The Bright Side of Night

Light as a Tool for Type 1 Diabetes Management

Strategic Design and Entrepreneurship (SDE)

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T1D since 2005

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Frösslund, 2024

Motivation

Our motivation stems from the belief that innovative healthcare design is crucial for enhancing the quality of life for individuals with chronic conditions such as type 1 diabetes. With a focus on user-centred design, we aim to create a design proposal that makes the everyday management of the condition less stressful for those affected. Our approach to the design proposal is based on the understanding that everyone has unique needs and preferences regarding their condition, resulting from our strategy to prioritize the user in the project. Drawing on our industrial and spatial design expertise, we have developed a proposal aimed at helping individuals achieve better long-term glucose levels and a more holistic approach.

Please use the glossary for clarification about medical terms, you can find it in the appendix.

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Vrucinic & Frösslund, 2024

01 Problem statement

How can design positively impact the night-time experience for people with T1D?

Can light be a means of communication and support in reoccurring nightly difficulties for people with T1D?

02 Introduction

This project is the result of a successful collaboration between Molly and Emma, focused on exploring Type 1 Diabetes (T1D) and communication. Our comprehensive exploration, drawing on our skills from Strategic Design and Entrepreneurship and our backgrounds in spatial and product design, has culminated in a project that integrates strategic and design perspectives. Our strategy is to create a calming nighttime environment for young adults with T1D by combining a light and app, which could have a positive impact on their well-being.

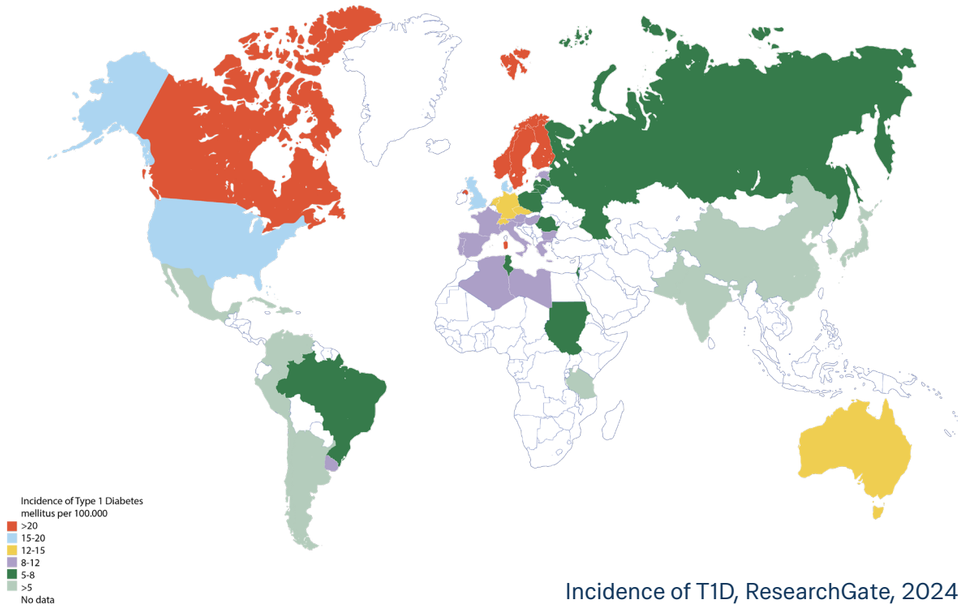
Based on an in-depth understanding of T1D, our work responds to its global impact. Approximately 8.75 million are diagnosed with T1D. In addition to this, there are almost 530 million adults living with other types of diabetes. (International Diabetes Federation, n.d.; JDRF, n.d). The increasing prevalence of T1D and other chronic conditions, buoyed by medical advancements, marks a critical evolution in healthcare, transitioning from managing acute, life-threatening diseases to focusing on long-term, chronic care.

This shift underscores several pivotal changes within healthcare systems:

1. Expanding Patient Demographics
Reclassifying illnesses like T1D from acute to chronic conditions has resulted in growing patient populations requiring sustained healthcare services, stretching healthcare resources, and challenging existing infrastructures. By 2050, a larger share of the European population is expected to live into ancient age, notably among women, with the median age projected to rise by 4.5 years from 2019 to 2050. This demographic transformation is set to reshape the demand for healthcare services, emphasizing the need for sustained care for older adults and challenging existing healthcare infrastructures to adapt to this new reality, according to Eurostat.

2. Focus on Prolonged Care
Chronic conditions require a comprehensive care strategy beyond episodic treatment. This involves continuous patient support and holistic care plans addressing the full spectrum of patient needs over time.

03 Relevance



Incidence of T1D, ResearchGate, 2024

According to the United Nations (2015), Goal 3 of the Sustainable Development Goals aims to ensure good health and well-being for all by 2030.
It specifically focuses on reducing mortality from non-communicable diseases and improving mental health.

Our master's thesis on the internal communication between a device and a person with T1D. Managing type 1 diabetes, a chronic non-communicable disease, aligns with this goal. It also addresses the mental health challenges associated with living with a chronic condition, thereby contributing to the broader objectives of Goal 3. This underscores the importance of thoughtful design in global health and well-being initiatives.

United Nations, n.d

04 Framing

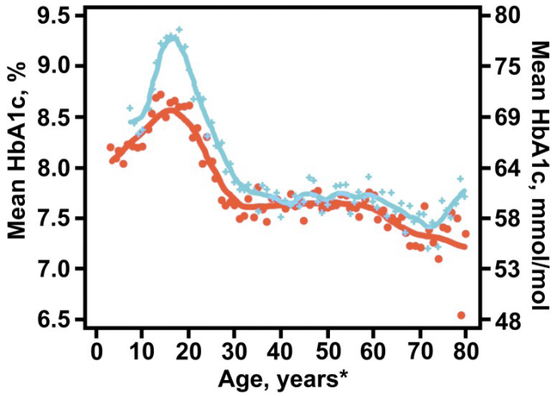


Diagram of difference of long-term glucose between ages. Foster, 2019

To explain and introduce our problem statement as we have framed it, we have broken it down into essential determinants. Those determinants are what, who, where, when, how and why.

What?
We are working with Type 1 Diabetes and communication. We have decided to work with the topic by focusing on the individual with T1D and how different means of communication could help them better manage their condition. We have found that the current products on the market offer many other options but are not targeted towards supporting mental health and lack customizable and tailored solutions that impact the overall well-being of a person with T1D.

Who?
Our target group is young adults aged 17 to 25 with Type 1 diabetes. We have chosen this group because approximately 50% of all individuals in Denmark are diagnosed with type 1 diabetes below the age of 30 (Videncenter for Diabetes, n.d.), making it a condition deeply intertwined with the formative years of young adulthood.

This demographic faces the dual challenge of managing a complex, lifelong condition while navigating the pivotal life stages of independence, identity formation, and social integration.

Where?
The project is based in Denmark, and we will utilize its data and infrastructure to inform our studies. Denmark was chosen because it has one of the highest numbers of people with Type 1 Diabetes. Copenhagen is also home to one of the most important companies in the world in the field of diabetes—Novo Nordisk. Novo Nordisk is the world's largest insulin producer and a leader in diabetes treatment. It is the location of the largest diabetes centre in the Nordics, the Steno Diabetes Center.

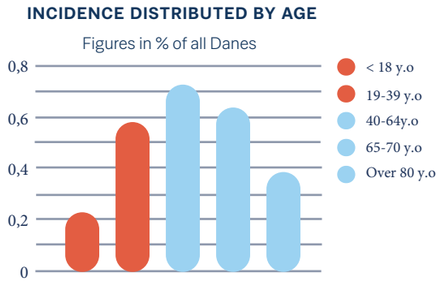
When?
The design proposal needs to consider immediate relevance, long-term appeal, and the specific time when the target group will use the object. The focus is on nighttime support for young adults with T1D, addressing the challenges of managing blood sugar levels during sleep. This is especially relevant for young adults who start living alone and need to take care of their condition without the help of parents or caregivers for the first time. As indicated by the target group, nighttime is a period of unease. They often wake up due to alarms warning them of hypo/hyperglycemia, affecting their sleep, long-term glucose levels, and overall health.

How?
We have created a night light and mobile app prototype to assist young adults with T1D during nighttime emergencies. The night light uses coloured light to communicate blood sugar levels and integrates with Continuous Glucose Monitors (CGM) for the necessary data. Through specific colours, the night light minimizes the impact of blue light on the user's sleep cycle, making it easier for them to return to sleep after an emergency. Additionally, it provides the user with essential information about their glucose levels quickly and intuitively, eliminating the need to check their smartphone. This could reduce screen time by decreasing the frequency of checking smartphones for health data, such as glucose levels.

Why?
We aim to provide support and comfort during this vulnerable time by creating an object designed to assist in these moments of hardship. A person with T1D makes 180 more health decisions daily than an average person. These constant decisions can lead to significant stress and anxiety, particularly during the night when vigilance is naturally lower. By addressing this critical need, our design seeks to alleviate some mental and physical burdens associated with managing T1D, promoting better sleep and overall health.

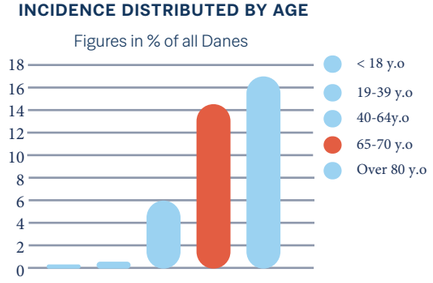
05 Background

T1D IN DENMARK



(Diabetesforeningen, 2023)

T2D IN DENMARK



(Diabetesforeningen, 2023)

Here, we will briefly describe the difference between Type 1 and Type 2 diabetes and give context to the situation of T1D in Denmark. Furthermore, we will explain the main terminology that we referenced in the rest of this Design Report.

Diabetes mellitus, commonly known as diabetes, is a group of metabolic disorders characterized by high blood sugar levels over an extended period. The condition is broadly classified into two main types:

- Type 1 Diabetes (T1D)
- Type 2 Diabetes (T2D)

Both types result in high glucose levels but differ significantly in their causes and developments. These differences impact how they are managed and the overall outcomes for patients.

Type 1 Diabetes
Type 1 diabetes (T1D) is an autoimmune condition in which the body attacks its insulin-producing cells, leading to insulin deficiency (Diabetesforeningen, 2023). The exact cause of T1D is unknown, like other autoimmune diseases, which also increase globally (Sanchez, M., 2019).
Diagnosing T1D can be challenging due to its vague symptoms, such as increased thirst, frequent urination, and unexplained weight loss. This often results in many cases going undiagnosed until severe consequences of *hyper-* or *hypoglycemia* occur. Research suggests that while T1D can develop at any age, most diagnoses occur before age 30, with around 37% of cases diagnosed after that (Fang et al., 2023). T1D is a life-threatening condition.
(see appendix for more information)

Type 2 Diabetes
Type 2 diabetes (T2D) is a condition that occurs due to a problem in how the body regulates and uses glucose. This long-term condition results in high glucose levels over an extended period, which can lead to circulatory, nervous, and immune disorders. T2D is the most common type of diabetes and affects over 380 million people worldwide (Novo Nordisk, n.d.).

In T2D, there are primarily two problems:

1. The pancreas does not produce enough insulin.
2. The cells respond poorly to insulin (insulin resistance).

In cases of type 2 diabetes, the pancreas continues to produce insulin, but not at the same level of quality as a healthy pancreas.

Typically, the onset of type 2 diabetes occurs later than that of type 1. In Denmark, the average age for people who develop type 2 diabetes is 63 years old, compared to those who develop type 1 diabetes, who are under 30 years old. (Diabetesforeningen, 2023).

Diabetes in Denmark
Our research focuses on Type 1 Diabetes (T1D), which affects around 34,000 individuals in Denmark. It primarily affects younger people and usually appears during childhood or adolescence as an autoimmune condition. We are targeting support for young adults aged 17 to 25 with T1D, as this age group often struggles with managing long-term glucose levels (see graph x) due to significant developmental changes and stress.

Our goal is to address challenges related to sleep, anxiety, and stress to prevent the long-term consequences of T1D, reducing the burden of living with a chronic condition during this vulnerable stage of life. Managing T1D requires continuous and complex self-management, including insulin regulation and careful monitoring of diet and exercise.

This self-management does not stop at night, and diabetes does not sleep. The psychological burden of managing T1D can be cumbersome for young adults, who are at a critical point in establishing their independence and lifestyle patterns.

06 Terminology Used

Now, we will introduce key terminology essential to our project, which focuses on several factors regarding T1D management. The primary focus areas include:

- The incorporation of Continuous Glucose Monitors (CGMs).
- Analysis of factors affecting glucose levels.
- The significant role of sleep in diabetes management.

For more information, please see the glossary in the appendix.

CGM

Due to technological advancements, particularly the development of Continuous Glucose Monitors (CGMs), individuals with diabetes now have a more comprehensive and less intrusive method of monitoring their glucose levels than traditional finger-pricking.

Frösslund, 2023

The CGM system tracks glucose at regular intervals throughout the day and night, providing data on glucose trends via a small device typically placed on the arm, leg, or another area not subjected to impacts or slept on. CGM, which stays on the arm from 7 to 14 days, revolutionizes diabetes management by continuously monitoring glycemic fluctuations, thereby preventing dangerous hypoglycemia. (Diabetesforeningen, 2023).

However, while CGMs offer significant benefits, they also introduce new challenges, such as the potential for increased anxiety due to constant monitoring. Users may feel pressured to continuously check their data, leading to stress and an overwhelming sense of vigilance over their condition. We will use CGMs as part of our strategic and design proposal.

Vrucinic & Frösslund, 2024

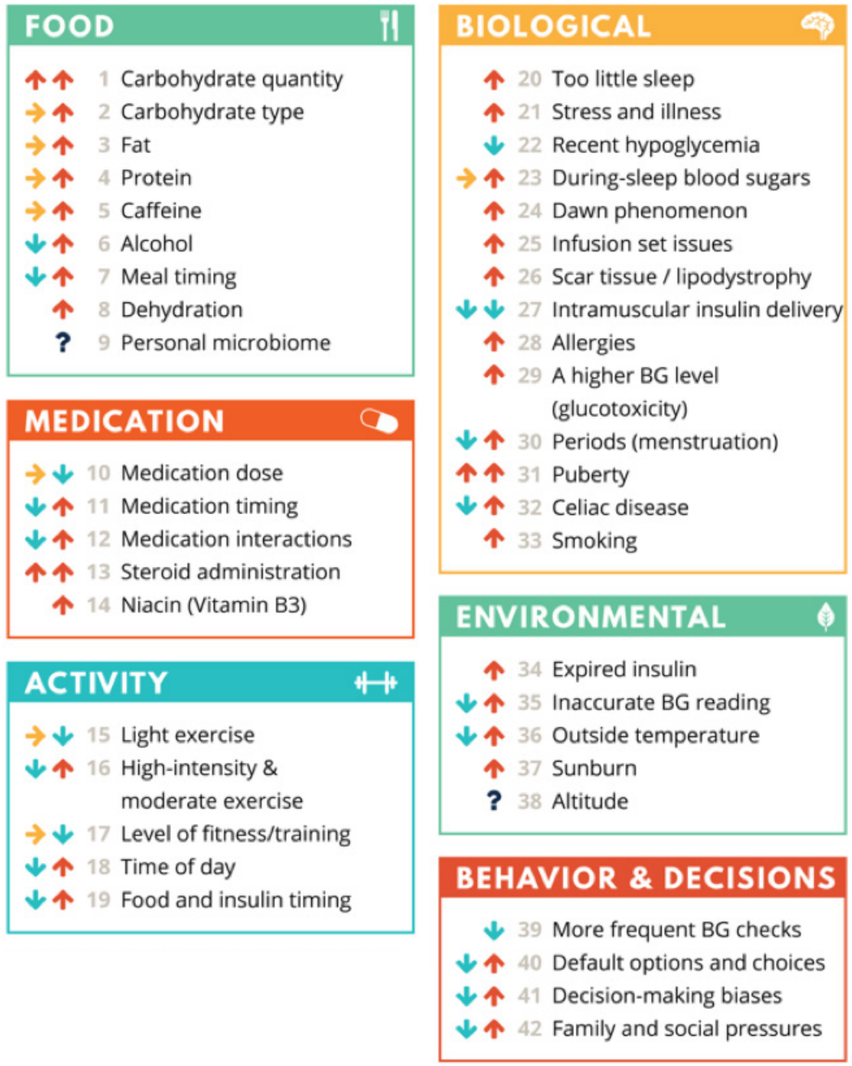
Sleep and chronic conditions

Sleep is crucial for individuals with Type 1 Diabetes (T1D). Overnight CGM alarms, necessary for diabetes management, disrupt sleep and can negatively affect blood sugar levels by changing insulin sensitivity and hormonal balance (National Sleep Foundation, 2021). Additionally, adequate sleep helps regulate stress-related hormones and strengthens the immune system, essential for those at higher risk of infections (Sleep Foundation, 2021). Furthermore, managing type 1 diabetes can be mentally challenging, and lack of sleep can exacerbate mental health conditions such as anxiety and depression (Centers for Disease Control and Prevention, 2022). Consistent, quality sleep is vital but challenging due to glucose fluctuations.

42 factors affecting your glucose levels

Managing diabetes is a complex task that goes beyond diet and exercise. It involves understanding and navigating through a range of factors that can influence glucose levels. These factors, such as meal composition and timing, physical activity, environmental conditions, stress, and overall health status, are crucial in effective diabetes management (DiaTribe, 2021). On the next page, there is a comprehensive list of the 42 current factors that affect glucose levels to ensure you are well-informed and prepared.

42 factors that affect blood glucose



diaTribe, 2021

07 Theory

In this section, we will discuss the theories we have used to inform our project and give us a deeper understanding of its overall framing. These theories range from those studying our target group to the theoretical aspects of some of the methods we later employed, like Design thinking, user-centered design, and prototyping. Lastly, we investigated the theories around light and sleep, which tie into our design proposal, the night light.

Emerging Adulthood- Jeffrey Jensen Arnett 2000

As Jeffrey Jensen Arnett (2000) described it as a distinct stage of life typically occurring between 18 and 25, but it can extend into the late 20s and early 30s. This phase is characterized by exploration in three key areas: love, work, and worldviews. Although this group is diverse, they share one common trait - instability. This instability can manifest in residential status, profession, financial stability, and education. For instance, during this stage, many emerging adults experiment with their living arrangements by entering a co-living or semi-autonomous situation such as student housing, flat mates, or a romantic partner. Arnett (2000) suggests emerging adulthood fundamentally differs from adolescence and young adulthood. Adulthood is marked by specific developmental milestones that signify the transition from youth to maturity. These milestones are not merely chronological but are deeply rooted in social, economic, and personal dimensions. The commonly accepted criteria for adulthood include achieving personal responsibility, financial independence, and the ability to make independent decisions. Unlike adolescence, where identity formation begins, emerging adulthood allows for deeper exploration and reevaluation of beliefs and aspirations developed during earlier stages of life. According to Arnett (2000),

"Emerging adults do not see themselves as adolescents, but many of them do not see themselves entirely as adults" (p.471).

This demographic is primarily observed in industrialized societies, facilitated by extended education and, or in the process of obtaining and framing for a long-term adult occupation.

07 Theory

Design thinking
Design thinking is an innovative problem-solving framework that prioritizes understanding people's needs through empathy and a human-centered approach. It involves collaborative teamwork across different fields to explore multiple solutions and uses an iterative process of prototyping and testing to develop sustainable and contextually relevant solutions (Brown, 2008).

According to Brown (2008), the design thinking process begins with understanding the user experience through empathy, followed by defining clear problem statements. The ideation phase generates diverse solutions, which are then rapidly prototyped and tested for refinement.

This approach aligns with strategic objectives by placing users at the center of the innovation process and adapting to dynamic market environments. It ensures that solutions are not only desirable but also viable and feasible.

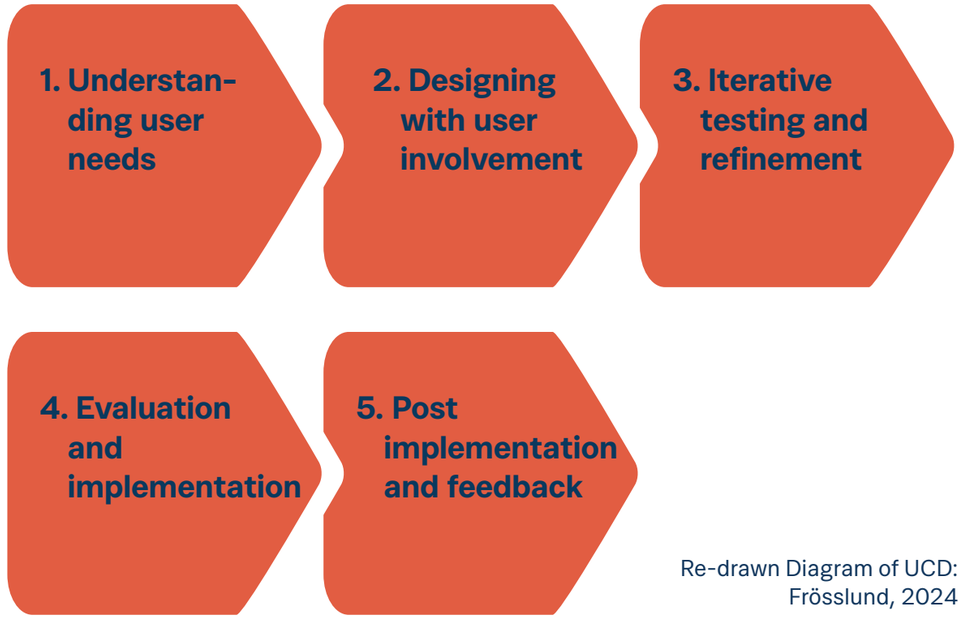
User-centered design
In the design field, user-centered design (UCD) is a philosophy that prioritizes users' needs, experiences, and limitations.

Don Norman's seminal work, The Design of Everyday Things, provides profound insights into this approach, advocating for a design that is accessible and intuitive for all users (Norman, 2013).

Fundamental Concepts of User-Centered Design
UCD aims to understand users' contexts, behaviors, and challenges to address the correct problems. The design process revolves around user needs and feedback for continuous refinement (Norman, 2013).

Importance of Discoverability and Understanding
Discoverability and understanding are crucial for intuitive user interaction with products, enhancing the user experience (Norman, 2013).

Design Principles for Effective User-Centered Design
Essential principles include visibility, feedback, mappings, and affordances to facilitate natural and error-free interactions (Norman, 2013).



Re-drawn Diagram of UCD:
Frösslund, 2024

Challenges in Implementing User-Centered Design
Implementing UCD challenges balancing user needs with business objectives and technological capabilities (Norman, 2013). Our project focuses on User-Inspired Design, which takes inspiration from user feedback but differs from User-Centered Design (UCD). While UCD places users' needs and feedback at the center of the design process, User-Inspired Design uses these insights as a foundation for inspiration. However, it does not actively involve users in creation or decision-making. By gathering valuable insights from users to inform the design direction without requiring their direct involvement in the development phases, this approach allows us to create compelling designs that meet the users' needs.

07 Theory

The Anatomy of Prototypes: Prototypes as Filters and Manifestations of Design Ideas
Prototyping is crucial to human-computer interaction (HCI), software engineering, and design. It is used to evaluate a design's success or failure and as a powerful tool for learning, discovery, and iterative refinement within the design process.

Prototypes allow designers to rapidly test and iterate ideas, enabling them to explore different layouts, user interactions, and concepts. This could be for a mobile app interface using paper mock-ups, which can save costs and time. Prototypes serve as filters and manifestations of design ideas, focusing attention and making ideas tangible for easier evaluation and refinement. They support reflective design practices by allowing designers to project ideas, receive feedback, and refine designs based on interactions with prototypes.

Understanding prototypes as filters and manifestations deepen theoretical insights and practical applications. This dual perspective is helpful, with diagrams showing how prototypes can narrow design options while giving concrete form to ideas. Prototypes inherently support reflective design practices. Prototypes inherently support reflective design practices. They allow designers to project ideas, receive feedback, and refine designs based on interactions with prototypes. For instance, testing an e-commerce site's checkout process might reveal that complex navigation leads users to abandon their carts, prompting further simplifications.

En ungdom med kronisk sygdom – Signe Hellung Schønning (2022)
Signe Hellung Schønning's 2022 study explores how T1D treatment in Denmark works, examining the impact of cultural norms and societal values on young individuals with diabetes. Schønning (2022) argues that diabetes is not just a medical issue but also an aspect of individual identities, social relationships, and daily routines. Cultural narratives about illness and health influence how teenagers with T1D perceive their capabilities and responsibilities in managing their diabetes. Such narratives also influence the strategies employed by healthcare professionals.

As adolescents transition from family-centred management to self-driven care, they face the challenge of asserting their independence while effectively managing their condition. This often requires a reevaluation of both personal and social identities.

In addition, Schønning (2022) examines how healthcare strategies are tailored to meet the developmental needs of adolescents. Schønning found three different strategies:

- Introduce a technological solution
- Guide the young adult towards greater autonomy in their diabetes management
- Setting more achievable targets for diabetes management during the emerging adolescent years.

The study highlights the importance of social and familial support networks in managing T1D during emerging adolescence. Effective management requires collaborative efforts involving healthcare providers, families, and the broader community. Balancing support and promoting independence is vital, as it can significantly affect the young individual's ability to adapt to and manage their condition.

Light theory
"Researchers have shown in humans that light influences hormone secretion, heart rate, alertness, sleep propensity, body temperature, and gene expression."
(Holzman et al., 2010)

Individuals with T1D have unique reasons for exposing themselves to artificial light at night, such as high or low blood sugar alarms that cannot be avoided. These critical alarms are always connected to their smartphones, which emit blue light through their screens. This is designed to disrupt sleep and wake people up so they can act upon the emergency. What it does not do is help them go back to sleep once the alertness ends. Our deliverable will examine light as a form of communication during nighttime.

Artificial light has been proven to have detrimental effects on the body, disrupting the brain's natural circadian rhythm and reducing melatonin production, which can impact psychological, cardiovascular, and metabolic functions. (Cho Y, Ryu SH, Lee BR, Kim KH, Lee E, Choi J., 2015.) According to Dieter Kunz, director of the Sleep Research and Clinical Chronobiology Research Group at Charité–Universitätsmedizin Berlin, maintaining synchronized circadian rhythms is essential for one's health and well-being. Desynchronization of circadian rhythms may play a role in various diseases like tumoral diseases, diabetes, obesity, and depression.
(Holzman D. C., 2010)

08 State of the Art

We wanted to assess how different technologies can impact diabetes management for individuals with T1D to determine the best approach for our project and proposal. In this section, we will examine three different technologies relevant to our design proposal:

- AI-powered insulin dosing systems
- Wake-up lights
- Current glucose-monitoring apps

These technologies provide various solutions and improve quality of life. Two are directly aimed at people with T1D, while one is related to sleep and utilizes light to facilitate waking up.


Deepika, 2024

AI (Artificial Intelligence) dosing
Introduction: We explored the future impact of technology on diabetes management for individuals with T1D.

Description: Artificial intelligence (AI) can act as a support system to manage insulin dosing with insulin pumps for people with T1D. AI-powered systems use data from CGM to provide personalized insulin dosing recommendations, helping to maintain optimal glucose levels and reduce the risk of hypo- or hyperglycemia.

Analysis: AI dosing lightens the mental load on people with T1D by providing decision support and reducing the complexity of daily diabetes management tasks. When you combine the data from the CGM and the data from the insulin pump, it is called a closed-loop system. (Vigersky, 2021) This system is only compatible with insulin pumps, which some people may find daunting.

McGrath, J. 2024

Wake-Up Lights
Introduction: We wanted to investigate how light impacts behavior and physiological responses, so we narrowed our focus to tools that support better sleep.

Description: Wake-up lights help regulate the body's natural circadian rhythms by simulating sunrise and sunset, reducing morning grogginess (sleep inertia), and helping individuals struggling with waking up due to irregular sleep schedules or insufficient natural light. They are also popular among those who suffer from Seasonal Affective Disorder (SAD). (Sleep et al.; Hunker, n.d.).

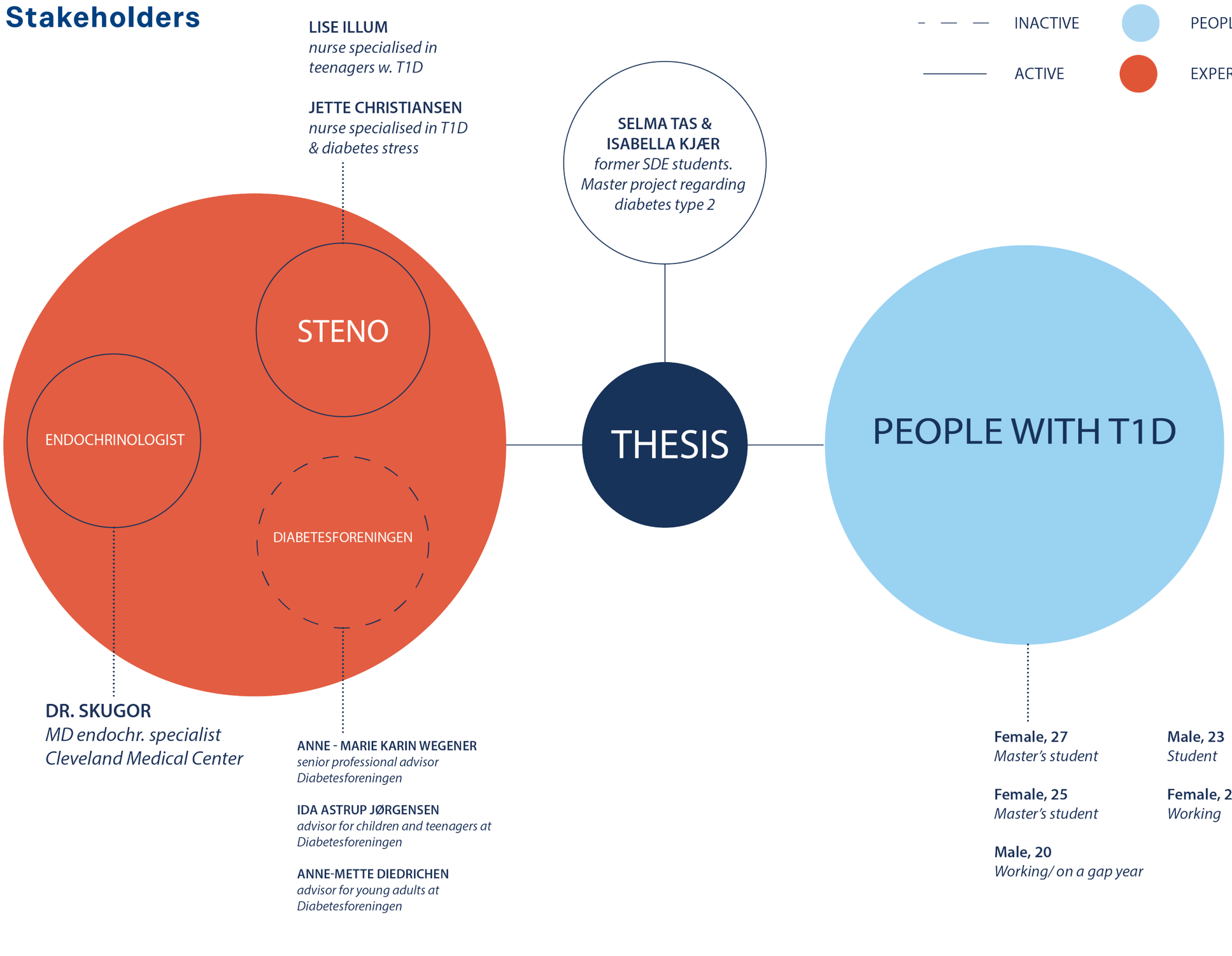
Analysis: It's important to remember that wake-up lights are designed for gradually waking up after a night, while CGM devices focus on changes in glucose levels. (Everyday et al.).

Frösslund, 2024

Glucose Monitoring Apps
We tested a few of the Glucose Monitoring Apps available on the market to analyze how essential information about T1D is communicated. This analysis will inform the design of the interface for the night light prototype and how data will be displayed.

Our criteria were clarity of informational hierarchy, easy navigation, customizability, understandability of how glucose levels are displayed and overall communication style. Based on our analysis, we have identified the need for a simplified and user-friendly experience and interface. It is important to have a clear hierarchy in the initial display of health data and to provide the option for users to customize and prioritize the information they wish to see.

09 Stakeholders



Vrucinic, 2024

09 Stakeholders

Throughout the semester, we collaborated with several experts and individuals who have Type 1 Diabetes (T1D) or work with it. These discussions influenced our process and design proposal based on user-centered design. We gathered insights from various sources, including specialized nurses treating T1D at Steno Medical Center, an endocrinology MD at the Cleveland Medical Center in Ohio, individuals living with T1D and their parents, and advisors from the Diabetesforeningen organization. We will now go through our stakeholders that have been divided into the Experts and Target group & support.

Experts


Diabetesforeningen, 2023

Diabetesforeningen
The Diabetes Association is an interest organization that has supported people with diabetes since 1940. Today, the association has approx. 90,000 members and one of Denmark's largest patient associations. (Diabetesforeningen, 2023) They have been a key player in diabetes awareness, education, and support through numerous initiatives. Some of these initiatives are more in the research sphere, while others focus more on food, mental health, movement, etc. They support both parents and their children, following them into adulthood. Because of their broad spectrum of work and over eighty years of experience working with diabetes, we felt that talking to them in some capacity could bring us a lot of information and resources as well as potential access to our intended user group of young adults.

Healthcare professionals
Dr Škugor, MD endochr. Specialist, Cleveland Medical Center


Skugor, 2023

Throughout the project, a key informant was an endocrinology and diabetes specialist from the Cleveland Medical Center. Dr Škugor has more than thirty years of experience working in the field and has been a great contributor to our project, bringing a balanced and seasoned perspective to the experience of treatment of Type 1 diabetes from a doctor's point of view.

Steno Diabetes Center Herlev (SDCC)


Mikkelsen Arkitektur, 2022

As the biggest diabetes center in the Nordic region is right in Copenhagen, it was natural that we contacted them. SDCC is the largest Diabetes Center in Scandinavia, annually serving up to 13,000 people with T1D and T2D. They are renowned for their expertise and 91 years of experience in treating diabetes. The center is located in Herlev. The facility was designed by COWI, Vilhelm Lauritzen Arkitekter, and Mikkelsen Arkitektur in 2021. We started contact through Molly's nurse, Jette Christiansen, a specialized diabetes nurse who helped us uncover the issues and concerns plaguing nurses. We learned practical information about how she works with patients. She emphasized the mental health aspect of working with patients who live with a chronic condition like T1D and how the role of the nurse is to support the patient and guide them through whatever they may face.

Target group & support

People with T1D
The primary focus of our project is the individuals with T1D. We interviewed and collaborated directly with five people aged 18-27.

Parents/ primary caregivers of people with T1D
We understand the crucial role of parents and primary caregivers in the upbringing of young adults with T1D. However, as individuals between the ages of 17 and 25 start to become more independent, the direct influence of their parents and caregivers will diminish. While our project has not centered around a target group that relies on their parents and caregivers as much, we acknowledge the important support system that parents and caregivers provide for young adults with T1D.

10 Methods

In this section, we will provide a brief overview of the methods utilized throughout the project. These methods were crucial in shaping the project, our strategy, and the design proposal. We employed qualitative and quantitative data collection methods to ensure a thorough understanding. Detailed observations, interviews, and engagement with experts enriched the depth of our research, aligning our findings with our objectives.
To see where each method was used in our project process, refer to the Gantt chart overlaid with the Double Diamond framework. add about strat design.

User-Centered Design
User-centered design was the cornerstone of our project. This method and theory helped us understand the users' needs and provided a framework to guide us throughout the process. These are the critical steps of the UCD process that we used, see diagram to the right.

Design Thinking
Design thinking has been a central method and theory in our process. We utilized it to analyze our approach, consistently applying its principles in a user-centered manner.

Desktop research
In the initial stage of our project, we conducted desktop research to explore the global and local significance of T1D worldwide, with a specific focus on Denmark. The research involved gathering general information to lay the foundation for further inquiries and identify potential stakeholders for collaboration.

Interviews
To gather the issues, life and work with T1D in Denmark, we interviewed representatives from Diabetesforeningen, nurses from the STENO Diabetes Center, endocrinologist Dr. Skugor, and young adults living with T1D. These interviews helped shape our project, deepened our understanding of T1D, and guided our approach to potential proposals. We designed an interview guide to explore how our target group with T1D makes decisions, creating six scenarios reflecting their challenges. Meeting our target group in person provied a depth of understanding that cannot be captured through secondhand reports or clinical data. Our interview guide is in the appendix.

UCD process

1. Understanding user needs and context of use

The interviews with the interview guidehelped us gather information about our target group.

2. Designing with user involvement

Through prototypes of our concepts, we can directly involve users and ensure that the design and strategy meet their needs and expectations.

To complete the UCD process, we would need to do the following:

3. Iterative testing and refinement

The prototypes we create need to undergo user testing to collect feedback, which we can use to refine and enhance the product and service.

4. Evaluation and implementation

5. Post-implementation and feedback

Adopted UCD diagram.
Vrucinic, Frösslund, 2024.

10 Methods

Double-Diamond Model
This model offers a clear structure for our creative process, dividing it into four distinct phases: Discover, Define, Develop, and Deliver. This approach ensures that we progress with our project.
(See picture x of our double-diamond combined with methods)

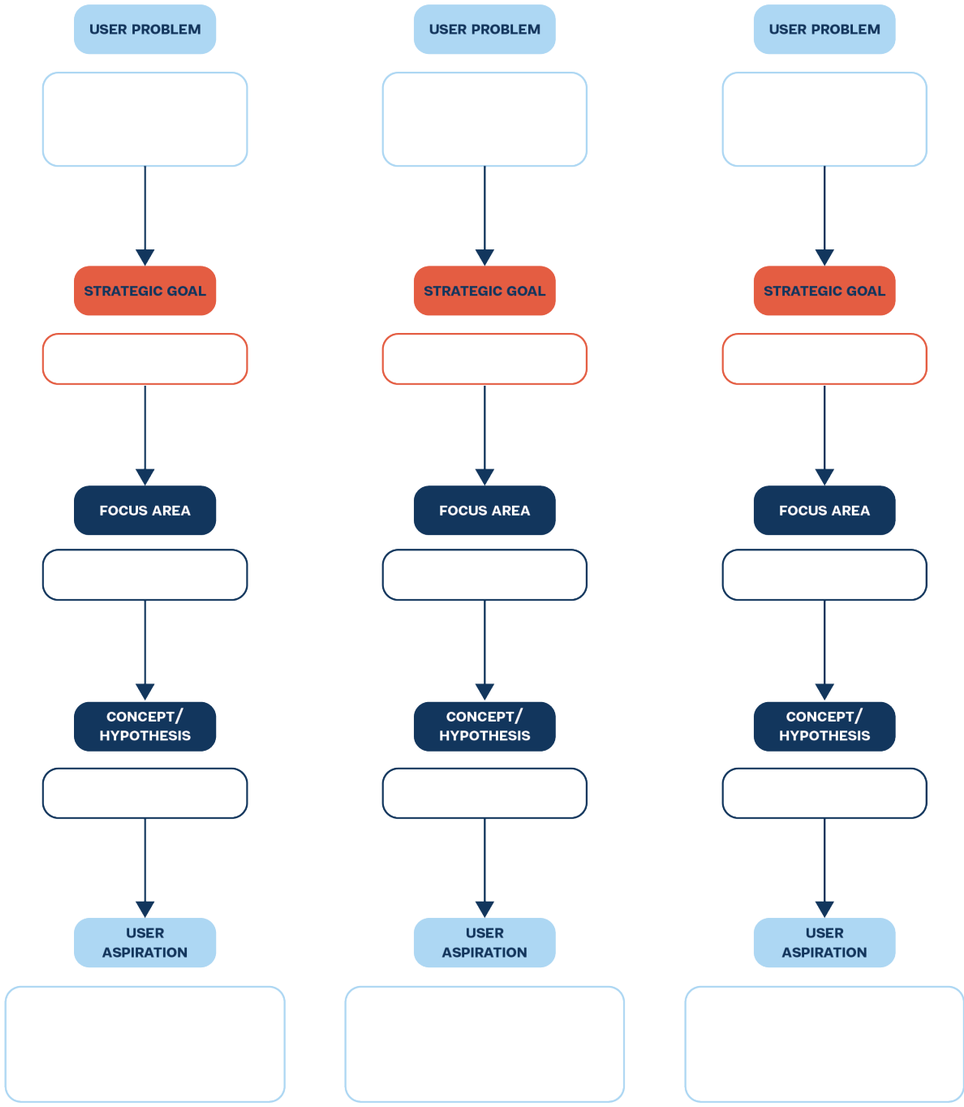
User Personas
By transforming our interviews into user personas, we were able to consolidate our research findings into practical insights. These personas represent typical users in our target demographic and serve as reference points throughout the design and decision-making process.

Prototyping
Through the work with prototypes, we explored various ideas and concepts. Prototypes allowed us to experiment with different solutions and quickly adjust based on user feedback and test results. Interacting with prototypes allowed us to test our ideas and collect valuable feedback. This iterative process of prototyping and feedback is crucial for refining our communication solutions, ensuring that they align with the needs and preferences of the target group.

MOSCOW method, see diagram above
The MOSCOW method is a prioritization technique used in project management to determine the importance of various requirements. (Clegg & Barker, 2007)

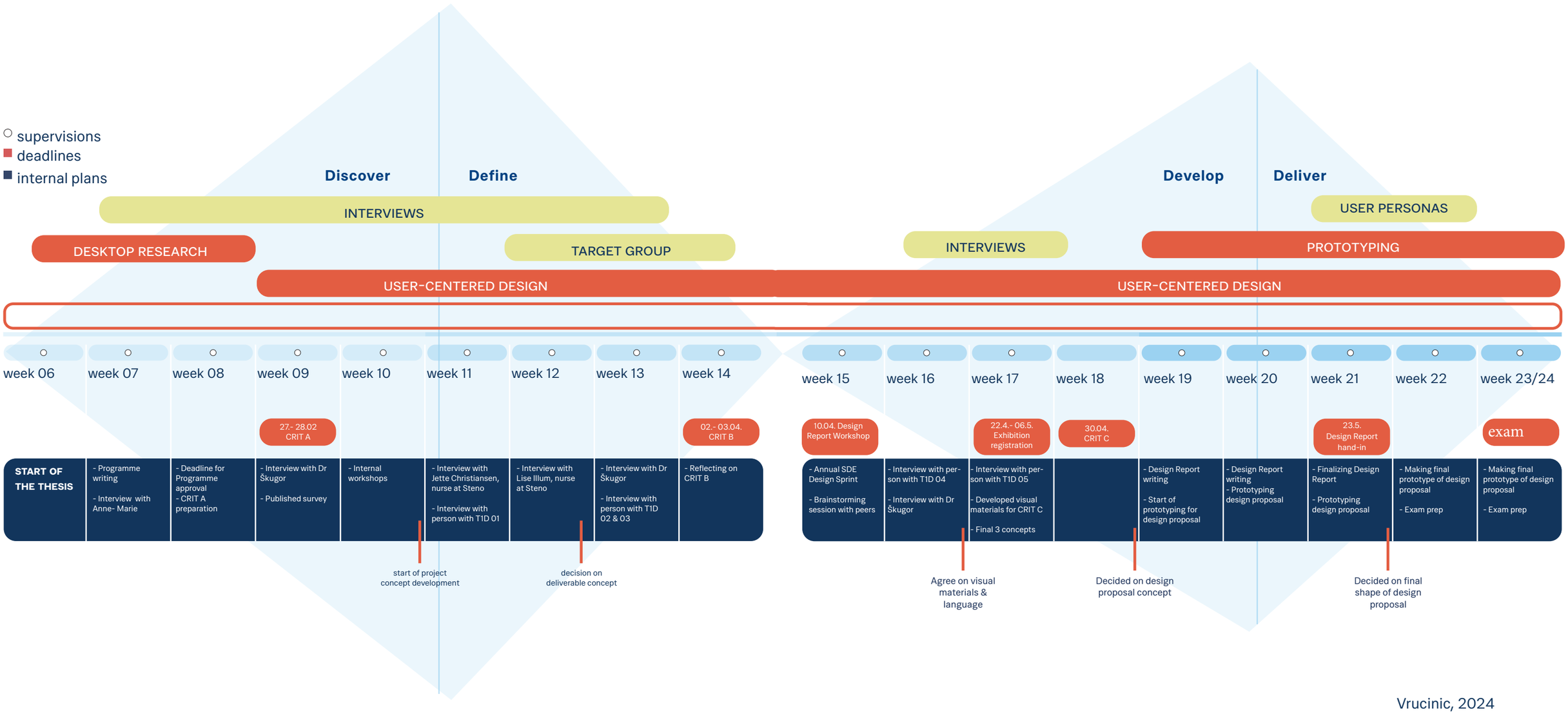
Strategic Framework - 1508
We utilized a strategic framework from the strategic design agency 1508 to identify concepts and establish a framework for three ideas. This approach helps us align the design proposal with strategic objectives.

1508 framework



Re-drawn model. Vrucinic, 2024

11 Project Plan



Vrucinic, 2024

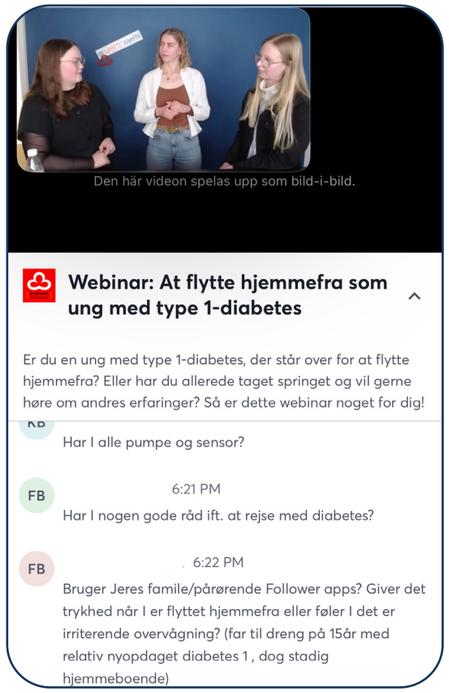
12 Process

Our goal was to grasp the challenges experienced by individuals with T1D to develop a design proposal and a strategic design plan. This section outlines our approach to identifying major pain points and the valuable insights obtained through the methods chosen, which have influenced the current form of our project.

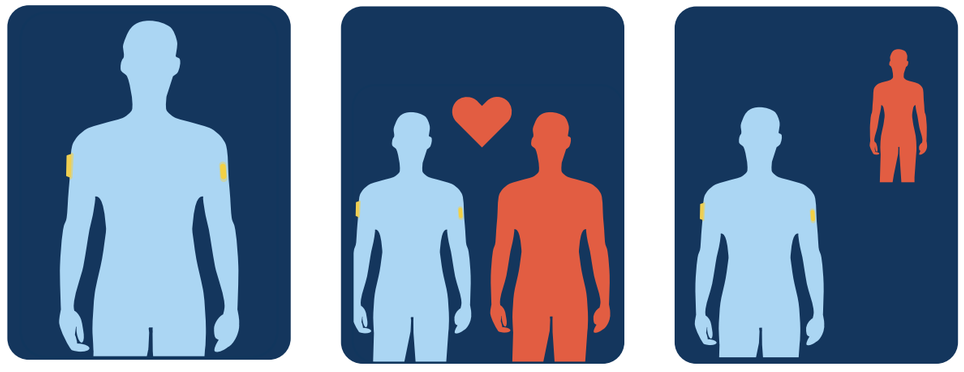
Engagement with Experts

Diabetesforeningen
Our work with stakeholders began with insights from Anne-Marie Karin Wegener, a senior professional advisor at Diabetesforeningen, introduced to us by Nuri Cayuelas i Mateau from Diabetesforeningen. Anne-Marie identified the transition from teenage years to young adulthood as a significant challenge for people with T1D. She directed us to Diabetesforeningen's spokespeople for children and young adults: Ida Astrup Jørgensen, a child and youth consultant, and Anne-Mette Diedrichsen, an advisor for young adults. They explained their work as an organization to support children and young adults with T1D, including a mentorship program, support groups, and a roadshow to raise awareness about T1D throughout Denmark. They also mentioned the challenges young adults with T1D face in transitioning from pediatric to adult clinics.

Webinar Participation
We participated in the "At flytte hjemmefra" online seminar organized by Diabetesforeningen, which provided more profound insights into the concerns of young adults and their parents/caretakers regarding independent living with T1D. This webinar was crucial in confirming our focus on this age group.



Screenshot from webinar. Frösslund, 2024



Internal Communication:
Focuses on the individual's interaction with their diabetes management devices

Immediate Communication:
Involves family and close friends who aid in daily diabetes management.

External Communication:
Involves broader social interactions with employers, colleagues, and the public.

Communication levels. Frösslund, 2024.

Key Findings
Our findings from the interviews and involvement with Diabetesforeningen resulted in us categorizing communication levels involved in T1D management, see picture x

12 Process

Healthcare professionals
To further explore how healthcare works with patients with T1D, we contacted an endocrinologist at Cleveland Medical Center and two nurses at Steno Diabetes Center Herlev. The healthcare team provides medical guidance, monitors other health conditions, and helps patients develop personalized management plans. They also serve as a source of emotional support and education.

Dr. Škugor - Endocrinologist
We collaborated with Dr. Škugor throughout our project, who generously shared his expertise and insights on treating T1D patients.

This collaborative approach ensured that our project included perspectives other than those of Steno Diabetes Hospital. During our conversations with Dr. Škugor, he described a typical interaction during a patient visit and the topics he would usually discuss. He also emphasized the importance of nonjudgmental communication with patients, highlighting the need for trust between physicians and patients. The nonjudgemental communication manifests in how he formulates questions about the patient's habits and other information, leaving room for a truthful answer without suggestion. He inspired us to think of ways design can motivate a young individual with T1D to be more diligent and proactive in treating and managing T1D. Some strategies we discussed include personalized goal setting and peer support networks.

Interview with Jette Normann Christensen and Lise Illum, Nurses from SDCC
We interviewed two nurses, Jette Christensen and Lise Illum, from SDCC to gain insight into the experiences of young adults with T1D. The interviews revealed the following key findings:

1. Patient Visit Drop-off
Lise highlighted a significant issue—a 20% drop-off in inpatient visits. This decrease means that some patients need more preparation before their visits, causing problems for nurses and patients, especially those who require the most help during difficult periods.

2.Management of T1D Over Time
Lise also emphasized the need for T1D management to evolve, requiring new strategies and support tailored to the patient's current life stage. T1D is a constantly evolving and changing chronic condition that requires personalized care.

A day in life with T1D: Frösslund, 2023

3. Young Male Patients Need Help Knowing What to Ask For
As Lise mentioned, young men may need help recognizing when they need help, making it harder to provide timely assistance.

4. Diabetes Stress Management
Jette emphasized the challenges of managing diabetes stress and the importance of providing nonjudgmental support, as managing diabetes can become even more complicated when other issues occur.

5. Mental and Emotional Burden
Both nurses pointed out that diabetes management does not take a break, and the continuous mental and emotional burden can significantly impact patients' well-being.

12 Process

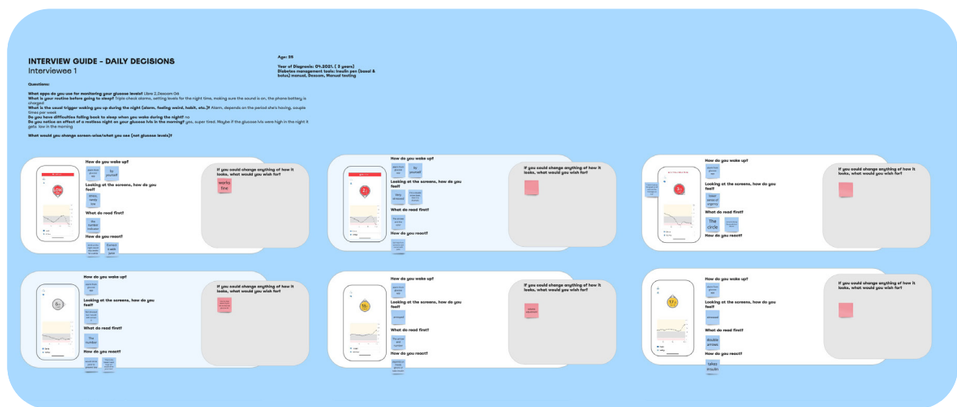
Engagement with people with T1D - Nighttime Challenges in Diabetes Management

To expand on our previous research and investigate the internal communication between individuals with T1D and their health devices. We did five qualitative interviews with an interview guide to it. The aim was to explore their interactions with diabetes management devices such as Continuous Glucose Monitors (CGMs) and insulin pumps.

The interview guide involved scenarios displayed on the phone, showing various glucose levels ranging from low (under 2.0 mmol) to high (17 mmol).

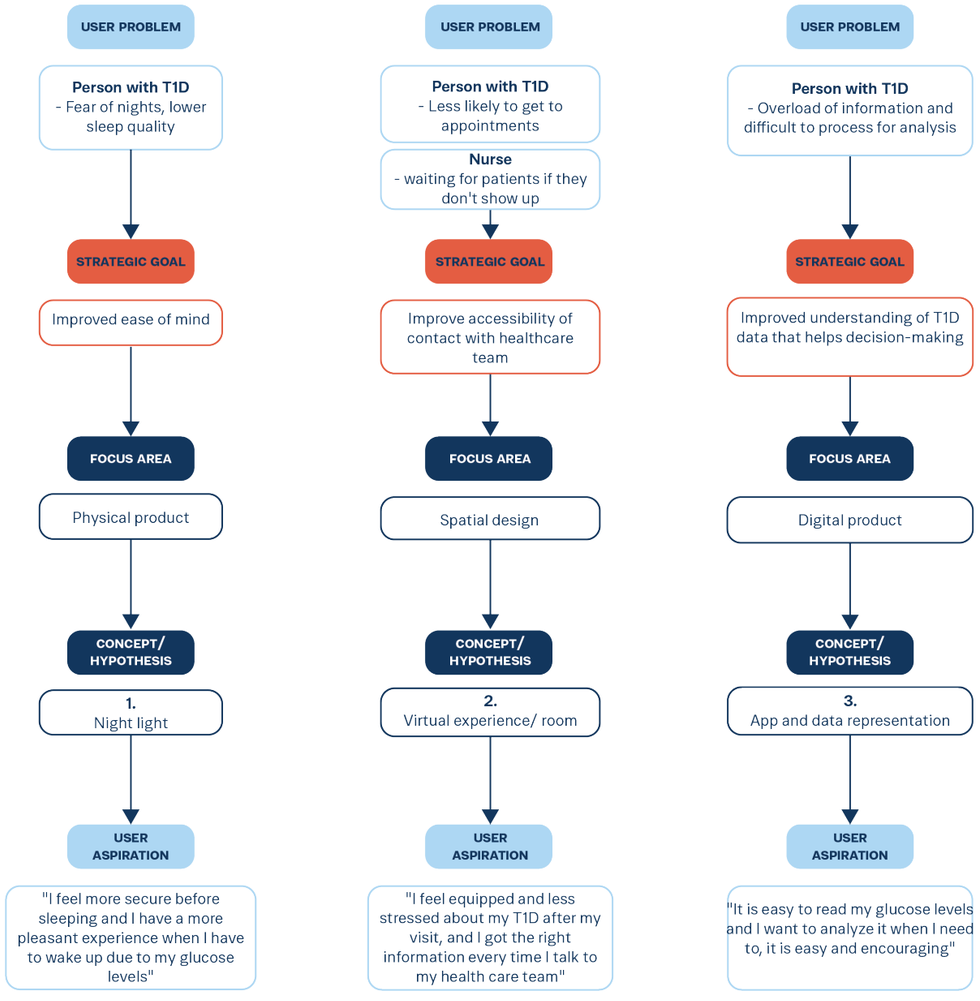
We asked our interviewees to share their immediate reactions, feelings, and actions in response to the presented data. Our research uncovered a universal challenge among users: the stress associated with fluctuating glucose levels at night and the need for vigilant monitoring. This was particularly evident in the management of diabetes during the night, a significant concern for many interviewees who expressed anxiety about nighttime management, fearing hypoglycemia while asleep.

Interview with interviewee 1. Frösslund, 2024.



Interview guide. Vrucinic, 2024

13 Concept development and prototyping



Vrucinic & Frösslund, 2024

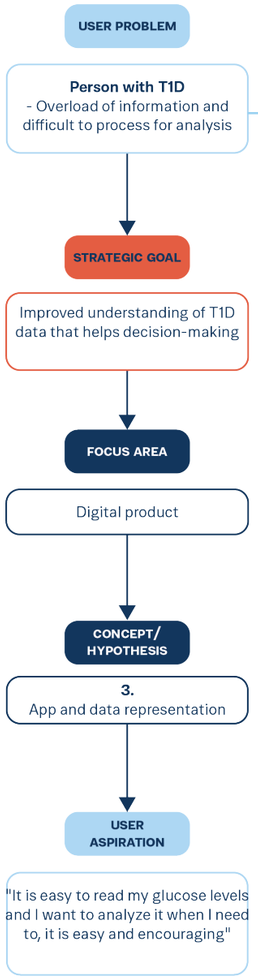
With our thorough research and findings, we could start shaping concepts. Our design process used iterative prototyping, where we tested and refined our ideas through interviews and physical prototyping. We had three different concepts, a redesign of a glucose monitoring app for better data representation, a virtual meeting space and a night light. We primarily focused on the last concept, and most of the prototyping was done in the development of that concept into a design proposal.

Outcomes

Here we list and analyze the outcomes of the different prototyping methods by considering the objectives we set for each.

In the first round of testing, we gathered information and insights from our interviewees about the challenges they face in their lives. By providing them with a basic mobile phone application to organize this information, we learned about their priorities and how they manage their condition during times of stress and vulnerability. Through the prototyping process for the design proposal, we obtained numerous outcomes, such as determining the night-light size, shape, and functions we wanted to incorporate into the design. These outcomes will guide our decision-making and help us track our progress until the final examination.

14 Concept 1: Mobile App, Redesign



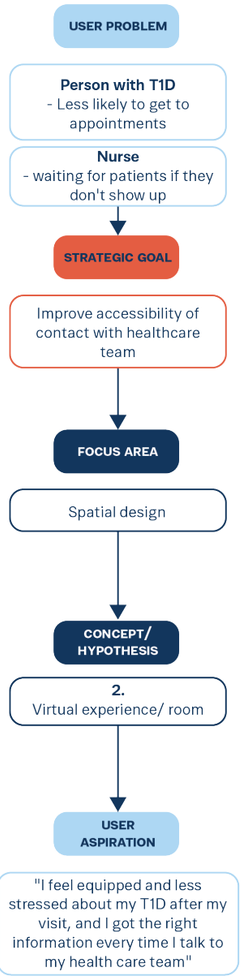
Vrucinic, 2024

Vrucinic & Frösslund, 2024

Initial Stages: Mobile App Redesign

During the first two stages of the Double Diamond, we focused on gathering information and insights from our interviewees through prototyping. For example, we explored our first concept, a glucose monitoring app, by using a lo-fi prototype to create a simplified interface with which we could easily interact and work. The goal was to test diverse ways to present glucose level data in a Glucose Monitoring App.

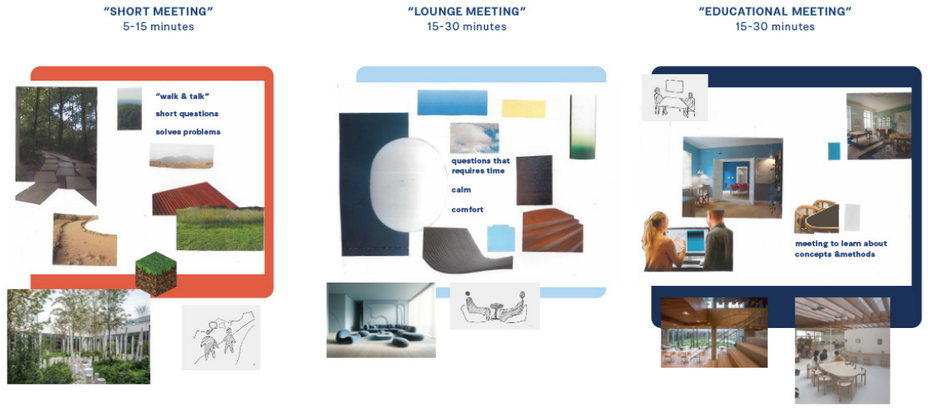
15 Concept 2: Virtual Meeting Spaces



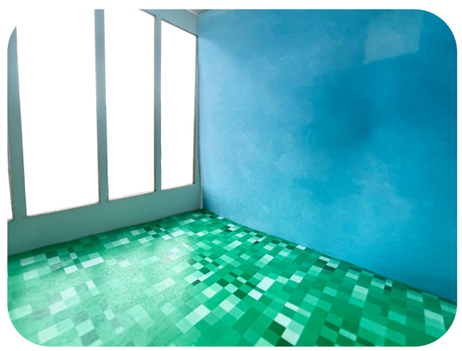
Vrucinic, 2024

Exploring Virtual Meeting Spaces

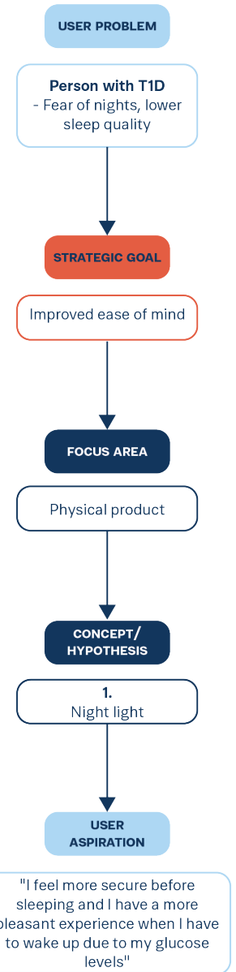
The second concept for our design proposal was, through basic lo-fi models, to rethink what a virtual meeting space with a diabetes nurse might look like. We tested different virtual meeting spaces tailored for various durations and purposes, including brief meetings (5 to 10 minutes), casual lounge-style meetings (15-30 minutes), and educational sessions (15-30 minutes). Both ideas were discarded in favour of a third, which will be the focus of our prototyping and design proposal. This idea stemmed STENO's issues with a patient drop-off 20%.



Frösslund, 2024



16 Concept 3: Night Light



Vrucinic, 2024

Final Phase: Night Light Prototyping

In the final phase of the Double Diamond process, our prototyping became more specific as we decided to create a night light. We used the MOSCOW method under design thinking to establish a set of considerations and a simple framework. The MOSCOW method (see picture x) This concept would be strategically implemented into existing technology like CGMs to ensure seamless integration into the daily lives of people with T1D. To achieve this, the mono-functional night light would have a Bluetooth connection and method of displaying glucose levels combining colored light and numbered display.

Initial Sketches and Size Testing

We could question scale, usability, and user experience by sketching different shapes. To address the scale of our lamp, we printed out various-sized circles and tested them against a series of nightstands used by people in our age group. We then translated these sizes into the third dimension by creating crude shapes in Styrofoam to better understand the potential lamps' dimensions.

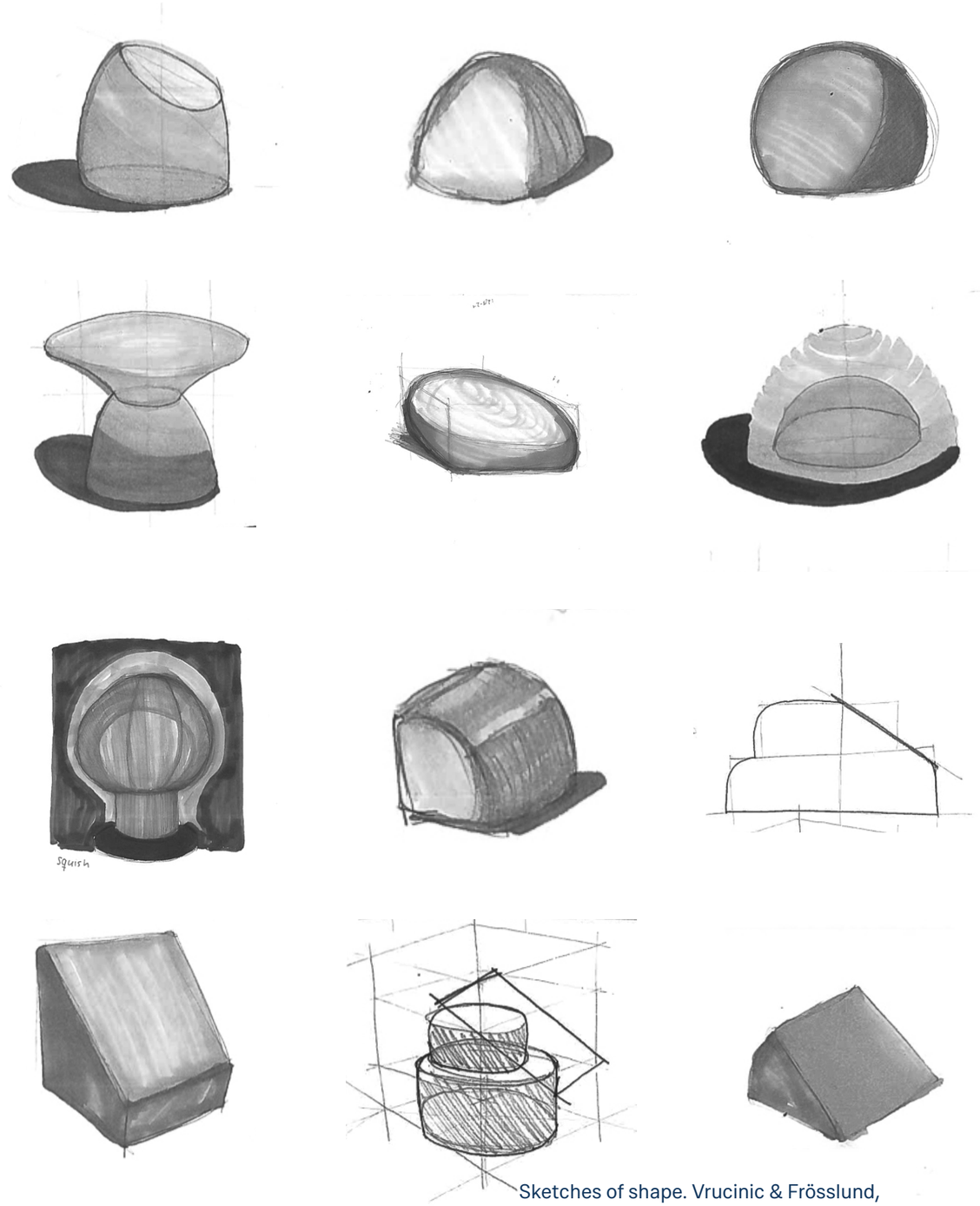
Look and feel. Vrucinic, 2024

17 Design Proposal

Description
We chose to develop the concept of a night light. Its purpose is to support young adults with T1D during their nightly emergencies. We decided to prototype three different shapes to test the various options we imagined for the user experience and haptic elements. By focusing our attention on the user's experience and optimizing how they interact with the nightlight we used that as our main criteria in shaping the object. Its size is made to fit onto a nightstand. The shape is simple and reduced prioritizing practicality and clean aesthetics to communicate glucose levels through light and numbers clearly.

Strategy of our design proposal
Our design proposal is to integrate into the daily lives of our target group, providing seamless interaction with existing devices such as the CGM. Rather than relying on a smartphone only, we focus on a nightlight. The nightlight's functionality, displaying only the glucose levels, makes it easy to navigate, especially in vulnerable situations.

We focus on improving sleep and stress management, which is crucial for managing the short-term and long-term health effects of living with a chronic condition. One direct consequence of fluctuating glucose levels, mentioned in the 42 factors affecting glucose levels, is poor sleep and stress. If our product can positively influence glucose levels, it could help people with type 1 diabetes adhere to necessary lifestyle restrictions in the long term. By improving sleep and stress management, our holistic healthcare design promotes overall well-being and supports long-term adherence to the many limits faced by individuals with Type 1 Diabetes (T1D).



Sketches of shape. Vrucinic & Frösslund, 2024

18 User Personas

Profile 1: Female, Student, 22

"I want to enjoy my life without my diabetes management always being at the forefront."

Approach to T1D

- Avoid severe low blood sugar without constant management.
- Live like her peers with minimal disruptions.
- Scared of the development of an eating disorder due to constant monitoring.

Struggles:

- Balancing fear of nighttime low blood sugars with a carefree lifestyle.
- Reducing alarms and monitoring while staying healthy.
- Overcompensating for low blood sugar.

Profile 2: Male, Full-time work, 19

"I want to do as little as possible with my diabetes"

Approach to T1D

- Manage diabetes with minimal disruption to his lifestyle.
- Work, take care of himself, and enjoy a balanced social life.

Struggles:

- Ensuring long-term health with a relaxed management style.
- Finding a balance between avoiding low blood sugar levels and not letting glucose levels get too high.
- Staying motivated to manage diabetes effectively without feeling overwhelmed.

Profile 3: Female, Student, 25

Vrucinic, 2024

"I am a bit of a perfectionist. I have to maintain tight control over my diabetes to achieve my goals."

Approach to T1D

- Maintain tight control over her blood glucose levels.
- Use data and technology to optimize her diabetes management.
- Graduate and secure a job in her field.

Struggles:

- Ensure precise glucose control to avoid complications without becoming too obsessed with numbers.
- Not becoming too anxious about glucose levels.

19 MOSCOW

Must Have	Should Have	Could Have	Won't Have
Bluetooth connection to CGM & phone	A portable piece/ segment	Emergency contact	Voice Control Integration
Non-disruptive tinted light	A haptic element that confirms you have checked your blood sugar	Storage for glucose tablets etc.	Wearable for vibrations
Tactile	Customizable functions available through the app.		
Integrated speakers for alarms			
Display with simplified information on blood sugar			

Re-drawn MOSCOW. Frösslund & Vrucinic, 2024

20 Prototyping: Haptic Experience

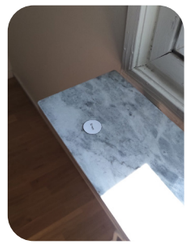
When we hold our different shapes in our hands, we can explore the tactile experience of our created objects. As a result, we conducted a series of usability tests to determine how a person with Type 1 Diabetes could interact with the object.

Would they click, hit, grab or squeeze it?

These potential scenarios influenced the future shape of the night light, leading us to create various sketches to visualize an object designed for these experiences.

Frösslund, 2024

21 Prototyping: Scale


30 mm


110 mm


140 mm


230 mm


30 mm


60 mm


90 mm


110 mm


140 mm


170 mm


200 mm


230 mm


260 mm


290 mm

To test the size of the lamp, we registered how it would look on our nightstand from a radius of 30 mm- 290 mm.

Vrucinic & Frösslund, 2024

22 Conclusion

In the conclusion, we will summarize the course of the project explaining what led us to our strategy and design proposal. Additionally, we will address the difficulties that young adults with Type 1 Diabetes (T1D) encounter at night through a human-centric design approach. We will combine design thinking principles with user-centred design (UCD) to introduce our design proposal and strategy for both our process and the design proposal, which will be customized to real-world user contexts.

Findings
By combining design thinking principles with User-Centered Design (UCD), we are working with a design proposal tailored to users' real-world contexts. Design Thinking as a theory and a method encourages a human-centric problem-solving approach involving rapid prototyping and iterative testing to explore various solutions (Brown, 2008). This method complements UCD by understanding user needs from a broader perspective before focusing on specific design solutions.

We continuously tested different approaches and frequently revised and refined our problem statement due to our target group's input. By prioritizing the target group rather than a specific object or solution, we identified the crucial need for personalization in diabetes management devices. Despite the diversity in individual experiences and management strategies, a common thread across all responses was the necessity for devices to adapt to individual user needs while minimizing the stress associated with nighttime glucose control.

23 Next steps

- Further development of the prototype of both lamp and UI/UX design of additional app
- Additional series of testing
- User feedback

24 Deliveries

Our deliveries consist of visual communication of the project and a prototype of the product we are developing.

- Posters
- Presentation slides
- A short video
- Prototypes of various phases of the product

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26 Appendix

Glossary

Autoimmune Disease
A condition where the immune system wrongly attacks and destroys healthy tissue, like in Type 1 Diabetes.

(Diabetesforeningen, 2023)

Blood glucose
The main sugar found in the blood and the body's primary source of energy. Also known as blood sugar.

(European Food Safety Authority, 2010)

Insulin
A hormone produced by the pancreas that regulates blood sugar levels by facilitating the transport of glucose into cells.

(Diabetesforeningen, 2023)

HbA1c
HbA1c is your average blood glucose (sugar) levels for the last two to three months.

(Diabetes UK, n.d.)

Diabetes mellitus - Type 1 Diabetes (T2D)
Type 1 Diabetes (T1D) is an autoimmune condition where the body attacks its insulin-producing cells, resulting in insulin deficiency.

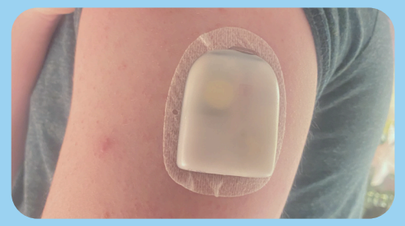
(Diabetesforeningen, 2023)

Hypoglycemia
A condition characterized by abnormally low blood glucose levels, often resulting in symptoms such as: shaking, sweating, and confusion. It can be dangerous if not treated promptly.

(Diabetesforeningen, 2023)

Insulin pump
A medical device used to administer insulin continuously throughout the day to manage diabetes.

(Omnipod, n.d.)



Type 2 Diabetes (T2D)
A common type of diabetes where the body struggles with insulin use or production, resulting in high blood sugar. It's influenced by lifestyle, genetics, and age. Management involves diet, exercise, and possibly medication.

(Diabetesforeningen, 2023)

Hyperglycemia
High blood glucose levels, which can occur when the body has too little insulin or when it cannot use insulin properly.

(Diabetesforeningen, 2023)

Continous Glucose Monitoring (CGM)
A system that tracks glucose levels at regular intervals throughout the day and night, providing real-time data on glucose trends.

(Diabetesforeningen, 2023)

Appendix

State of the Art

Dexcom

Description of the App: Dexcom provides a continuous glucose monitoring (CGM) system designed to assist individuals with diabetes by displaying their glucose levels in real-time. The application is recognized for tracking glucose trends through graphs and notifications alerting users to high or low readings (Dexcom, n.d.).

Our Informants' Thoughts:
- Color and Design: "The grey is not encouraging when you are in the right zone."

- User Experience: "The arrows make me anxious."

- App Utilization: "I think it works with the colours and such, but I do not use that much of the actual app."

- Readability: "It can be hard to read, especially the graphs."

Happy Bob, Dexcom (Gamified Version)

Description of the App:
Happy Bob is a mobile application that is integrated with Dexcom CGM devices. It offers a gamified experience for managing diabetes. The app encourages users to maintain their glucose levels by converting readings into stars. These stars accumulate to meet daily targets, aiming to make diabetes management more engaging and less burdensome. (Happy Bob, 2024)

Our Thoughts:
- Simplicity as a Plus: The app simplifies diabetes management with a playful interface.

- Grading System: The system of rewards and feedback could be perceived as judgmental, especially when feedback is negative, which may discourage some users, particularly younger children (Diatribe.org).

Sugarmate, Dexcom (Tech-Heavy Version)

Description of the App:
Sugarmate is a detailed companion app for Dexcom CGM systems, offering an in-depth and customizable interface for glucose tracking. It appeals to users who desire comprehensive data analysis and the ability to personalize notifications and displays. (Sugarmate, n.d.)

Our Thoughts:
- Customizable Screen: The app's ability to be tailored to individual preferences is a significant advantage for data-focused users.

- Information Overload: Its complexity may overwhelm those who prefer simpler interfaces, potentially alienating our target group, which favours less dense information formats.

Apple Health (CGM Integration)

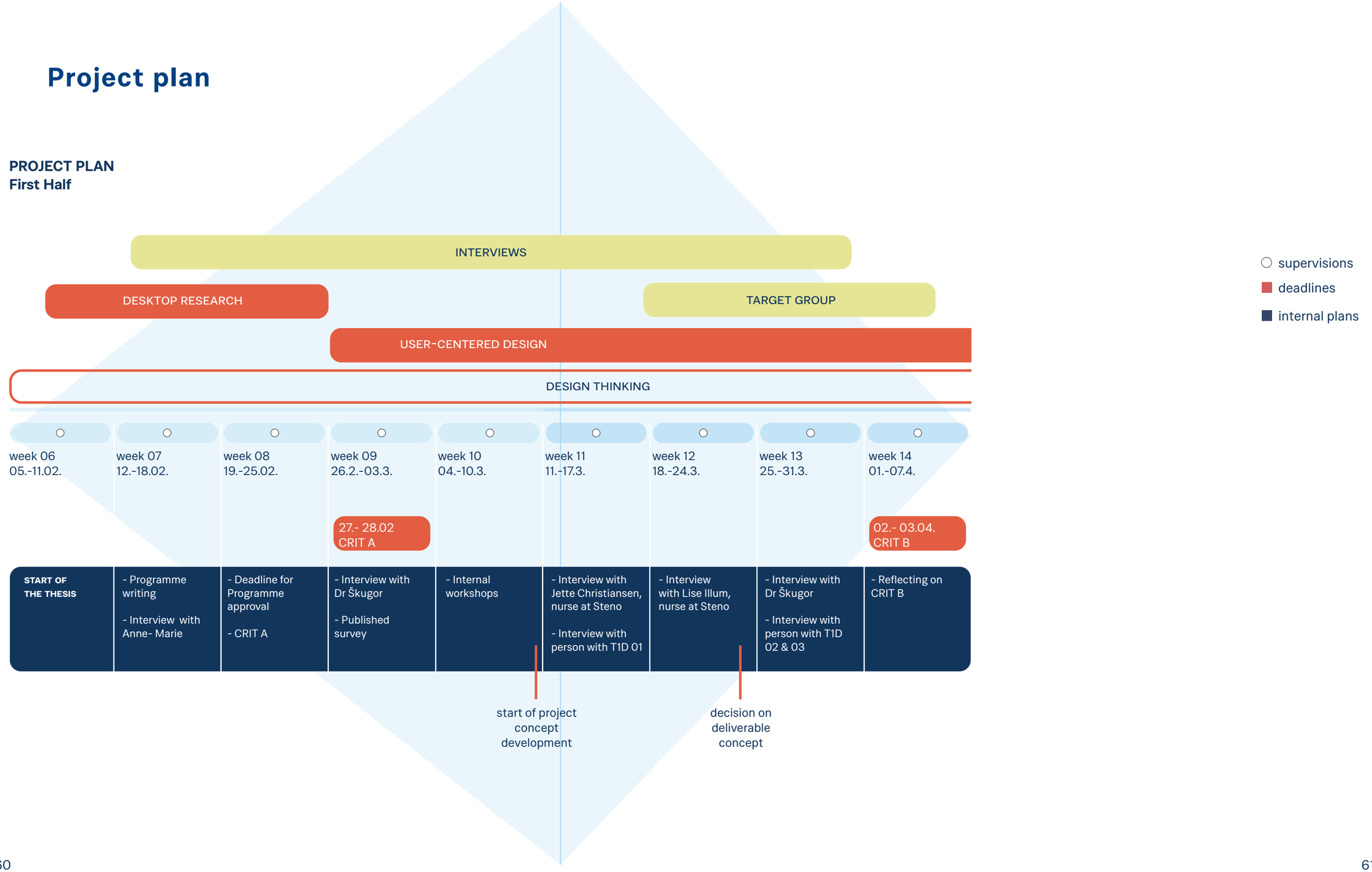
Description of the App:
Apple Health can integrate with various CGM devices, including those from Dexcom, to track and display glucose levels. This integration allows users to view their glucose data alongside other health metrics within a single app. (Apple, n.d.)

Our Thoughts:
- Nice colours are another way of showcasing data.

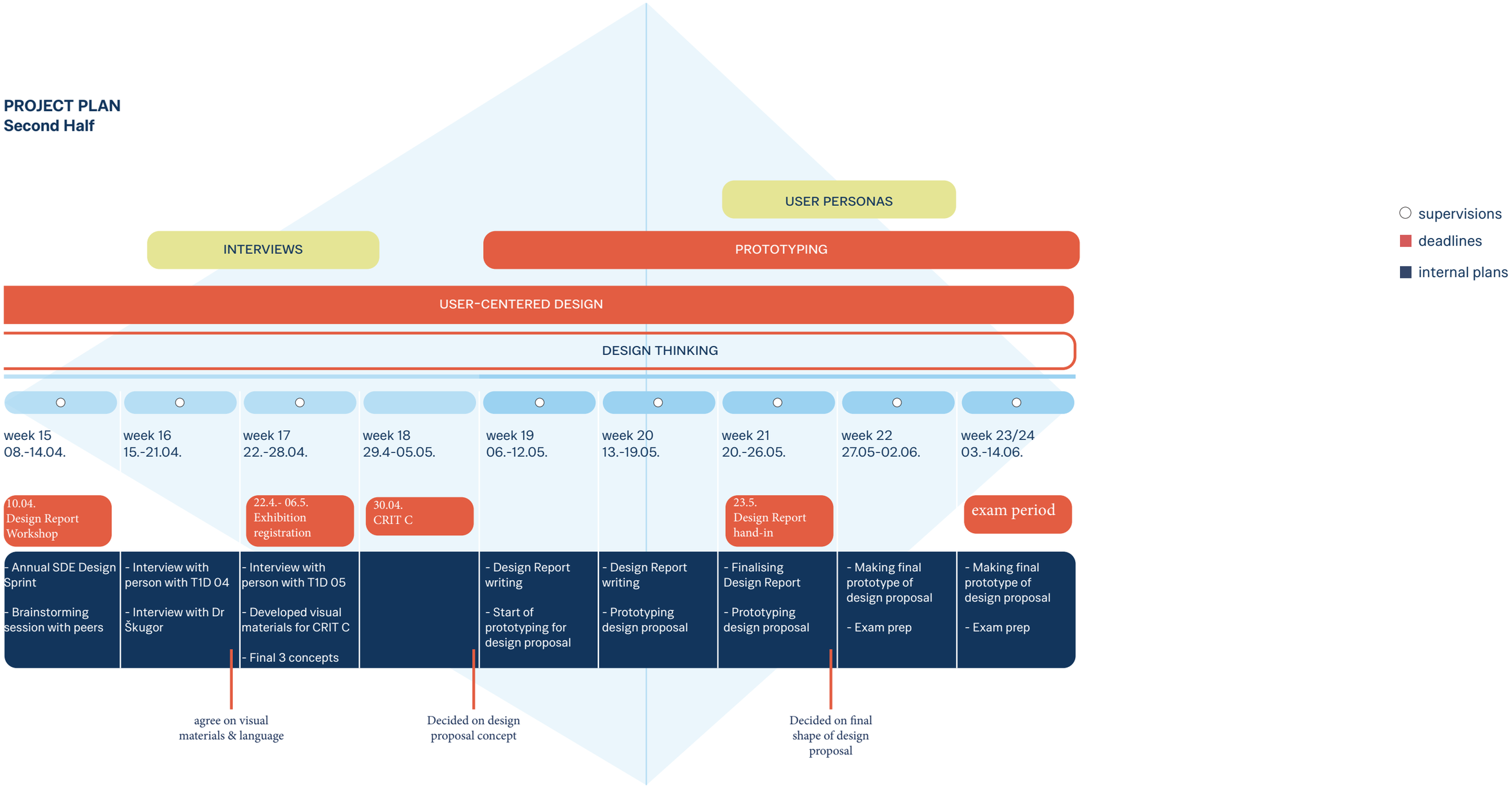
- Complexity: The data is confusing.

Project plan

PROJECT PLAN
First Half



PROJECT PLAN
Second Half



- supervisions
- deadlines
- internal plans

Reiterations of problem statement

1. How can design improve the daily lives and communication of young adults with type 1 diabetes?
How can we use tangible objects as a means of facilitation in conversation?

2. How can implementing user- centred design into medical apps improve the understanding of patient's T1D data?
Focusing on young adults, their parents and medical team

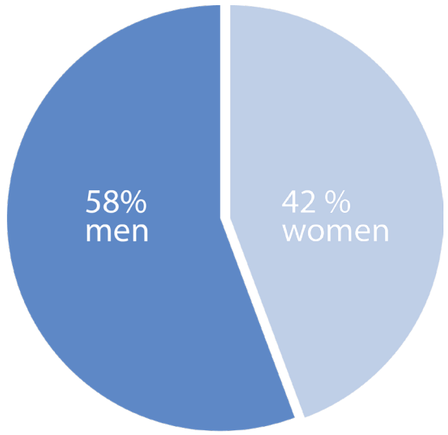
3. How might we ease the impact of chronic illness such as type 1 diabetes through user-driven design?
How can telehealth and digital innovations be designed for young adults with T1D to enhance their engagement and self-management?

4. Can user-centered design ease the impact of chronic illnesses such as type 1 diabetes?
How can digital innovations be designed for young adults with T1D to enhance their engagement and self-management?

5. How can design positively impact the nighttime experience for people with T1D?

Can light be a means of communication & support in difficult situations for people with T1D?

Additional data points



Gender representation in T1D

Number of T1D patients, 1996

Number of T1D patients, 2023