Implementing health data interfaces is a helpful approach to enhance and strengthen the healthcare system [52]. When dealing with health data interfaces, it is important to take a moment to reflect on the information presented. This can be helpful for both healthcare professionals and patients, as analyzing the data can lead to more informed decisions and appropriate actions. Upon reviewing the data and analyzing it, health outcomes can be improved [44].
Design practices can aim to support reflection by reminding users to track their data regularly through phone reminders. This improves the reflection process by collecting data regularly, allowing for more efficient prognosis and comparison. Additionally, incorporating the reflection process into daily life becomes more accessible as a result [44].
In a study by Bentley et al.[23], participants showed high levels of engagement with a mobile application. The app successfully provided regular reminders to the participants, which helped the system make more accurate observations about their well-being. As a result, the participants were able to gain a better understanding of their overall health and make significant changes to their target behaviors [23].
Photo journaling has proven to be a valuable way to prompt reflection. Capturing pictures of daily experiences can be surprising and enjoyable and help foster positive emotions towards the reflection process. This is because the experiences can be relived more visually [44].

In summary, research has shown that reminders, prognoses, and comparisons are effective design approaches to encouraging participants to engage in reflective thinking. To achieve comparisons and prognoses, regular data donation is necessary, for which reminders are useful tools.

3 Methodology

Human-centered design (HCD) involves iteratively designing a system that focuses on creating products, systems, or technologies (e.g., smartphone apps, smartphones, interfaces), aligning with users' needs and preferences. This is achieved by involving users in the design process [18].
HCD is a design approach that prioritizes the needs and preferences of the users by focusing on usability throughout the entire development process [29]. One way to incorporate users into the development is by involving users and asking them to perform specific tasks [29]. Their feedback, including any difficulties and ideas for features, can then be incorporated into the development process [29]. To achieve this, it is essential to understand the user's needs and behaviors by empathizing with them and seeing things from their perspective [29].
It is important to follow an iterative and incremental approach when developing systems. Each iteration should include an analysis of the users' needs, a design phase, a documented evaluation, and suggestions for design alterations based on the evaluation. The design should then be redesigned accordingly [29].
Reflection is a deeply personal topic that involves human experiences, emotions, sexuality, culture, and religion. These factors should be considered when designing technology that encourages reflection. Therefore, the development process should prioritize a human-centered design approach [18].
The following describes and explains the human-centered design process according to Figure 4. To ensure a well-performing human-centered design process, it is crucial to have a clear understanding of the system's purpose and context from the beginning. This includes identifying the users' goals and the tasks they need to accomplish [29]. Active involvement of users throughout the project is also crucial [29]. Proper representation of intended users is essential, and planning should begin early on to determine how users will be involved in the project [29].

To achieve the application's goals, it is important to determine the requirements and needs of the users [29]. To gain a thorough understanding of the user's challenges and characteristics, various methods can be used, such as surveys, interviews, observations, and creating personas. These methods can help identify issues like the tension between technology capabilities and the subjective experience of using it, as well as demographics such as age, education, ethnicity, or the user's goals [29]. Once the user's needs are identified, functional (what the system should do) and non-functional (performance, security, etc.) requirements can be defined [29].

For systems to be evaluated, maintaining a simple and comprehensible design is crucial[29]. Prototypes can be created to give users and stakeholders a basic understanding of how the final system will function [29]. One way to implement this is by using basic sketches or mock-ups instead of relying on Unified Modeling Language diagrams (UML) [29], UML diagrams are structural diagrams that depict the static components, relationships,

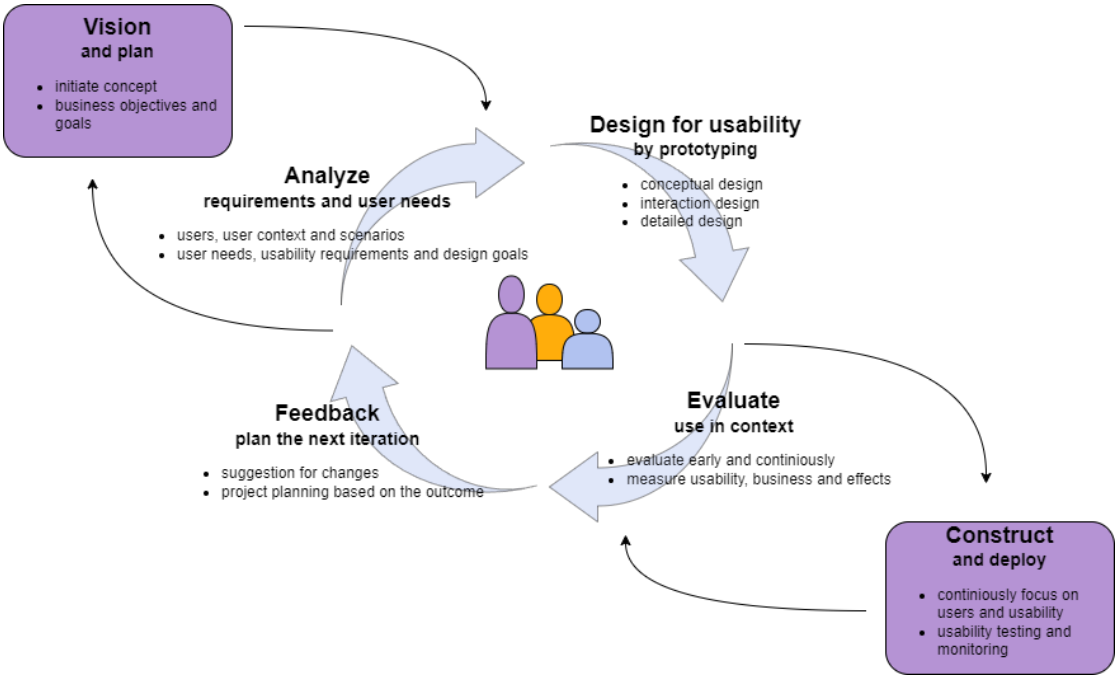

Figure 4: Human-centered system design process. Own representation based on [29].

and data structures of a system, or requirement specifications [22].
It is advisable to begin prototyping early and consistently throughout the design process to effectively visualize and assess ideas and solutions in collaboration with the end users [29].
Starting with simple prototypes, such as paper prototypes, can be valuable. It is also important to create variations of these prototypes [29]. Using simple and easily accessible materials allows designers to maintain creative openness [29].

To move forward with development, it is important to prioritize which issues need to be addressed [29]. To do this, input from the evaluation process is required [29].

In summary, when working with HCD, involving the user in all aspects of the development process is necessary. They help define the goal by describing essential tasks that must be accomplished with the application and contributing requirements. In the active design process, they add their thoughts and difficulties that they encountered while interacting with the prototypes. Without the involvement of the users, the requirements and needed features couldn't be defined as clearly and concisely as with user involvement.

Methodological Approach The Human-Centered Design process guided most parts of the thesis; however, it was adapted to suit the specific requirements, like incorporating the scoping review and involving an expert in the evaluation of the thesis, see Figure 5. The methodology of this thesis was structured as follows:

First, the "vision and plan phase" was used to structure the work. This involved conducting preliminary research on reflection by studying publications, exploring various methods for collecting research literature and creating research questions to answer in this thesis.

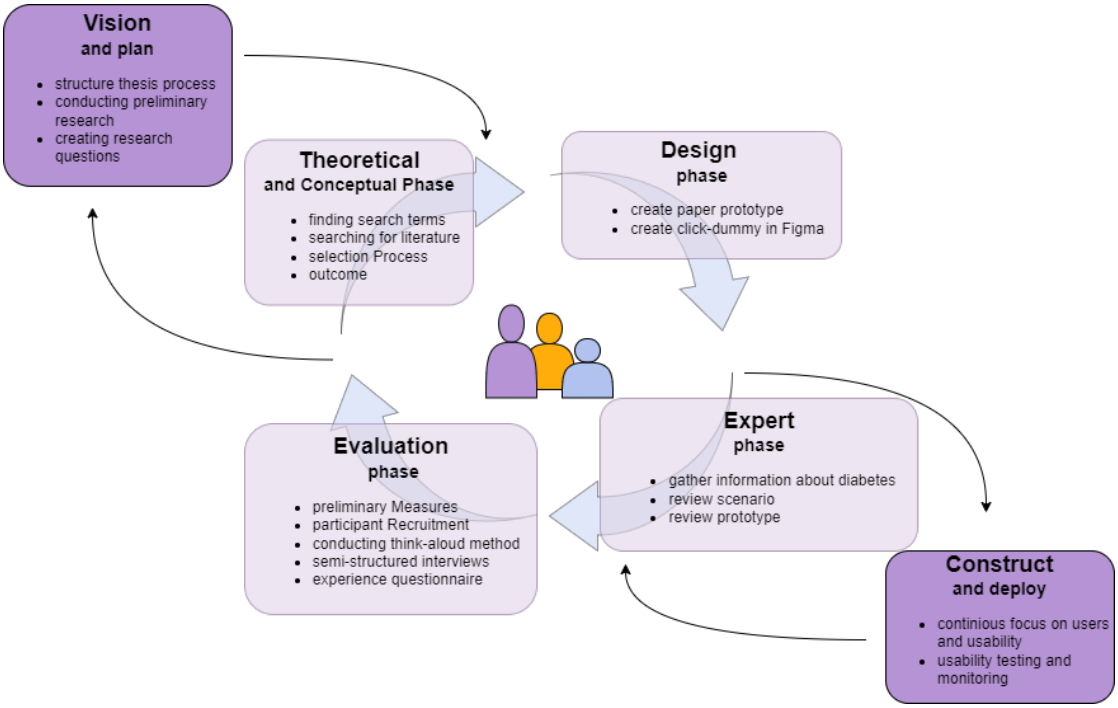

Figure 5: Human-Centered Design process adapted to suit the thesis.

Second, the analysis phase of the human-centered design process in Figure 4 was replaced by the "theoretical and conceptual phase" in Figure 5, which involved gathering information from existing literature utilizing a scoping review.
Third, the "design phase" is included in both processes in Figure 4, but is specified in Figure 5 to include designing a low-fidelity paper prototype and creating a high-fidelity clickdummy prototype. Fourth, prior to the evaluation phase of the human-centered design process, see Figure 4, the "expert phase", see Figure 5 is conducted. This phase helps to better understand the target group's needs and wishes, allowing adjustments to the prototype accordingly.
The evaluation phase of the human-centered design process shown in Figure 4 exists as well in the adapted process in Figure 5, which includes participant recruitment, conducting the Think-Aloud method with the high-fidelity prototype, and conducting a semi-structured interview to gather more information of the reflective processes and the usability of the prototype.

The human-centered system design process was modified to align with the project's

needs. The goals and tasks were refined, and the Analyze phase was renamed as the "theoretical and conceptual phase," which encompasses the entire scoping review process. During the design phase, a paper prototype and a high-fidelity click-dummy will be created. To accommodate two evaluation phases - the expert phase and the evaluation phase with a qualitative study - the process had to be adjusted to incorporate additional insights into user needs. Due to time constraints, more evaluation of the click-dummy needed to be included in one iteration, as the thesis does not allow for multiple iterations of the human-centered design process.

3.1 Theoretical and Conceptual Phase

During the theoretical and conceptual phase of the project, a scoping review is conducted to gain a good understanding of reflection in human-centered computing. A scoping review is a type of literature review that aims to identify the nature of the available evidence on a topic, usually to determine if a systematic review is necessary [21]. The review provides insights into the implementation of reflection in interactive user interfaces.
To conduct the scoping review, I followed the PRISMA statement for scoping reviews [21].

3.1.1 Systematic Investigation of Literature on Reflection

To start the scoping review, research terms were developed based on the information needed to be gathered to answer the first research question. As this thesis primarily revolves around reflection, the most significant search terms "reflection", "self-tracking" and "self-reflection". These three search terms limit the literature to only reflection-

Table 1: Search terms of the scoping review.

	Reflecion	**Health Data**
Search terms	reflection self-reflection self-tracking	health data health feedback personal health record personal informatics
Type of information	Articles that demonstrate ways to support reflection and how it is defined. Design elements that aid in reflection.	Information pertaining to an individual's health, including relevant data used to assess and enhance overall well-being.

related topics. Search terms that are also included are "health data", "health feedback",

"personal informatics", and "personal health record" to narrow the literature to health data. The search terms have been defined to encompass all significant aspects of the development process and are listed and described in Table 1.
To begin the literature search, relevant publications related to the topic of the review were selected and gathered. The search terms were combined with the 'AND' combination while searching in three chosen databases: ACM Digital Library,ScienceDirect Database Search, and IEEE Xplore Database Search. These databases were chosen based on their reputation as the best databases for computer science research [42].
To improve the accuracy of the search results, several filters were applied. Firstly, only literature written in English or German was considered. Next, the literature was narrowed down to only those published in the last five years. To ensure a balanced distribution of information, only research articles were included in the selection of literature. Lastly, all the results from the database were ordered by relevance.

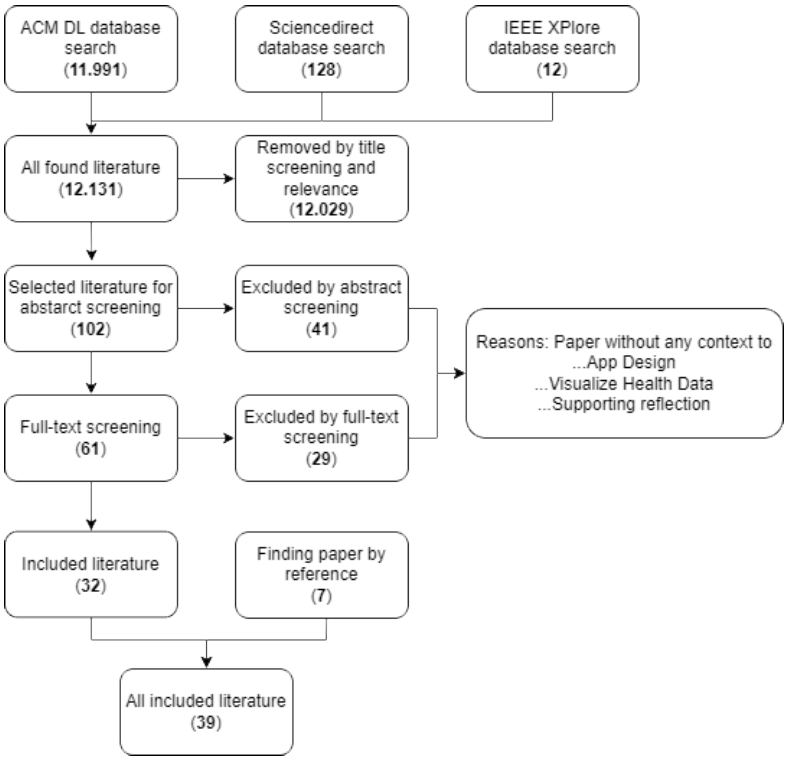

Figure 6: Graphical representation of the selection process for the scoping review.

Due to the vast amount of literature available in the ACM digital library and ScienceDirect database search, see Figure 6, the results were narrowed down to the top 200 most relevant articles by ordering the results with the relevance filter and choosing the top 200. In the IEEE Xplore database, the number of resulting articles was already small enough that it didn't need to be limited.
The literature selection process involved searching for relevant titles across different

databases. Subsequently, the literature was screened based on the abstracts to narrow down the results. Only literature that provided insights on how to support reflection, visualize health data, design health apps, or develop apps that foster reflection was included, see Figure 6.
The last step in determining which literature was included in the scoping review was a full-text review of the remaining literature. This and the publications found formed the basis of this scoping review, see Figure 6.

3.1.2 Results

The scoping review aimed to explore reflection and its implementation in interactive user interfaces. The categorized results below offer insights into design components for incorporating reflection-supportive design and possible methods for implementation.

Table 2: Results of scoping review. Four design approaches with subcategories.

Design Approach	Definition	Example
Temporal Perspective	Reflect by being presented with data of different times (Past), making them memorize experiences (Memory), giving predictions (Future), or slowing processes down (Slowness).	Timelines (Past) Prompting users with questions (Memory) Predictions about Health with current lifestyle (Future) Slowing processes down (Slowness)
Conversation	Reflect while conversating with real people or technologies can help comprehend the significance of experiences.	Conversational interface (Technology) Platform to chat (Real people)
Comparison	Comparing the own data (absolute) or the data of another person (social).	Leaderboard (Social Comparison) Progress bars (Absolute Comparison)
Confrontation	Presenting things in a new light to encourage discovering something (Provocation).	Confrontation with unpleasant information (Provocation)

Temporal Perspective The literature included in the scoping review shows that temporal perspectives are widely used to encourage reflective behavior. Temporal perspectives are often used in health data tracking apps through timelines that offer a different view of a user's collected data [40].

- Past: The past in Temporal Perspective feature aims to display historical tracked data in a way that allows users to reflect on how the data has changed over time and how different behaviors have contributed to the results. Personal informatics

systems frequently display past data to improve self-reflection [39]. This can be implemented by using graphs to help users reflect on their health data over a certain period. These graphs classify the state of health and help users conclude the data [44] [40]. In a study conducted by Prioleau et al. [60] that focused on health data tracking with wearables for diabetes patients, it became clear that patients appreciate receiving an overview of patterns and trends in their behavior. This could be achieved by presenting users with these trends to encourage reflection on their past behavior.

- Memories: The difference between the past and memories as a design approach lies in the fact that the past is a factual representation of events. In contrast, memories are a subjective view of the past. To evoke memories, users are presented with specific events from their past. They are asked to rate their emotional state during that period or their overall satisfaction with their past selves [59] [40].

- Future: In the context of the future-oriented Temporal Perspective design approach, users are encouraged to contemplate their future and consider the implications of their actions. Apps that incorporate this approach use messages written by users to their future selves, as well as considerations of various life decisions and their anticipated outcomes. Apps can also offer a forecast function to showcase how the action might affect the user's future [49] [40].
  Desai et al. [48] proposed a strategy in their paper on personalized prediction in diabetes self-management to provide a personalized forecast at the time of meal-time decision, predicting the change in blood glucose levels.

- Slowness: Slowing down a process encourages users to reflect on their actions. This can be applied to social media uploads and learning with prompts and questions [36] [40].
  In a study by Lim et al. [14] exploring self-care practices among people with chronic conditions, participants valued the chance to pause and engage in new thought processes. The study involved creating self-care cards and rating them. These activities were found to facilitate deeper understanding.

Bussone et al. [1] compared two visualization styles to determine which was more engaging: a timeline and a Clockplot diagram is a type of graphic organizer that illustrates how items are interconnected in a time-oriented cycle. The Clockplot had slightly fewer reflections than the Timeline, possibly because it is less familiar. In later interviews, participants mentioned that while the Clockplot was aesthetically pleasing, the Timeline was more accessible to the process. It was emphasized that the Timeline requires meticulous planning. The data presented should be narrowed down to the essential information. The participants suggested a more interactive approach wherein they can selectively view specific types of data [1].
It's important to note that simply presenting data to a user doesn't guarantee that they will reflect on it. It's advisable to allow the user to rate their past data entries based on how they currently feel about the time period when the data was tracked, for instance. Giving the data an emotional value might help the user to reflect on it [39].

Conversation The literature included in the scoping review suggests that engaging in a conversation can help users understand the importance of their experiences and organize them quantitatively [20] [41]. In an article by Hartmann et al. [4], it is also described that not only does describing experiences support reflective processes, but also dissonance in a conversation works well to encourage reflection. In a study by Mols et al. [27], 85% of the participants reported reflecting through conversation with a partner, colleague, or friend. Bussone et al. [1] interpreted design requirements to include reflection in design provocations. These requirements include allowing users to share and ask questions about their information and allowing peers to respond [1].

There are two methods for achieving reflection through conversation. The first method involves conversing with the technology itself, which includes **reminders**, **reflection prompts**, **follow-up questions**, **questionnaires**, **paper journaling** and **interviews** after manual data collection or after ending automatic data collection [15] [26] [41] [3]. Edixhoven et al. [61] utilized both yes/no questions and Likert-type questions, which is a specific type of question that collects rank-ordered responses to assess levels of satisfaction, quality, importance, agreement, disagreement, or frequency, to investigate the root causes of success and failure [6]. They also asked participants to select a mood from a series of illustrated figures representing different emotions. Contemplating key information previously learned during data investigation can be done by using reflection prompts [15]. This method is commonly used in running or other sports tracking apps [40]. Karaturhan et al. [44] suggested that reflecting on experiences can be facilitated by asking reflective questions. Broad reflection questions can guide thinking about a general subject, while specific questions can help focus attention on the learning process [49].

Chan et al. [12] discussed the challenges of implementing reflective thinking in higher education. They pointed out that **reflective writing** is often perceived as simply recounting events, and students may feel uncomfortable with reflective practices if they lack a solid grasp of reflective theories and critical thinking skills. Chan et al. [12] also emphasized the importance of providing context for reflection in order to effectively engage in the process. Another way to achieve reflection is by having conversations with real people. This can be achieved by allowing users to share the collected data with others, providing a platform for commenting and discussing the collected information [40].

A **conversational interface** is an interface a user can talk or write to in plain language. Considering which features can be combined with the quantitative self-approach is crucial. The user's goal must also be considered, and whether manual tracking is necessary to achieve the goal should be determined [17]. Conversational interfaces are underutilized and mainly employed to provide information rather than gather data [40].

As Kiskola et al. [32] outlined in their study on emotional regulation and self-reflection in online discussions, they discovered that the absence of nonverbal cues in written communication hinders the management of emotions. This makes creating communication interfaces more challenging, as more design effort must be put in to create a pleasant environment for users to reflect.

Comparison According to the literature included in the scoping review, including a comparison feature in a personal informatics tool can encourage users to reflect on their data. This comparison can be of two types - absolute and social [40].
Absolute Comparison One can compare their actual and target values to support learning from their own experiences [14]. For instance, the ideal daily water intake can be displayed compared to the user's. Progress bars can be used to indicate progress [40].
Social Comparison refers to comparing one's data with data belonging to others and ensures competitive behavior [2]. A leaderboard can be created to add a competitive element, which can motivate people to achieve their goals and avoid unhealthy behavior. Social comparison can also help people reflect on their health status. In a study by Bussone et al. [1], patients were able to compare their medication use with that of others, which helped them better understand the possible outcomes [1].
Another way to make social comparisons is to compare current and past data. This allows users to see their progress and reflect on their everyday experiences. Karatura et al. [44] discovered that tracking daily progress helps users remember and reflect on their progress.

Confrontation The final category to encourage reflection discovered in the literature included in the scoping review is Confrontation. It aims to trigger reflection by presenting things in a new light that can cause users to reflect [40] or by presenting ideas, stories, and information that can prompt individuals to reflect on their own lives [28]. Confrontation involves not only gaining knowledge but also comprehending the relationships between different pieces of information. It is essential to analyze situations from various perspectives to gain a complete understanding [49]. Ravi Karkar [34] also mentions how providing insights, rather than just presenting data, can encourage critical thinking.
Cho et al. [20] suggest that future research should investigate the effective application of provocative prompts for reflection justifications in personal informatics (PI) tools in light of the potential of multimodal and conversational interfaces. To encourage individuals to discover something new, it can be helpful to utilize **provocation** by confronting them with information that may be unpleasant. For instance, predictions regarding an individual's health based on their consistent lifestyle can be provided to encourage reflection on their well-being [40].
Practicing reflection with Confrontation enhances understanding one's behavioral patterns without further explanation.
Rajcic et al. [50] proposed confronting users with their physical reflection to prompt reflection on their internal emotional state. Subsequently, users are confronted with their momentary reactions.
Patients with Parkinson's disease were monitored daily to track their symptoms. The data revealed the degenerative nature of the disease, prompting the patients to consider the activities that could exacerbate the degeneration and explore ways to slow down the progression of the disease [31]. It was also shown that patients often needed help making sense of information when there was a gap in their understanding. This could

be addressed by providing patients with explanations of the information to help them comprehend it [31].

3.1.3 Summary of Findings

The scoping review has identified four main design components for reflection in interactive user interfaces: Temporal Perspective, Conversation, Comparison, and Confrontation.
Temporal Perspective encourages memory reflection and thoughtful contemplation by presenting past data and providing future forecasts. In contrast, conversation with the app or other people promotes reflection through interaction. When users compare themselves with others or their past behavior, comparison has a social aspect, and they can gather more information. Confrontation can fit into the other three design components by discovering new information. This can be accomplished in several ways, such as praising a user's improvement or pointing out where their behavior fell short. This can also be implemented by utilizing other design components for assistance, such as using the Comparison design component to discover better overall health data and understand the reasons behind it. Similarly, individuals can realize their poor food choices by reviewing their data from the past few days, possibly with an indication to point out the unhealthy food.
Chan et al. [12] also pointed out how the quality of reflection is influenced by the technique used. In their study, they discovered that some participants reacted better to reflective writing than being video-recorded for reflective analysis, while others were unable to reflect using reflective writing. This demonstrates how the background of each individual matters and poses a challenge for designing for reflection, as each individual reacts differently to the above-described design components.

During the design phase, these design components are used as reference points. The aim is to incorporate all design components into a clickdummy.
The whole literature of the scoping review can be found on OSF, an open-source cloud-based project management platform.

3.2 Design Phase

During the Design Phase, a prototype will be developed for diabetes patients. Diabetes is a condition that often develops as a result of unhealthy lifestyle choices, such as a poor diet and lack of physical activity. Type 2 diabetes can be cured with a change in behavior to a healthier lifestyle, while those with type 1 diabetes will always need to monitor their blood sugar levels and maintain a healthy diet. Both types of diabetes require a certain lifestyle to be effectively managed and can be improved with healthy habits. This condition provides an opportunity to track various health data, enabling individuals to reflect on their behavior and better manage their health [24]. Therefore,

this prototype enables data tracking to assist patients in improving their behaviors and making healthier choices.
The prototype for a diabetes patient app was developed based on the scoping review results and existing diabetes-tracking apps and food-tracking apps. The approach is to test the design components of the results from the scoping review in diverse scenarios.

To further inform the design phase, research considered data visualization techniques to produce accurate and informative visual representations of health data. This research allowed to determine which geometries were most appropriate for different data types. The findings of this research have been compiled in a visualization directory, which serves as a helpful reference point during the design phase. The directory was created by researching literature in the field of data visualization to support the design of the prototype, in addition to the results of the scoping review.

3.2.1 Directory of Visualization

It's important to be able to select the appropriate plots and charts for different types of data. The visualization guide provides instructions on when to use specific chart types for different data, the reasons for choosing them, and how to create effective color visualizations. As Schmeltzer et al. [35] pointed out, the ever-growing amount of data emphasizes the importance of good visualization. Data visualization involves finding the right way to visually represent and intuitively display data based on its characteristics and properties. This can help with understanding the data and extracting useful information from it [65].

Amounts Bar plots, whether they are vertical or horizontal, are frequently used for comparing amounts and displaying data. However, they are known for having low data density. Instead of bars, dots can be used to indicate where the corresponding bar ends. Bar plots are useful for displaying counts but not group means. When multiple categories need to be displayed, their bars can be grouped or stacked. It is important to note that bar plots can sometimes be misleading because they always start at zero, which can make differences between the bars appear larger or smaller than they really are. Heat maps and Cleveland dot plots are two methods used to display comparisons and quantities. Heat maps represent numerical values using color gradients, while Cleveland dot plots use dots to illustrate quantitative values in relation to categorical variables [58].

Compositions and Proportions It is common to use pie charts to display compositions and proportions, but this method has become less popular due to its limitations in making visual comparisons. Instead of using side-by-side bar plots, it's better to use stacked or clustered bar plots, stacked density plots, mosaic plots (a special type of stacked bar chart that shows percentages of data in groups), and treemaps. Treemaps are particularly useful as they capture two types of information in the data: the value of

individual data points and the structure of the hierarchy. These alternatives are more effective for addressing the challenge of comparison [58].

Distributions Geometries are a way to represent data in a compact manner. One such geometry is the box plot, which can display five types of information in a single object. Other useful geometries for visualizing multiple distributions at once are violin plots, strip charts, and sina plots. Histograms and density plots are also highly intuitive representations of distribution. For visualizing a large number of distributions or changes in distributions over time, ridgeline plots are an alternative to violin plots [58].

Relationships Visualizations, such as scatterplots, are commonly used to display x- and y-coordinate data. The basic scatterplot can be modified with size and color to highlight information effectively [58]. If three quantitative variables need to be visualized, one variable can be represented using the dot size to create a variation of the scatter plot known as a bubble chart[58].
Paired data can also be shown as a slope graph of paired points connected by straight lines. Scatterplots may not be effective with many points due to overplotting. An alternative to scatterplots is to use contour lines, 2D bins, or hex bins [63](Chapter 5, 6).

Alphanumeric Data Tables are a visual representation of alphanumeric data. They are an effective way of displaying summarized information in a clear and concise manner and provide an easy means of referencing exact numerical values. It is recommended that tables be created as supplementary information [58].

The types of data can be classified as quantitative or qualitative. Quantitative data refers to numerical data, whereas qualitative data refers to categorical data [63].
To ensure a clear and accurate visual representation of data, it is crucial to define a one-to-one scale that establishes a clear correspondence between data and visual elements [63]. Once the most suitable geometry has been identified, the next step is to customize it according to the specific data to be displayed.

Color is a powerful tool in data visualization. Bright and colorful visualizations are more memorable, mainly when using more than seven colors. It is essential to use color intentionally as it can convey information directly or indirectly [63] [58].
It is essential to use a combination of colors, symbols, and line types to convey information, especially for users with color vision deficiencies. Using a highlight color is a powerful way to emphasize important information visually. Not all information has the same level of importance, so less important information can be made more transparent. On the other hand, key information or specific categories may need to be highlighted more strongly. Accent colors can be incorporated into the color scheme to achieve this. The color scheme should consist of a set of muted colors along with a matching set of

more intense, darker, and more saturated colors [63] [58].

A helpful method for comparing data is to create multiple figures with the same geometry but different data. This approach helps to make comparisons and analyze the data. The axes and scales remain consistent across all figures, while the data variables change, making it easier to identify the differences. It is recommended that detailed captions be provided for the geometries to enhance clarity. Furthermore, the use of infographics can significantly improve clarity and memorability. Infographics have been found to have the highest score for memorability, and diagrams are more memorable than points, bars, lines, and tables [58].
Data visualization refers to finding the best way to represent data visually based on its unique characteristics and properties [65]. This helps understand the data better and extract valuable insights from it [65]. Data visualization involves organizing data systematically and logically, converting them into quantifiable features [63].
Meng et al. [65] developed a four-step process for implementing data visualization: analysis of requirements, extracting the data, and creating a visual scene.
The requirement analysis process involves identifying and clarifying the expectations and needs of the implementation for visualization. This included topics to be analyzed and possible viewing angles [65].
The process of data extraction involves cleaning the data to ensure its quality and consistency [65].
The last step is to create a visual scene [65]. Midway [58] proposed design principles for data visualization to avoid the risk of data being misinterpreted or confusing to the user due to poor presentation. Midway [58]suggests that to interpret data effectively, one must have a good understanding of the figures involved.
When creating visualizations, it is crucial to prioritize the information that needs to be conveyed first. This will ensure that the most critical data is highlighted and easily understood. It is essential to state the purpose of visualizing information, whether it is for comparison, ranking, or composition [58].
Careful selection of figures' geometries, shapes, and features is necessary to display data effectively.

In summary, to present data in a way that makes sense and is easy to understand, it's important to know its limitations and possibilities for visualization. It's also important to have a clear goal in mind for the data, whether it's to make comparisons or represent proportions, before choosing a visualization method. Once the method has been chosen, color schemes can then be considered. These considerations are crucial when designing a prototype, as different types of data will need to be presented in different ways.

3.2.2 Procedure

The design phase began with developing a traditional paper prototype. The prototype should include various designs and visualizations for all four result areas of the scoping

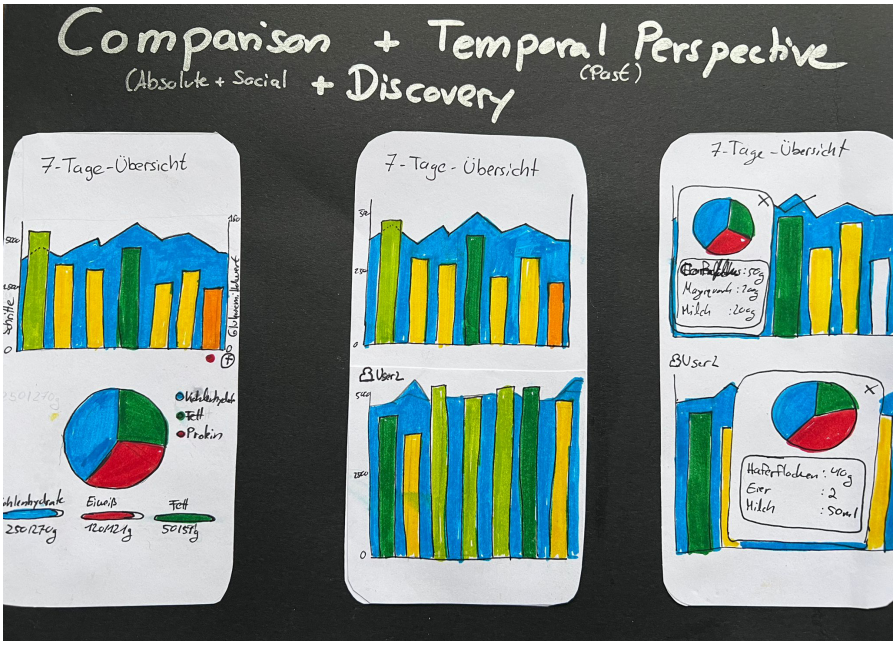

Figure 7: Activity levels are shown with bar plots and glucose levels with a graph, respectively. Macronutrients, which are fat, protein, and carbohydrates, are displayed via Pie Charts and progress bars.

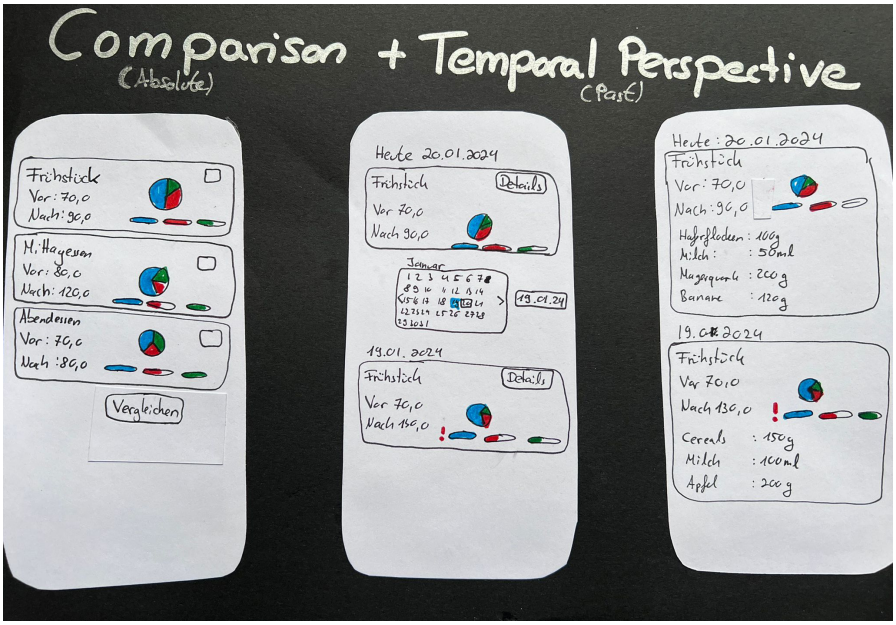

Figure 8: Meals from different days can be selected via a calendar and compared to tracked meals.

review.

As the app was intended for diabetes patients, the displayed parameters were selected

to primarily analyze patients' blood glucose levels based on the composition of carbohydrates, fats, and proteins in their meals. This analysis was complemented by measuring patients' movement parameters, which helped establish a correlation between their physical activity, food intake, and average blood glucose levels. The food tracking function allowed patients to track their food intake and estimate its impact on blood sugar levels. The prototypes' features were inspired by different apps, including Diabetes Log, DiaConnect, and MySugr.
In Figure 7, there is a sketch of a seven-day overview. The first screen displays the steps as bar plots and the blood glucose level in a graph behind the steps. Below the graph, there is a pie chart showing the distribution of macronutrients and accompanying bars describing the actual intake of carbohydrates, protein, and fats, as well as the recommended intake for each macronutrient. The screen in the middle, as depicted in Figure 7, displays two graphs. The first graph represents steps taken as bar plots, while the second graph shows the user's blood glucose levels. The bottom graph displays data from a different user, allowing for comparison with another person's data. The last screen in Figure 7 shows the macronutrient distribution for the user's selected day at the top and another user's day at the bottom to allow for comparison. These screens can be categorized into the design components of Comparison and Temporal Perspective, as well as Confrontation
In Figure 8, there is an overview of the blood glucose levels. The first screen on the left shows the before and after values of the blood glucose vealues for each meal. It also includes a pie chart displaying the macronutrient distribution for each meal, as well as bar graphs showing the nominal and actual values of the macronutrients. In Figure 8, the middle screen shows a comparison of two days of breakfast selected using a calendar. The breakfast is again described with a pie chart for the macronutrients and the values of the blood glucose levels before and after the meal. There is also an exclamation point next to the bar for carbohydrates, indicating that too many carbohydrates were consumed in that meal. The right screen in Figure 8 shows the detailed view of the two selected days in the previous screen. The user can now also see what they ate that day for breakfast, and how much of it. These screens can be categorized into the design components of Comparison and Temporal Perspective.
In Figure 9, there is a sketched screen displaying a conversational interface that prompts the user to textual answer questions about their day, as well as a question that requires a Likert scale response. This screen falls under the design component of Conversation and Temporal Perspective. During the paper prototyping process, it was discovered that implementing design components separately was not feasible because most screens required some aspects of one or more design components. This is demonstrated in Table 3, which shows the components included into each prototype feature.

After creating the paper prototypes, they were transferred to Figma, a prototyping software commonly used in UX and UI design for web applications.
For the first iteration of the high-fidelity prototype, the goal was to recreate the paper prototype using Figma. I opted for a simple dark mode prototype with several highlight colors, as shown in Figure 10.

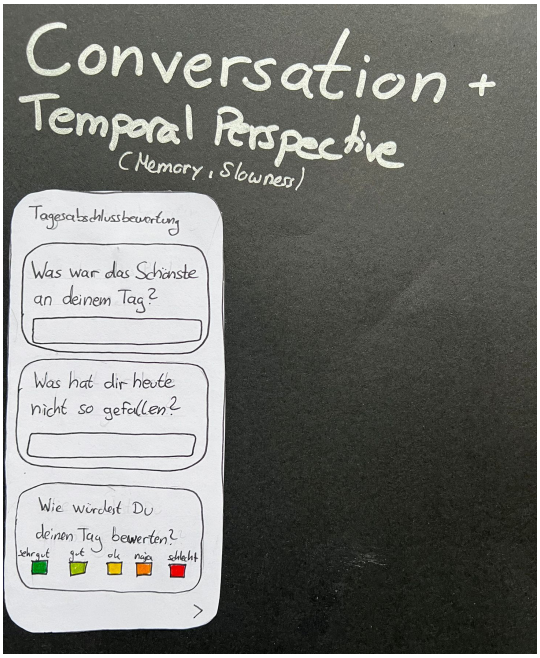

Figure 9: Paper prototype of an app feature that encourages daily reflection and falls under the temporal perspective category. The feature prompts the user to slow down and think about their day by engaging in conversation with the app.

In the second iteration, see Figure 11, efforts were put into selecting the appropriate color scheme for the diabetes-tracking app prototype. After research, green was discovered to be a suitable choice, as it symbolizes growth and new life [57]. To generate the color palette an online platform called Coolors was utilized. The palette was implemented using the 60-30-10 rule, which means to cover 60% in one dominant color (the background color), 30% in a secondary color (the color of the menu bar and buttons), and 10% in an accent color (the yellow buttons) [57].

All prototype screens can be classified into the design components identified in the scoping review. This will be described in detail below, including how the classification was implemented and the reasons behind it. To provide clarity on the design components of prototype screens based on the scoping review, they have been listed in a table, see Figure 3.

Temporal Perspective In the Temporal Perspective reflection approach, a bar plot that displays the daily activities and average blood sugar levels of the past seven days is created, see Figure 12 and Figure 13. Additionally, a calendar highlighting each day with a different color depending on that day's average blood sugar level is added, see Figure 14. The calendar marks the days with good blood sugar levels green or yellow, while the days with worse blood sugar levels are marked orange or red. This way, users

Figure 10: First high-fidelity prototype design with dark color scheme.

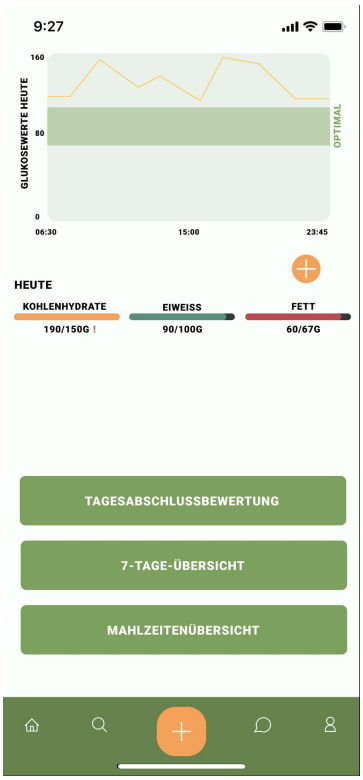

Figure 11: Second high-fidelity prototype in lighter colors.

can easily track and comprehend their blood sugar levels relative to their daily activities. On the start display, the user can view a daily glucose graph that indicates any spikes and whether the glucose levels are within the optimal range, see Figure 15.
The daily evaluation feature encourages users to take a break and slow down to reflect on their day, see Figure 24.

Comparison The Comparison component was implemented in various ways. One is a bar plot that enables users to compare their daily activity levels over seven days, see Figure 13. Users can compare blood sugar, activity levels, and daily macronutrient distribution to better analyze daily data, see Figure 13. Implementing macronutrient presentation is modeled after food-tracking apps such as *YAZIO* and *MyFitnessPal*. According to the literature included in the scoping review, pie charts are commonly used to display compositions and proportions. These apps utilize pie charts to illustrate the distribution of macronutrients and calorie intake for each day.
Besides implementing absolute comparison, social comparison is also included in the prototype. Users can select a friend in the social comparison section and compare their seven-day overview with their friend's, see Figure 12. Additionally, users can get an insight into the macronutrient distribution of their friend's diet and how their blood

Table 3: The design components, their definitions as presented in the scoping review as well as the design approaches utilized in the prototype.

Design Components	Definition	Prototype
Temporal Perspective	Different sets of data gathered at various times can offer unique perspectives on users' collected data. (Past, Memories, Future, Slowness)	Seven-Day-Comparison13 Start-Screen15 Meal Overview17 Daily Evaluation25232426
Comparison	Including comparison tools in design can encourage users to reflect on data. (Social Comparison, Absolute Comparison)	Seven-Day-Comparison1312 Start-Screen-Comparison15 Calendar14 Meal Overview17 Food Tracking20
Confrontation	Presenting data in a new light can enhance reflection. (Provocation, Data in different context)	Seven Day Comparison131216 Meal Overview17 Start-Screen-Comparison15 Food Tracking212220
Conversation	Conversation can assist in comprehending the significance of experiences. (Conversation with technology, Conversation with real people)	Daily Evaluation25232426

sugar levels are affected by their food intake and activity levels, see Figure 16.

Confrontation Designing for Confrontation was the most challenging aspect of the project as it is an outcome rather than a feature. The literature included in the scoping review explained that confrontation encourages users to explore and discover new things, which can be achieved through provocations. Unpleasant information can be one type of provocation that can be used to engage users.
One way to promote confrontation is to use social comparison. Users can view their friend's blood sugar levels, macro distribution, and activity levels to identify areas for improvement in their health, see Figure 16.
Another method, highlighting unhealthy food choices, see Figure 20, was employed. Using the application, users can track their dietary habits and receive a notification of the required insulin dosage if they decide to consume the food. To help users make healthier food choices, the app suggests options with lower blood sugar impact, see Figure 21 and Figure 22.

Conversation Conversation was challenging to incorporate into the clickdummy prototype. The mood questionnaire, see Figure 24 was used to simulate conversation with the technology to address this issue and include a feature that allows the user to indicate if any significant events occurred on a particular day, see Figure 23. However, an app for daily use with a real-time conversation feature could be a subject of future research.

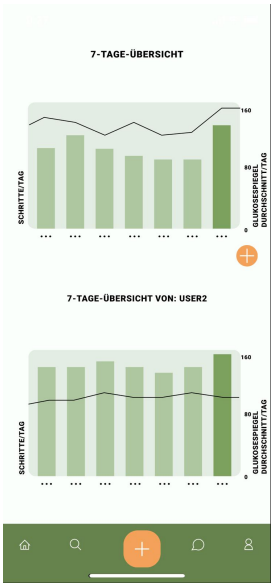

Figure 12: Users are able to compare themselves with other users about steps taken and average glucose level of the day. They are able to get more details of the selected day.

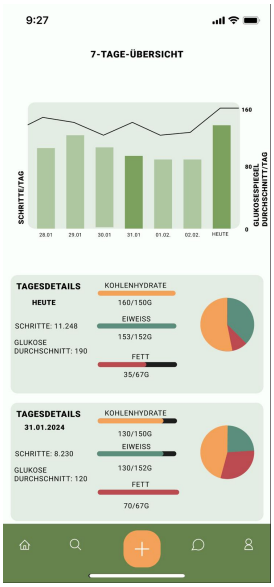

Figure 13: Users can compare their daily steps, macronutrient intake, and average glucose levels with previous tracked days.

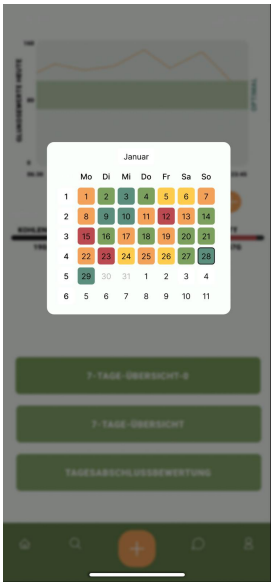

Figure 14: Users can select a date from the calendar to compare it with the current date.

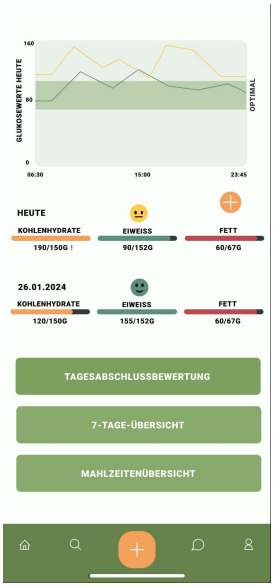

Figure 15: Users have the option to compare the macronutrient intake on different days and view the corresponding glucose level graph.

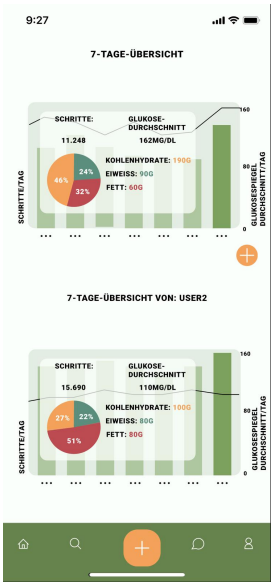

Figure 16: Information in comparison about the macronutrients consumed, number of steps taken, and the average glucose level for a selected day.

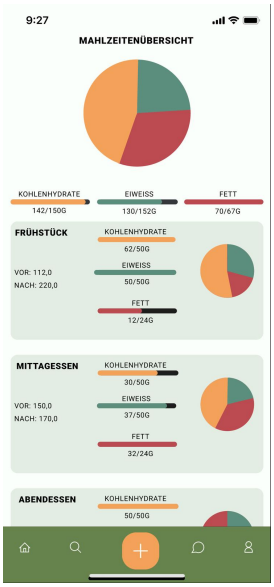

Figure 17: Tracked meals of the day are displayed and can be compared by macronutrients and glucose level changes before and after each meal.

Figure 18: It is recommended that users track their current glucose levels prior to tracking a meal.

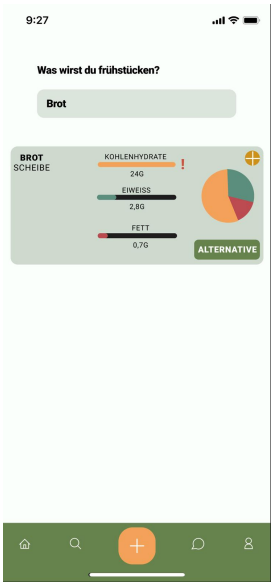

Figure 19: Users can easily search for their preferred food by using the search field.

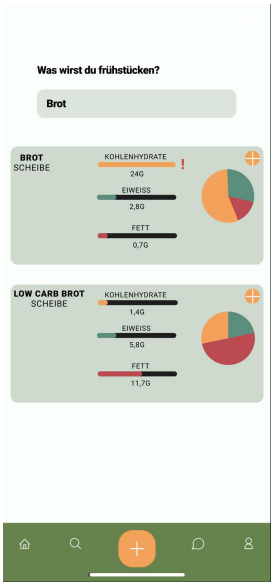

Figure 20: Users can select food alternatives that offer superior macronutrient values.

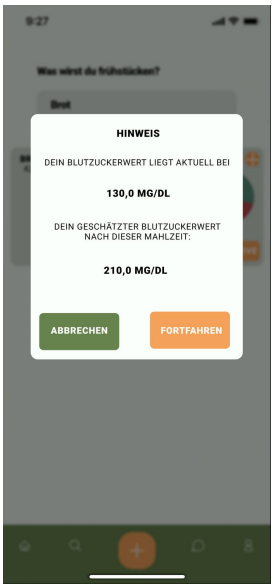

Figure 21: Selecting a food high in carbohydrates: A warning will be provided regarding the estimated increase in blood sugar levels.

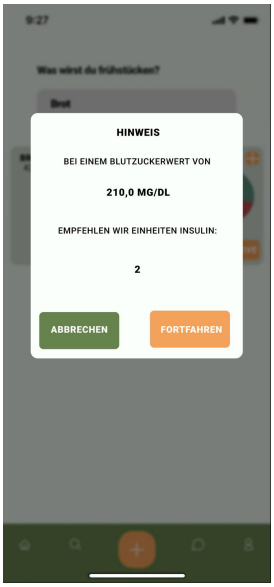

Figure 22: The user will receive a notification and be cautioned that they may require insulin injection.

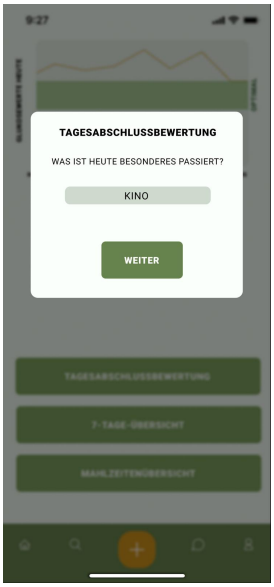

Figure 23: Users can tell the app if something special happened that day via a text field.

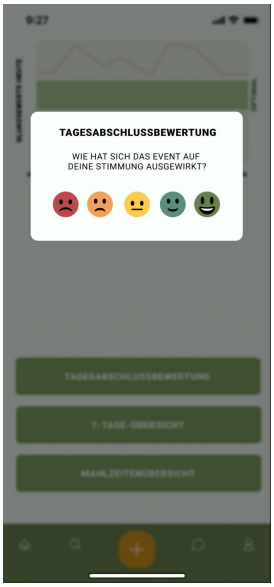

Figure 24: The special occasion and the day's mood can be rated with the Linkert scale.

Figure 25: The app will give the user a rating for the day.

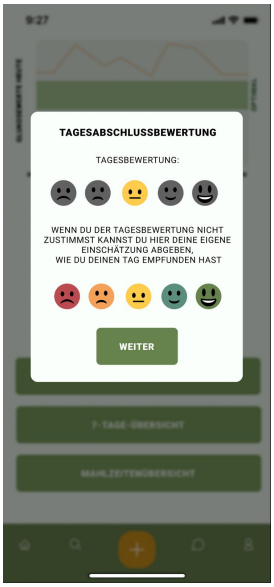

Figure 26: Users can agree or disagree with their result and change it accordingly.

3.2.3 Combining the Design Components

During the process of creating the prototype, it was discovered that the four design approaches of the scoping review could only, in particular cases, be used separately. As the design phase progressed, various combinations of design components were identified and integrated into the prototype. The newly discovered design combinations have been documented as Design Combinations in Table 4 as well as their corresponding screens.
In a study by Cho et al. [20], it was noted that the human-centered design approach needs to provide more guidance on integrating reflection into user interfaces .
This prototype aims to create guidelines for implementing interfaces that promote reflection in users. It categorizes different types of scoping review results and determines which work best together.

The prototype has four design combinations: "Temporal Perspective and Comparison", "Temporal Perspective and Confrontation", "Temporal Perspective, Confrontation and Conversation", and "Confrontation and Comparison".
The design combinations were established during the design phase and will be assessed during the evaluation phase. This will provide valuable insights into which design combination is the most effective in helping users reflect and is most likely to be used in their daily lives. The aim is to assist users in managing their illnesses and getting back on track.
Interestingly, three out of four design combinations of the design approaches are associated with the temporal perspective aspect.

Temporal Perspective and Comparison This design combination was frequently used for comparisons that involve a temporal perspective. Absolute comparisons require data from different times and can't be implemented without a temporal perspective. The design combination is visualized in Figure 13. The user can compare two days and see a detailed overview of the macronutrients and the average blood sugar, as well as the daily activity.
Another implementation is shown in Figure 14. Here is an absolute comparison and temporal perspective implemented by using a calendar that shows the color of the daily evaluation of the user over the past month.
Temporal perspective and social comparison are only implemented in Figure 12. This feature allows users to compare their data with others over the past seven days.

Temporal Perspective and Confrontation When presented with specific data, users often come across new information. This concept has been applied in diabetes management, where users are shown the amount of insulin they need to take before making a food choice. This not only helps users discover more about their condition but also

Design Combination	Definition	Prototype	Name
Temporal Perspective AND Comparison	Combining aspects of Temporal Perspective with aspects of comparison.	Seven-Day-Overview13 Start-Screen15 Meal Overview17	Comparison - Absolute
Temporal Perspective AND Confrontation	Seeing data in a new light with the help of Temporal Perspective.	FoodTracking192122	Confrontation
Temporal Perspective AND Confrontation AND Conversation	Reflecting through conversation with technology that utilizes Temporal Perspective, leading to Confrontation.	Daily Evaluation24232526	Conversation with Technology
Confrontation AND Comparison	Discovering new insights by comparing one's data.	Social Comparison 16	Comparison - Social

Table 4: The design components were combined to fit the prototype screens into four new design combinations, as shown in the table.

encourages them to consider the impact of their choices on their future health, see Figure 21, and Figure 22.

Temporal Perspective, Confrontation and Conversation The Mood Questionnaire's and daily rating system provides a concise overview of the user's responses and a general evaluation of their day. This design combination is visualized in Figure 24, and in Figure 25. As users are asked to reflect on their day, recall their mood, and rate their food choices, this process falls under the Temporal perspective category. Answering the questions also has a conversational aspect and a Confrontation aspect when confronted with the overall daily rating.

Confrontation and Comparison When comparing their data with another user's data, like in Figure 16, the user is presented with the other user's achievements, whether It is maintaining a stable blood sugar level or the amount of carbohydrates they consume. This can lead to discovering new and effective ways of dieting and help the user improve their overall quality of life.

The complete prototype can be found in Figma.

Certain design component subcategories are not included in the prototype, such as conversations with real people. This leaves room for further research and would probably work best with a real application rather than a prototype.
While conversation with technology was included in the prototype, participants were unable to write their own events into the text field due to the limitations of the Figma prototype. However, conversation with technology is still expandable and can be improved to allow users to write down their real feelings and notes of the day, in addition to the mood rated on the Likert scale.

In summary, during the design phase, it became clear how different theory and practice can be. In the scoping review, four main design approaches with subcategories were discovered. The goal was to create a prototype that would represent each design approach individually. However, the design process revealed that this was not possible. Even when an element was intended to represent only one design approach, it often ended up incorporating multiple design approaches. For instance, if a design element was intended for a temporal perspective but displayed data from various times and allowed the viewer to see the information differently, it could also reveal insights related to Confrontation.

3.3 Expert Phase

To ensure that the prototype is feasible in the context of diabetes, a diabetes expert was consulted for feedback on how to adjust the prototype accordingly. The expert chosen for this interview specializes in the field of psychosomatics, which deals with the interaction between the body and mind. She also works with diabetic patients at Charité Berlin. This provides her with the expertise to assist in specifying and refining the needs of patients with diabetes for an app designed to help them with their condition.
The expert was invited to assist with the evaluation and provide further expertise, due to her previous work with the HCC group at the Freie Universität Berlin.
The semi-structured interview was conducted online via Webex at the beginning of March 2024 and lasted about an hour.

Study Procedure The expert was given a scenario in advance to assess the accuracy of the diagnostic procedure described. This scenario is crucial for the qualitative study, as it allows participants to evaluate the prototype from the viewpoint of a diabetes patient. For the purpose of obtaining more insights into the challenges faced by diabetes patients, the underlying causes of this condition, and the available treatment options, a semi-structured interview was carried out.
After the interview, I shared my prototype click dummy in Figma with the expert through screensharing. The prototype review focused on trackable health data and whether features and functionality were selected based on the needs of diabetes patients, per the expert's opinion.

Findings One of the key questions regarding diabetes diagnosis is what symptoms a patient would present during the consultation. Type 2 diabetes patients are usually diagnosed later in life, with the average patient being around 40-60 years old. They may experience symptoms such as obesity, weakness, and other related conditions before seeking medical attention. In contrast, type 1 diabetes patients are typically born with the disease.
When patients have high HbA1c levels, which is the glycated red blood pigment [51], in their blood tests, they are asked to return for a glucose tolerance test. During this test, patients have to consume a sweet liquid that is made by mixing 75 grams of sugar with water to make it drinkable.

> *"It is important to inform the patient that the procedure requires to come early on an empty stomach." (Expert)*

Before administering the sugary liquid, the patient's blood sugar level is checked by pricking their finger and collecting a small drop of blood.

> *"Diabetes type 2 patients have a high blood sugar level, even on an empty stomach. " (Expert)*

The cells of patients with type 2 diabetes cannot properly process glucose, leading to high blood sugar levels. This is due to a diet high in sugar and unhealthy foods that have exhausted the cells' ability to process sugar.

> *"The primary issue in type 2 diabetes is not a deficit of insulin. Rather, the sugar molecules cannot enter the cells and be used as energy." (Expert)*

After measuring the blood glucose level, the patient is asked to consume the liquid and wait for two hours before measuring the blood glucose once again.

> *"If levels are above 140mg/dl, glucose tolerance is impaired, which indicates diabetes type 2." (Expert)*

High blood sugar levels are not immediately dangerous. Eating a lot of sugary foods or desserts like ice cream won't cause immediate harm. However, if they persist over a long period of time, they can damage vital organs and shorten patients' lifespans. It is important to manage blood sugar levels through a healthy diet, exercise, and medication if necessary. It is common for patients who have been diagnosed with type 2 diabetes to have so-called pre-diabetes. Pre-diabetes is characterized by blood sugar levels between 110 mg/dL and 125 mg/dL in the glucose tolerance test. If a patient is only diagnosed with pre-diabetes, it means that there is still a chance to reverse the condition by adopting a healthier diet and losing weight.

"For some patients who are starting to work out and can lose weight, suddenly diabetes Type 2 is gone again." (Expert)

Low blood sugar levels can be extremely dangerous, particularly for those with type 1 diabetes. If left untreated, this condition can lead to death. When blood sugar is low, It is common to consume sugary foods like gummy bears, fruits with high sugar content, or even pure dextrose to help raise blood glucose levels. These patients rely on insulin to lower blood sugar and sugary foods to raise it.

Type 2 diabetes patients may not require insulin. Some can manage their blood sugar with diet or medication.

"Some patients do not require any medications, while others may receive a medication such as Metformin. To determine the correct dosage of this medication, patients will need to measure their blood sugar levels more frequently than they typically do." (Expert)

To manage diabetes without medication, it is crucial to maintain a low-carbohydrate diet consisting mainly of complex carbohydrates.

"They should always prefer eating complex carbohydrates such as whole grain bread rather than toast. However, many guidelines are available on what a good diet for Type 2 diabetes patients should consist of." (Expert)

It is important to take into account that individuals with type 2 diabetes may also experience depression. This can result in overeating during periods of low mood, which can contribute to elevated blood sugar levels and weight gain if the depression persists.

"When feeling down, some patients tend to resort to eating, which, in turn, leads to an increase in their blood sugar levels." (Expert)

Although most patients with type 2 diabetes do not need to measure their blood sugar as frequently as those with type 1 diabetes, they still need to monitor their levels while adjusting their medication. As a result, the blood sugar measurements in the prototype can be useful and can assist patients who are new to the diagnosis.
During the prototype review, the expert emphasized again the significance of monitoring the mental state of diabetes patients who are suffering from depression in addition to their condition. This feedback led to a daily mood rating feature in the prototype. Users can now rate their mental state using a Likert scale and note special occasions, which helps to determine any deviations in their diet and blood sugar levels, see Figure 25, and Figure 24.

In summary, the interview with the expert was very informative and provided valuable insights into patients' lives with diabetes. During the interview, new information was presented that led to adjustments in the diagnosis aspect of the scenario. The expert highlighted the importance of including a mood and mental health tracking feature in the app, as diabetes patients often struggle with depression. As a result, a mood questionnaire was designed. It also emphasized the need for an app that can support diabetes patients in their day-to-day lives and help them make positive changes in their lifestyle and dietary habits, ultimately leading to a healthier life without the disease.

3.4 Evaluation Phase

The purpose of the evaluation is to investigate the feasibility of the prototype design by conducting a qualitative study. Qualitative studies are an excellent option for investigating human experiences, opinions, and behaviors in a detailed and comprehensive manner. This evaluation determines which design elements encourage users to reflect, when reflection occurs, and whether users reflect on submitted data.

3.4.1 Preliminary Measures and Participant Recruitment

To recruit study participants, I contacted various diabetic associations, such as Deutscher Diabetiker Bund and berlin diabetes through email and social media over one month (January-February 2024). The feedback I received was disheartening, as it emphasized that diabetes primarily affects older individuals who may not be able to participate in an online study, especially one that involves using an app. In Germany, 7.2% of people aged 18 to 72 have the disease, with 90-95% suffering from type 2 diabetes, according to the German Federal Ministry of Health. [24].
I tried to gauge interest in possible participants by sending emails to various acquaintances, of whom 14 agreed to participate in the study.
The 14 participants, aged 21–64 years (mean = 34,86, median = 33,5), 4 identified as female, and 10 identified as male, were located in Germany.

3.4.2 Evaluation Procedure

In the qualitative study, the participants were given a scenario to read that was determined in the expert phase and contained a detailed description of diabetes and important facts about this disease that they have to remember during the interview.

Scenario

You've been experiencing prolonged complaints such as feelings of weakness, tiredness, and concentration problems. As a result, you have decided to schedule an appointment with your family doctor. After the doctor requested you to come on an empty stomach for a consultation,

The doctor has informed you that she intends to perform a glucose tolerance test. This test involves drinking a liquid and measuring your blood glucose level before and after consuming it.
Once the doctor has measured your blood glucose level using a small drop of blood from your finger, they will ask you to drink a sweet liquid from a cup. The liquid contains 75 grams of sugar, giving it a very sweet taste. After waiting for two hours, the doctor will measure your blood sugar level again.

The doctor takes another small drop of blood from your finger to measure your blood glucose level. The test result indicates type 2 diabetes.

Upon receiving the diagnosis of diabetes, you feel shocked and overwhelmed. The doctor notices your discomfort and recommends a new app that can help you cope with everyday life with diabetes. The doctor briefly introduces the app to assist diabetic patients with monitoring their blood glucose levels and making appropriate meal choices.

The app will prompt you to track your blood glucose levels before and after every meal. This will help you accurately assess your blood sugar levels and adjust your medication accordingly. There is also an option to track meals, which allows the app to monitor the impact of your food on your blood glucose levels. This information can provide a guideline for the insulin you need to add. Since you are new to your diagnosis, the app allows you to view the blood glucose values of other diabetes patients. This can give you insight into how other patients manage their diet and lifestyle around the disease.

In March 2024, 14 participants took part in a qualitative study, which was divided into three steps, which are explained below. Every participant was asked to provide consent to participate in the qualitative study and allow the use of their answers in this thesis.
First, participants evaluate the prototype using the Think-Aloud method. The participants are requested to verbalize their thoughts and emotions while accomplishing a task in the prototype [13]. To ensure a standardized implementation of the Think-Aloud method, the evaluation course should be discussed beforehand [13]. The evaluation execution will be recorded and turned into unstructured simultaneous Think-Aloud protocols [13].
To evaluate the prototype, the participants were assigned tasks using the Think-Aloud method. The tasks were carefully selected to ensure that all aspects of prototyping were thoroughly carried out. The participants were asked to track their meals twice—once with their regular choices and once with healthier alternatives. This task was designed

to highlight the differences between the two options and to demonstrate the warnings that appear when an unhealthy choice is selected.
After tracking their meals for the day, participants could select the daily evaluation and answer questions using the Likert scale. After the daily evaluation, participants could compare daily blood glucose levels and evaluations using the compare function, which displayed graphs of two different days.
To discuss different forms of comparison and which design choice led to more reflective behavior, the next task focused again on absolute comparison, using data from the last seven days and corresponding macronutrients and step measurements. After examining absolute comparison, the social comparison was discussed. Users were shown their data from the past seven days and compared it to another user's data from the same period. This task aimed to examine whether participants felt the need to change their behavior to achieve similar goals as another user.
The last task was to check out the meals of the day, including the blood glucose levels before and after each meal and the macronutrients of each meal and the whole day. The task aimed to investigate whether participants could observe the impact of their food choices on their blood glucose levels.
Second, the usability of the prototype design elements is determined by using the User Experience Questionnaire [5]. Participants must complete the questionnaire before the semi-structured interview to avoid bias [5].
Third, a semi-structured interview is conducted, which aims to identify which screens or interactions made participants reflect and why.
As an analysis method of the evaluation results, qualitative content analysis will be carried out according to Mayring [47].
To ensure that the study could still take place, a scenario was created that participants should read beforehand to imagine themselves as diabetics.
The scenario was created and adapted according to the information gathered in the expert interview.

3.4.3 Results

I collected demographics and interview transcripts during data collection. My analysis primarily focuses on the interview transcripts. The interview transcripts were used and analysed using the Mayring method [47]. The process of Mayring analysis can begin in two different ways: inductive and deductive. The inductive method involves developing categories based on the analyzed data, while the deductive method starts with a predefined set of categories. In this case, the deductive approach was chosen because new concepts were introduced during the design phase, resulting in four design combinations, see Table 4, which were used as categories for the qualitative content analysis. In order to guide the qualitative content analysis towards the research questions, they need to be defined. As this qualitative study is focused on addressing the second research question of this thesis, that question will be the main focus of the qualitative content analysis.

The next step involves summarizing the interview answers and simplifying them by focusing only on the important content. This helps in the process of coding the data, which is done by assigning segments of the text to the predefined categories.
The transcripts have been sorted into design combinations based on the concepts identified in the design phase as in table 4, in "Comparison - Social", "Comparison - Absolute", "Confrontation - with provocation" and "Conversation with Technology".

Comparison - Social During the study, participants were asked to compare themselves with an imaginary second app user. This feature offers multiple types of reflection to the user. First, it provides a temporal perspective by displaying the user's data from the past seven days. Second, it allows for Social Comparison by enabling users to compare themselves with other users. Lastly, it facilitates reflection through confrontation by highlighting differences in behavior and diet between the two users.

There were two main opinions about social comparison. Some mentioned it motivated and helped with diet and activity.

> *"I appreciate the comparison between myself and other app users. It reminds me that we are all in the same situation and facing similar challenges. This takes away any possible excuses for poor health habits and makes me realize that I cannot simply blame my illness for my struggles. Other people in my situation can manage their health effectively, and so can I." (P9)*

> *"If I compare myself and compete with a friend, it would motivate me to improve." (P14)*

Other people mentioned that comparing themselves to others is frustrating, so they prefer not to use this feature often.

> *"When comparing myself to others, I prefer to focus on my progress rather than theirs." (P13)*

Some individuals stated they would feel uncomfortable knowing others could access their health information online.

> *"Comparing myself to others is not something I usually do. While I may observe what they do well, I don't want them always watching me as this would limit my potential." (P14)*

This probably depends on the individual and is not related to any specific category.

Although not everyone was comfortable with social comparison, they acknowledged that they could learn from the other user's behavior and adapt it to their dietary and activity habits.

They noticed that adjusting their carbohydrate intake significantly impacted their blood

sugar levels, and they should adjust their macronutrient distribution based on other users' intake. Participants (P7, P8) clearly verbalized their understanding of the relationship between carbohydrates and their glucose levels.

> *"If I notice that another user is consuming fewer carbohydrates and thus maintaining a better glucose average, it will encourage me to modify my diet accordingly." (P7)*

> *"I consume significantly more carbohydrates, which is the important factor to consider, almost double the amount." (P8)*

They mainly noticed this by comparing their macronutrient pie chart with the pie chart of the other users.

> *"Based on the pie chart, it is clear that the other person has a better diet. The carbohydrates are way less, and they walk more steps than I do." (P10)*

It seems that the dominance of the pie charts made it easier to compare the percentage of carbohydrates between the two users.
However, users still checked the values of the macronutrients in grams, which were listed next to the pie chart, but only after comparing the two pie charts.

> *"I still refer to the nutritional values listed next to my food. For example, suppose I didn't eat much that day due to illness. In that case, a higher proportion of carbohydrates listed in the pie chart doesn't necessarily mean I ate more overall, but just more in comparison to fat and protein." (P9)*

This suggests that visual presentations of data are more effective than numerical data alone when it comes to reflection. The participants were drawn in by comparing the two pie charts and then proceeded to analyze the other data displayed on the screen to draw further conclusions.

Participants in the study mentioned the Temporal Perspective aspect of the screen the least. They were presented with two graphs showing the glucose and activity levels of the last seven days. Still, instead of focusing on their glucose levels on specific days, they compared their overall graph with the graph of the other users. This means that they did not specifically mention that their glucose levels were good on a particular day within the last seven days.

> *"His blood sugar levels remained stable, unlike mine, which peaked and dropped."* (P3)

However, this might also be because this graph, unlike the graph on the start page, did not display an optimum for the glucose levels. One participant (P14) mentioned needing a reference point to understand the graph better.

> *"I'm not sure if my values are good or bad in this graph since I lack the optimum range I use as a guide in the other graph." (P14)*

This also shows that participants required contextual data to reflect on it effectively.

Comparison - Absolute After comparing themselves with others, participants were shown different variations of comparing themselves with their past data. The various screens used in the study incorporated Temporal Perspective to display older data to the participants. Additionally, Comparison was used as two datasets were compared, and Confrontation was also implemented since users were required to identify the source of differences in their glucose levels.

In the first screen, participants were presented with two days of tracked macronutrient data, average glucose levels, and activity levels. In contrast to comparing with other users, there were no mixed feelings when comparing one's own data. According to one participant (P4), they enjoyed comparing the two days.

> *"I enjoy looking at the individual days in comparison and then see directly what I did well or badly on which day." (P4)*

In contrast to the social comparison, where the pie chart was the primary focus for most participants, in this view, participants seemed to focus more on the progress bar to track their performance.

> *"I have noticed that when I eat fewer carbohydrates, the progress bar stays darker. On one day, I consumed more carbs than on the other day, and it is quite visible on the progress bar." (P8)*

Participants had to select a day from the graph to compare with the current day, choosing from the previous six. The graph, therefore, was used, but they never mentioned wanting to pick any particular day out of the graph.

> *"Which day should I pick? Does it matter?" (P3)*

This could also be interpreted as the participants not finding any significant differences between the days presented to them. Since all the days had varying levels of activity and average glucose levels, they did not see any reason to choose a specific day. Simply presenting the measurements of their activity and glucose levels did not compel the participants to investigate further their behavior on other days.

Participants (P3) also mentioned that they would have liked to see how the days were rated and that the activity levels should maybe be colored accordingly to better differentiate between the days.

> *"I would like to inquire about how my days went last week, whether they were positive or negative. Maybe coloring the activity level bar with the daily evaluation results color could be helpful?" (P3)*

The second variation of comparing themselves with their past data was by presenting the participants with a summary of their complete meals of the day along with the glucose levels before and after each meal.
Participants (P9, P11) reported being able to grasp the clear correlation between meals and glucose levels.

> *"Also, I can observe how my values change based on what I eat, which gives me direct feedback. For instance, after dinner, my blood sugar level has risen from 120 to 200, making me realize that eating this way causes a significant spike in my values. In contrast, my lunch has left my values almost unchanged." (P9)*

> *"I find the meal summary very helpful. It shows me which meals negatively impact my blood sugar levels." (P11)*

By showing participants their tracked glucose levels in addition to their meals, they were able to self-evaluate their meal choices.

> *"The meal was not good for me since it caused a spike in my blood sugar." (P6)*

Not only were they able to detect a spike in their blood sugar levels, but they were also able to analyze the possible reasons behind it and determine what foods to avoid in the future.

> *"When I check the blood sugar spike, I check my carbs for that meal and see that I've consumed 62.5 grams of carbohydrates for breakfast, which is too high." (P3)*

The first two visualizations for comparison are notable for providing participants with a plethora of tracked data. They enable participants to view their macronutrient intake for the day or for different meals, their glucose levels before and after meals, and their activity levels.
The last variation is quite different since it shows just days in a calendar, with the days colored according to the daily evaluation results.
Although the calendar view only shows limited data, participants mentioned that they would be disappointed if it displayed numerous bad days.

> *"It would affect me negatively when there would be many badly rated days in the calendar" (P4)*

This shows that since the participants knew their daily evaluation would compromise all tracked data into a summarized result, they realized they weren't behaving according to their diet plan and goals when the calendar didn't have mostly green and blue entries.

> *"If I see a lot of green, I know that I have been eating well. However, if I see a lot of red, I understand that I need to make some changes." (P8)*

Some participants (P12, P3) even made a challenge out of it to see only good days in the calendar.

> *"It would be my motivation to have everything green and blue!" (P3)*

> *"I see this as a challenge to improve myself and only display good days here." (P12)*

The statements imply that utilizing a calendar overview can assist patients in maintaining their motivation.

Confrontation - with provocation Participants were warned about food with high carbohydrates and spiking glucose levels while tracking their next meal. If they chose to eat a meal with a high value of carbohydrates, they received a message that provided an estimate of their new glucose level and the amount of insulin they needed to inject after the meal.
This category also prompts participants to consider their future, including the Temporal Perspective.

Pointing out the high amount of carbohydrates in a food choice did not always lead to a change of decision. Some participants were still torn about eating bread with a high amount of carbohydrates.

> *"I think, when I'm craving bread, I wouldn't necessarily change my decision due to the carbohydrates." (P3)*

This still means that they considered the options but were so firm in their decision that they refused to change it.
When confronted with the exclamation mark next to the carbohydrate amount, other participants became concerned and looked for an alternative food option.

> *"When I see the exclamation mark, I immediately think about whether there might be a better alternative. And the app offers me some directly. That's practical and makes it quite easy for me to change my mind." (P8)*

The feature allowing users to view better alternatives to avoid glucose level spikes proved to be helpful in guiding their food choices toward healthier options. This suggests that users were interested in eating healthier but may not have known what to eat, and the app provided them with helpful suggestions for a more nutritious diet.

When presented with a hint of a potential spike in their blood sugar levels after consuming certain foods, two different reactions were observed among the participants. One group did not respond as expected and perceived the warning as a mere suggestion. They did not consider the rise in their glucose levels or the need to inject insulin as a negative outcome.

"I didn't mind it at all. I thought it was okay, not that it is a bad thing." (P2)

According to some participants (P9, P12), the warning provided did not seem alarming enough, which suggests that they were not able to determine whether the spike was too high or not. They felt that the warning lacked an emotional impact that would have made it more effective.

"It is just a value and just a value, and values don't speak to you emotionally." (P9)

"If there were a smiley face, it would be easier to understand if the values are good or bad." (P9)

These statements indicate that presenting data does not make participants reflect. They need an evaluation of the data to classify them and draw conclusions from them.

However, some participants (P1, P8) were uncomfortable with the warnings and immediately opted for the alternative food offered by the app.

"When the app tells me how much insulin I need to take, I reconsider whether the food is worth it or if I'd rather change my mind." (P1)

"I would really redecide to choosing the low-carb bread, if I see, oh, I have to take three insulin units when eating the normal bread. No, I'll leave that out straight away. That's not worth it." (P8)

Participants mentioned checking different foods to learn their impact on blood sugar levels could be something they would also do with this feature.

"I believe it is important to learn about the effects of different foods on my insulin levels, both good and bad. This means understanding which foods will have a positive impact and which ones will hurt my health." (P8)

This indicates that this feature can be used as a guideline for diabetes patients to learn from their past choices and make better food choices in the future.

Conversation with Technology As part of a daily evaluation, participants were required to rate their day and reflect on any special events that occurred during that day. This exercise made the participants recall their past experiences, which falls under the category of Temporal Perspective with memory. Through this exercise, they could converse with the app, be confronted with the rating they received, and discover its reasons. By editing their rating, they could reflect on their past experiences and compare their feelings about the day with the rating they received from the app.

Although participants couldn't rate their actual day and rated an imaginary day instead, they imagined how they would have felt during the special event specified in the prototype. This indicates that implementing slowness into the prototype was successful,

and participants considered how they would feel in such a situation.
Participants (P2, P12, P14) enjoyed reflecting on their day and rating it and appreciated how the result was displayed in their calendars.

> *"I think It is great that you are motivated to reflect on your day and collect a smiley face for it, which you can revisit later on the calendar." (P12)*

> *"I pause a little when I read the questions and think about the event and the day." (P14)*

> *"If you actively think about it again, whether you had a nice or not-so-nice day, you simply just deal directly with the feelings you had that day, which is good." (P2)*

Participants were even able to draw conclusions from their daily evaluations to glucose graphs on the start screen.

> *"I was at the movies and ate popcorn. That must be the spike at, what is it, 8 pm?." (P2)*

Although most participants liked the daily evaluation principle, not all could imagine using this tool every day.

> *"I don't know whether I would do the end-of-day assessment honestly, or whether I would rather tip through at some point." (P11)*

One participant mentioned that a reminder would help them do the daily evaluation, as it was unlikely that they would open the app on their own at the end of the day.

> *"I don't think I would click on it willingly, but it might be useful for me. It would help if the apps automatically pop up at the end of the evening when I check my sugar levels before going to bed." (P10)*

After evaluating the mood, glucose levels, and meals eaten, participants were able to contest the rating the app estimated if it didn't align with their personal perception.

> *"The fact that I can include my perceived rating again also helps me, because then I would think about it." (P9)*

This led to participants wanting to change their rating after rethinking their day again, when not pleased by the result. If participants were to use this opportunity on a day with low overall ratings to cheat themselves is unclear.
Participants also mentioned that they might not use this feature at all when they know that their rating might be bad.

> *"I wouldn't do the daily evaluation when I know beforehand that my result will be a sad smiley. I would maybe do it on the next day when I feel better." (P1)*

This suggests that participants might reflect on their day before deciding not to do the evaluation, as they anticipate a negative outcome.

In summary, it is important to note that some variations of the reflective elements did not perform as expected. This could be due to how the prototype was evaluated, and whether these components would work in a real-world application is unclear. As a result, further research is needed to test the components that did not work in this situation. Still, all variations of reflection implementation supported participants in reflecting.

Usability with the User Experience Questionnaire As this thesis employs the Human-Centered Design (HCD) process, usability is a crucial aspect. Hence, I conducted a usability test during the interviews.
The usability testing used was the User Experience Questionnaire [5]. Below are the evaluation results of the questionnaire, see Figure 27, and Figure 28. The questionnaire

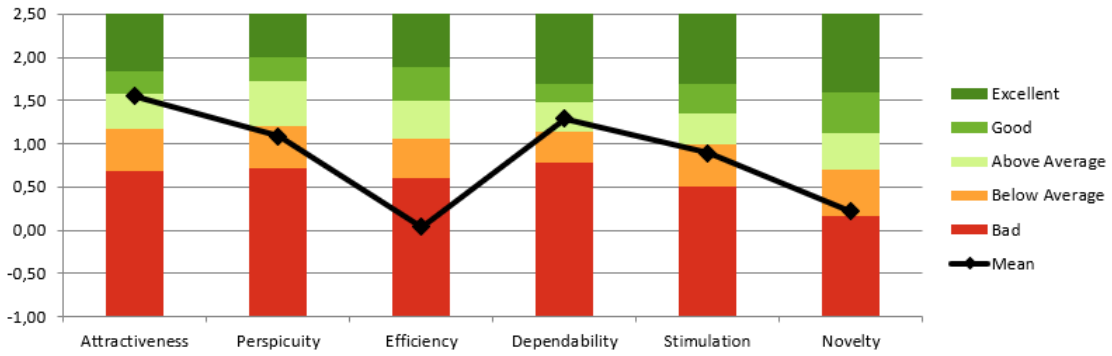

Figure 27: Results of the usability testing in a bar plot with standard deviation.

provides information on classical usability, including efficiency, perspicuity, and dependability, as well as aspects of user experience such as novelty and stimulation [5].
Attractiveness means the overall impression of the prototype. The participants rated the prototype 1.548, indicating an overall enjoyment.
The Perspicuity aspect of the prototype, which indicates how easy it is to become familiar with, scored 1.09. This application received a below-average score on the user experience questionnaire evaluation benchmark. This may be due to the unfamiliarity of the interactive user interface theme, which may have made it difficult to become acquainted with the application.
The Efficiency rating was the worst, with a mean of 0.04. Efficiency refers to how quickly users can complete their tasks. This poor result could be attributed to certain features of the app that were intentionally designed to slow down the user.
Participants in the study rated the dependability of the prototype with an above-average score of 1.29. This score measures the user's feeling of control during interactions. One reason for this could be that participants were able to move freely around in the proto-

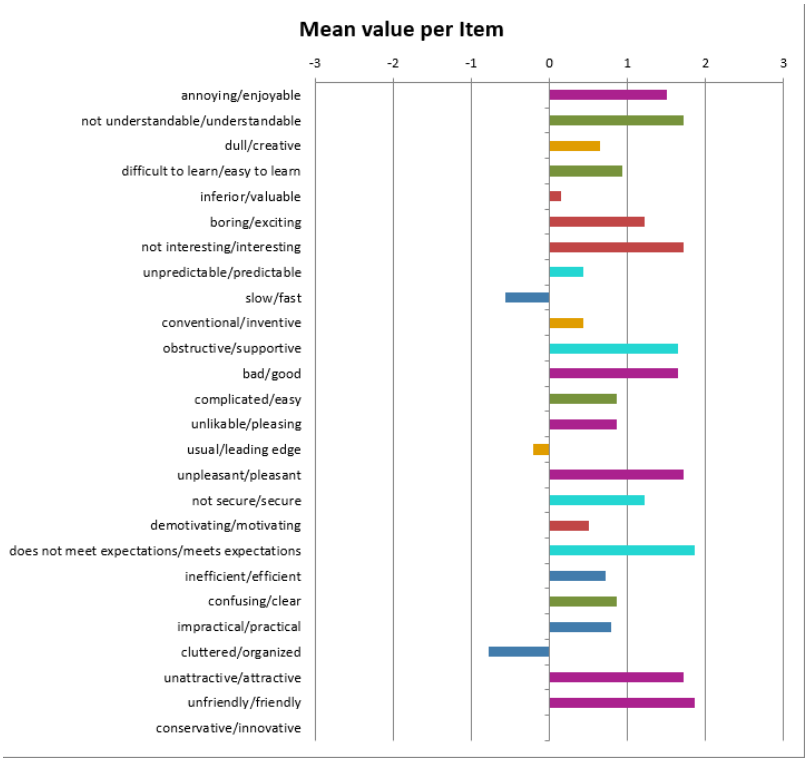

Figure 28: Usability testing results with all 26 items. Items can be rated from -3 to 3.

type and could easily return to their starting point. Additionally, they were able to use all features of the app without getting stuck or encountering any difficulties.

The app's stimulation, which refers to how motivating and exciting it is, received a below-average rating with a mean of 0.89. This is in contrast to the Think-Aloud method, where participants mentioned that they would feel motivated to maintain a good diet while using the app, but this does, of course, not mean that using the prototype is exciting.
The metric of novelty, which gauges the creativity and interest level of the design, received a below-average score of 0.21. This can be attributed to the fact that all design elements used in the app have already been used in other apps but not with the intention of reflection. As a result, this design feature does not appear to be innovative, despite the fact that the app itself may be innovative as it can offer reflective thinking and, therefore, gain new insights and develop a critical perspective.

The complete analysis of the User Experience Questionnaire, as well as the questionnaire, can be found on OSF.

Findings The main findings of this qualitative study indicate that while social comparison was effective in facilitating reflective thinking, not everyone preferred being compared to others. Comparison with oneself generally led to greater acceptance. Furthermore,

the study revealed that presenting fewer data, as done in the calendar, still prompted some reflective thinking, as opposed to presenting a large amount of varied data for comparison, which led participants to focus on the most noticeable visualization on the screen, in this case, the pie chart.
The study revealed that certain participants disregarded warnings or suggestions about their food choices and still chose unhealthy options. However, individuals with a better understanding of the topic were more inclined to heed the warnings and attempt to select healthier foods. This demonstrates the importance of knowledge and suggests that more information should be provided to the users.
The Conversation screens were effective in slowing down the participants and making them think about how they felt, even though it was just an imaginary scenario and they didn't actually attend the event mentioned in the prototype. This demonstrates that taking the time to reflect can be quite effective. Opinions about receiving feedback on their overall behavior varied, as most participants expected that they wouldn't want to do the evaluation if their performance for the day wasn't optimal. This indicates that they would think about their eating behavior beforehand, but it could also lead to decreased usage of the app, which is not the desired outcome.
The user experience questionnaire overall showed good results. It indicated a need for redesigning the prototype to bring it up to modern standards. The prototype also appeared to lack efficiency, which could be the result of intentionally slowing down the participants to allow for reflection. In this case, this could also be the desired outcome, as the app should provide a feeling of having time to reflect without needing to rush.

4 Configuration Tool for Reflection

The results of the scoping review and the subsequent qualitative study were made more accessible by creating a web tool that offers the possibility to configure an app screen that aimes to support reflection. The web tool provides information about reflection in human-centered design and demonstrates how reflection is implemented in the app prototype. To further explain the possibilities of reflection, the prototype was expanded for the implementation of the web tool to showcase the addition of different design components to the existing design combinations.

During the development of the web tool, the prototype underwent another iteration to address issues that became apparent during the qualitative study. Furthermore, the prototype was updated to adhere to modern design standards.

4.1 Design Considerations

As Cho et al. [20] pointed out, designing for reflection can be challenging since no guidelines exist. Baumer et al. [18] also explained that designing for reflection is a complex and multifaceted process that involves deep thinking and self-examination, which makes designing interactions that lead naturally to reflection. This leads to the reflection configuration tool, which explains the use of reflection in human-centered design and to provide important information about reflection. besides informing about reflection and its use in human-centered computing (HCC), the web tool also aimed to demonstrate how reflection can be integrated into interactive user interfaces, highlighting both successful and unsuccessful situations and showcasing the challenges of doing so.
This was achieved by using the design categories identified in the qualitative study and modifying them to include the missing design components within each category. The goal was to demonstrate how additional design components could have been integrated into the prototype and illustrate how certain design components may not complement each other well.

4.2 Preparatory Measures

The app prototype underwent a complete redesign based on feedback from the qualitative study. The configuration tool for reflection didn't look modern due to the overly scientific prototype, so this was another reason to rethink the design.
The app prototype was redesigned, taking into account designs from other fitness apps like *Fitbit*Fitbit, *Yazio*, or *MyFitnessPal*. The seven-day overview was overhauled; it now displays data from the last seven days, the last month, or the last year. The bar plots' appearance was also changed to be more rounded and slim, which can be seen in Figure 29.
To prevent confusion, the visualization of blood glucose levels was changed to display as

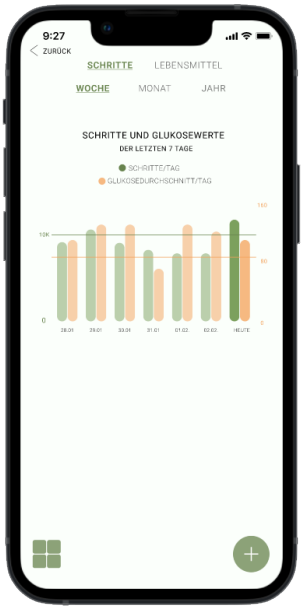

Figure 29: The redesign of the seven-day overview to an overview of the last seven days, the last month, or the last year.

Figure 30: Additional feature to also show macronutritions in comparison to blood glucose levels in the overview.

bar plots, and a goal value was added. More subtle colors were chosen. The redesigned app screen can be found in Figure 30.
The new prototype has an additional feature where the overview not only displays steps and blood glucose levels in one graph but also provides the option to show the macronutrients and blood glucose levels in another graph. To represent the three different macronutrients, three bar plots for the macronutrient data are stacked above each other, colored in the corresponding colors used already in the prototype for carbohydrates, fat, and protein. Carbohydrates, being the most important macronutrient for patients with diabetes, are positioned at the bottom to facilitate easier comparison over time, see Figure 30.
The new design for the overview was also implemented in the social comparison screens, both for steps as well as with the addition of the new feature to show macronutrients and blood glucose levels in another graph, see Figure 31. The navigation bar has been redesigned to feature two small buttons placed in the bottom corners. The button on the left opens other app features, while the button on the right is for tracking food. This design was seen in the *Yazio* app, where a single button in the corner makes it easy to add food to the food diary, see Figure 32.

Additional screens The redesign includes additional screens that were not implemented in the prototype before since they are not used to support reflection, such as a screen

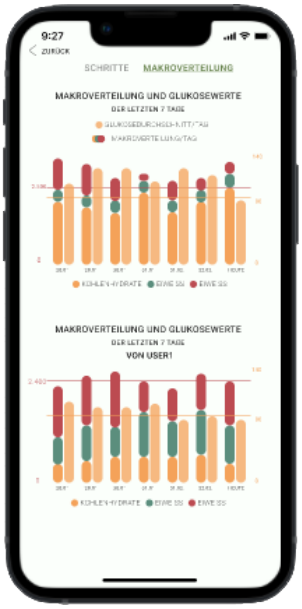

Figure 31: The social comparison screens have the new feature of comparing the macronutrients.

Figure 32: The new navigation consists of two buttons that open a menu for selection.

for tracking blood glucose levels throughout the day. This screen is accessible through the left button of the new navigation. Users can input their blood glucose levels and the corresponding time of day and specify whether they are before or after a meal, see Figure 33.
A "data protection and privacy settings" screen was added, as some participants of the qualitative study mentioned that they were not comfortable with sharing their data. The data protection and privacy settings are, therefore, useful for choosing if and who has insight into the user's data, see Figure 34.

To compare data with someone, a screen has been created where the user can select who they'd like to compare themselves with. Users can choose from their friends who have granted access to their data or from a list of users recommended by the app. These recommended users offer interesting insights and have made their data available for everyone while remaining anonymous, see Figure 35. The complete prototype can be found in Figma.

In summary, the latest version of the prototype design has given it a modern new look and introduced new functionalities that were previously unavailable. These functionalities are geared towards enhancing the app's usability rather than its support for reflection. The prototype is now closer to becoming a comprehensive app for diabetes patients. Furthermore, this iteration has prepared the prototype for future expansion as a configuration tool for reflection.

Figure 33: Functionality for tracking blood glucose levels is implemented with a drop-down menu to choose the time when the data is tracked.

Figure 34: Data protection and privacy settings screen gives users the option to withhold their data or choose who can access it.

Figure 35: Choosing a person to compare the tracked data with.

4.3 Creating the Prototype Screens for the Reflection Configurator

The configurator uses a screen from the app prototype, which is categorized into one of the design combinations. The design combinations do not include all the design components found in the literature. This means that the screens of the app prototype can be adjusted to include the missing design components to showcase how all design components could work or not work.
This means that to create the configurator in the web tool for reflection, all design components needed to be included in the selected app prototype screens for each design combination. This required a creative approach because it wasn't feasible to add more design components to every category screen, so the design combination screens needed to be selected carefully.

When selecting the app prototype screens for the reflection configuration web tool, it was important to figure out how to expand them while still maintaining usability. This was a challenging process because not all categories are typically used together. It was important to keep the prototype user-friendly and not overloaded with too many features needed to incorporate various design components.

For each selected app prototype screen, a screen for each missing design component of the design combination was created, and a prototype screen for all missing design components was added to the existing design combination. The design process for the screens followed the results of the scoping review on how these design components could be implemented, as well as the guideline suggestion in Figure 55 that was based on the results of the qualitative study and the scoping review.

Adding Conversation To provide the chosen screens for the configurator with the conversation component a commentary function was implemented. This would allow friends and other users to view the data and provide comments on the user's progress, or offer helpful tips. The idea for the commentary function was inspired by apps like *Reddit* or *Instagram*, which have been using commenting features for a long time. Users can add comments, which will be displayed below the data graph. Furthermore, users can choose to respond to comments, see Figure 36.
Another method for implementing conversation was to provide a text field where the user could respond to a question posed by the app. This method was used in the daily evaluation as well as in the food tracking feature. In both cases, the user is asked a specific question intended to prompt reflection, such as recalling past memories or explaining why they want to eat a particular food even though it doesn't align with their macronutrient goals, see Figure 37.

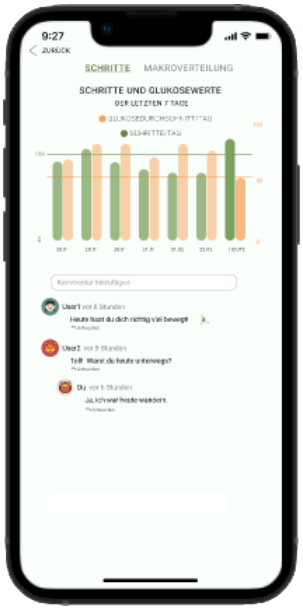

Figure 36: Conversation added with a commentary function.

Figure 37: Adding conversation by integrating a text field and asking the user questions.

Adding Confrontation In order to create a more confrontational screen, it's important to include some form of provocation or to present the information in a new light. This can be achieved by explaining to the user which foods are beneficial and which foods are detrimental to their diet, using small pictures of the food alongside the data overview, see Figure 38.

Adding Comparison Comparing two datasets may not always lead to reflection. The user needs to have a desire to investigate the data or have an emotional connection to it. In this case, we are comparing two days' worth of self-assessed eating behavior. The user will receive feedback on their past experiences, such as how they felt the last time they attended a special event and how they assessed their eating behavior. This comparison can show whether the user has improved or if their behavior has worsened since the last assessment. Another aspect could be that the user might want to know what they ate at the last event and, therefore, delve into their past data to find answers about the change in behavior, see Figure 39.

Adding Temporal Perspective To incorporate the temporal perspective component, a screen that currently does not display temporal perspective is required. For this purpose, a screen was chosen that only displays data for a specific day in comparison to another day for a different user. This is what is called the social comparison feature. The issue here was that, even though it only showed data for one day and was not as temporal

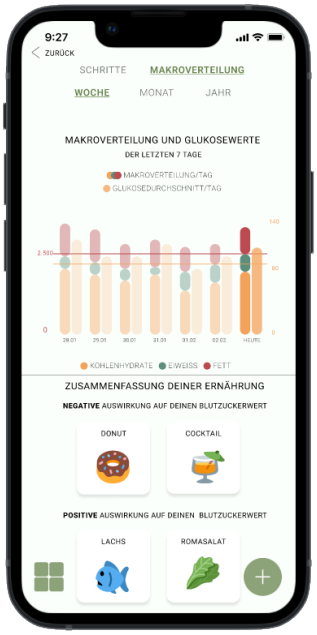

Figure 38: The tracked food is categorized into good and bad food choices.

Figure 39: Comparing two self-assessments of eating behavior.

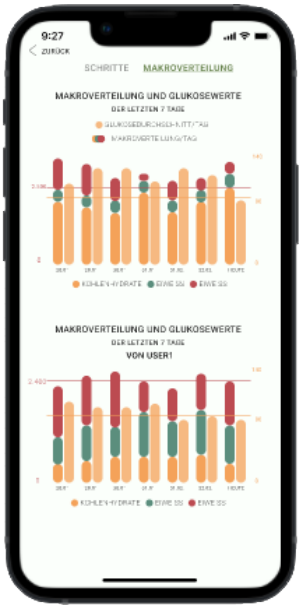

Figure 40: Addition of the macronutrients bar plot to make the screen involve more of a temporal perspective.

as showing data for all past seven days, the screen still had some temporal aspects. However, the main focus of the screen, and the reason it was identified as the comparison

and confrontation design combination, was that these two design components were the main focus of the screen.
The screen now includes a new feature to show a complete graph of macronutrients for the last seven days in comparison to the user's own data. Previously, users could only compare their macronutrients with another user for a single day, see Figure 40.

4.4 Implementing the Tool

The configuration tool for reflection was built as a website using WordPress as a development platform, offering creativity through a user-friendly interface. The homepage offers preliminary information about the process of reflection, its purpose, and the results of the scoping review.

Home The starting page of the configuration tool for reflection provides an introduction to reflection, discussing its purpose, advantages, and relevance to human-centered computing. Additionally, the site aims to introduce the four design components identified through the scoping review, see Figure 41.

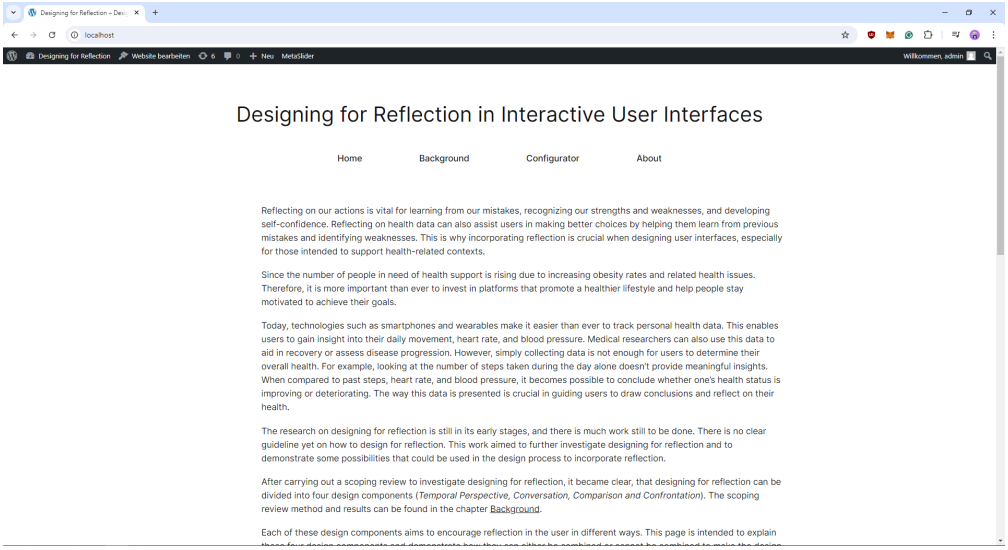

Figure 41: Start page of the configuration tool for reflection with an introduction to reflection and its purpose in human-centered computing.

The four design components - Temporal Perspective, Conversation, Comparison, and Confrontation - are presented by displaying prototype screens along with a brief introduction and a simple example of how they can be used, see Figure 42.

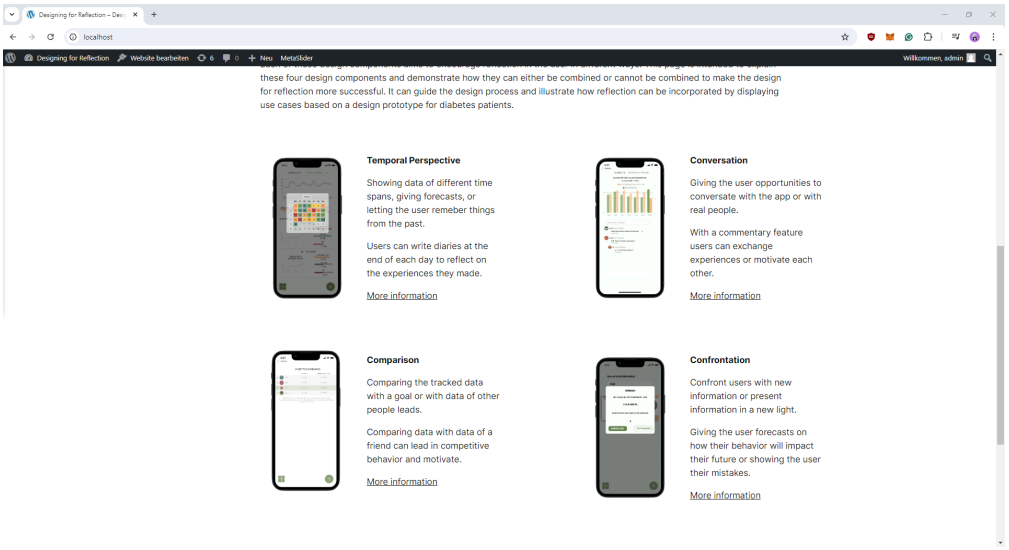

Figure 42: Start page of the configuration tool for reflection with a short introduction of the four design components.

The Design Components Each design component is represented and thoroughly described in its own subsection of the configuration tool for reflection. The descriptions include all the information found in the scoping review, as well as a section for examples and possible design elements, see Figure 43, and Figure 44. Additionally, it provides design recommendations identified during the qualitative study and the scoping review, see Figure 45.

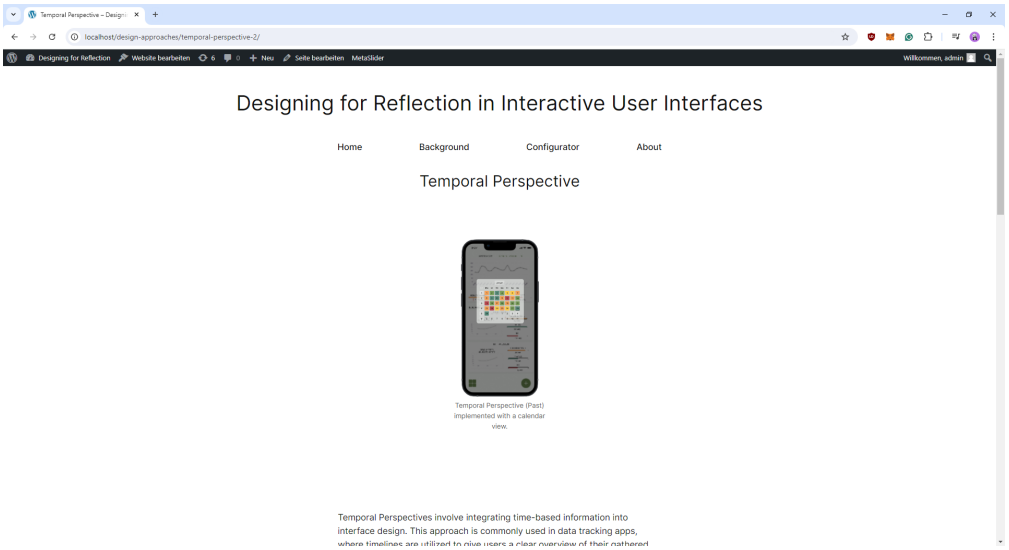

Figure 43: The section for Temporal Perspective begins with a calendar view, symbolizing the concept of temporal perspective.

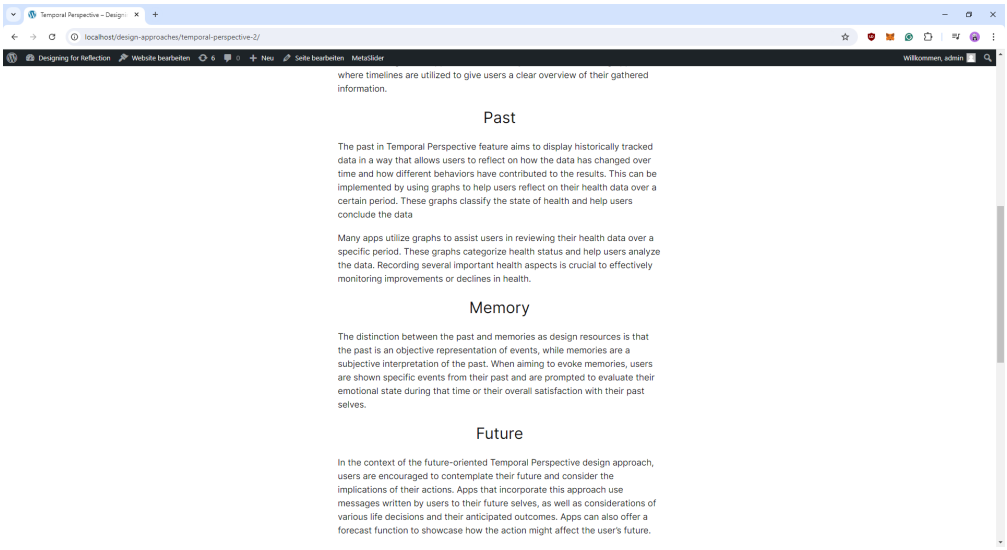

Figure 44: Thorough explanation of what temporal perspective means.

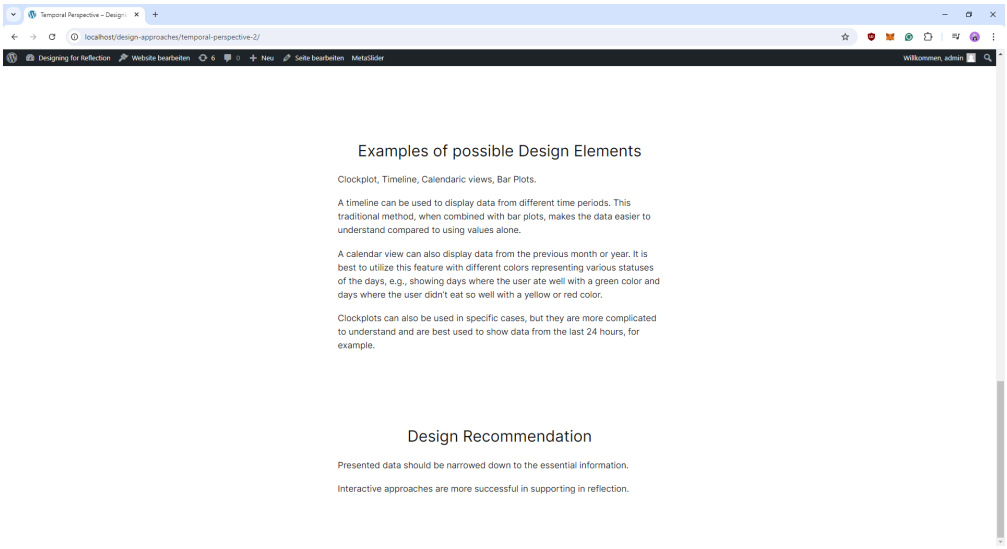

Figure 45: Examples of possible design elements and design recommendations.

Background For more information about reflection, users can visit the Background section to learn about reflection in general, reflection in human-centered design, and the scoping review methodology, see Figure 46.
The scoping review is thoroughly explained along with the libraries used, as well as a link to the literature. Literature filtering is depicted using a graph, see Figure 48.

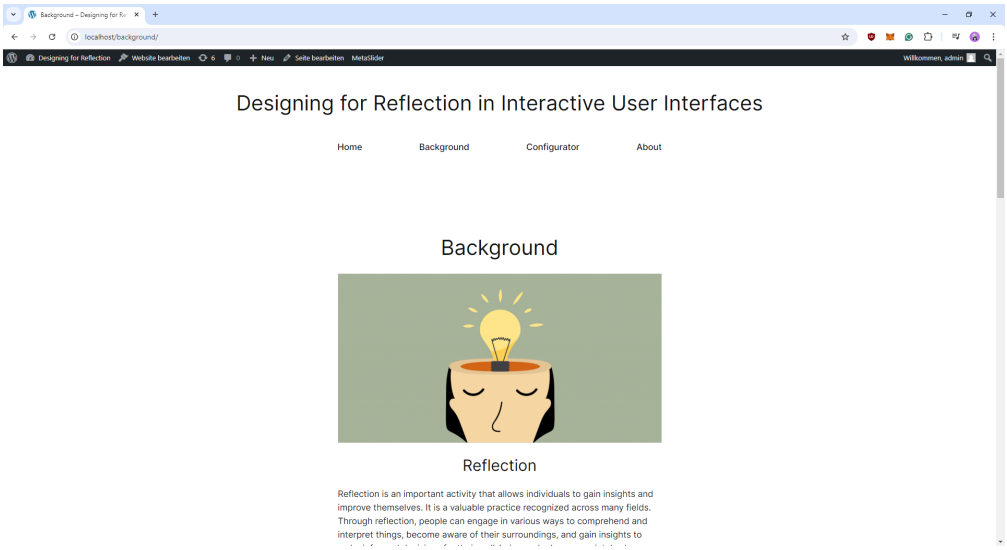

Figure 46: Further explanation of reflection can be found in the Background-section (Image source [38]).

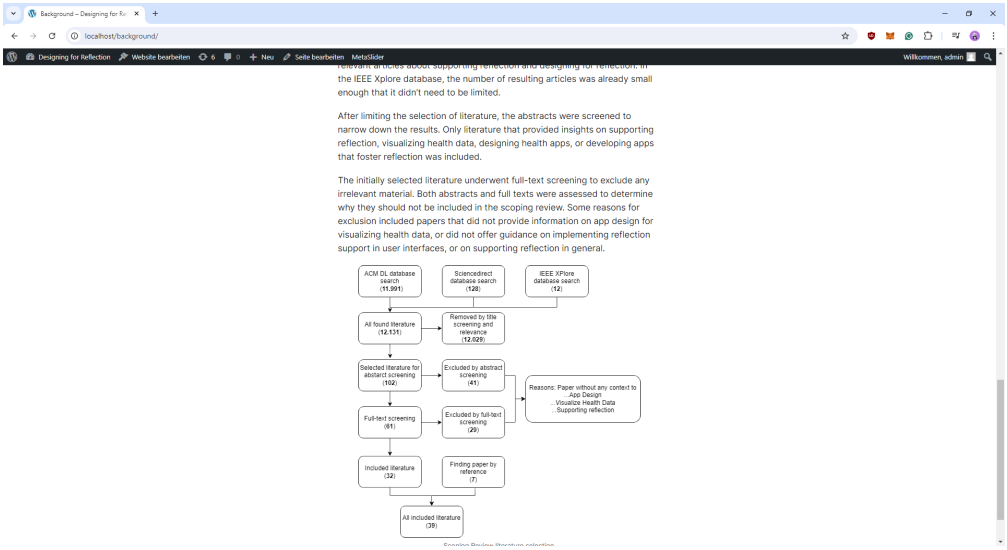

Figure 47: The scoping review is explained in the Background-section.

The Configurator The configurator is the interactional part of the configuration tool for reflection. The introduction page for the configurator shows the four design combinations that were conducted.
When clicking the button of each design combination, the user gets to the actual configurator. Each design combination has its own subsite, which offers the possibility to change the showcased prototype via button clicks to add or remove design components to the design combination, see Figure 49.
To change the prototype the user can use the buttons and add the corresponding design

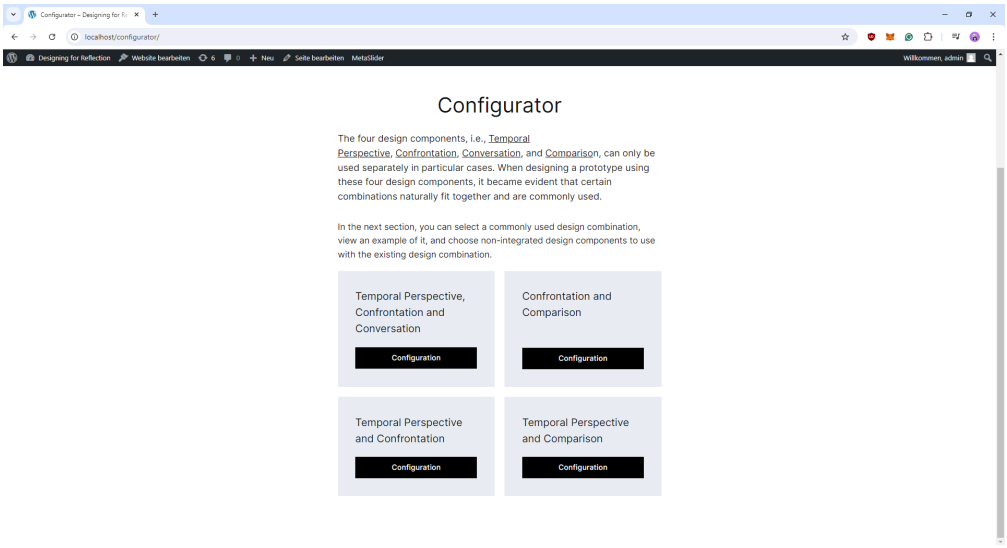

Figure 48: The configurator starting page showing the four design combinations.

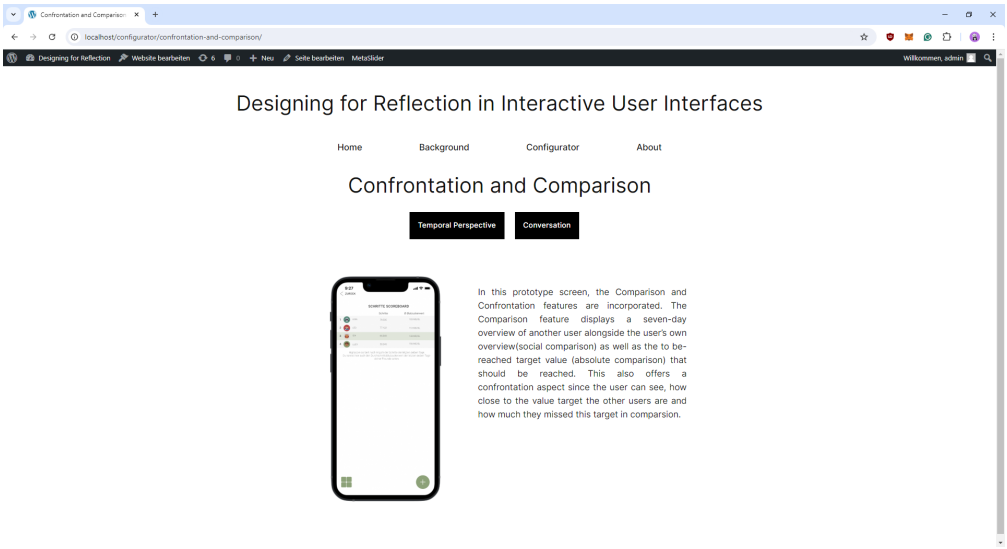

Figure 49: Configurator for the Confrontation and Comparison design combination.

component to the prototype screen. This design includes a comparison and confrontational aspect by displaying a scoreboard of the steps taken by each user in the user's friend list and showing the average blood glucose level of each person.
The scoreboard includes a confrontational aspect by clearly displaying the user's standpoint in contrast to their friends, and also by showing the average glucose levels of their friends in relation to their activity level. This helps the user realize the close connection between activity level and blood glucose level. The scoreboard is sorted only by the steps taken and not by the glucose level. This is intended to encourage users to be more

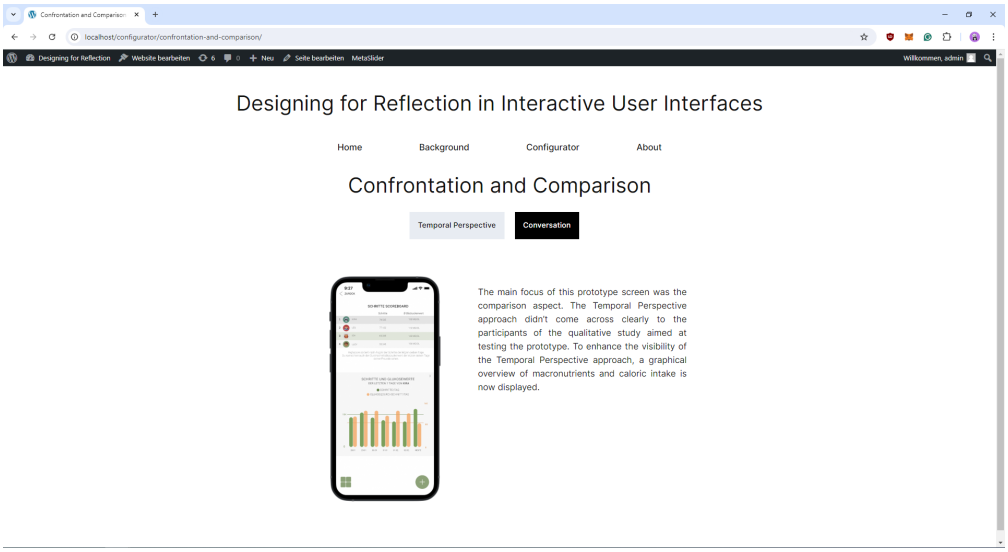

Figure 50: The prototype now enables users to share the scoreboard with another app for communication.

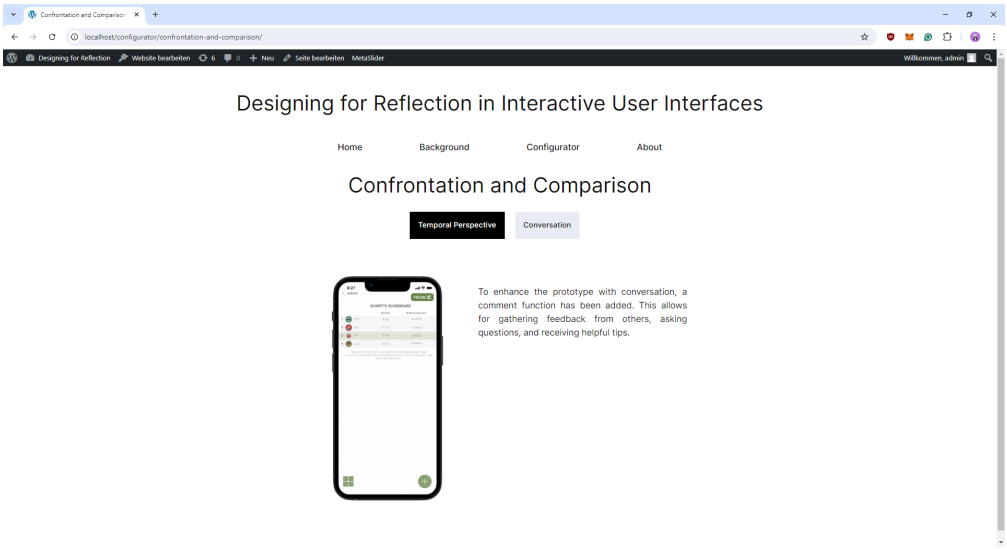

Figure 51: The prototype now shows aspects of temporal perspective by showing the last seven days of steps and blood glucose levels of one user of the scoreboard.

active, as it is more feasible to incorporate into their daily lives.
On the site, there are two buttons for the missing design components: temporal perspective and conversation. The user can press each button separately or both to change the prototype screen accordingly. When pressing the button to add a temporal perspective, the prototype screen includes an overview of the user's steps and average blood glucose levels, with a focus on the temporal perspective. By allowing users to see the results of those who perform better, they can learn and incorporate improvements into their daily lives, see Figure 50.

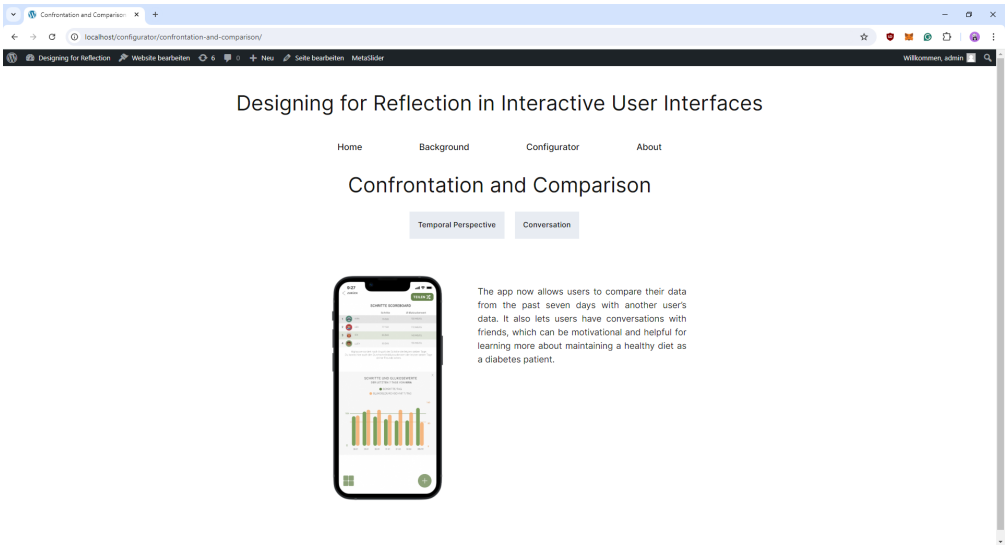

Figure 52: The prototype now includes all four design components.

When incorporating the design element for conversation, the prototype is altered so that users can now share the scoreboard with others and discuss their results via a button on the screen, see Figure 51
It is also possible to activate all four design components. This will create a screen that allows you to share data and investigate the data of your friends on the scoreboard for the last seven days, see Figure 52.

The configurator demonstrates how design components can be incorporated into the prototype screens to support reflection. However, it is not necessary to include all four categories on one screen in order to achieve the best results. It is important to consider the visual appearance of the screens and avoid overcrowding them with too many features in an attempt to incorporate all four design components.

The complete tool can be found as a compressed file in OSF. To fully view the tool, the compressed file needs to be uploaded to WordPress, or on GitHub.

4.5 Evaluating the Suitability of the Tool and the new Prototype Features

The first evaluation phase of the prototype involved interviewing a diabetes expert. This led to the addition of new features, such as a daily mood assessment, based on the expert's suggestions for addressing crucial aspects of the patient's well-being. Additionally, screens were added in the last prototype iteration to track blood glucose levels before and after each meal, requiring professional input on the design and functionality.

In the second stage of developing the prototype and the configuration tool for reflection, I reached out to the expert for another review of the new design and functionality. We held a semi-structured interview over Webex, during which she examined the configuration tool for reflection and the new prototype through screen sharing. Screen sharing was used because the configuration tool for reflection is a locally hosted website. The configuration tool for reflection displays the modifications to the prototype and illustrates how the absent design elements could be integrated into the four design combinations. The interview lasted for about an hour and resulted in some fascinating new insights.

Findings With the redesign of the prototype new functionalities were integrated. One of those was the screen to track the blood sugar before and after each meal.
The expert approved the feature and the screen design. Users can track their blood sugar levels using the current time, which is displayed by default, or they can input a different time to track levels from the past. They can also switch between tracking levels before and after each meal. Tracking blood sugar levels before and after each meal was something she highly recommended for diabetes patients since it helps identify blood sugar spikes.

> *"It is important to monitor blood sugar levels before and after meals to identify any subsequent peaks." (Expert)*

The expert also suggested the potential benefit of implementing an Application Programming Interface to gather data from continuous glucose monitoring systems. The users didn't have to track their blood sugar levels manually anymore since the continuous glucose monitoring would just send the measured blood sugar levels to the app.

> *"Those systems monitor blood glucose levels throughout the day, which is crucial for diabetes type 1 patients." (Expert)*

This could indeed enhance the app's usability and overall usage over an extended period since it doesn't require the effort of tracking the data. However, given that manual tracking can enhance reflection [20], it must be weighed to determine which option makes

more sense in terms of reflection.
After showing her the confrontational screen to point out bad food choices while food tracking, the expert stressed the significance of bread units. People with insulin-dependent diabetes need to ensure that their carbohydrate intake matches their insulin dose to prevent hypo- or hyperglycemia. In countries like Austria or Germany, carbohydrate calculations are often done in terms of Bread Units (1 BE = 12g carbohydrates) or Carbohydrate Units (1 CU = 10g carbohydrates) [62].

> *"According to the amount of carbohydrates consumed by a person with diabetes, they may need to take insulin, which is measured in bread units." (Expert)*

This is a very important thing to add to the prototype. It can improve a patient's understanding of why they have to take a certain amount of insulin.

When displaying the screen for social comparison, a question came up about whether a calorie goal indicator is necessary. It was important in the app's design to avoid being judgmental and to provide a safe space. The concern that the caloric goal might be seen as judgmental arose, suggesting that people may have eaten too much or too little. This can be a sensitive topic for some users and may not be necessary information when the user's goal is to track their blood sugar levels.
The expert explained that since patients with type 2 diabetes are often overweight, it may be necessary to show them how much they ate over their caloric goal. This also can lead to reflection when the user sees their calorie intake together with their blood sugar levels.

> *"Most patients with type 2 diabetes do not have an eating disorder that causes them to eat too little. Losing weight is a crucial goal for them to regain their health." (Expert)*

In contrast, she mentioned that patients with type 1 diabetes are rarely overweight. This suggests that there may be a need for a setting to turn off caloric goals for individuals who do not want to track their macronutrients to lose weight but only to get an overview of what they need to change in their macronutrient nutrition and activity level.
When discussing the configuration tool for reflection, it became clear that the chat function via comments under tracked data might be ineffective, due to lack of usage. It seemed to be rather rare to know a lot of other diabetes patients personally. Hence, most patients may not have a large number of friends on the app, and it is doubtful whether random people would comment on other people's health data. Furthermore, privacy settings can be enabled to restrict access to tracked data, further reducing the number of possible comments.

"Maybe some people bonded during rehab and now are friends in that app, but I'm not sure if they will comment much under those posts." (Expert)

She emphasized that the commentary feature could be used, but the idea of making the data shareable so that one can decide on their own to share a specific day when they ate well with friends would be more likely to be used.
This shows that not every component is visually easy to implement in one single app. Sharing data from the app to a real conversation app could lead to much better results for reflection. The user needs to realize that they did well that day and feel the need to share it with another person to communicate about their good eating behavior. This willingness to share seems more natural than commenting on someone else's post, see Figure 53.
This led to changing the prototype screens that utilized the commentary function and included a share button, making the screen clearer and more usable overall. Since the

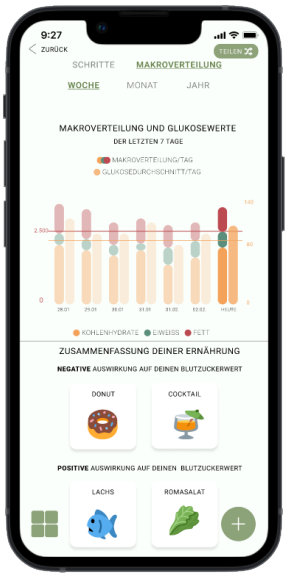

Figure 53: New button implemented to share the tracked data to another communication app.

configuration tool for reflection displayed all four design combinations, we also discussed whether the combinations were understandable. The expert mentioned that, in her opinion, the social comparison was temporary, even though the main focus was supposed to be on comparing and confronting data from a person who is doing better with the disease.

"I feel like it is very temporary because I can see the data from the last seven days. Perhaps if the data were combined instead of being separated by days, it would be clearer to me." (Expert)

This led to the idea of creating a scoreboard where users can view their step and blood glucose data, organized from best to worst results for comparison.
The configuration tool for reflection now includes a scoreboard screen of the prototype

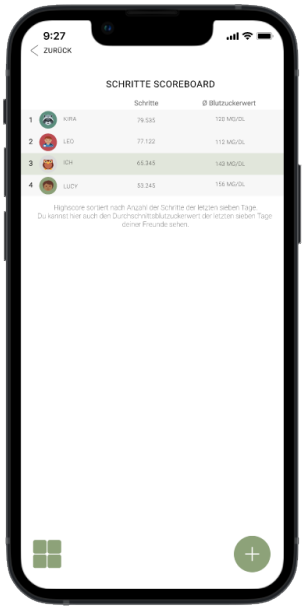

Figure 54: Scoreboard that is ordered by the number of steps of the last seven days. It also shows the average blood glucose level of the last seven days.

to present the Comparison and Confrontation design combination more effectively, see Figure 54.

In summary, the interview yielded valuable insights into potential improvements for the prototype as well as for the configuration tool for reflection. It also highlighted features and functionalities that could benefit patients with diabetes. Additionally, it was suggested that the configurator function on the configuration tool for reflection may require modifications, particularly in relation to the prototype screens designed for the configurator. This would involve removing and replacing the commentary function with a button to share data. It also addressed some wording issues related to diabetes that could be improved.
The expert noted that the app could be beneficial for diabetes patients, helping them learn about their disease and food choices, and might even help patients with type 2 diabetes to lose weight when they keep following the app's suggestions.
The most valuable outcome was the suggestion to overthink the screen for the comparison and confrontation design combination to make the intention of this design combination clearer and led to an update of the design combination, see Table 4 to the new version,

see Table 5, where the design combination for Confrontation and Comparison is updated to the new design scoreboard screen.

Table 5: Updated table for the four design combinations, with the Confrontation and Comparison design combination being updated to better represent this category.

Design Combination	Definition	Prototype	Name
Temporal Perspective AND Comparison	Combining aspects of Temporal Perspective with aspects of comparison.	Seven-Day-Overview13 Start-Screen15 Meal Overview17	Comparison - Absolute
Temporal Perspective AND Confrontation	Seeing data in a new light with the help of Temporal Perspective.	FoodTracking192122	Confrontation - with Confrontations
Temporal Perspective AND Confrontation AND Conversation	Reflecting through conversation with technology that utilizes Temporal Perspective, leading to Confrontation.	Daily Evaluation24232526	Conversation with Technology
Confrontation AND Comparison	Discovering new insights by comparing one's data.	Social Comparison 54	Comparison - Social

5 Discussion

The study aims to examine how the four design components identified in the scoping review combined into four components impact participants' reflective thinking through an interactive user interface.

5.1 Suggestions for Future User Interface Design in the Area of Reflection

The social comparison screens in the Figma prototype worked quite well in the sense that every participant noticed differences in the two datasets and agreed that the individual being compared had better control over their diet and activity. They also acknowledged that seeing data from other individuals could help get tips on how to divide macronutrients in a better apportionment to reduce blood sugar spikes. Some participants did not like to compare themselves with others, believing it could lead to frustration. This aligns with Cho et al.'s [20] research, which suggests that self-reflection is not always a positive experience and the adverse outcomes have to be considered as well.
The study revealed that when individuals compare their diets to those of others, they become more conscious of their own eating habits. This awareness is particularly important, as patients with type 2 diabetes often experience this condition due to being overweight, according to the expert. In the study, participants were shown two pie charts that displayed macronutrient distributions, and they could easily see the differences between their own diets and the average blood glucose levels. This led them to reflect on their dietary habits and consider making changes.
Choosing the right kind of visualization for each dataset is essential since pie charts are not always the best choice of visualization. It is vital to use a visualization that is easy to understand just by looking at it. The pie chart was used as an entry point to reflection by comparing the distribution of macronutrients. After examining the pie chart, all participants naturally wanted to learn more, so they went over to the additional information provided alongside the pie chart.

The participants were pleased to compare old datasets and notice differences in the impact of their diet on their blood sugar levels. All of the participants were able to conclude the differences between macronutrients in their diet and their blood sugar levels. When comparing their meals, they focused on the progress bars, which indicated if they had consumed too many carbohydrates. The pie chart also provided some information about the distribution, but the participants preferred the progress bars as an indicator of a healthy diet.
While comparing their old data with the current data, they realized that both indicated poor behavior in some way and no improvement. However, they did not feel as many negative emotions as they did when making a social comparison. Comparing oneself with others often leads to a sense of shame when the behavior isn't according to the plan. In contrast, participants did not feel as bad when they saw their own behavior was worse compared to a past dataset.

This indicates that when people compare themselves to their own past performance, they require a more emotional and visual representation of their data to understand their negative behavior and the need for improvement. Although all participants acknowledged that their data was not good, they did not express a desire to improve themselves as they did when comparing themselves to others. One possible explanation is that when comparing themselves to others, they received feedback and guidance on how to improve their blood sugar results, whereas, in self-comparison, they did not receive any guidelines on how to improve their diet and, as a result, their blood sugar levels.

The study also found a significant difference in how participants reacted to warnings provided by the Confrontation. Six out of the fourteen participants skipped over the warnings without considering their food choices. However, the remaining eight participants slowed down and considered the warning carefully before deciding whether it was bad or not. This highlights the importance of emotional visualization in appealing to individuals' emotional side, as raw data alone cannot facilitate reflection.
It is essential to mention that the study participants needed some level of knowledge to classify the data presented to them. Although all participants received a brief introduction to diabetes, not everyone was familiar with the impact of macronutrients on their blood sugar levels. Participants who were well-informed about dietary and health data tended to require less information while interacting with the app. On the other hand, participants who lacked prior knowledge of the necessary dietary information needed more information about which foods and macronutrients are beneficial or harmful to their blood sugar levels. It is also worth noting that during the prototype interaction, some participants who lacked a good diet beforehand learned about the impact of different macronutrient distributions on blood sugar levels.
This suggests that individuals with more background knowledge are better equipped for reflective thinking. Participants who do not regularly encounter daily diets tended to ignore the warning screens for increasing blood sugar levels. This result supports Bentzvelzen et al.'s [39] statement that effective implementation requires considering the individuals' knowledge level.

The daily evaluation results were mostly positive. The expert highlighted the significance of conducting mental health assessments for diabetes patients, as they are susceptible to experiencing depressive episodes. This can lead to unhealthy eating habits, which is why I included the daily evaluation in the app prototype. Participants enjoyed thinking about the imaginary event and took their time choosing the correct emotion on the Likert scale.
In the evaluation, they did not understand the impact of their average blood sugar level on the evaluation result, which indicates that there is again a need for further explanation of how the result is calculated. Another suggestion was only to include the overall mood of the patient in the daily evaluation result and not the blood sugar levels. However, this approach might lead to inaccurate conclusions about the patient's blood sugar levels because their mood can be good even if their blood sugar levels are not optimal.
Emotionalizing the blood sugar levels as well could have helped to give the participants

guidance on how they should feel about their current diet behavior.
Some participants have expressed that they may not want to complete the daily evaluation if they believe the result will be a sad smiley. It is essential to consider an individual's mental state when presenting them with emotional values, especially if they are dealing with mental imbalances such as depressive moods. One way to improve this is to not only inform the individuals that the results may not align with their goals but also to provide encouragement and a positive outlook on the situation. The study found that

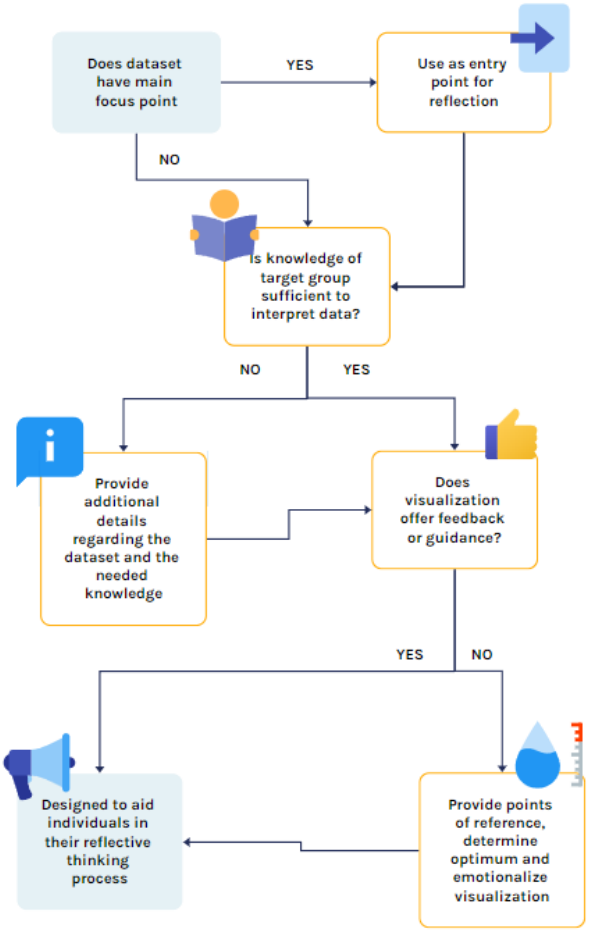

Figure 55: Guidelines for reflective design strategies based on the findings of the qualitative study.

simply presenting data did not necessarily lead to reflection or understanding. Providing a contextual framework around the data is crucial to help individuals evaluate it. In order to better support the individual in achieving their goal, it can be useful to provide them with additional information to bring them up to the required level of knowledge, introduce an optimum, evaluate the figures more emotionally, and give them tips on how they can achieve their goal. When presenting adverse outcomes, it is essential to

consider the individuals' mental state to avoid disappointment and reflection avoidance, see Figure 55.
The usability testing results indicate that improvements are necessary for the interactive user interface, particularly in stimulation and novelty. Whether the efficiency scale's poor outcomes resulted from deliberate delays in specific processes is uncertain.More research is needed to confirm this. If this is true, it is difficult to make improvements because taking time and re-evaluating processes are crucial aspects of reflection. Efficiency is not the desired outcome and should be avoided when evaluating components that support reflection.

5.2 Reflection on the Methodology

The methodology was divided into five phases, see Figure 5. The first phase was the vision and plan, which helped to structure the thesis by considering the structure of the methodology. The second phase was the theoretical and conceptual phase, which aimed to provide an overview of the current state of research in the HCI research area of reflection. This phase took longer than expected which was due to the fact that I never conducted a literature review myself. The scoping review was very revealing and gave a good insight into the current literature on reflection and health data donation.
The design phase went smoothly without any issues. The paper prototype was successfully transferred to Figma.
During the expert phase, a lot of insightful information was gained that proved to be useful during the qualitative study. This information was incorporated into the prototype and the developed scenario.
Significant challenges were encountered in recruiting the right participants for the qualitative study in the evaluation phase. Despite best efforts, the recruitment process did not go as planned, which made it challenging to find participants who met the required criteria. Despite contacting several diabetes associations such as Deutscher Diabetes Bund and even groups on social media, no satisfying answers were received regarding the requests.

However, despite the challenges, participants who did not have diabetes were successfully recruited. The results of the qualitative study were satisfactory. However, it is uncertain whether the results would have differed if the study included diabetes patients. This is because the prototype was designed for newly diagnosed diabetes patients who are not yet familiar with their new life situation. The recruited participants, who had little to no prior knowledge of diabetes, still belonged to the target user group somehow. In the future, the necessary steps are to ensure that the recruitment process is more comprehensive and that the right participants are selected for the study.
The evaluation of the Think-Aloud method with Mayring went well and provided good results in answering the second research question.

6 Limitations and Future Work

There are several limitations to the study that need to be acknowledged. The most significant limitation is that only one prototype was tested, making it difficult to generalize the findings. It would have been more insightful to observe participants' interaction with a real app in their daily lives. Additionally, due to the limitations of the prototype, some design components subcategories found in the scoping review, such as having conversations with other people, were not possible to implement. Similarly, the prototype did not allow users to write on their own, which made conversing with technology a bit challenging.
It is important to note that the guideline, see Figure 55 created to guide designing for reflection is based solely on the results of a specific study and has not yet been tested. Further research is required to test the validity of the guideline and explore its functionality and limitations. Additionally, it is necessary to investigate if the guideline needs more details to improve designing for reflection. Also, more research is needed to find out if designing with the guidelines helps individuals stay motivated to reach their goals as an effect of reflection.

One of the challenges I faced was figuring out if the participants in the qualitative study genuinely reflected on their experiences, as there are no specific metrics for measuring reflection. Since the study relied solely on evaluation using the think-aloud method, I can't be sure if the app users would keep up with reflecting on their daily lives or if they would lose interest in reflection when the tracking behavior becomes repetitive.
Further research is needed to determine whether individuals will continue using an application even if they receive unpleasant results. Participants have expressed their reluctance to receive negative feedback, so it is crucial to investigate how to provide negative feedback without causing them to avoid reflecting on their performance.

7 Conclusion

The goal of this thesis was to develop a prototype app that included support for reflection. Additionally, the thesis involved evaluating the prototype through a qualitative study and creating a web tool for configuring reflection using the app prototype.
Through the literature review, four design components were identified: Temporal Perspective, Conversation, Comparison, and Confrontation. Temporal Perspective refers to visualizing data in a temporal manner, such as using timeline or calendar views. It also involves prompting users to reflect on their past, make forecasts for their future, and encourage them to slow down to engage in reflective thinking. Engaging in conversation can encourage users to reflect. This can be achieved through conversational interfaces, follow-up questions, journaling, and sharing tracked data and progress with real people. Comparison can be divided into comparing with oneself and comparing with

other people. Not everyone likes to be compared with others, as it can be discouraging. Confrontation involves presenting data in a different light or confronting users with unpleasant information to prompt reevaluation.
In the creation of a paper prototype, it became clear that using the four design components separately did not seem feasible because the functionalities that needed to be implemented often utilized more than one design component. This led to the determination of the following design combinations in this thesis: Temporal Perspective and Comparison (*comparison absolute*), Temporal Perspective and Confrontation (*confrontation*), Temporal Perspective and Confrontation and Conversation (*conversation with technology*), Confrontation and Comparison (*comparison social*). *Comparison absolute* absolute combines aspects, as seen in the Seven-Day Overview and Meal Overview. This combination appeared to work well for making comparisons and providing an overview of multiple data sets in relation to oneself. *Confrontation* was utilized to present data in a new light and confront users with unpleasant information about their food choices. This combination was used to provide forecasts on the outcome when specific foods were chosen. *Conversation with technology* were utilized in the Daily Evaluation, incorporating a conversational interface and Likert-like questions, compared with an estimation of the tracked data in relation to the user's goal. *Comparison social* were used in the social comparison to display users in direct comparison to others. This is a design combination that can be used for scoreboard-like screens.
The first high-fidelity prototype was discussed with a diabetes expert. Based on the information from the diabetes expert, a scenario was created to conduct a qualitative study with participants. This study utilized the think-aloud method, a semi-structured interview, and a user experience questionnaire.
The evaluation uncovered crucial factors to keep in mind when designing for reflection. Besides the design combinations, various conditions are necessary to promote more effective reflection among individuals. The User Experience Questionnaire showed that participants generally found the prototype appealing, but recommended enhancements in terms of Novelty and Efficiency. It's important to note that Efficiency is not a significant rating in this context, as slowing down can promote reflection.
A guideline was created based on the study results. The study found that simply presenting data did not necessarily lead to reflection or understanding. It is crucial to provide a contextual framework around the data to help individuals evaluate it. To better support individuals in achieving their goals, it can be useful to provide them with additional information to bring them up to the required level of knowledge, introduce an optimum, evaluate the figures more emotionally, and give them tips on how they can achieve their goals. When presenting adverse outcomes, it is essential to consider the individual's mental state to avoid disappointment and reflection avoidance, see Figure 55.
A configuration tool for reflection was created to demonstrate the practical application of designing for reflection. It features an introduction to the four design components, the procedure of the scoping review, background information, an introduction to the four design combinations, and a configurator to further explain the possibilities of reflection. To realize the configurator on the configuration tool for reflection, the prototype was expanded to showcase how additional design components could have been integrated

and to illustrate how certain design components may not complement each other well. An additional interview was held with the diabetes expert to gather feedback on the new prototype and the developed configuration tool for reflection. The feedback highlighted some necessary changes, such as including bread units in the description of the required insulin dosage for the patient. Additionally, the commenting functionality implemented needed to be changed to a data-share functionality with a simple share button. The expert also shared opinions on the configurator in the web tool and felt that the *comparison social* screen didn't seem to fit the design combination that it is categorized in (Confrontation and Comparison). The screen was changed to a scoreboard, allowing users to compare their step counts. This feedback was used to increase user motivation to use the app in their daily lives and improve its overall benefits.

This thesis explored the difficulties of designing for reflection and provided guidelines for doing so. While the scoping review offered valuable insights into facilitating reflection, it was still challenging to identify effective combinations and design implementations. Not including the temporal perspective presented the greatest difficulty. This thesis can support research by offering design categories and a decision tree to facilitate reflection and prevent errors. The prototypes can also demonstrate how reflective design can be implemented and can serve as a template for developing an app to study how the design enhances reflective thinking in daily life and encourages regular data contribution.

8 Appendix

8.1 Expert Phase: Semi-Structured Interview Questions

"Under what circumstances should a doctor conduct a diabetes test on a patient?"

"What is the difference between the diagnostic criteria for diabetes type 1 and diabetes type 2?"

"What is the main difference between diabetes type 1 and diabetes type 2?"

"When are patients diagnosed with type 1 diabetes compared to type 2 diabetes?"

"How would you describe a typical diabetes type 2 and a typical diabetes type 1 patient?"

"Could you please provide information about the common comorbidities experienced by patients with diabetes?"

"What are the normal blood sugar levels of a diabetes type 2 patient versus a patient with diabetes type 1?"

"How do the treatment possibilities differ between diabetes type 1 and diabetes type 2 patients?"

"How do carbohydrates influence the blood sugar levels?"

"Do fats and protein affect the rise of blood sugar levels?"

"How does being active influence the health of diabetes patients?"

8.2 Qualitative Study: Semi-Structured Interview Questions

"Which app feature would encourage you to analyze your tracked data the most?"

"Why do you believe this feature would encourage thinking about your tracked data?"

"Which app feature would encourage you to analyze your tracked data the least?"

"Which improvements would you make to the feature to help you analyze your tracked data?"

"Are you able to picture integrating this app into your daily routine?"

"What would hold you back the most from integrating data tracking into your day using this app?"

"How would you feel when the daily evaluation would give you negative feedback?"

"When you know that you would receive negative feedback, would you still do the daily evaluation?"

"How do you feel when comparing yourself to others?"

"Do you feel like you get more information when comparing yourself with others?"

"Does the warning about the amount of carbohydrates in the chosen food influence your decision?"

"Would you use the app to learn more about healthy and unhealthy food choices in the context of your condition (diabetes)?"

8.3 Evaluating the Suitability of the Tool and the new Prototype Features: Semi-Structured Interview Questions

"Are the new app functionalities helpful for diabetes patients to manage their condition?"

"Are the offered information useful for diabetes patients?"

"Could this app with its functionalities be integrated into the daily life of a diabetes patient?"

"Could this app be helpful for diabetes patients with type 2 diabetes to stay active and change their dietary behavior?"

"What is important information that is missing in this app?"

"Are the additional options that can be inserted in the configurator useful for diabetes patients?"

Configurator: Temporal Perspective and Comparison The following images showcase the configurator of the website for the design combination of Temporal Perspective and Comparison.

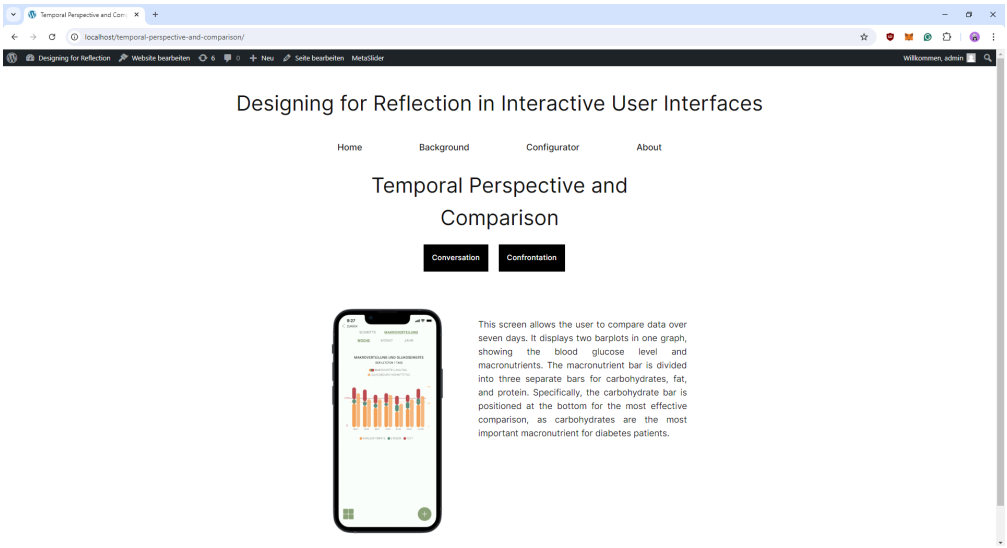

Figure 56: The site to configure the design combination Temporal Perspective and Comparison, with an explanation of this design combination.

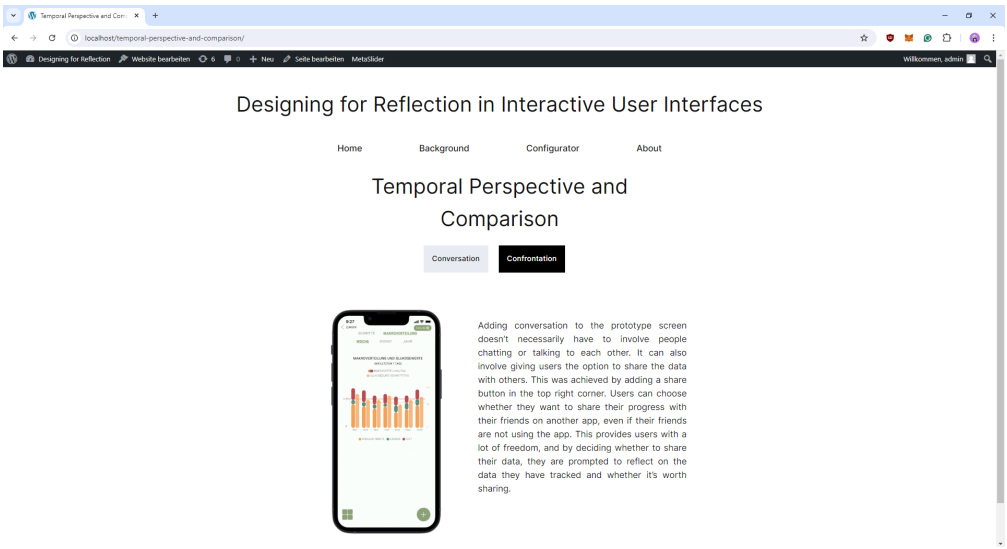

Figure 57: A share button is added to make communication possible.

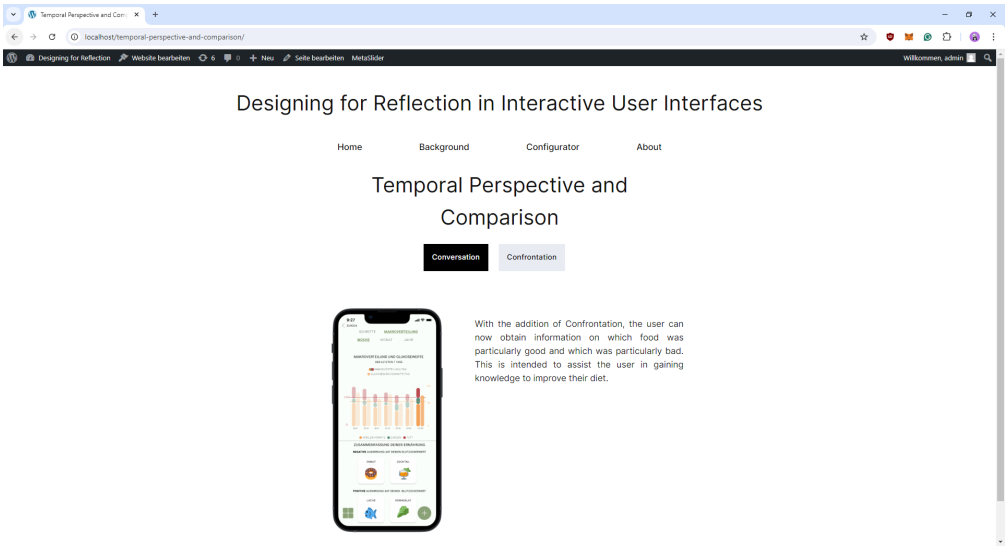

Figure 58: Food choices throughout the day are divided into categories to illustrate both healthy and unhealthy choices.

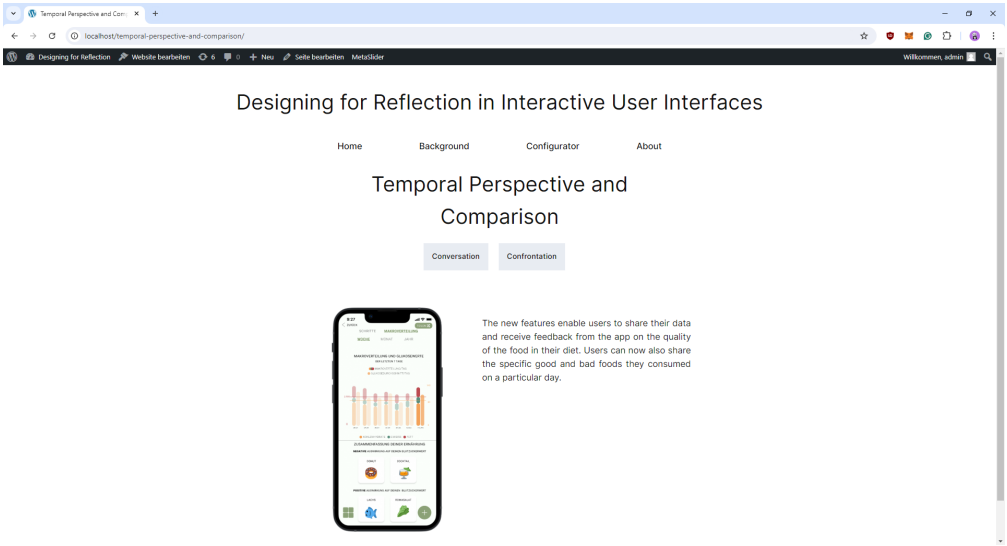

Figure 59: The data can now be shared and food choices are categorized.

Configurator: Temporal Perspective and Confrontation The following images showcase the configurator of the website for the design combination of Temporal Perspective and Confrontation.

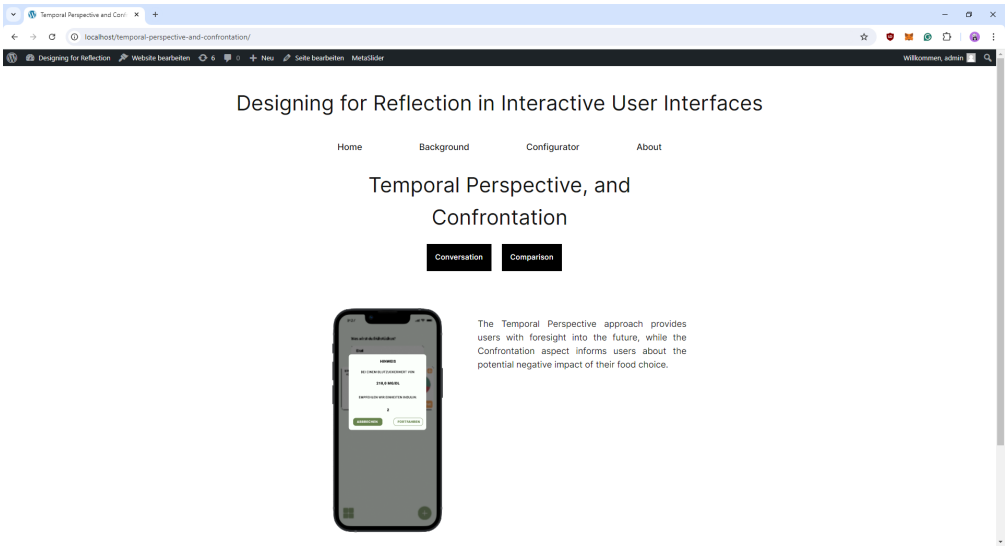

Figure 60: The site to configure the design combination Temporal Perspective and Confrontation, with an explanation of this design combination.

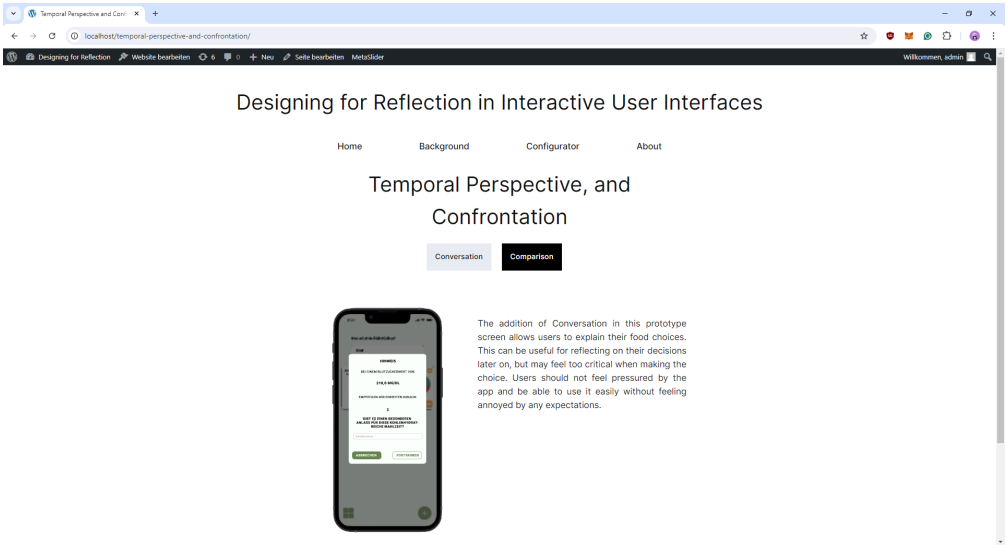

Figure 61: A Textfield is added to the screen with the question of why the user chooses the unhealthy food option.

Configurator: Temporal Perspective, Confrontation and Conversation The following images showcase the configurator of the website for the design combination of Temporal Perspective, Confrontation and Conversation. [64]

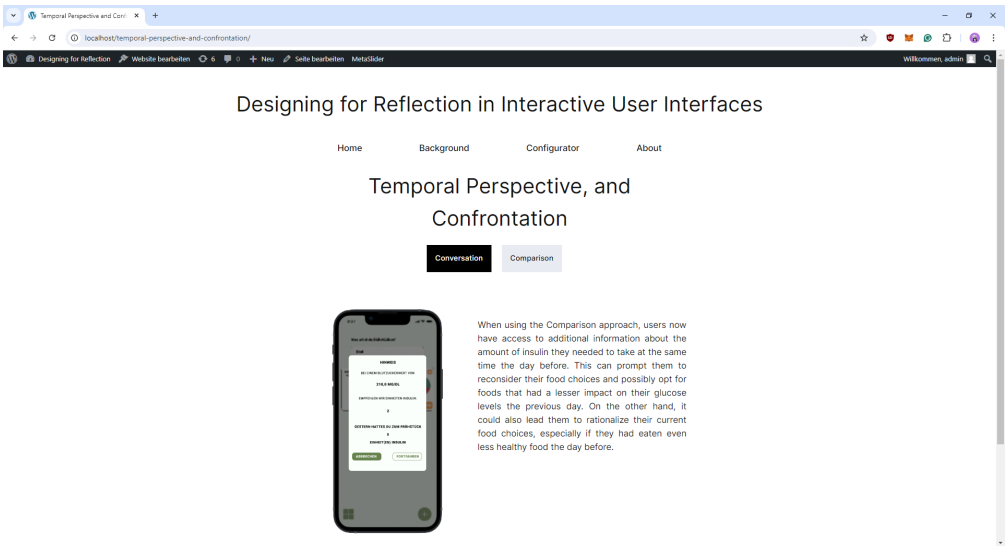

Figure 62: A comparison between today's insulin doses and yesterday's insulin doses is displayed.

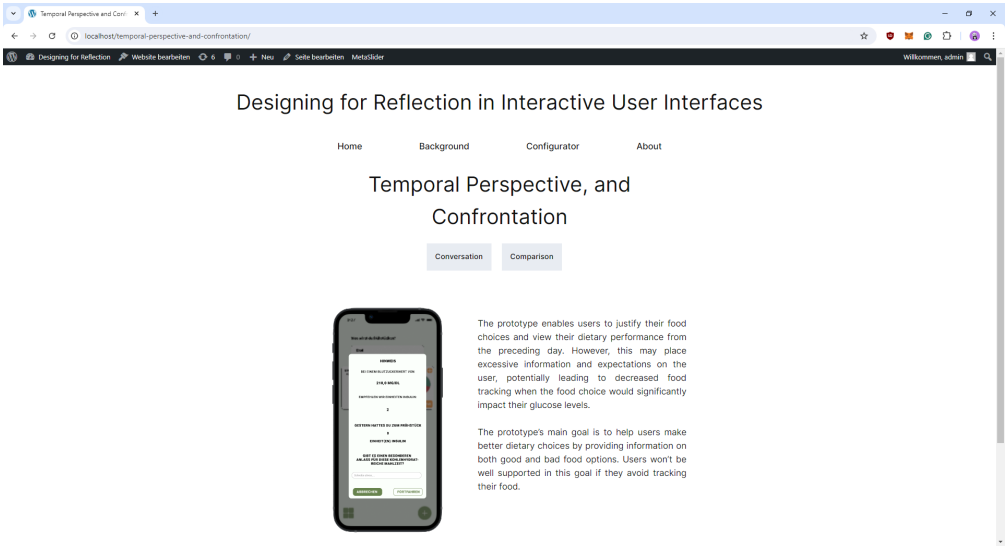

Figure 63: The screen includes a text field to answer the question as well as the comparison between the insulin doses.

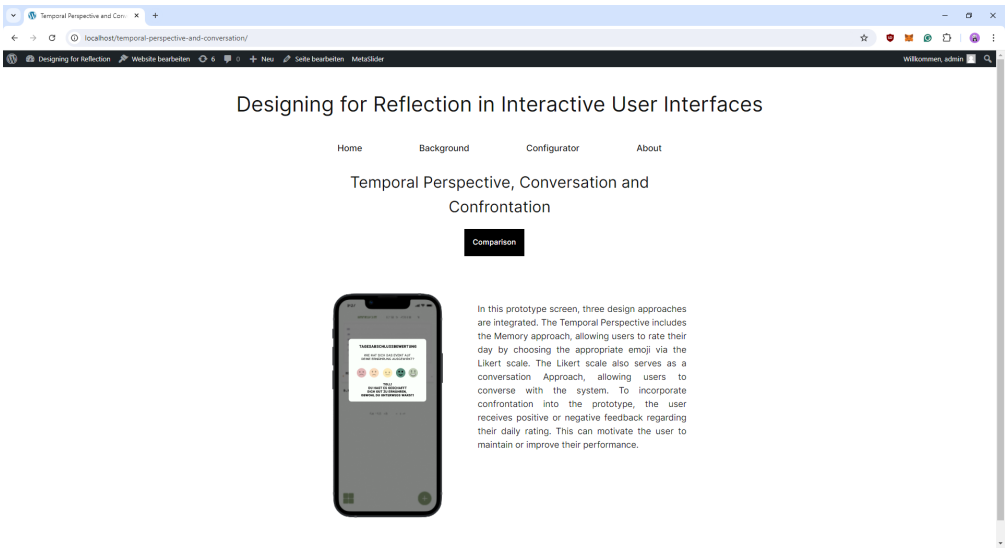

Figure 64: The site to configure the design combination Temporal Perspective, Confrontation, and Conversation, with an explanation of this design combination.

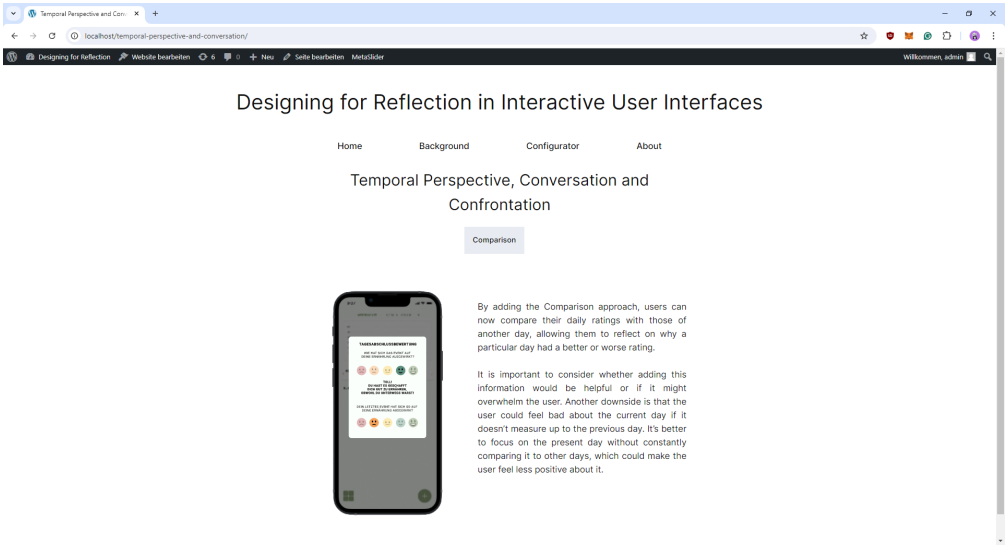

Figure 65: The screen now shows a comparison of how the event affected the users' self-assessment of food choices of another time and their food choices today.

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