LIVING A BETTER LIFE WITH TYPE 1 DIABETES

JULIE ROLAND SØRENSEN I INDUSTRIAL DESIGN I MA I THESIS I 4.TERM I 35.901 CHARACTERS

Image 1) Outline of insulin pump

Image 2) Outline of monitor

Graduation project	Type 1 diabetes
MA Industrial Design	KADK IBD
4.Term 2018	February-May
Supervisor:	Karina Mose
Author:	Julie Roland
Hand in date:	29/05/18
Characters:	35.901

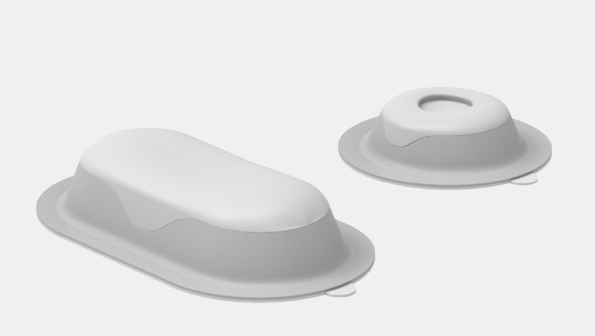


Image 3) Insulin pump & monitor design suggestion

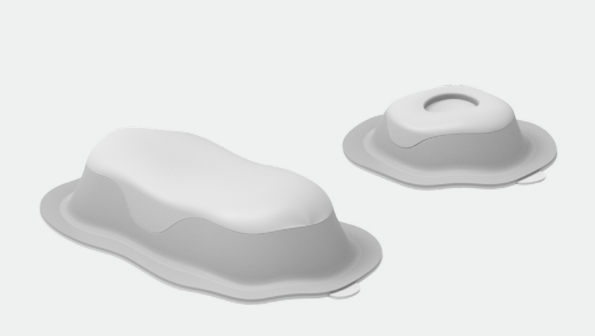


Image 4) Concepts are made in flexible materials

Image 5) Concept parts

SUMMARY

This thesis explores the process of designing electronic self-treatment medical products that are used in the everyday life of adolescents people with type 1 diabetes.

First, desktop research was carried out to increase knowledge. Then a second research phase focused on users needs and problems with the existing products and their everyday life. Questionnaires, interviews, and observations were afterwards performed to increase the understanding of the problems that exist in this field.

After analyzing the research, initial insights was selected as a foundation for the ideation phase. The aim was to create a family of electronic devices that minimised the need for manual user interaction. They should be comfortable to wear, customizable for each user, and with a visual appearance that users could trust and relate to, in a way that could integrate the devices in the users everyday life. Trough sketching, models, 3D drawing, user testing and evaluation I then developed a design suggestion.

The result of this project is a modular family of self-treatment medical electronic devices designed for type 1 diabetes patients. The family consists of one blood glucose monitor device and one insulin pump device, which are modularly attached to patches that are then fastened on the users body. The patches can be placed everywhere on the body with 3 different types of patches that fit different skin types. The blood glucose monitor measure the body's blood glucose level with sensor technology, and the insulin pump gives the user insulin trough a small plastic pipe that is inserted into the body. The two devices communicate wirelessly and the blood glucose monitor informs the insulin pump whenever the body needs insulin. Both devices are made of flexible materials and technology adapting to the movement of the body.

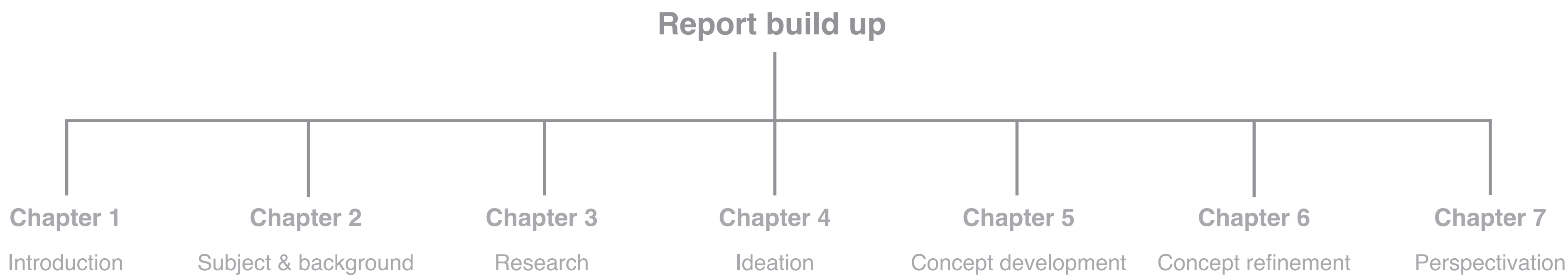


Figure 1) Report build up

THESIS OUTLINE

This thesis project has not yet been completed. The report will give an overview over the projects current state and the elements that needs to be developed further prior to the exam.

The first chapter introduces to the starting point for the project and give an overview over the process and the methods used in the project.

The second chapter explains the topic, scope of the project and the context of the situation.

The third chapter describes the research process of identifying the problems. It also explains the problems and the insights to why they occur.

The fourth chapter unfolds the ideation phase of the process and how I came to the end result trough testing and validation.

The fifth chapter shows the process of conceptualizing the results and insights from the previous chapters.

The sixth chapter describes how I detailed the solution trough 2D and 3D experiements.

The seventh chapter review the current state of the project and make a perspectivation to which elements need further development prior to the exam.

CONTENT

INTRODUCTION

INTRODUCTION

Chronic illnesses or conditions such as type 1 diabetes, are one of the biggest problems today. Type 1 diabetes is on the rise worldwide together with other chronic illnesses because the medical industry has gotten more competent at discovering diseases earlier. Chris Register (1991) expresses that earlier and more precise diagnosis, more effective remedies against acute problems, and better means of maintaining health have slowed the course and limited the impact of some diseases that used to be quickly terminal. They are no longer illnesses to die of, and yet not thoroughly curable. They have become illnesses to live with. Even though this is a positive development it also poses new challenges. It puts more demands on society. Living with Type 1 diabetes demands of us to develop new, reliable, and well designed self-treatment medical equipment.

For many years the medical industry has been creating medical products focusing on treating diseases. But there has been a change in the market and medical equipment has now become consumer products. (Thomas Brixen, 2014).

The medical industry is profit based and therefore they have an interest in creating products that the consumers want. We therefore see a slow change in the medical industry from being based on treating diseases to making products that the consumers also find pleasurable to use.

This project focuses on brigding the gap between technology-based medical products and the everyday life of the users that these products are intended for. The project rises from my interest in this change in the medical industry and also from my interest in approaching the design of medical equipment with a human centred perspective to create value for the users in their everyday life.
This is also why, in this project, I have made it a strategy to work closely with users that suffer from type 1 diabetes. In close collaboration with patients, I have designed a family of self-treatment electronic medical devices that adapt to the body's movement and operates automatically, with the goal of minimising the need of manual user intervention, thus integrating life with diabetes with the users daily routines.

With the help of these products, it is my hope, that the awareness around the topic of creating medical products with more value for the user will increase, and a greater discussion around the issue will rise.

How can design improve type 1 diabetes patient's life and well being by amending the **electronic self-treatment medical devices**, with a greater focus on the everyday life of users?

PROBLEM FIELD

Upon starting the project I defined the above question to guide the project. A main problem I found early on in the research was that the electronic self-treatment medical devices, currently on the market, did not adapt well to the users everyday life. They are currently focused on treating the users diabetes but not considering the users other needs regarding the products, such as being comfortable and easy to wear, being invisible in public, being customizable, and giving the user a feeling of trust in the product.

I have continuous explored these problematics and made a deeper research on what specific problems the users face with their current products. Some of the key problems were:

Psychological problems

- Needles used for monitoring and the pump feels invasive and creates an uncomfortable situation when inserted.
- Users are vulnerable if technical errors occur as it makes them feel more insecure.
- Users tend to want to hide the products due to the visual appearance of products

Figure 2) Psychological problems

Physical problems

- It is time consuming to manually collect and enter data into the insulin pump.
- Many users get a rash from the current products with patches and some people are allergic to them so they cannot use the products.
- The user needs many different products which takes up space and the user needs to have a bag to storage them in.
- In the case of users wearing a pump, it can be difficult to find a place to attach the pump to clothing.
- Users of current products suffer from interrupted sleep.

Figure 3) Physical problems

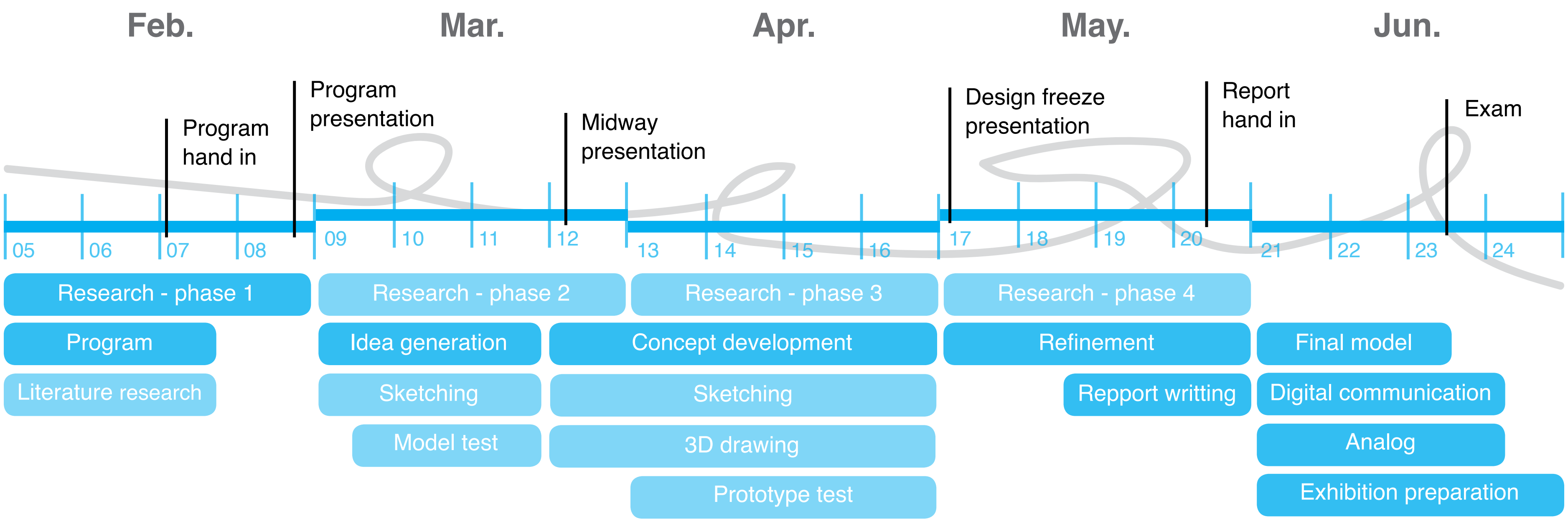


Figure 4) Timeplan

ORGANISATION STRUCTURE

One essential part of doing a master thesis project is to manage the project by yourself. To be able to make the most out of the project it was important to organise and plan the time. Therefore a general timetable was made.

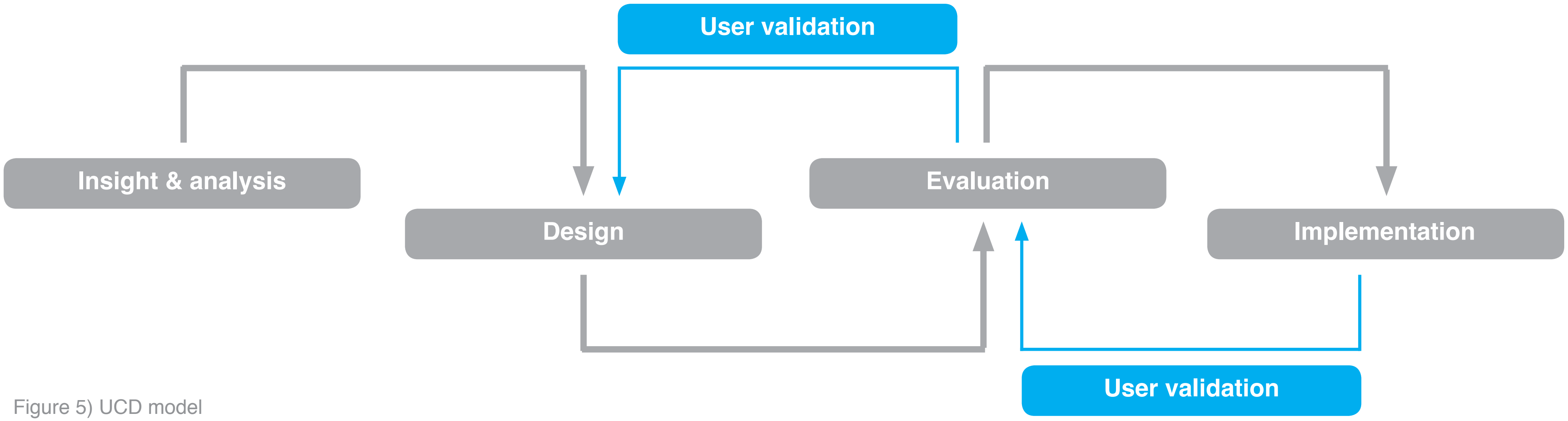


Figure 5) UCD model

METHODS & STRATEGY

Medical device design and development is a complex process and requires structured processes.

The main model I have used in this project is a user centered design process (Norman, 1998). User-centered design (UCD) is an iterative design process that focuses on the users and their needs in each phase of the design process. UCD calls for involving users throughout the design process via a variety of research and design techniques to create usable and accessible products for them.

I decided to work along the lines of UCD, because my goal with the project is to create medical equipment that are more relevant in the users everyday life. It has therefore been necessary to work collaboratively with the users in the project to be able to design for them.

PROJECT APPROACH

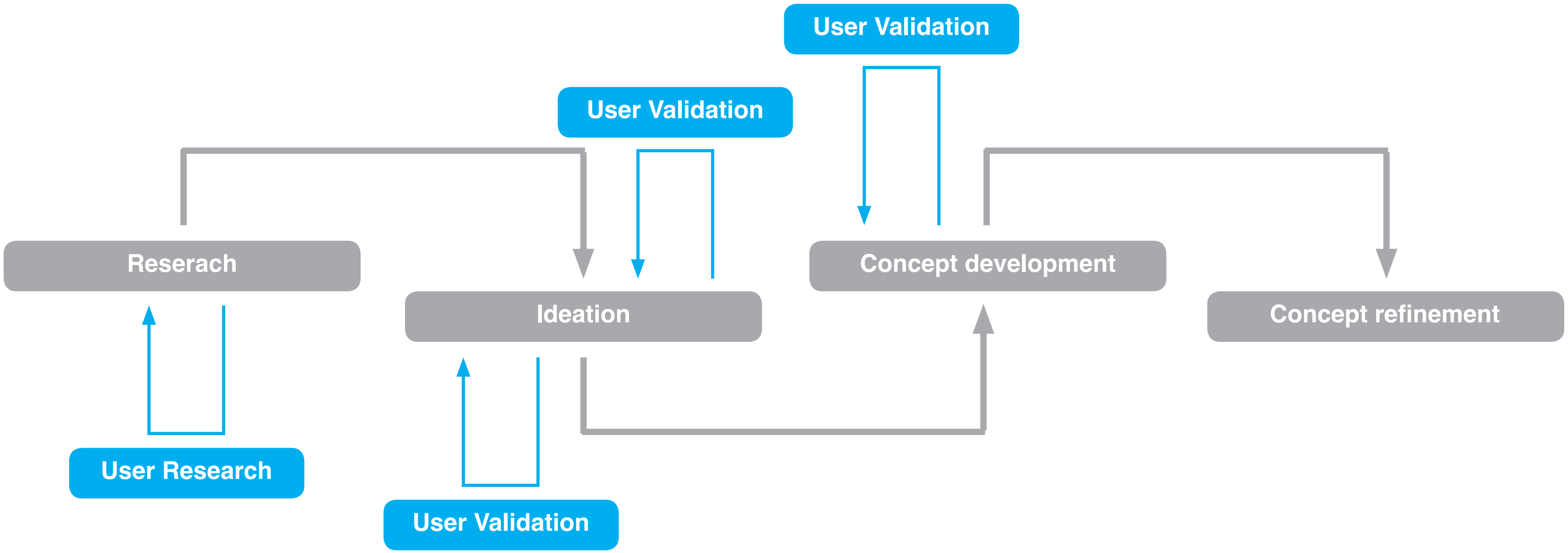


Figure 6) Project process approach

PROJECT PHASES & TOOLS

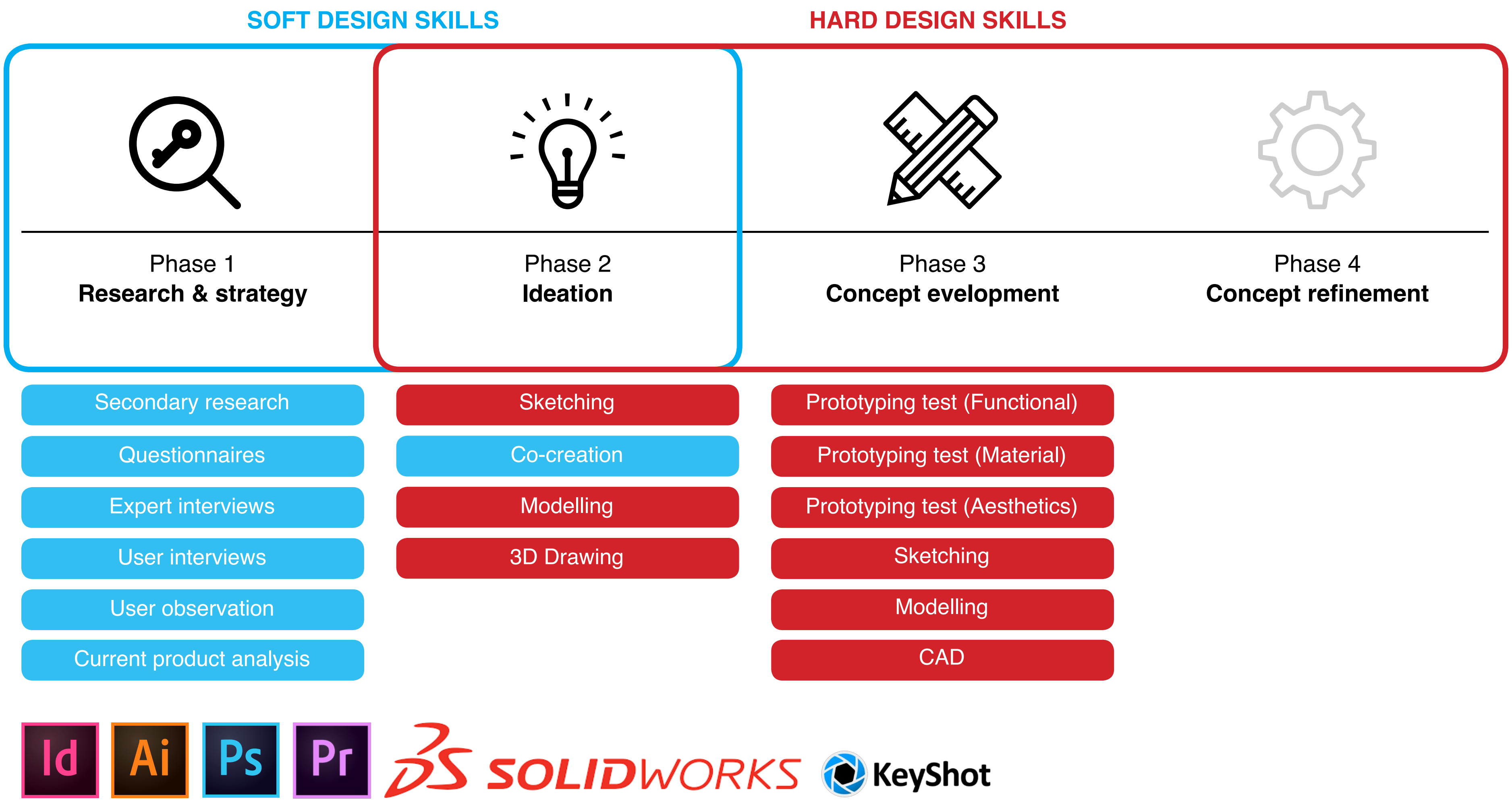
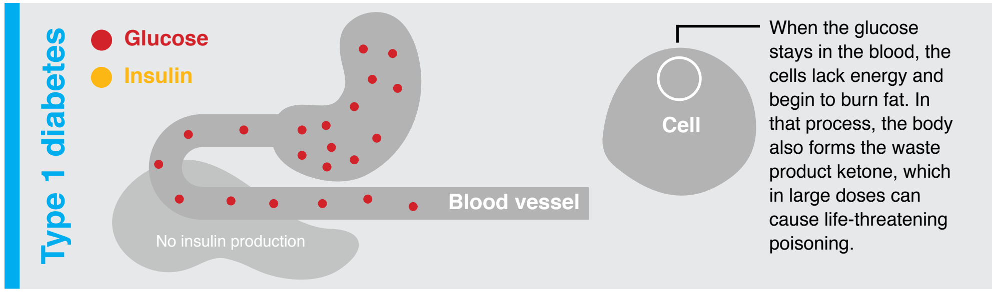


Figure 7) Project phases and tools

SUBJECT & BACKGROUND



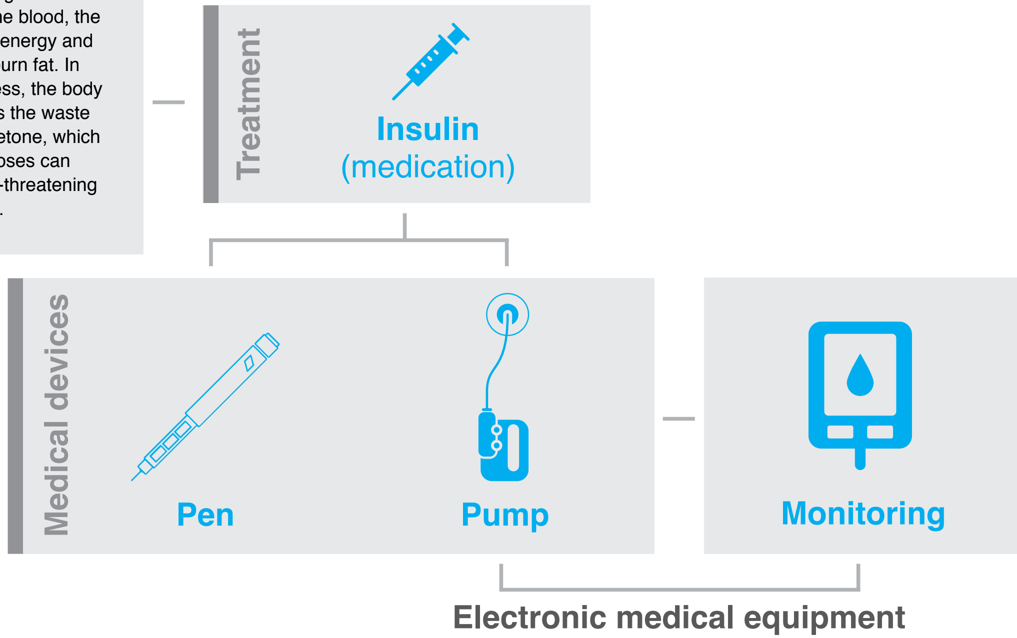


Figure 8) Diabetes and treatment

DIABETES & TREATMENT

Living with type 1 diabetes means that your body no longer produces insulin by itself. Therefore, patients need to give to their body the vital insulin with insulin injections.

When we eat and digest food, carbohydrates are transformed into sugar (glucose). Sugar is a necessary fuel for the cells and helps to give us energy. The sugar can only penetrate into the body's cells and give us energy using insulin.

In type 1 diabetes, the body completely stops producing insulin. The cells that produce insulin have been destroyed by the body's own immune system, which mistakenly perceive the insulin producing cells as a foreign body. Scientists do not yet know what triggers Type 1 diabetes, and therefore, the disease cannot be prevented or cured.

When you have type 1 diabetes you need to take over the pancreas function manually by injection insulin into the body and to know when and how much insulin to inject, the patient need to monitor the blood glucose level.

There are many different types of products that can be used to treat type 1 diabetes. Early on in this project, I decided to focus on developing electronic medical devices, because I found that one of the main problem for users was the task of manually controlling their diabetes. This requires a lot of time and planning. I came to the conclusion that the electronic devices, the creation of a more automatic system, held the biggest potential.

BLOOD GLUCOSE MONITOR

Blood glucose monitoring is a way of testing the concentration of glucose in the blood. Stable blood sugar close to normal is important for doing well in everyday life and for reducing the risk of complications. What your blood sugar should depend upon is determined by several factors, such as; what you have done or should do, your type of diabetes, your age, and any complications the patient may have related to diabetes.

MARKET

In the project I have mapped out the market of current products for type 1 diabetes patients to get a better understanding of how existing products function and why. Furthermore, I collected some of the most recommended diabetes solutions on the Danish market to disassemble them and get knowledge about the product build-up and technical details.

Abbott Freestyle Libre

Image 6) Abbot CGM

Eversense

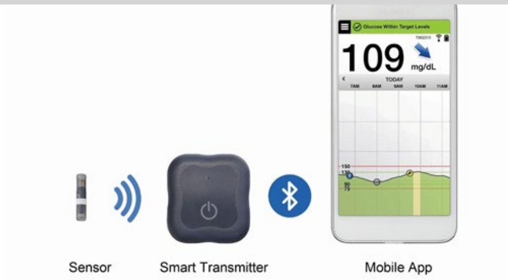


Image 7) Eversense CGM

Abbott Freestyle Libre
Disassembly

Image 8) Abott frestyle libre parts

Image 9) Abott frestyle libre disassembly

INSULIN PUMP

An insulin pump is a small battery-powered and computer-controlled machine that constantly leads insulin into the body.

People without diabetes constantly produce a little insulin. When they eat a meal, the pancreas automatically supplies to produce all the insulin that is needed. The insulin pump mimics insulin production and continuously transfers a small amount of insulin, but it cannot automatically transfer the extra insulin that you need when you eat carbohydrates. Therefore, you must measure blood glucose before a meal and evaluate how many grams of carbohydrates it consists of. When entering the information in the pump, it suggests how much extra insulin is needed to cover the upcoming meal. Once approved, the insulin is transferred.

Medtronic 530G with Enlite

Image 10) Medtronic tube insulin pump

OmniPod

Image 11) Omnipod tubeless insulin pump

Omnipod tubeless pump
Disassembly

Image 12) Omnipod parts

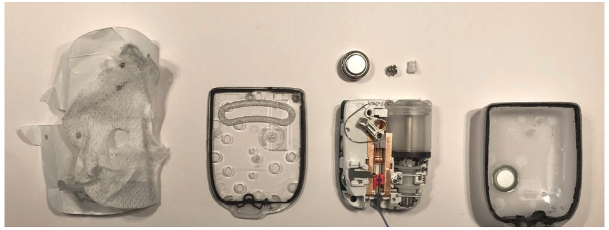


Image 13) Omnipod disassembly

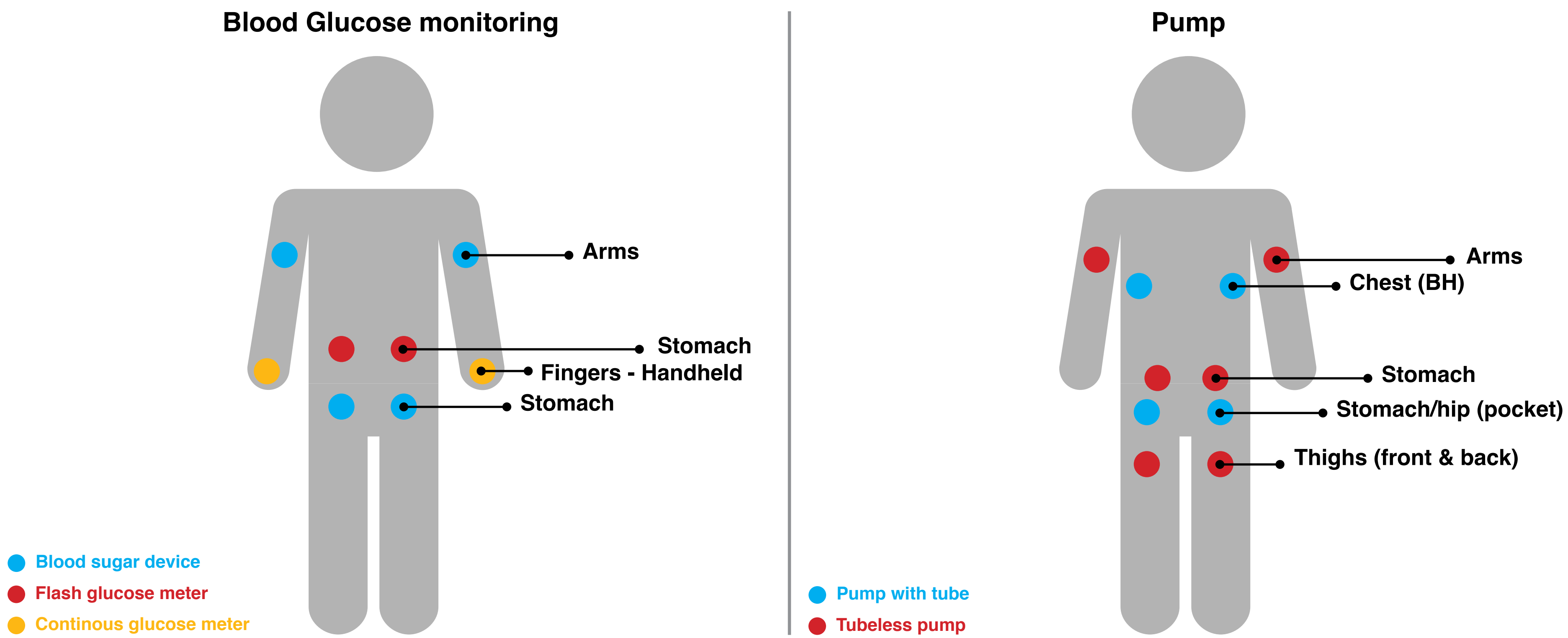


Figure 9) Product placement on body

PLACEMENT OF PRODUCTS ON BODY

Both the monitor device and the insulin pump are wearable objects and can be placed in different places on the body, it usually depends on the users individual preferences. There are some limitations, however, as they have to be placed on the upper arm, upper leg, stomach or buttocks. Above, I have mapped out where the products could be placed to understand which parts of the body I have been working with, because this has affected the form and function of the solution.

Figure 10) Target group and Sub target groups

TARGET GROUP

Target group

Type 1 diabetes usually affects children or younger adults in quite severe ways, because during this phase of life individuals are growing up and are focusing on getting independent and finding their own identity. They start being responsible for their own lives, they start drinking, having sex and spending more time alone. It is challenging for anyone who has to live with type 1 diabetes, but having this disease while going trough this transformation phase creates even more complications. I based my project on this target group both because it was here I found most problems in my research, but also because I think this is an interesting target group to work with. The project has been limited to working with 9 users in the age group from 12 to 25 years, located in Denmark.

CONTEXT

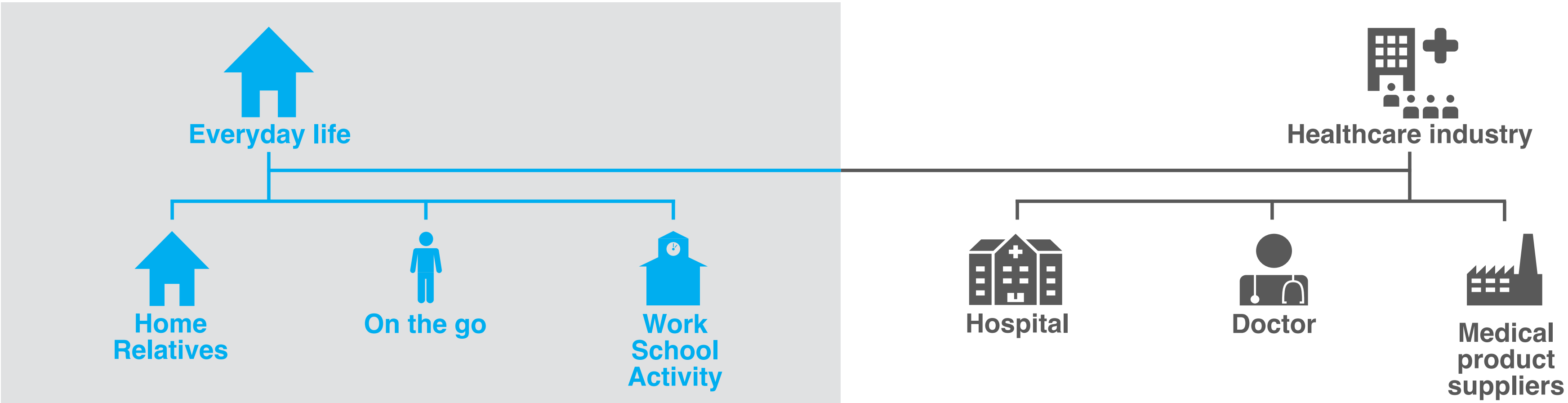
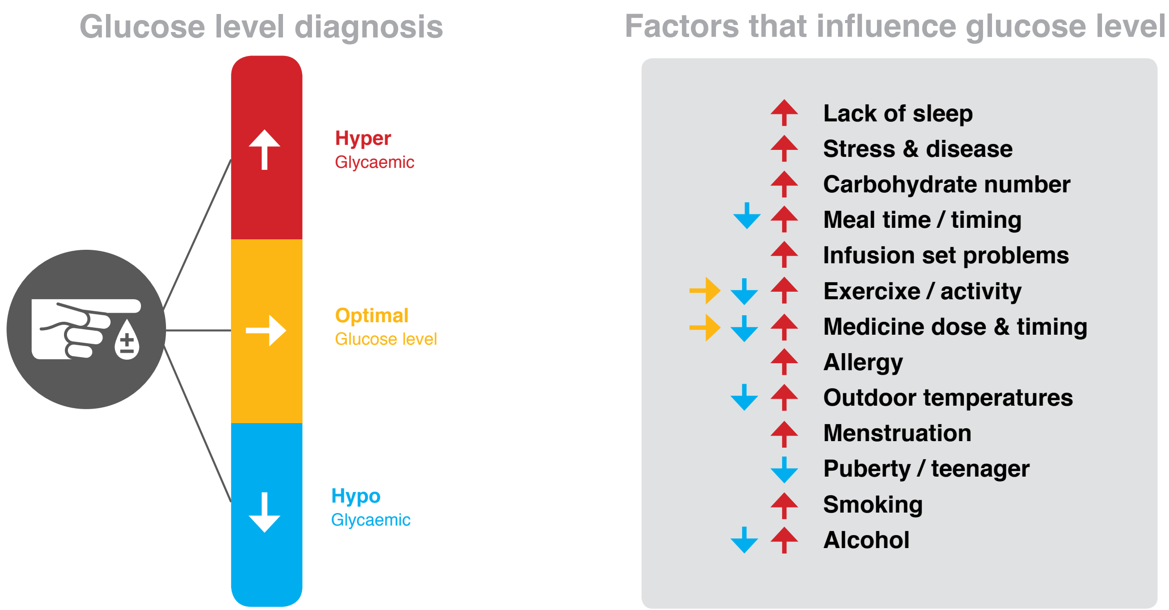
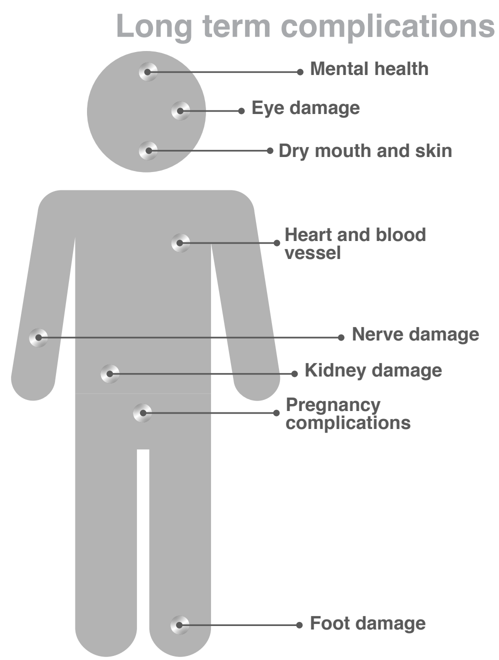


Figure 11) Context





PHYSICAL IMPLICATIONS

Figure 12) Physical diabetes implications

There are several physical implications with having diabetes and to understand what happens to the body has been relevant to my project, because some of the design decisions have been taken to accommodate the different physical implications the users have. As an example, diabetes patients often have problems with their eye vision and therefore they cannot see small buttons or interfaces. I also explored the symptoms of patients when their blood glucose level is high or low because it is often in this situation that the patient needs to interact with the devices. For example, if the user is shaking because of low blood glucose level, it is important that the products are easy to interact with despite the shaking. An activity like walking or training also affects the blood glucose level, but the user often does not need any insulin in these situations. Therefore, I have worked with designing a feature in the pump, which stops or only gives a small amount of insulin when the user is active.

Figure 13) Key physchological diabetes implications

PSYCHOLOGICAL DIABETES IMPLICATIONS

Chronically ill patients do not only have physical problems but also psychological challenges, and I believe these have been as important as the physical and technological challenges in this project. In this part I will unfold some of the key psychological problematics that I have considered.

It is difficult to cope with a chronic illness and one of the elements that affect this is the persons feeling in a social context. Coping with a chronic illness does occur in broader social contexts, which include family, friends, neighbours, the community, employers, schools, and the health-care service. The different context a person is put in influences its behaviour. Miller (2000), emphasise that the major social coping tasks for individuals with a chronic illness include maintaining a sense of normalcy, adjusting to altered social relationships, dealing with role change, dealing with the social stigma of illness, and maintaining a feeling of being in control. In this project I have worked to create a design focusing on maintaining a sense of normalcy and control for the user.

Trough my research I also learned that people with type 1 diabetes experience stigma. To be able to accommodate this in the design solution I explored peoples psychological reaction to stigmatisation. Wright (1983) has described three different types of responses of individuals to stigmatising behaviour. First is to ignore it, bury one's head in the sand. Second, overreact with rage, retaliation, and overt hostility; and third, use humour, which may result in further self-depreciation. These different behaviours are affected by the personality factor and therefore how the types of behaviour influence the person will be unique to each individual. Some people may prefer to ignorer a situation to feel more normal, when others prefer the two other types, but because of peoples different preferences this can easily create a miscommunication between the patient and non-patient. I have considered this in the design suggestion by designing objects that are customizable to accommodate each individual's preferences.

RESEARCH

PROCESS SUMMARY

Figure 14) Research summary

Secondary research	User Quostionair	User Interviews	User observations Observations	Product disassembly
In this part I gathered information trough desktop research. Both on user platforms and in academic articles. I did this to gain general knowledge about the project area.	In this part I did questionnaires with a broad group of users. Both people using non-electronic and electronic diabetes products. I did this to gain a broad understanding of the user problems and find out where I should focus the project.	In this part I selected users that fitted to the project focus and did in-depth interviews with them. The purpose of this phase was to increase my knowledge about the users.	Following the interviews I made user observations to gain knowledge about the problems the users did not necessarily think was a problem.	To be able to understand the current products and how they work I collected different products and disassembled them to learn about how they function.
Tools: Desktop research	**Tools:** Questionair, photo	**Tools:** Interview questions, photo, moodboards, user diary tool	**Tools:** Photo, video	**Tools:** Photo, video

PROBLEM IDENTIFICATION

The problem identification was done by using 3 methods to gather information.

I made a questionnaire with open-ended questions with the goal of gaining an understanding of the life with type 1 diabetes and to form an overview over the initial problems. I shared the questionnaire on a Danish Facebook group called "type 1 diabetes" targeted users aged 15-30. I obtained answers from 18 people, where 9 of the users answered the questions in depth. As expected the answers from the questionnaires only gave me insights into initial problems, such as, how it is uncomfortable to insert the needle from the insulin pump catheter into the body. To get more in depth understanding of the users problems I performed interviews with 3 users.

The users were:

- A male aged 23 with a tube insulin pump
- A male aged 12 with a tubeless insulin pump and a Continues glucose monitor
- A female aged 20 with a tube insulin pump and a Continues glucose monitor.

From these interviews I got more in-depth insights into the problems the users have. For example, the users are dependant on the electronics in the medical devices to function at all times. Because of the dependency of the electronic medical devices, the users are more vulnerable if technical errors occur and this makes them feel more insecure. For this reason, two of the users I interviewed had a manual needle blood glucose monitor with them, simply to feel more secure.

Simultaneously with the interviews I conducted observations of the users, using their medical equipment and performing everyday tasks in their home. The priority in this stage was to gain knowledge that the users did not yet describe. Even though the user does not experience a situation as a problem it could perhaps still be one.

The challenge in this approach was to be able to document all the information. To ask questions, note and record at the same time may have caused me to miss some insights because of the many tasks I had to perform at once. Reflecting back over the process it could have been an idea to split up the interview and observation part into two individual sessions. It could also have been useful to create a diary tool for the users so they could have recorded a day in their life. Furthermore it would have been a good idea to be two people conducting the interviews, so one person could ask questions and the other could record.

USER JOURNEY ANALYSIS

From the observations and the discussions with the users I mapped out the tasks the users had related to their diabetes from morning to night. The tasks vary from individual to individual depending on their daily routines and plans, but this map gave me an overview of the tasks that they have to perform.

There are several tasks the user has to perform trough a day related to their diabetes. The one the users emphasized as the most problematic were:

- Structuring and planning the day according to their diabetes
- Inserting catheter for tube insulin pump and inserting continuous blood glucose monitor into the body.
- Double-checking blood glucose level when the continuous blood glucose monitor is not monitoring correctly.
- Storage of all the different medical equipment when the user is on the go.
- Calculation of carbohydrate intake from food eaten.
- Manually data entry of blood glucose level and carbohydrates into the insulin pump, that has to be entered into the insulin pump so the pump know how much insulin to transfer.
- Finding the right placement of insulin pump and continuous blood glucose monitor.
- Sleeping with the insulin pump.
-

Figure 15) Tasks analysis

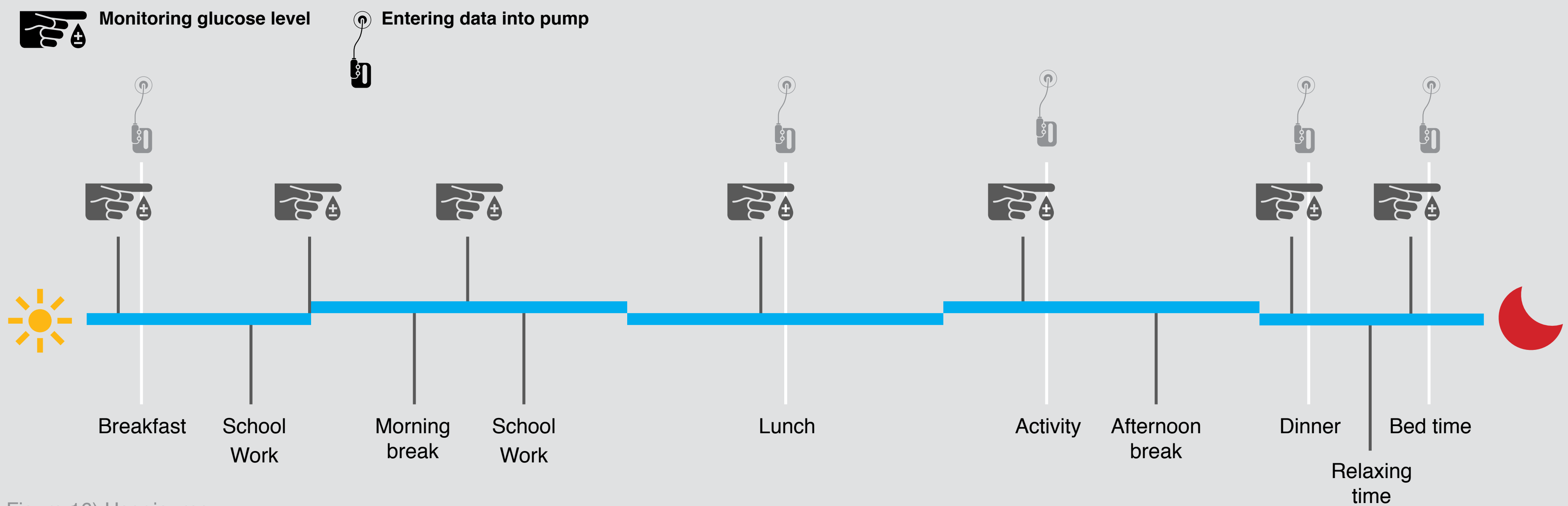


Figure 16) User journey

PROBLEM FORMULATION

Situation

The user has to insert a pipe into the body with a needle to transfer insulin into the body and the continuous blood glucose monitor sensor also has to be inserted with a needle into the body.

Problem one

The current medical devices are connected to the body with a needle, which feels invasive for the user and creates an uncomfortable situation when the users have to attach the devices to their body.

Image 14) Key problem 1

Image 15) Key problem 2

Situation

The user manually have to enter the data of the blood glucose level and the carbohydrates they have obtained trough food into the insulin pump, so the pump know how much insulin to transfer.

Problem two

Manually collecting and entering the data into the insulin pump is a task performed approximately between 6-12 times a day, it requires full focus and is time consuming.

Image 16) Key problem 3

Situation

The CGM monitor and tubeless insulin pump only comes with one type of patch, needle and pipe.

Problem three

The users have different skin types and many users get rashes from the current patches, needles and pipes. Some people are allergic to them so they cannot use the products.

Situation

The users are dependant on the electronics in the medical devices to function at all times.

Problem four

The are left vulnerable if technical errors occur. This makes them feel insecure, this is why they often carry extra medical equipment around that functions mechanically. Simply to be able to double check their blood glucose level.

Image 17) Key problem 4

Image 18) Key problem 5

Situation

The user needs to use many different medical products troughout a day. Therfore they need to storage in a bag when they are on the go.

Problem five

The medical equipment takes up space and creates practical challenges in the users everyday life as they always need to have a bag with them.

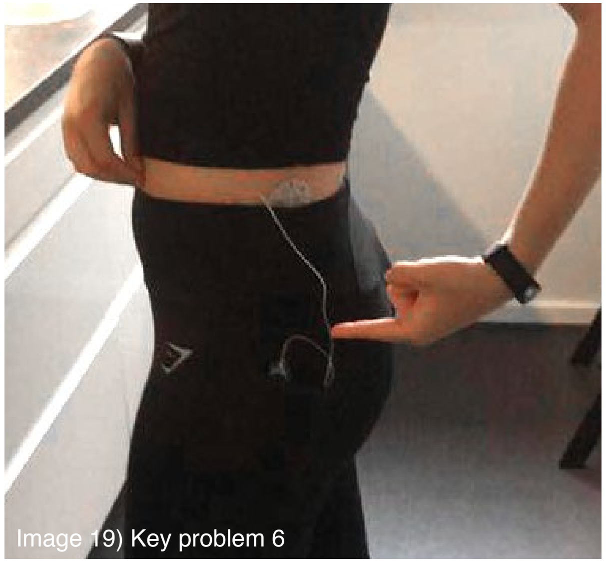


Image 19) Key problem 6

Situation

The user try to hide their medical equipmeny underneath their clothes.

Problem six

The users feel like their medical devices expose their condition, as a result they try to place the devices underneath clothing so they are not visible for strangers.

Situation

Getting dressed in the morning according to the placement of the insulin pump.

Problem seven

The users wear the tube insulin pump by clipping it on to clothing, but it it can be difficult to find a placement for the pump if the user is wearing a dress.

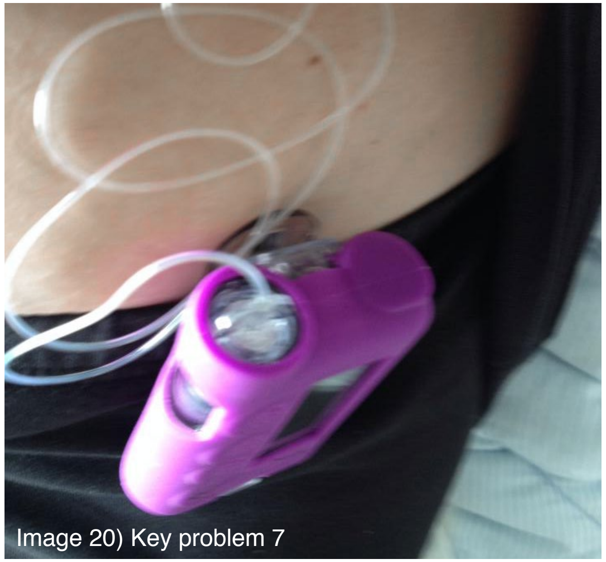


Image 20) Key problem 7

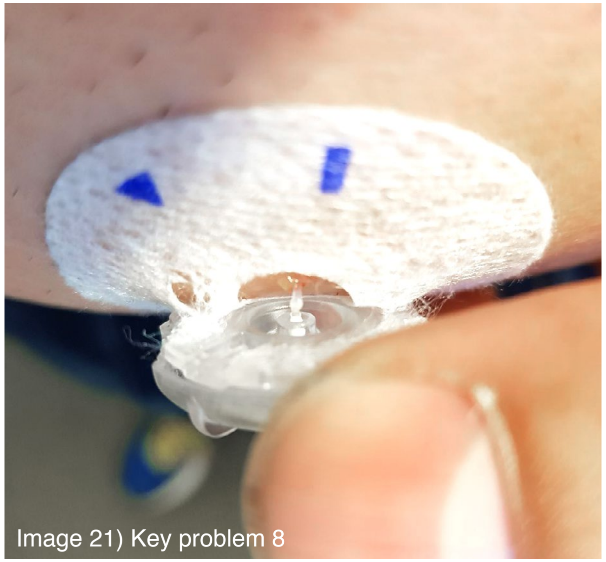


Image 21) Key problem 8

Situation

When the user is sleeping the insulin pump often gets ripped of the skin, the user gets tangled into the tube or lays on top of the pump.

Problem eight

The users often wake up and have an interrupted sleep, which affect them the following day.

DESIGN CONSIDERATION

Emotions
Independence Freedom to control and have a flexible everyday life.
Security Feeling of safety and stability.
Confidence Feeling of certainty in task performance
Sensuality Feeling of an everyday device and not being sick
Power Patients are given control.
Innovation Continuation of the innovative spirit and quality expected of the products.

Identity
Point in time Product must establish a new visual aesthetic in the arena of diabetes products.
Sense of space Design must be approapriate to the human body and the medicin dosage needed.
Personality Appearance to go with the expected image of the patients.

Ergonomics
Comfort Feeling of satisfaction experienced when using product: Components must be comfortable to wear and use.
Safety Product must be safe to use and must not pose a significant threat to the patients.
Ease of use Product functions must be accomplished through a few simple steps: user controls must be easy to learn and to react to: product must be easy to carry and wear.

Impact
Social Should have a positive impact on the quality of the patient experience.
Environment Must be produced to the standards required for medical devices.

Aesthetics
Visual Product must have an appropriate appearence as a complement to high-end computerized technology system.
Tactile Surface and finish must promote effective use.
Auditory Should only create comfortable noises.

Quality
Reliable Product must perform consistently and be easy to service and repair.
Durability Must be able to maintain functionality and appearence appropriate throughout product lifecycle.
Craftmanship Must maintain the integrity expected of medical devices: should not be seen as a cheaper option but rather as a less expensive and invasive option.

Figure 17) Design considerations that have acted like a guideline in the project and as an analytical tool, I have used when evaluating ideas and thoughts.

IDEATION

PROCESS SUMMARY

Figure 18) Ideation summary

100 Ideas	10 Ideas	6 Ideas (User validation)	5 Ideas	4 Concepts (User validation)	Selection
I started the ideation phase with sketching around a 100 ideas, to push myself to think out of the box and sketch also ideas that weren't immediately obvious.	Then I narrowed down the 100 ideas to 10 ideas and furthermore developed these more detailed. With the purpose of getting a deeper understanding of the ideas possibility.	After developing the 10 ideas I realised that a few of the ideas were not relevant compared to my research. I then carried on developing 6 ideas. These were the ideas I tested with users.	From the insights I obtained from the user test I combined and developed 5 ideas in more detail.	I then learned that the 5 ideas had a lot of similarities, so I combined and developed the most interesting ones into 4 concepts. The 4 concepts I developed in models and tested with users.	From the insights I got from the user validation I selected 1 monitor concept and one insulin pump concept.
Tools: Brainstorm, Post-it notes, Sketching	**Tools:** Sketching, moodboard	**Tools:** Sketching, moodboard, models, user testing, InDesign, Illustrator, Photoshop	**Tools:** Sketching, 3D Soliworks	**Tools:** Sketching, 3D Soliworks, models, user testing, 3D printing, InDesign, Illustrator, Photoshop	**Tools:** 3D Solidworks, models, analysing tools

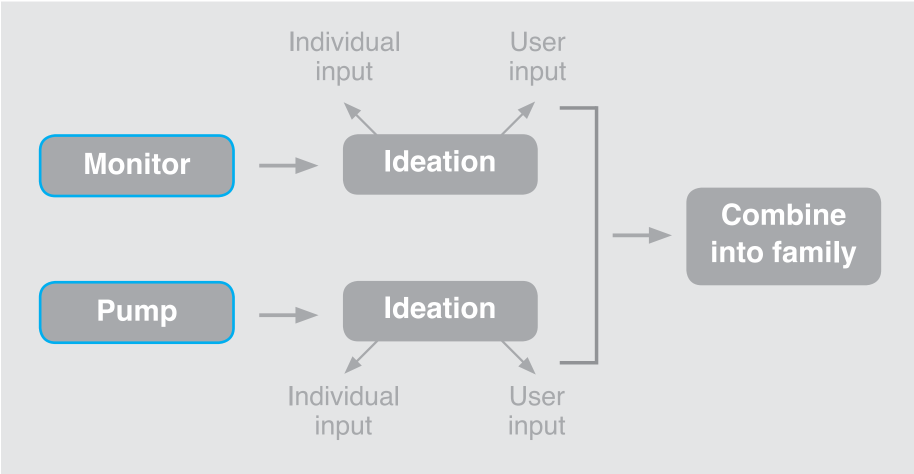


Figure 19) Ideations approach

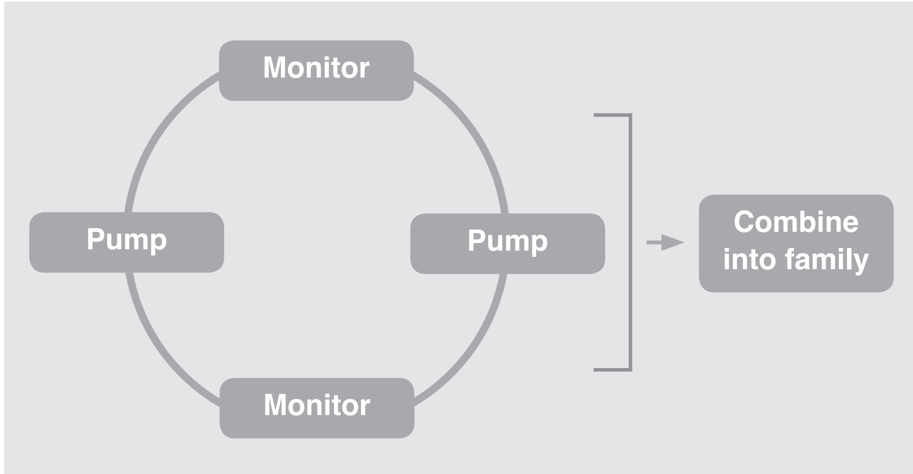


Figure 20) Ideation process

Approach to ideation

The approach to the ideation phase was based on solving the problems recognised in the previous phase. I both ideated on my own and involved the users ideas trough validation sessions with mock-ups. As I have worked with designing two products, I divided them and tried to solve their individual problems before combining them as a family. The two objects were influencing each other and instead of ideating on the two products simultaneously in a linear process, the ideation of the two products inspired each other and the process ended up being more circular. It was difficult to idea generate on them as two separate objects because they work together as a system. By making the idea generation more circular it was possible to view the objects as a holistic system that influences both aspects.

PROBLEM HIRARCHY

Upon starting the ideation phase I organised the problems. The hierarchy of the problems was based on which problems were highlighted by the users as the most problematic ones. It was difficult to know where to start the idea generation phase and the purpose of organising the problems was to create an overview over the key problem field and thereby having a starting point for idea generation and also to use as an evaluation tool for the ideas.

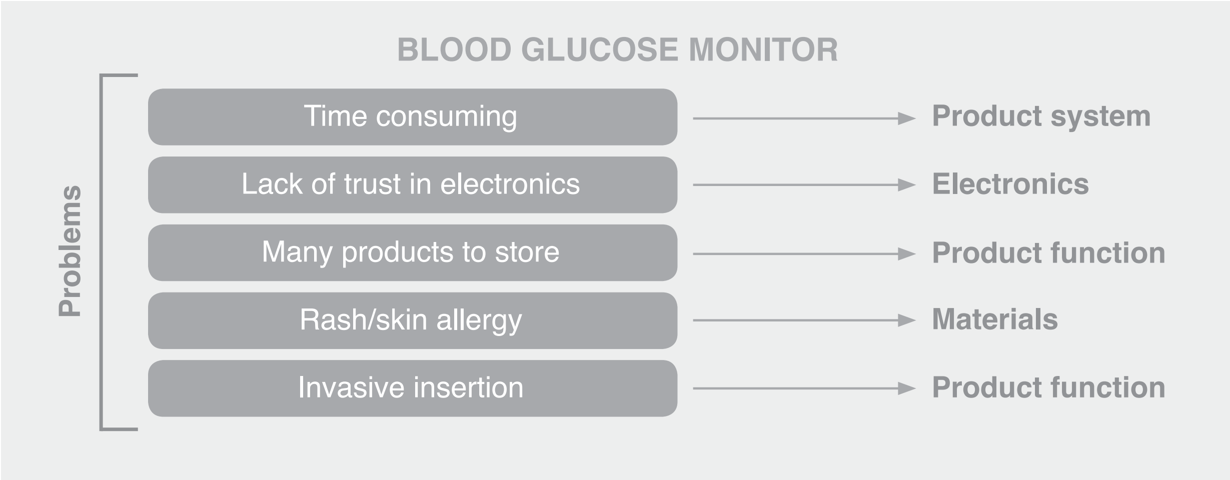


Figure 21) Problem hirarchy for blood glucose monitor

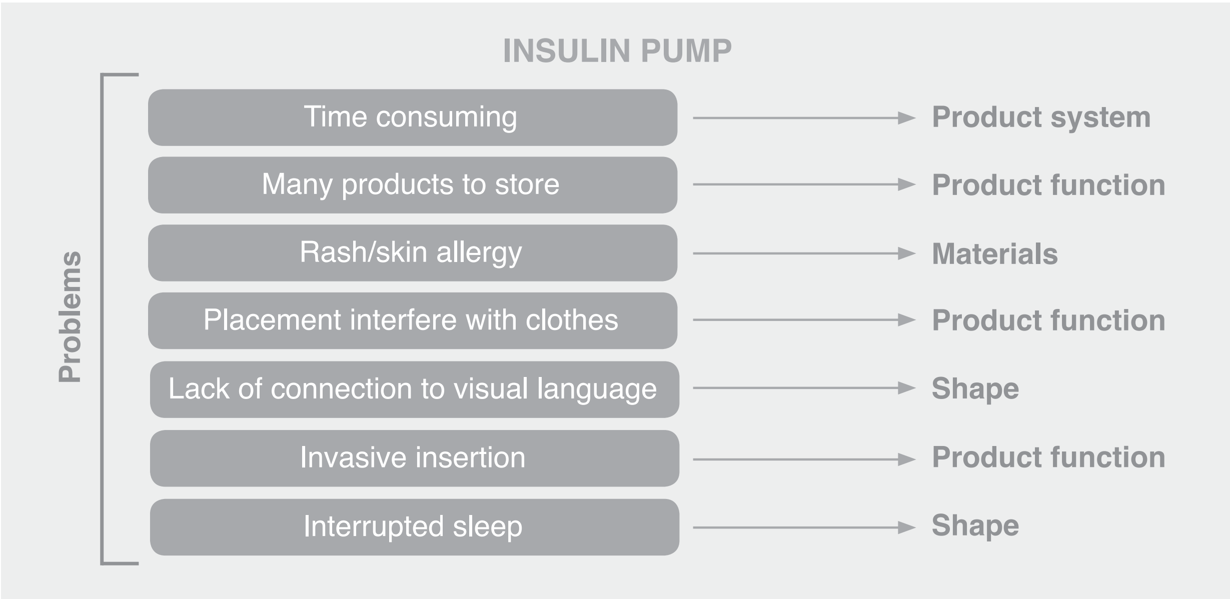


Figure 22) Problem hirarchy for insulin pump

INITIAL IDEAS

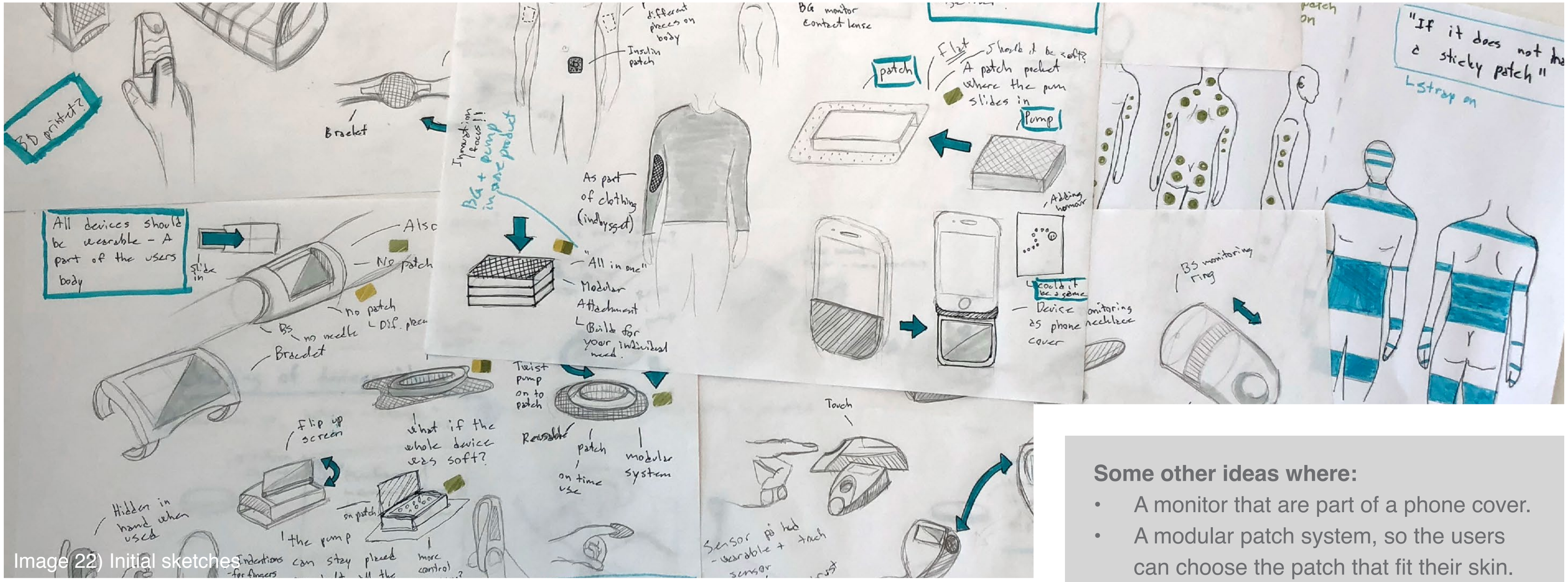


Image 22) Initial sketches

The first ideas were based on solving the problems obtained in the research but they were also inspired from the user interviews and observations. Through the initial idea generation I used my recorded notes and photos from the research phase to inspire me to new ideas. First I sketched approximately 100 ideas, some where realistic and some unrealistic but with the purpose of getting an idea foundation I could then develop further. From the 100 ideas I combined several ideas form that phase into 10 ideas that I continued to work on. As an example; a monitor and insulin pump made up of entirely flexible materials and electronics so it follows the body when it moves.

Some other ideas where:

- A monitor that are part of a phone cover.
- A modular patch system, so the users can choose the patch that fit their skin.
- A system implanted in the body.
- A strap on product that had the feeling of being an accessory and not a medical product.
- A monitor and insulin pump that communicates wireless
- A body powered device without battery.
- A double check monitor, so the user do not need to products to feel secure.

Figure 23) Initial ideas

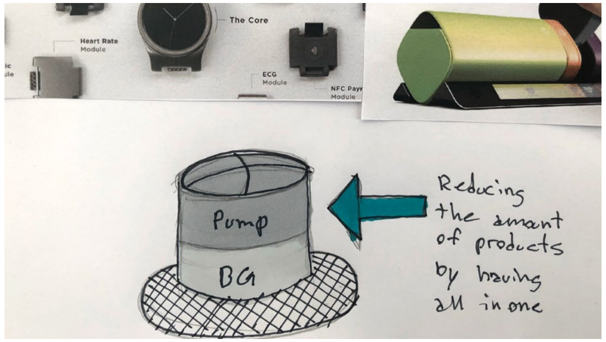


Image 23) **Sketch of all in one concept**

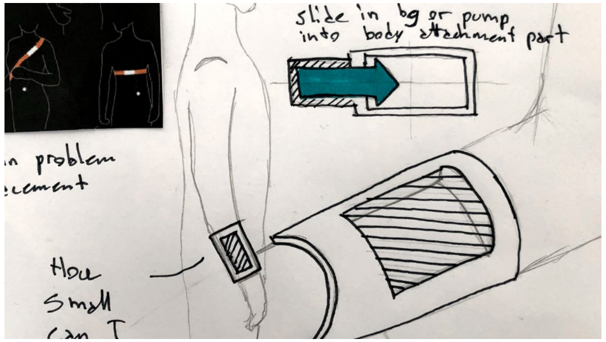


Image 26) **Sketch of strap concept**

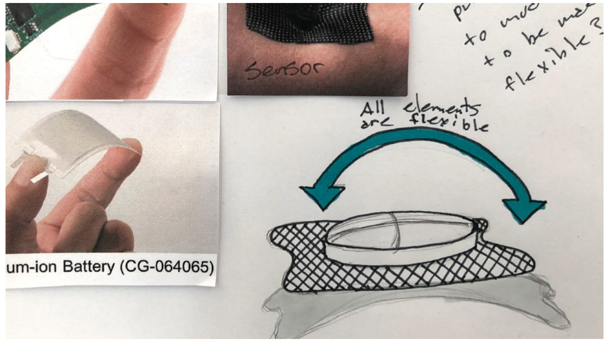


Image 29) **Sketch of flexible concept**

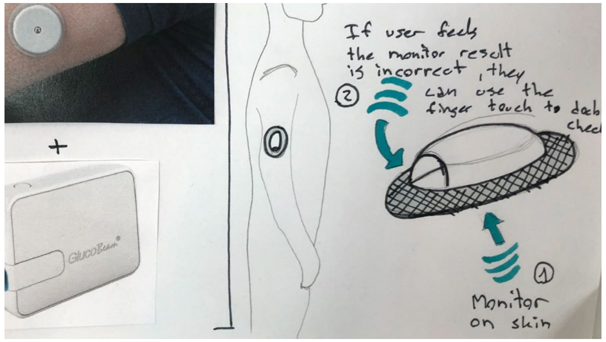


Image 24) **Sketch of double check concept**

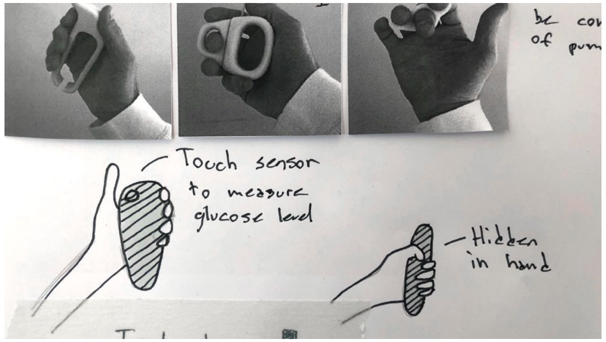


Image 27) **Sketch of part of hand concept**

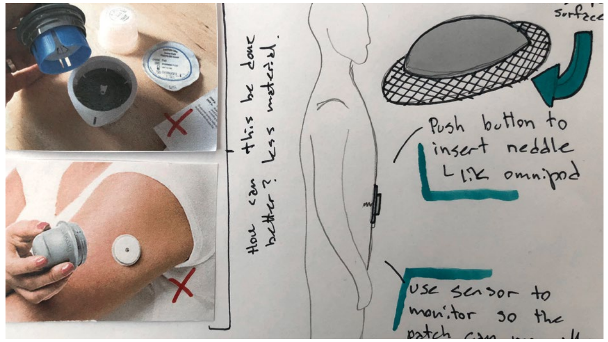


Image 30) **Sketch of easy to take on concept**

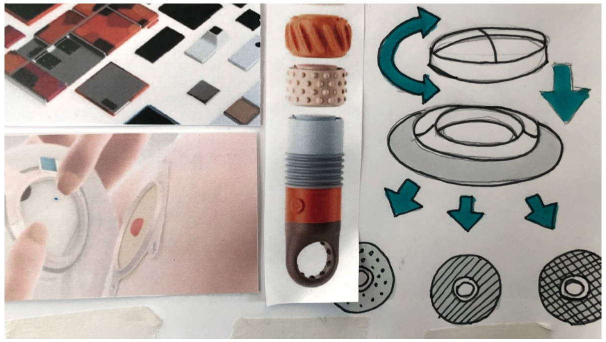


Image 25) **Sketch of modular concept**

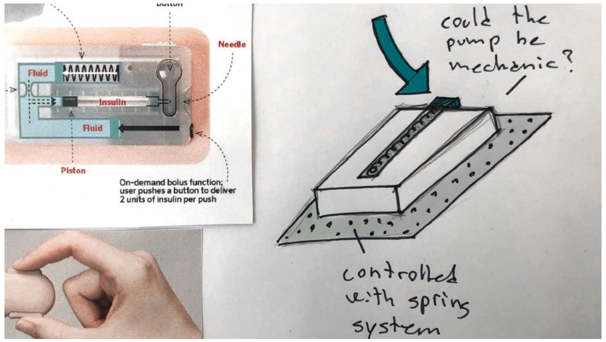


Image 28) **Sketch of flip screen concept**

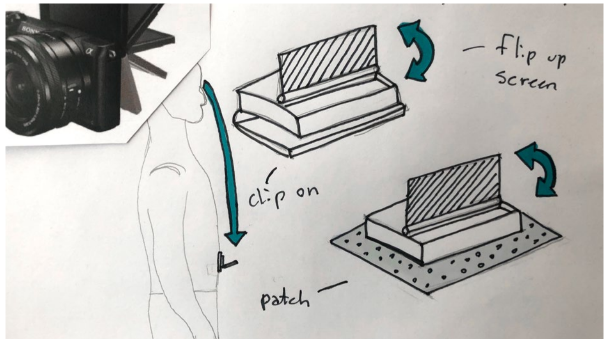


Image 31) **Sketch of mechanic concept**


Image 32) Apple watch


Image 33) Inhalator


Image 38) Woobi play


Image 39) Wrist support

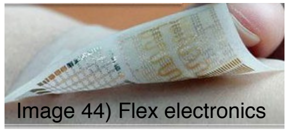


Image 44) Flex electronics

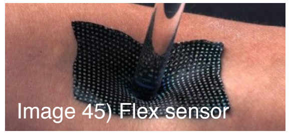


Image 45) Flex sensor

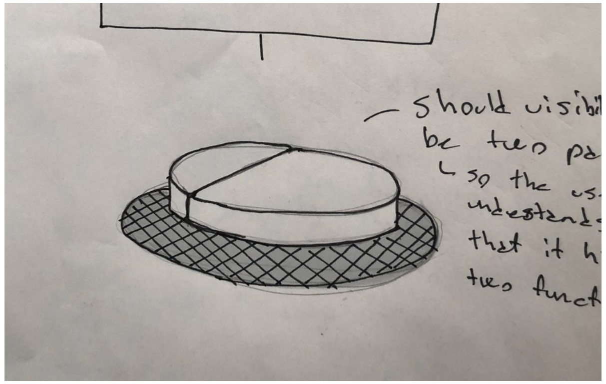


Image 34) Monitor and insulin pump in one

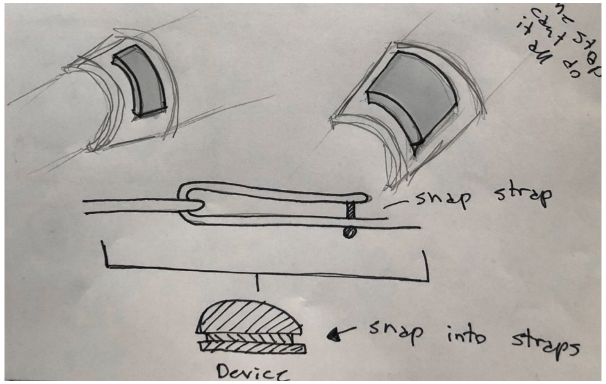


Image 40) Strap on to body

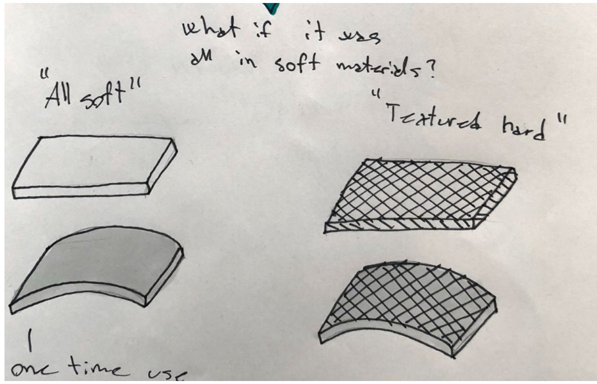


Image 46) All flexible materials


Image 35) Charger

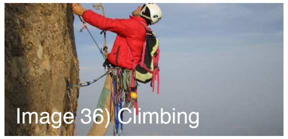


Image 36) Climbing


e 41) Mouse


Image 42) Monitor


Image 47) Modular phone

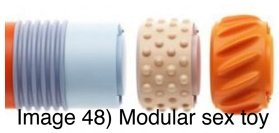


Image 48) Modular sex toy

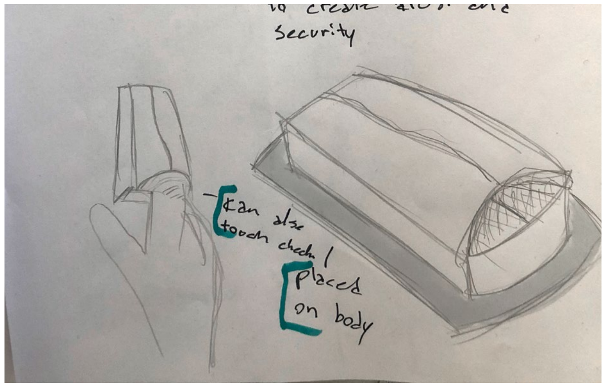


Image 37) Double check monitor

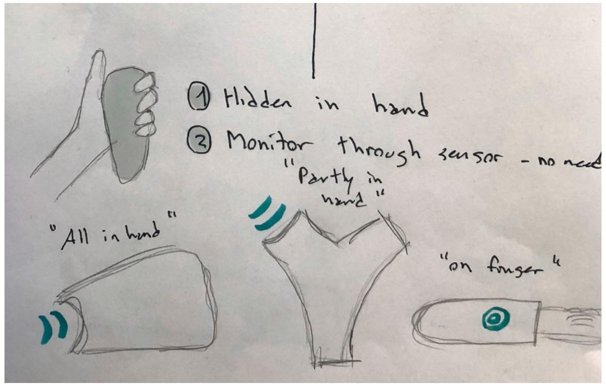


Image 43) Hidden in hand

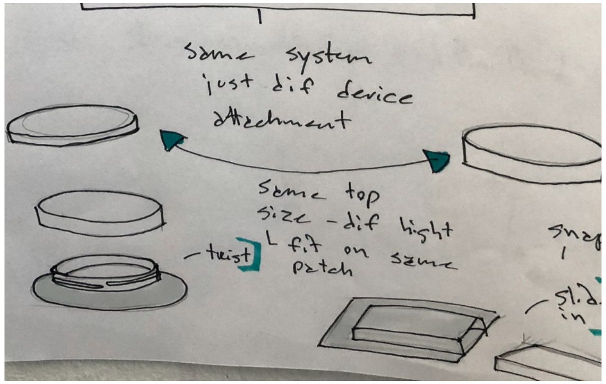


Image 49) Modular system

FIRST USER VALIDATION

Approach to validation

After the initial idea generation I narrowed down the most interesting ideas based on my research and created mock-ups to test with users. My user validation sessions have been limited to one user, a 20 year old female that uses a tube insulin pump and a continues glucose monitor. It could have been ideal to have more users involved in the user validation sessions, because one user only offer one perspective. Several perspectives could have given a more in depth evaluation of the ideas. Several user validation sessios were carried out in the project, in this report I will only show a few examples of these.

My approach to the first user validation session was to create mock-ups with the purpose of using these to test on the users body. As the ideas at this stage were still rough, the mock-ups ended up acting more like a dialog tool as the mock-ups created more questions from the user than actually solutions. As an example the strap on idea with the goal of creating a product that looked and felt more like an accessory, where the strap on the model was made in a material that was not flexible enough so when the user tried on the model it kept sliding down. But the user expressed that the idea about wearing an accessory was interesting because then she would not feel the need to hide the product underneath clothing.

The ideas that was tested in the first user validation session were:

- A monitor and insulin pump build into one
- A monitor and insulin pump that are strapped on to the body
- A monitor and insulin pump only made of flexible materials
- A monitor that the user could check their blood glucose level with two different places on the body
- A monitor that are build into the hand and hidden when used
- A Modular system that could be customized for each user

Figure 24) Ideas tested in first user validation session

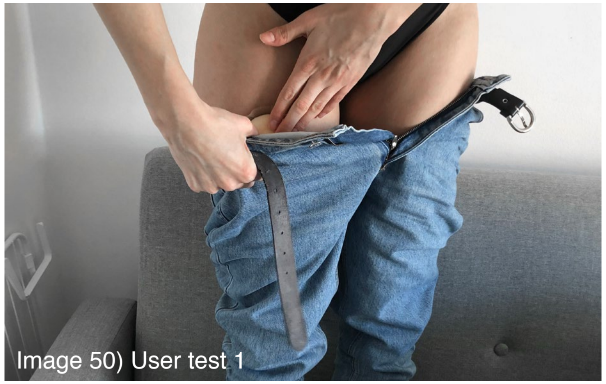


Image 50) User test 1


Image 51) User test 2


Image 52) User test 3

KEY INSIGHTS

Image 53) Illustrates that, It is technically not possible to monitor BG level next to where the insulin is injected because the insulin affects the monitoring results.

Image 54) Illustrates that, the user liked the idea that there are different patches so you can choose the one that fit each individual the best. In general the element of being able to customize the user expressed was interesting.

Image 55) Illustrates that, it worked well that the idea was flat and flexible. The user liked that it felt more like a part of the body because it moves with the skin.

Image 56) Illustrates that, the user thought idea created a feeling of security and that I would reduce the need to have extra monitoring products.

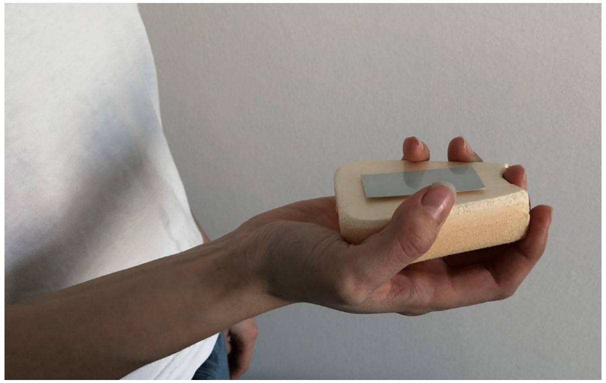


Image 57) Illustrates that, this idea was familiar to the user as it was similar to the existing products. But it is not a possible to make into a circular system - The user has to use it manual and it cannot communicate with pump.

Image 58) Illustrates that, the users expressed that it was positive that there was no patch and it felt more like a watch.

INDIVIDUAL IDEA GENERATION

Image 59) Ideation development


Image 60) Coloplast sensura mio interaction test


Image 61) Idea testing

Ideation development

I used the feedback I obtained from the first user validation session to carry out another individual idea generation session. I evaluated on the users feedback and used the knowledge as inspiration to develop some ideas further. As an example the strap-on idea, were I from the user validation session learned that if the strap is tight to the body, there are rolls of fat on each side of the strap. So I worked further on developing a solution to this problem.

Non-user driven inspiration

Besides being inspired from the user feedback, I also acquired inspiration from existing products functionality. As an example for the modular idea with the goal of creating a product system that fits all sizes and skin types I got inspired from the above product from Coloplast, that has an easy and secure way of attaching product parts together.

Non-user driven test

From the first user validation test I learned that the mock-ups were to rough to test so in this part of the project, I made mock-ups to test on myself both to create mock-ups that had the quality level needed to be able to test with users but also to learn about the initial parts of an idea that was not working. As an example the vacuum suction cup idea, that had the goal of using the body's skin to attach to the body with vacuum. After testing it on myself I could conclude that it was painful and that the vacuum was not strong enough to stay attached to the body if the suction cup bumped into something.

CONCEPTS TESTED IN SECOND USER VALIDATION SESSION


Image 62) **Visualisation of modular patch pump concept**


Image 63) **Visualisation of modular strap pump concept**

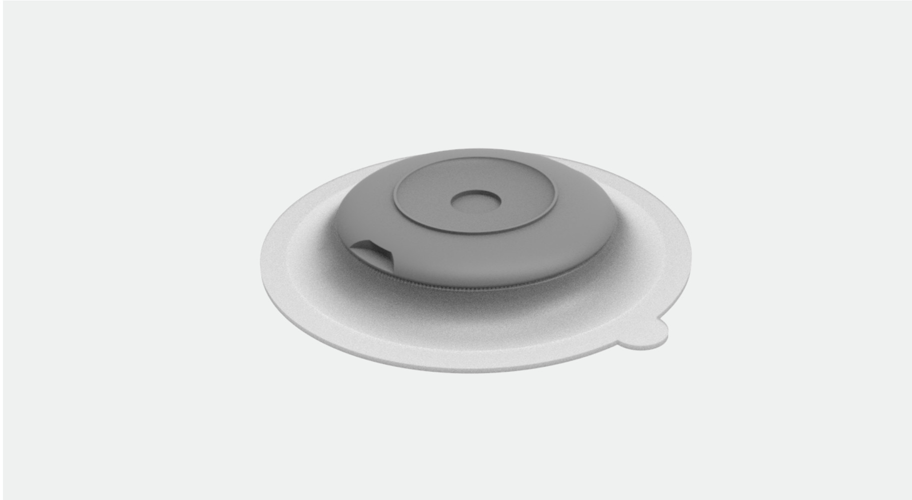


Image 64) **Visualisation of double check monitor concept**

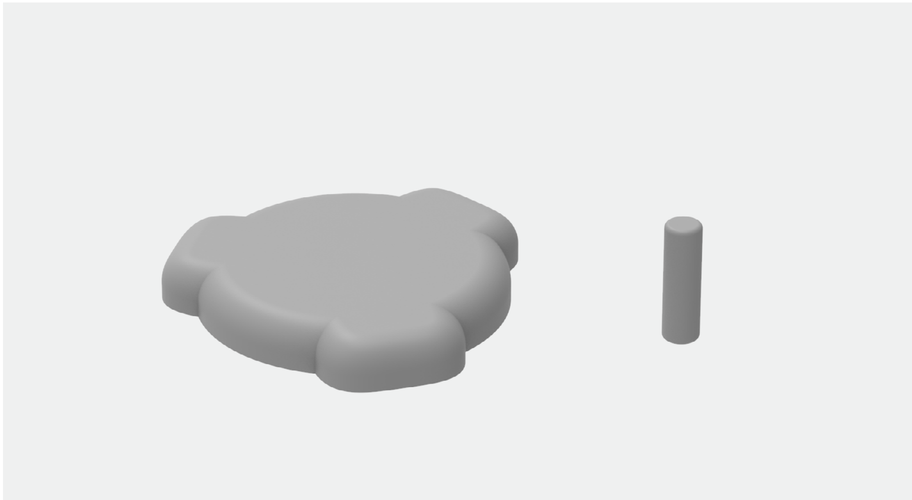


Image 65) **Visualisation of implantable monitor concept**

SECOND USER VALIDATION

Approach to validation

The intention with the second user validation session was, to find out how the user interacted with the concepts and to have a discussion about what worked and what did not work with each concept.

The approach was to make a variety of models for each concept that the user could test. The validation session was carried out in the users home and took 2 hours. As I wanted to learn about the interaction with the concepts I instructed the user to take on the mock-ups on different places of the body.

I also wanted to get insights into how the concepts worked as a wearable when the user was performing everyday tasks and movements. So I instructed the user to get dressed with the mock-ups placed on the body, to understand if it was possible. I also asked the user to reach after something on the top shelf in her kitchen, and to tighten her shoes to observe how the models were acting when the body performed different movements.

The challenge in this user validation session was that it was intimate to ask the user to get dressed and undressed and because she felt uncomfortable in the situation she was not moving naturally, which may have affected the insights. Therefore it was important for the result of this phase to have a further discussion with the user about the concepts, as it was difficult to obtain knowledge only from observations.


Image 66) User test 4


Image 67) User test 5


Image 68) User test 6

KEY INSIGHTS FROM SECOND USER VALIDATION SESSION

Image 69) Illustrates the modular patch pump, which was an idea of an object that is attached to the skin with a patch so it can be placed everywhere on the body depending on the users preferences. It was a modular system, where the user could attach the electronic part to different types of patches depending on the users skin type. The idea was that it was made of flexible materials so it followed the bodies movements. The feedback was that the user felt secure with the pump because it was glued to the skin and it was satisfactory that it was made in flexible materials because it did not feel like a brick that was attached to the skin.

Image 70) Illustrates the strap pump the purpose with the ideas was to try to create a solution that was more related to being an accessory where the patch pump on the opposite side related more to a medical product. The key challenge with this idea was that the user was concerned that it would move and the pipe transferring insulin into the body would then fall out.

Image 71) Illustrates the the double check monitor that was an idea trying to solve the lack of trust the user has in the current wearable blood glucose monitors. This idea suggests a solution of a monitor attached to the arm that automatically monitors and sends the data to the pump, but if the user feels insecure they can double check their blood glucose level. This is done by placing a finger on top of the monitor device. The user therefore has the opportunity of checking their glucose level on two different body parts in one product. My respondent confirmed that she felt very secure and liked that it would reduce the amount of products she needed.

Image 72) The implantable device I could not test, but I made models as a dialog tool. For example, the user thought it would be nice to reduce the amount of time spend on changing and checking the monitor, but she also expressed a concern towards having a surgery to get it implanted.

SELECTED CONCEPTS

Insulin pump

This concept consists of a reusable tubeless insulin pump that connects to a one-time use patch that attach to the body. The pump receives data from the monitor that gives information on how much insulin to transfer into the body. Both the shell and the electronics are made in flexible materials so it adapts to the movement of the body.

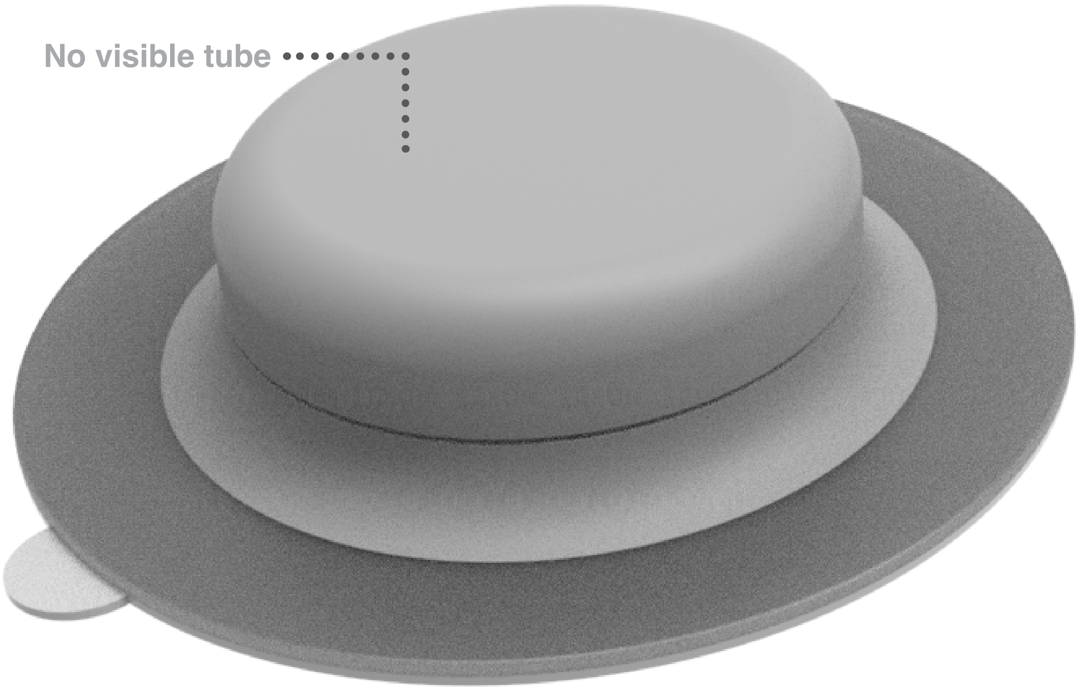
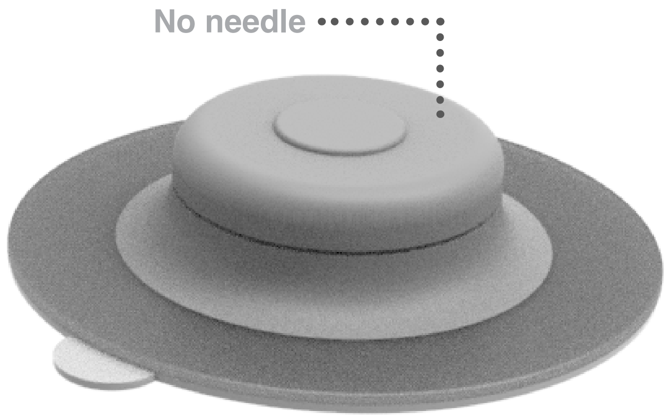


Image 73) Selected concepts



Blood glucose monitor

This concept consists of a reusable blood glucose monitor sensor that connects together with a one-time use patch that is attached to the body. The monitor can also monitor the blood glucose level if the user place their fingertip on the button on the top of the monitor. The monitor measure the blood glucose level with sensor technology, and is not penetrated trough the skin. The monitor sends data wirelessly to the insulin pump. Both the shell and the electronics are made in flexible materials for body comfort.

PRODUCT JOURNEY

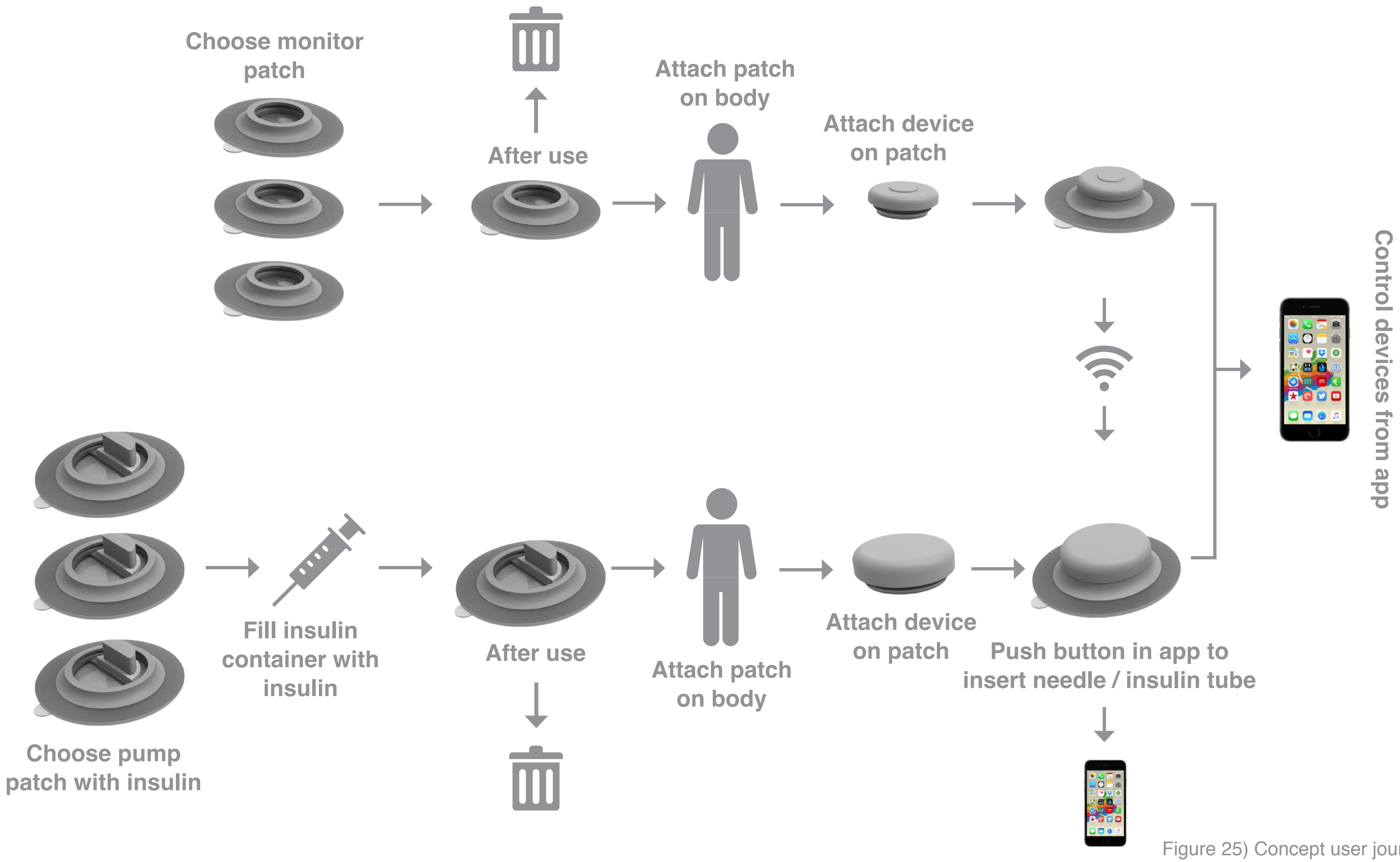


Figure 25) Concept user journey

CONCEPT DEVELOPMENT

PROCESS SUMMARY

Figure 26) Concept development summary

Functional development	Structure development	Shape development	Material development	Colour development	UX development
I developed the 2 concepts further regarding function. I made functional models that I tested with users to understand the user interaction. **Tools:** Sketching, 3D Soliworks, models, user testing, 3D printing, Keyshot	After solving the functional elements I started developing on the technical build up of the concepts. **Tools:** Sketching, 3D Soliworks, 3D printing, InDesign, Illustrator, Keyshot	With all the functional and technical elements solved I developed the shape, focused on my user insights. I developed in 2D and 3D. **Tools:** Sketching, 3D Soliworks, models, 3D printing, InDesign, Illustrator, photoshop, Keyshot	While developing on other elements of this phase I also researched a tested materials to find a material that fulfilled the material requirements the concepts had. **Tools:** Research, test	I then tested different colours and colour combinations based on the users insights. **Tools:** Models, InDesign, Illustrator, photoshop, Keyshot	I early on found out that the experience of getting the products at the hospital was confusing and I therefore wanted to create a user experience the users could emotionally adapt to. **Tools:** Sketching, 3D Soliworks, models, InDesign, Illustrator, photoshop, Keyshot

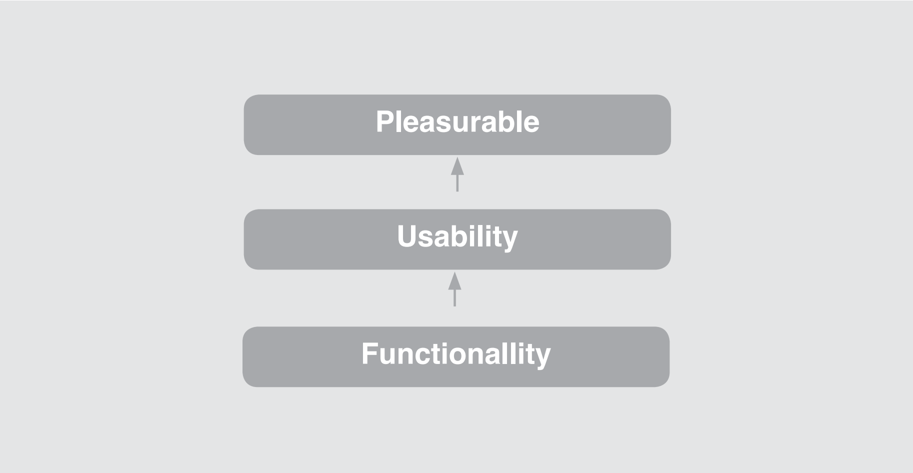


Figure 27) Aarron Walters model

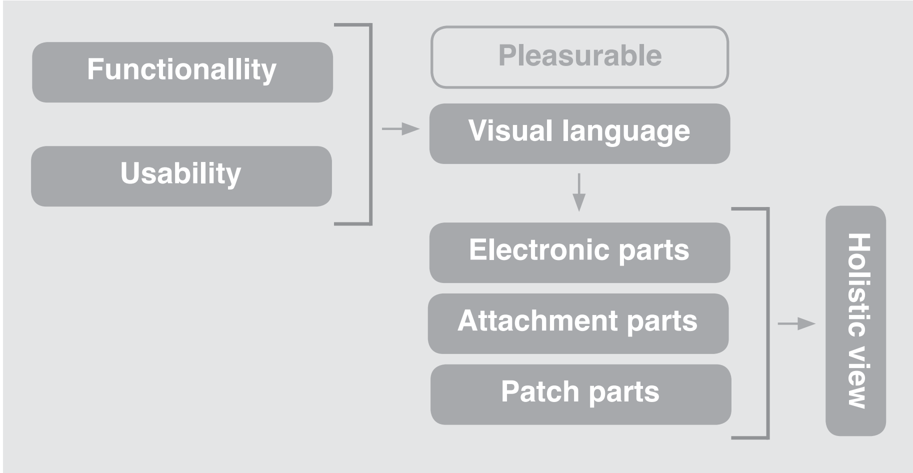


Figure 28) Concept develoment process

Approach to concept development

The approach to the concept development phase was based on Aarron Walters model focused on Designing for Emotion. I carried out the concept development by focusing on designing with one element in focus at the time. Firstly, I developed the functionality and usability trough sketching and models that I tested with non-users and users.

Following, I continued developing the usability and pleasurabillity trough the visual language of the concepts. I did this by making shape experiments in 3D drawings and physical model and testing usability models with users and furthermore having a dialog based on 3D drawings of shape suggestions.

FUNCTIONAL AND USBAILITY REQUIREMENTS

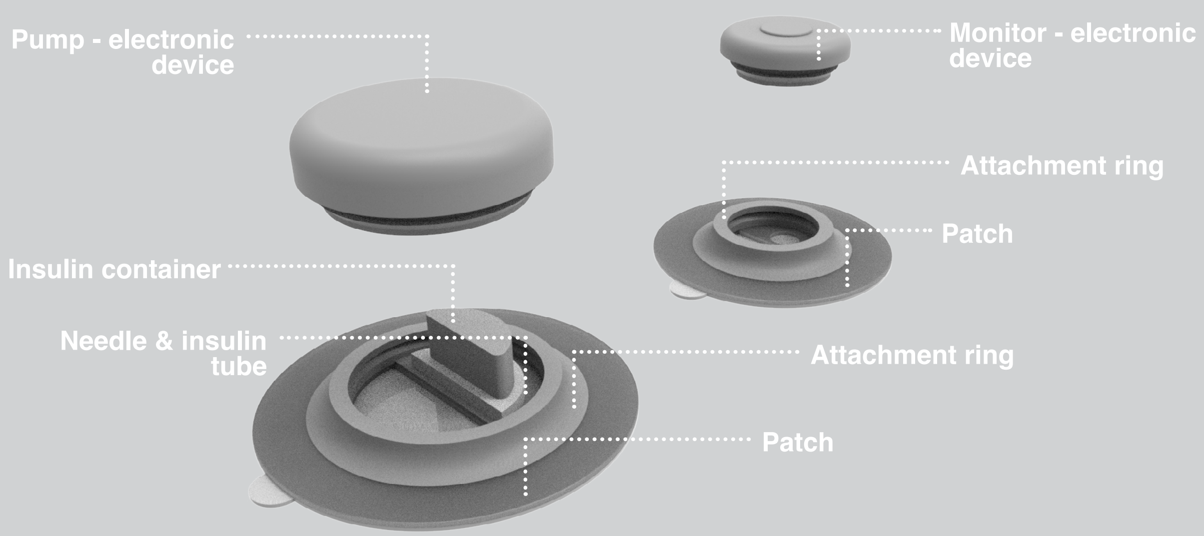


Figure 29) Concept parts

Prior to developing the function and usability of the product I defined the requirements for the two concepts based on the results from explorations. The purpose was to create an overview over the requirements the functional solutions in the product should fulfil.

The requirements for each concept were:

- Should be easy to take on and off body
- Should be easy to assemble and disassemble electronic part from patch
- Should have an indication of when the parts are assembled correctly
- The patch and electronic part should not fall apart when in use

Figure 30) Functional requirements

THIRD USER VALIDATION

Approach to validation

The intention with this phase was to test functional models with the user to learn how the user interacted with the product. To make the session as realistic as possible, I did not instruct the user. I laid out the models on a table and the user then took on the models the way she thought they where intended to be used. The purpose of this approach was to learn about the user interaction without interfering and affecting the user with my own thoughts.

The functions that were tested in this phase was:

- Push snap from top
- Push snap from side
- Snap ring
- Twist
- Twist snap

Figure 31) Functional ideas

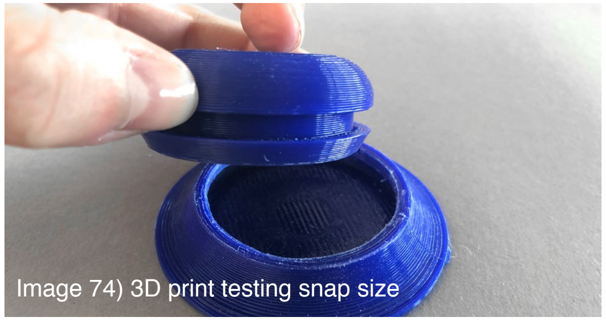


Image 74) 3D print testing snap size

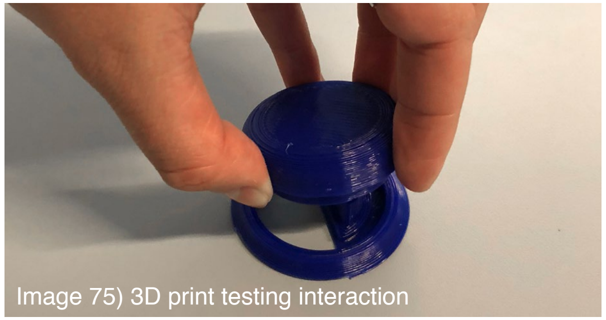


Image 75) 3D print testing interaction

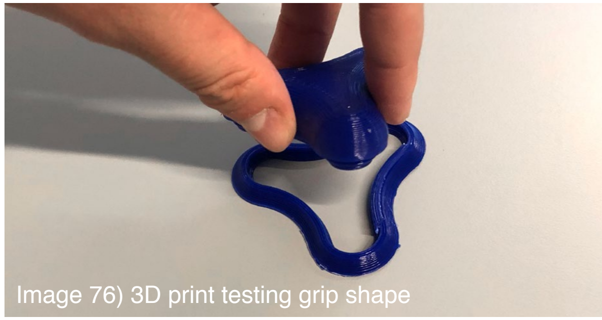


Image 76) 3D print testing grip shape

Image 77) Patch test 1

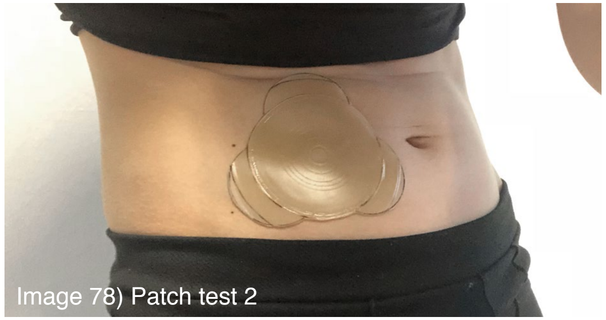


Image 78) Patch test 2

Image 79) Patch test 3

KEY INSIGHTS

Modular attachment 1

Snap from top

Image 80, 81) Illustrates that precision was difficult, it was difficult to find the two holes that the device had to snap into. The user trusted that the two parts were securely attached together.

Modular attachment 2

Snap from side

Image 82, 83) Illustrates that this solution had many things to consider. How should it turn? Where are the holes? The user was worried that it could detach.

Modular attachment 3

Snap Ring

Image 84, 85) Illustrates that the user expressed that this solution was easy to take on. No need to think about which direction it should be placed in. But the solution was missing an indication of when it was attached. As an example it could be a sound.

Modular attachment 4

Twist

Image 86, 87) Illustrates that the idea was easy to use, the user immediately knew how to interact with it. It was uncomfortable to twist the device on to the patch when it was on the skin.

Modular attachment 5

Twist snap

Image 88, 89) Illustrates that it was slightly difficult for the user to find the two holes, as she could not see the device probably because it was placed on the back of the arm. Again it was uncomfortable to twist the device on to the patch.

VISUAL LANGUAGE APPROACH

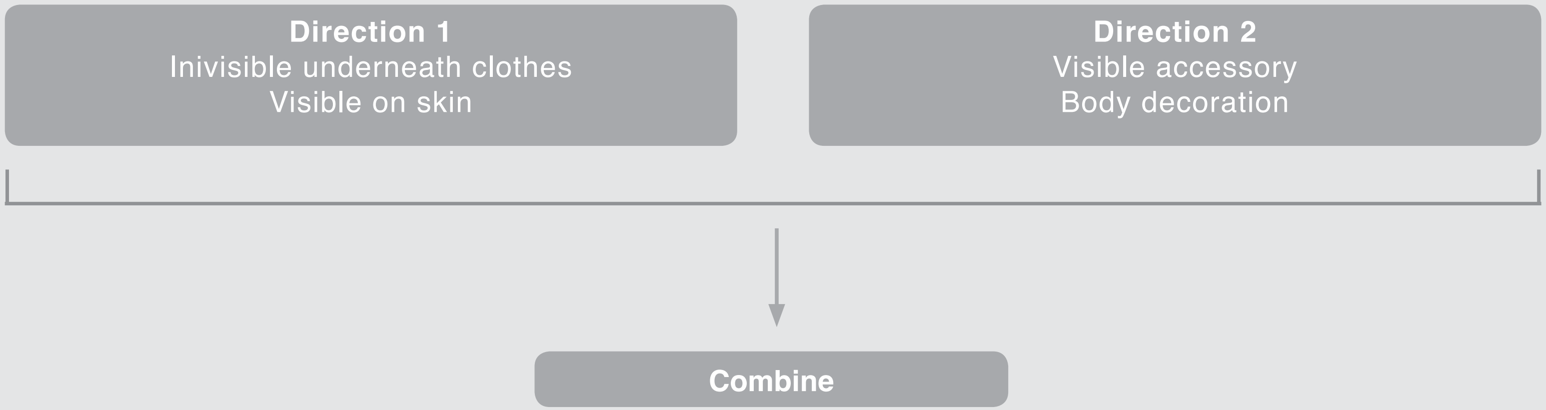


Figure 32) Visual language process

User requirements

In all 3 user validation sessions the visual language of the concepts were also discussed. The key insight I gained was that the objects should not be invisible when the user is wearing clothes so when the user meet strangers they do not need to explain their disease. The user also expressed that it should not look like a body part or medical product when visible but have the appearance of being a lifestyle product. I used the obtained research insights as a starting point for my visual language development.

Approach to visual language

The approach to the visual language was firstly to define what the shape of the products should express or avoid expressing.

These were the elements that the shape should avoid:

- It should not look like a body part.
- It should not look like a medical product.
- It should not have edges that can get stuck in clothing.

Figure 33) Elements to avoid in visual language

These were the elements that the shape should express:

- It should look flexible.
- The connection between the patch and the device should look trusting.
- It should be as invisible underneath clothes as possible.
- It should have the feeling of being a lifestyle product.
- It should fit to the bodies curves.
- The two concepts should have a relation to each other
- It should look hygienic and

Figure 34) Elements to express in visual language

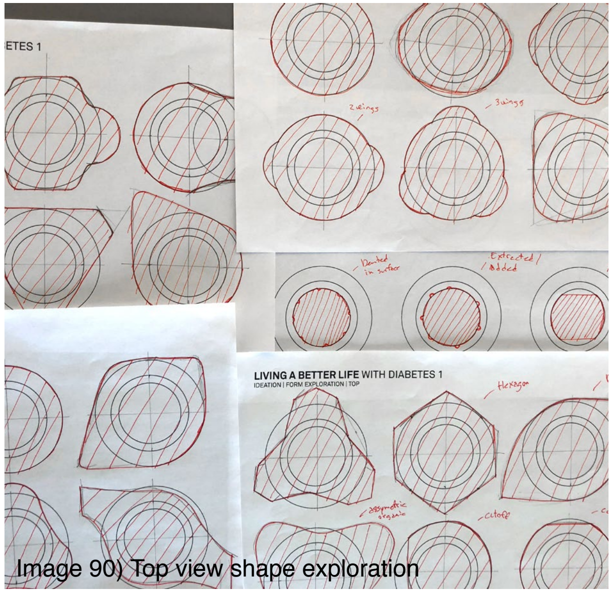


Image 90) Top view shape exploration

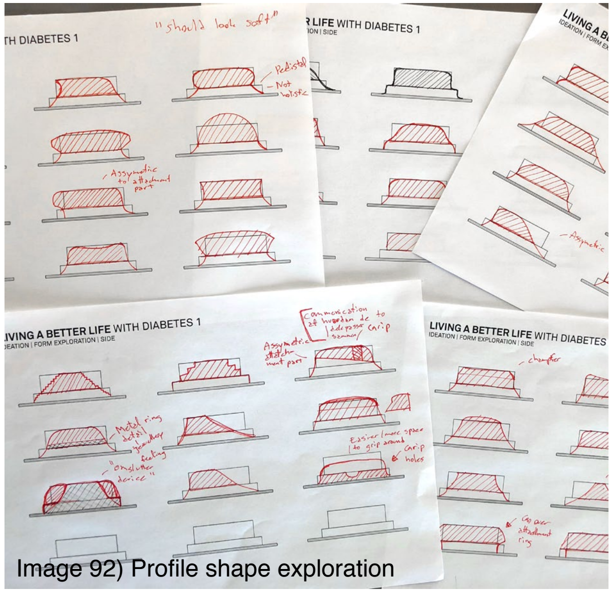


Image 92) Profile shape exploration

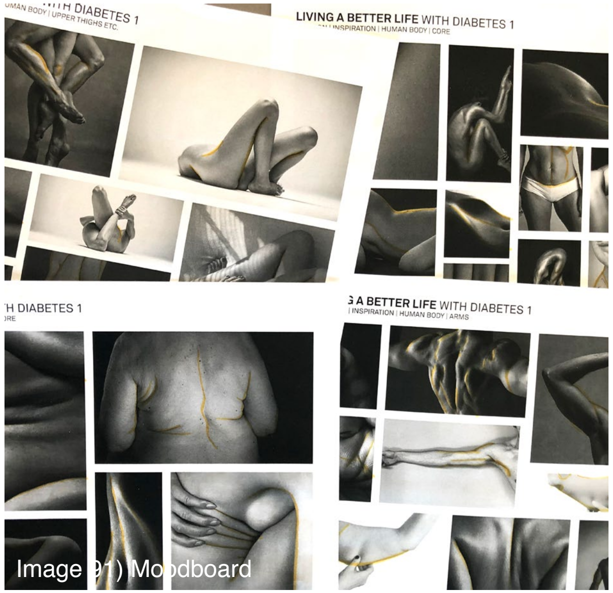


Image 91) Moodboard

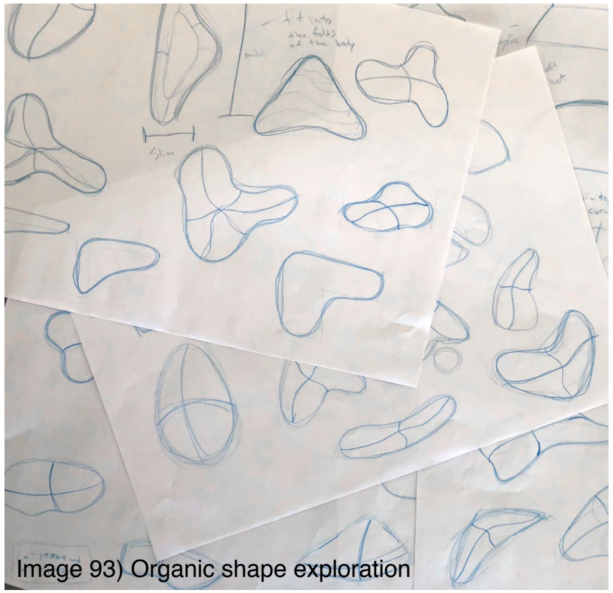


Image 93) Organic shape exploration

As I have been designing two products it was necessary to make a strategy for how to approach the shaping process. The insulin pump is the largest and most complex of the two objects and therefore I decided to start developing the shape of this, and let the shape of the monitor follow the insulin pump. Through the process of shaping the insulin pump, I realised that it was difficult to isolate the insulin pump from the monitor so the strategy was changed and the shape of the two concepts were developed in parallel, to consider the relation between the objects. On the following pages, I will show some examples of the shape development process.

FIRST APPROACH – BASIC GEOMETRIC SHAPES

Insulin pump

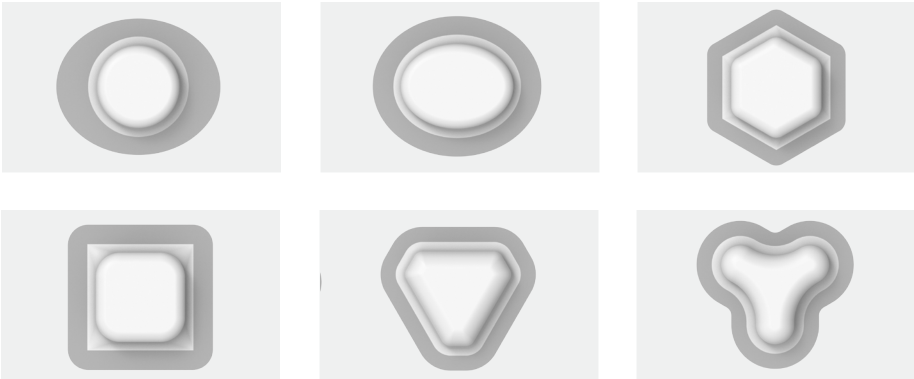


Image 94-100) Basic geometric shapes for insulin pump

Continous glucose monitor

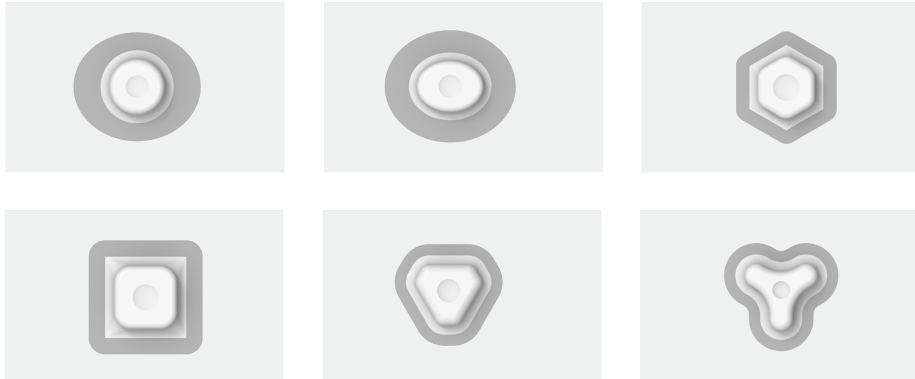


Image 101-107) Basic geometric shapes for monitor

I believe that to be able to argue for the shape of an object it is relevant to make a broad cover of shape opportunities. If a shape is not tested it is difficult to argue for why it was not the right shape for an object. Therefore, in the first phase, it was my goal to explore a broad range of shapes to understand what was working and what was not. As a starting point I based the first shape exploration on basic geometric shapes to gain a generic understanding of the consequences the different shapes have on the interpretations of the objects.

I tested basic geometrics shapes and explored which story the shapes were expressing. Parallel with this exploration phase I was testing different types of patches to find out which patch shape that attached best to the skin. I did this by making several different patch shapes that I tested on my own stomach to feel what was the most comfortable and secure. From that test I learned that the patch with two and three wings fulfilled the requirements to the patch best. I therefore got inspired from the functionality of the objects to explore geometrical shapes with three points that was derived from the triangle.

The challenge with this phase was that the outcome from the exploration had no relationship to the human body and as the objects are wearable it is important that it fit into the bodies shapes. It also did not appear flexible, which was one of the main requirements to the appearance.

ABSTRACT ORGANIC SHAPES

Image 108-119) Exploration of organic shapes in clay

I then changed focus and collected inspiration from the shapes of the human body. I was especially inspired from the stomach area and the shapes that are created when the stomach area is bended. In this phase I worked with creating abstract organic shapes. I explored shape opportunities by hand sketching sessions where I limited myself to only focus on sketching for two hours, I repeated this several times. It was difficult to obtain a detailed understanding of the organic shapes trough sketching and I therefore started modelling shapes in clay to be able to understand how the shapes were interacting with the body.

The result was asymmetrical organic objects that related to the human body but it appeared like a deform body part when it was placed on the body. It therefore had no relation to being a life style product, which I trough my user research had learned was important. Because life style consumer objects gives a feeling of normalcy and not sickness as if it appeared like a medical object.

GEOMETRIC PROPORTIONS AND ORGANIC CURVES

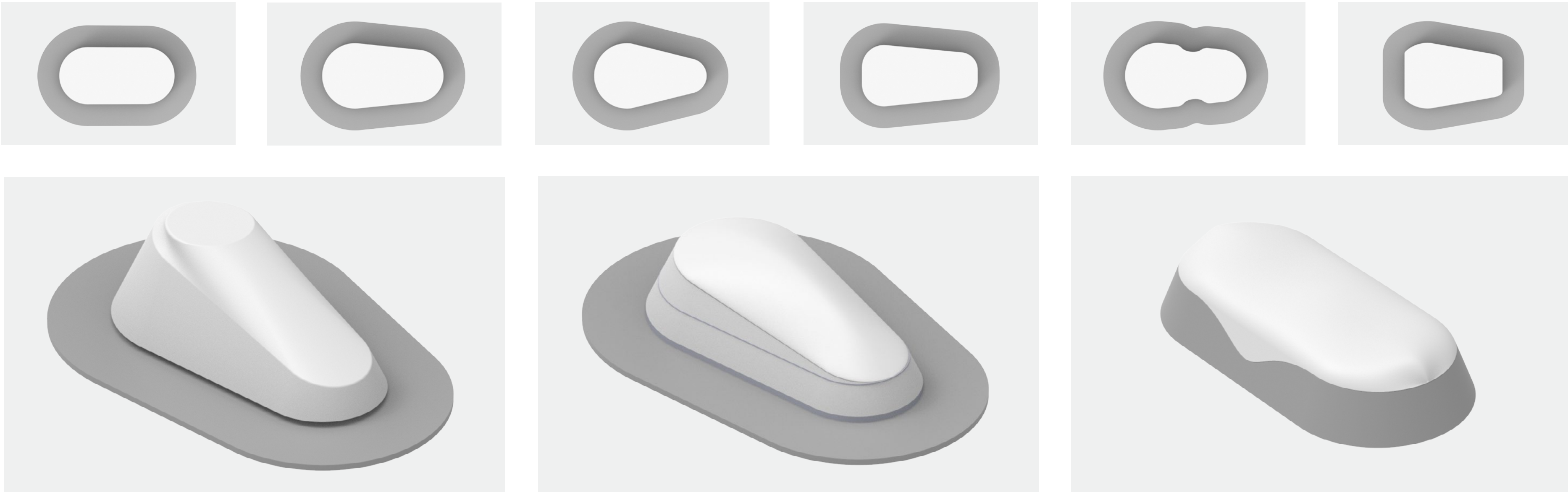


Image 120-128) 3D exploration of shapes with geometric proportions and organic curve.

In the third shape development phase I combined my learning’s from the first and the second phase and withdrawed the good elements. Such as an example, that the basic geometry of a circle visually represented completion, wholeness and harmony and that a curved organic surface communicated that an object was flexible.

The goal was to explore shapes with geometrical proportions and organic curves to create a visual appearance of the objects that appeared like a life style consumer product with the geometrical proportions and also had a relationship with the body trough the proportions and the organic curves.

The shape exploration was carried out with 3D drawing, with the purpose of creating more refined and detailed shape studies.

HOLISTIC VIEW

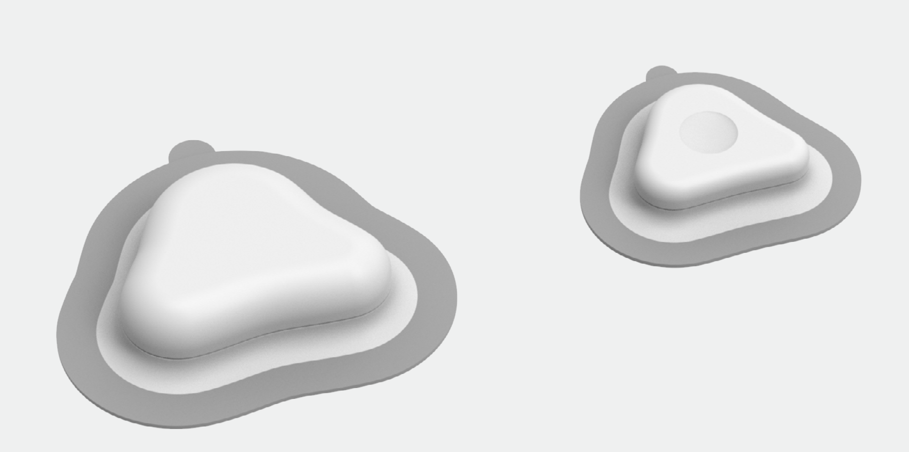


Image 129) Pump and monitor in same shape

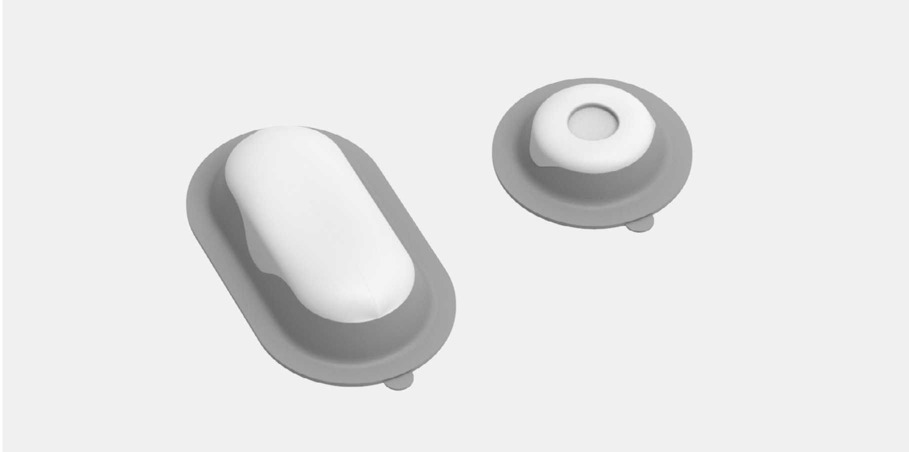


Image 130) Pump and monitor in different shapes

As this phase has been approached with the strategy of focusing on one element of the objects at a time, it has been important in the end of this phase to approach the objects with a holistic view, both regarding function, usability and visual language. Holistic is a term used for an entity that is encompassing as well as interconnecting all aspect of a design. The approach in this phase was to detail the objects as a whole and consider the interdependence of its parts.

Firstly I developed the relationship between the shape of the insulin pump and the monitor. As the two concepts communicate wirelessly together and the user will be wearing both objects at the same time I believed it was important that they had a clear relation to each other. Trough the process of shaping the concepts I learned, that it was hard to remember which object was the monitor and which was the pump if they were shaped alike. Therefore I started shaping the two concepts differently but with a relation. As an example, I created a drop shape for the insulin pump that rise from a large and a smaller circle connected, and I used the large circle of the insulin pump to create the shape for the monitor, so they clearly looked differently, but had still relations to each other.

Secondly I detailed the shape of each part of the two objects looking holistic at the design as a whole and how each part is interpreted both with repsect to function and the visual story it was expressing. The goal was to visually indicate all the functions in the objects, as an example I created a curve in the electronic device that dipped down into the patch part with the goal of indicating were the user have to grip around the device to attach and detach it from the patch.

CONCEPT REFINEMENT

PROCESS SUMMARY

Figure 35) Concept refinement summary

Shape refinement	Material refinement	Color refinement	UX refinement
When the shape was found I worked on refining it in detail. Both concepts are very small and therefore every detail has a large impact on the appearance. **Tools:** 3D Soliworks, models, InDesign, Illustrator, photoshop, Keyshot	I also refined the materials both regarding the material chemical balance, the thickness and texture. **Tools:** Research, test	In this phase I also decided on the colors for the concepts and how to combine them. I worked on how I could make it possible for the user to customize the colors for their individual preference. **Tools:** 3D Soliworks, models, InDesign, Illustrator, photoshop, Keyshot	I then refined the UX. I modelled the packaging, developed the framework for the App and a strategy for the information guides. **Tools:** 3D Soliworks, models, InDesign, Illustrator, photoshop, Keyshot, Laser cutting

Figure 36) Parts of project that was refined

Approach to concept refinement

In the refinement phase the shape, materials, colours and the UX was worked through in detail. The approach to this phase was, as previously, to split up the elements that had to be refined and develop them individually before combining them with a holistic view. From my research insights I defined requirements for the materials and colours to fulfil. As an example the materials had to be flexible but medical approved and the colours had to be invisible underneath clothing but also give the user the possibility for customising it for their individual need. Following that development the shape was refined in detail to accommodate to the material and colour suggestions. In the end of the process I also developed the user experience of the product focusing on creating a positive experience for the user when they receive the products. The parts developed were the app framework, the packaging and the information guides. The goal was to create a pleasurable experience when the user receives the product that should feel more like receiving a consumer product than medical equipment. This phase has not yet been completed.

COLORS

Image 131) One color

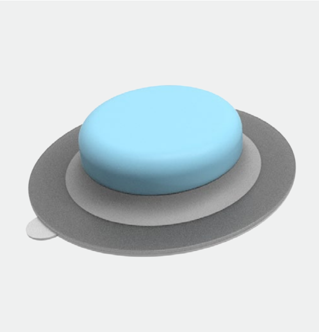


Image 132) Device colored

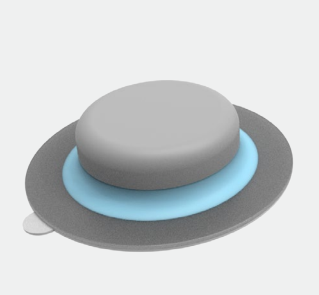


Image 133) Attachment colored

Image 134) Color test underneath textile

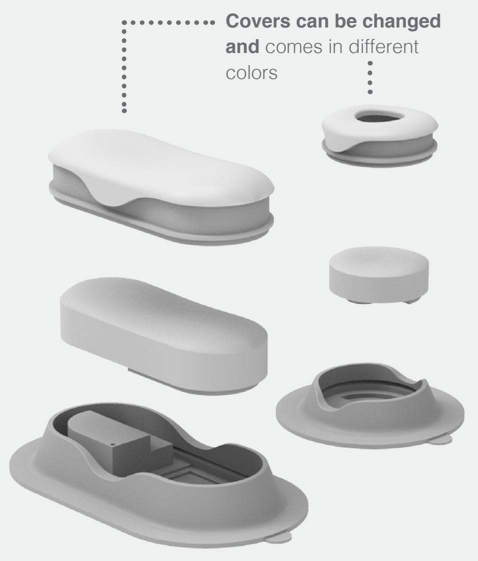


Image 135) Customizable cover

Colour requirements

The requirements for the colours of the concepts were based on the dialog with the users. They expressed that it should be invisible underneath clothing but visible on the skin and not be skin coloured, it should clearly be an object.

Color approach

The approach to this phase was to test different colours underneath clothing to understand which colours were visible and which ones were not. The colour that was found most invisible underneath different types of clothing is light gray, through explorations the colour was defined from the shadows that occur underneath clothing.

Trough the development I learned that deciding on one colour for the objects were not inclusive for the user. I then researched what the tendency for consumer brands are regarding colour. As an example the apple watch, which is also a wearable object, has a modular band system so the consumer can chose his or her own colour. This was a tendency I found in several consumer brands and I therefore thought that it was important to make the objects customizable for the users, as I am designing for a broad target group.

Following I developed the build structure of the product to create a way to customize the colour for the user. The solution was to create an extra modular part that makes it possible for users to customize the objects.

MATERIALS

The materials for the objects have been considered trough the whole design phase as one of the concept features are that both products are made of all flexible materials. The illustration shows the key requirements there was for each part of the concepts.

A key requirement was that the main electronic parts had to be made of flexible materials, to achieve a product that follows the body.

The shell of the electronic devices had to be flexible but hard so it protects the electronics, as it is a reusable part of the concepts.

Another challenge was to find materials for the different patches; the goal was to create different patches so as many patients as possible can use the product. After researching I decided to create three different patches as a starting point because the concept would then fit to a broad range of different skin types.

Figure 37) Materials overview

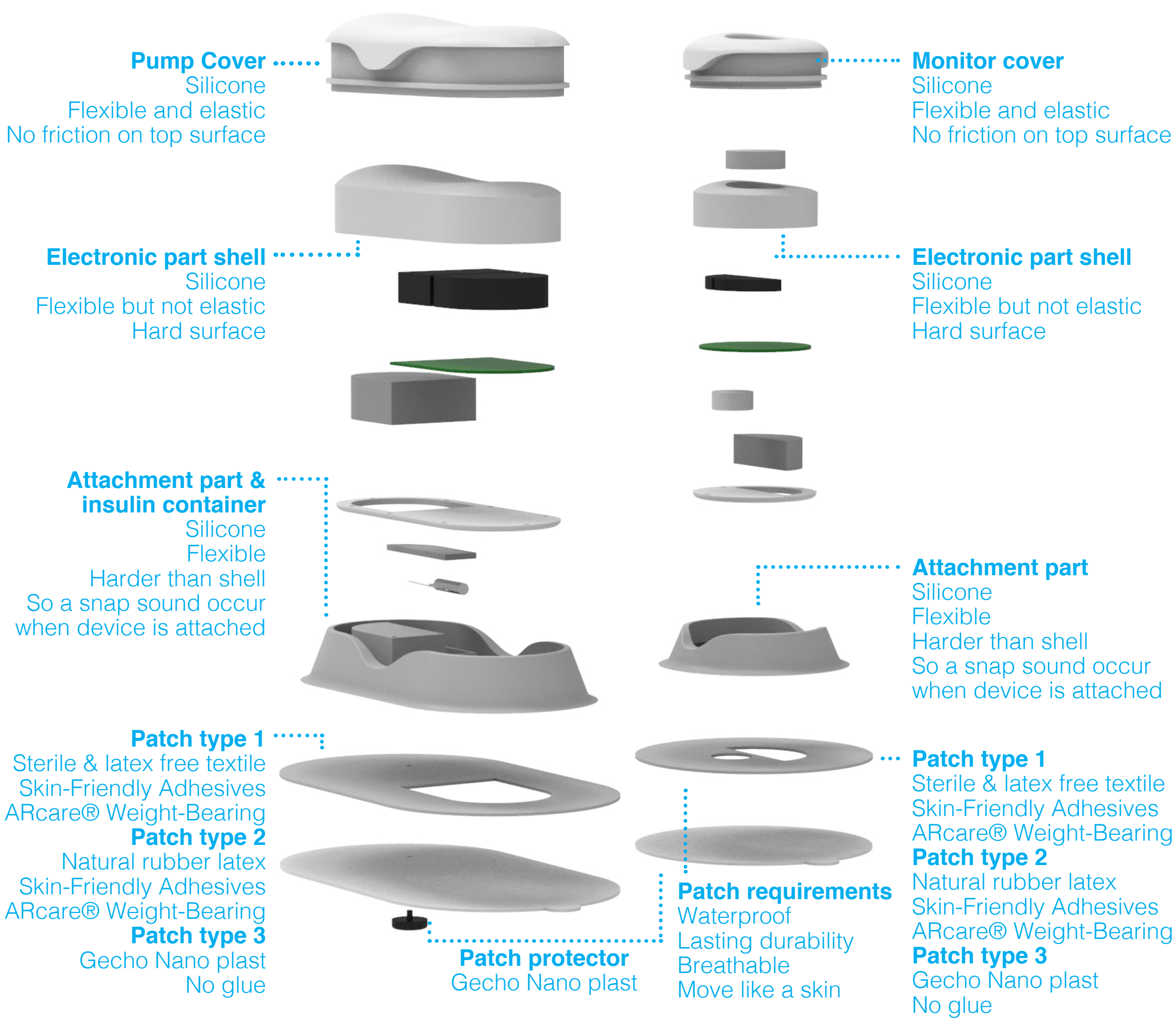



Image 136) Pump in perspective


Image 139) Monitor in perspective


Image 137) Pump in side view


Image 140) Monitor in side view

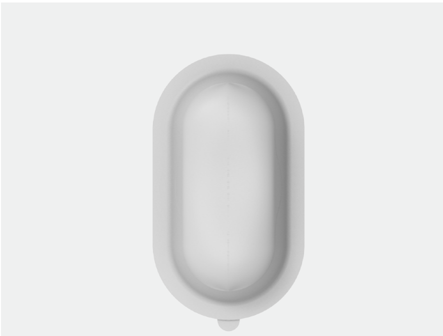


Image 138) Pump in top view

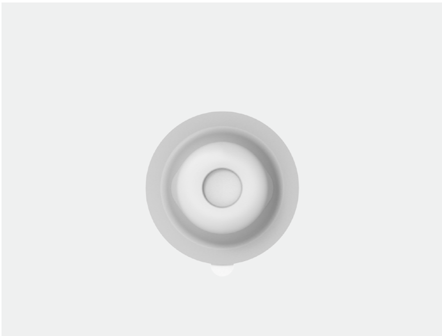


Image 141) Monitor in top view

SOLTUTION SUMMARY

The design suggestion for this thesis project is a circular product system for type 1 diabetes patients, containing a blood glucose monitor and insulin pump that communicates wireless and takes over the pancreases function. The two devices are connected to an app that controls the devices and storage data. The products are attached to the body with patches so the devices can be placed different places on the body. Each product is modular and consists of an electronic unit, a cover and a patch. The user can chose between different types of patches depending on their skin type. Furthermore the covers for the electronic devices can easily be changed and the user can chose between a variety of colours. All parts of both products are made of flexible materials so they follow the body's movements.

The insulin pump is tubeless and connects to the body with a needle and plastic tube that is inserted into the users body. The patch for the pump contains insulin for approximately 3 days.

The blood glucose monitor measure the blood glucose level with sensor technology on the skin. The monitor has two sensors that monitor the blood glucose level. One that monitors on the skin 24/7 and a sensor away from the skin were the user can place their fingertip on a platform to double-check their blood glucose level. The monitor patch has to be changed every two weeks to avoid skin irritation.

On the following pages I will describe some of the design suggestions details.

Image 142) Modular systems were the user can chose different patches and a large variety of colours for the product cover.

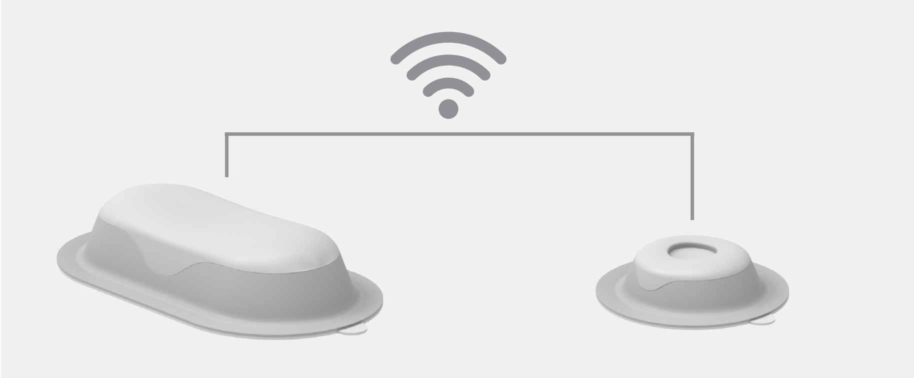


Image 143) The product communicates wirelessly and creates a circular system.

Image 144) An app controls the devices and storage data.

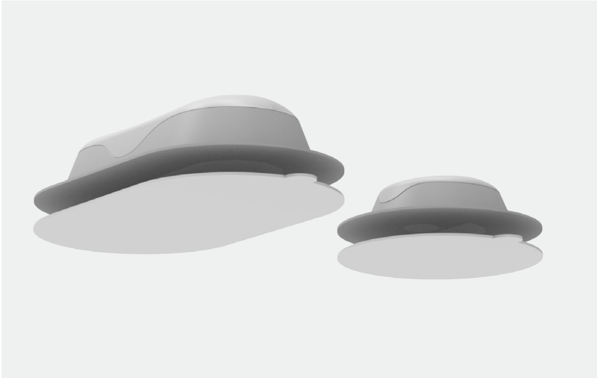


Image 145) Attach to the body with a patch so it can be placed everywhere.

Image 146) A blood glucose monitor that monitors with sensor technology.

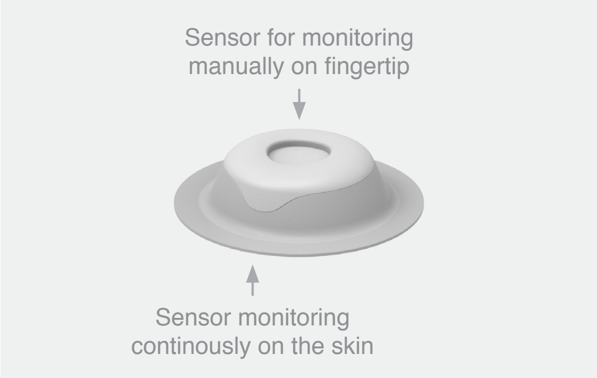


Image 147) A blood glucose monitor with two monitor sensors, one that monitor 24/7 and one that monitors when the user wants to double-check if the monitoring is correct.

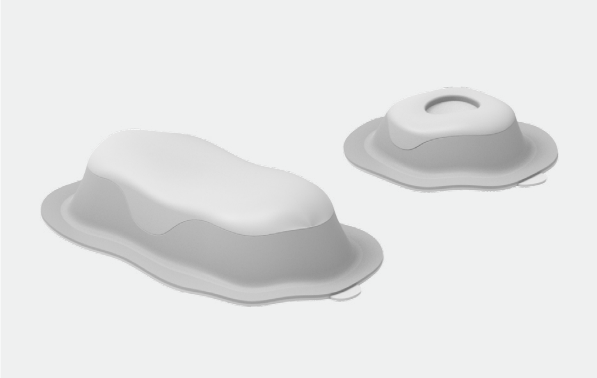


Image 148) Made of all flexible materials so it follows the body.

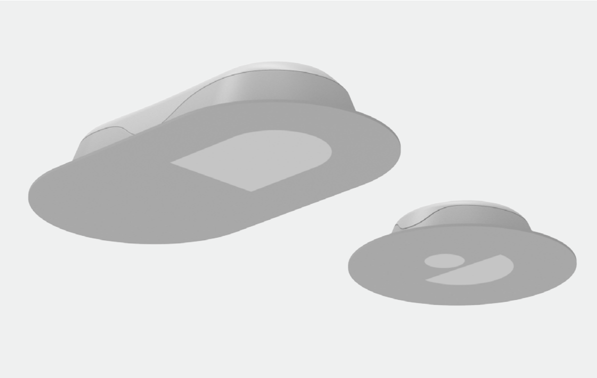


Image 149) Have a battery that are powered by the users body so it never needs to be plugged into a charger.

Image 150) The insulin pump has an automatic alarm if the blood glucose level is high, low or there is an error.

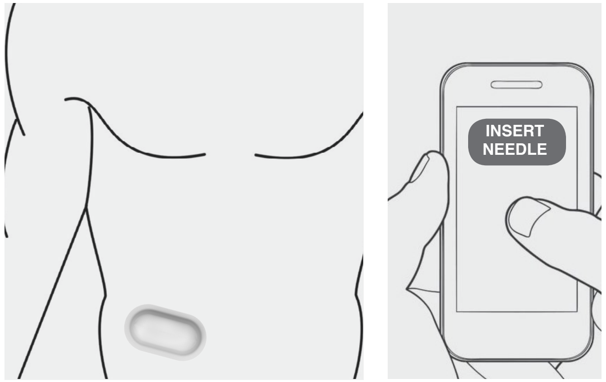
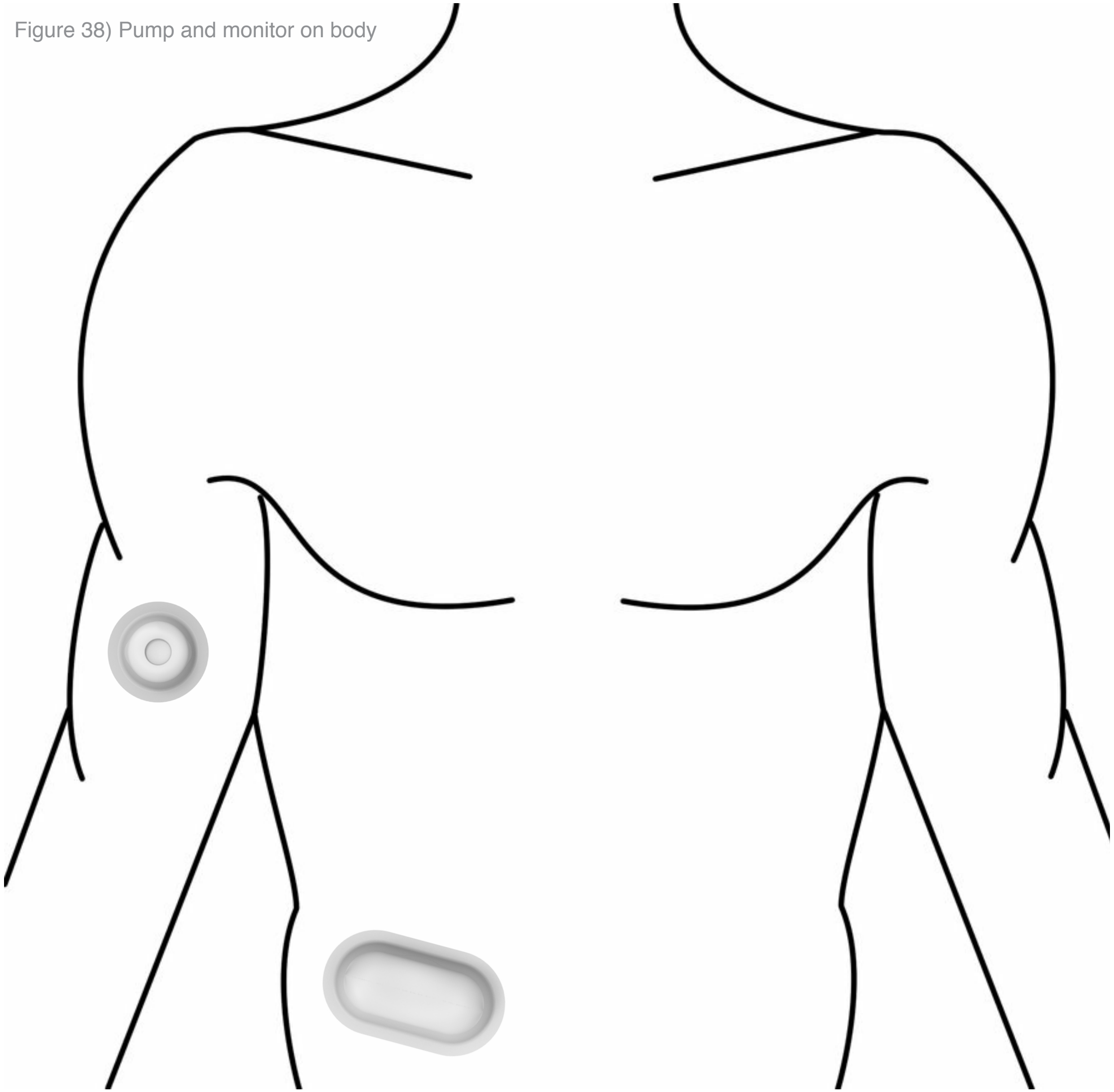


Image 151) The insulin pump has an automatic insertion of the needle that are controlled by the app.

Figure 38) Pump and monitor on body



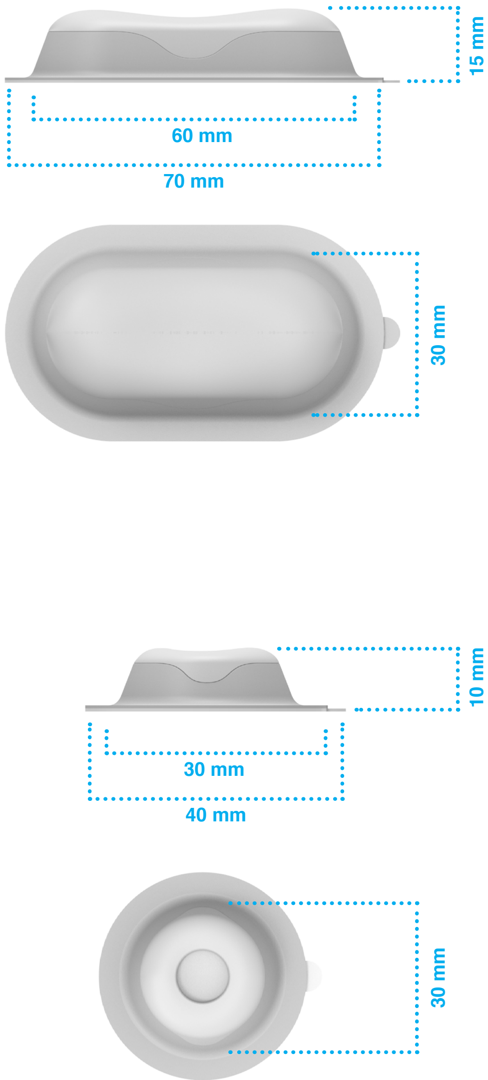


Figure 39) General dimensions

*dimemsions may change when the shape is refined

HANDLING PARTS

Blood glucose monitor

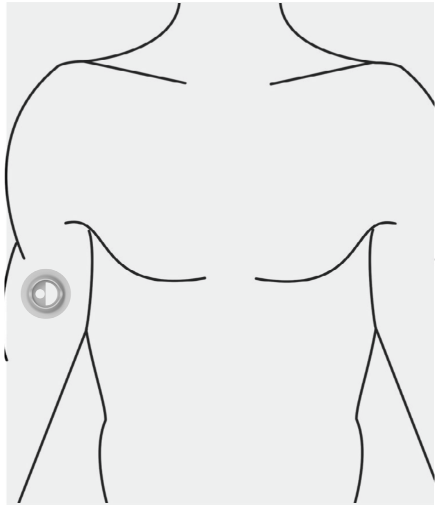


Image 152) Attach patch to skin

Image 153) Attach cover to device

Image 154) Attach device to patch

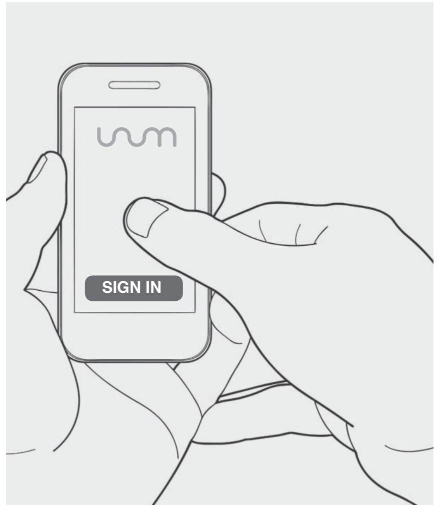


Image 155) Start device

Insulin pump

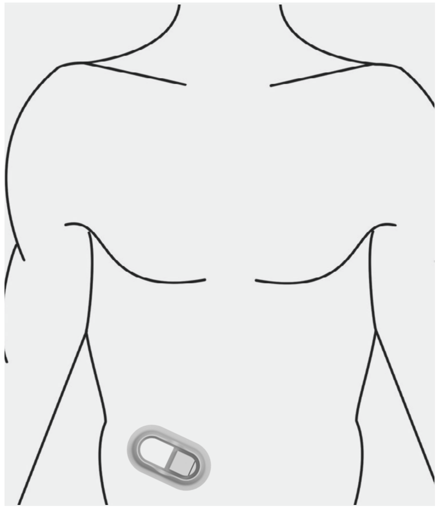


Image 156) Attach patch to skin

Image 157) Attach cover to device

Image 158) Attach device to patch

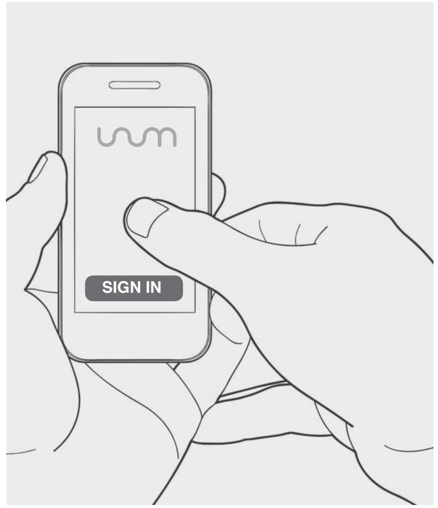
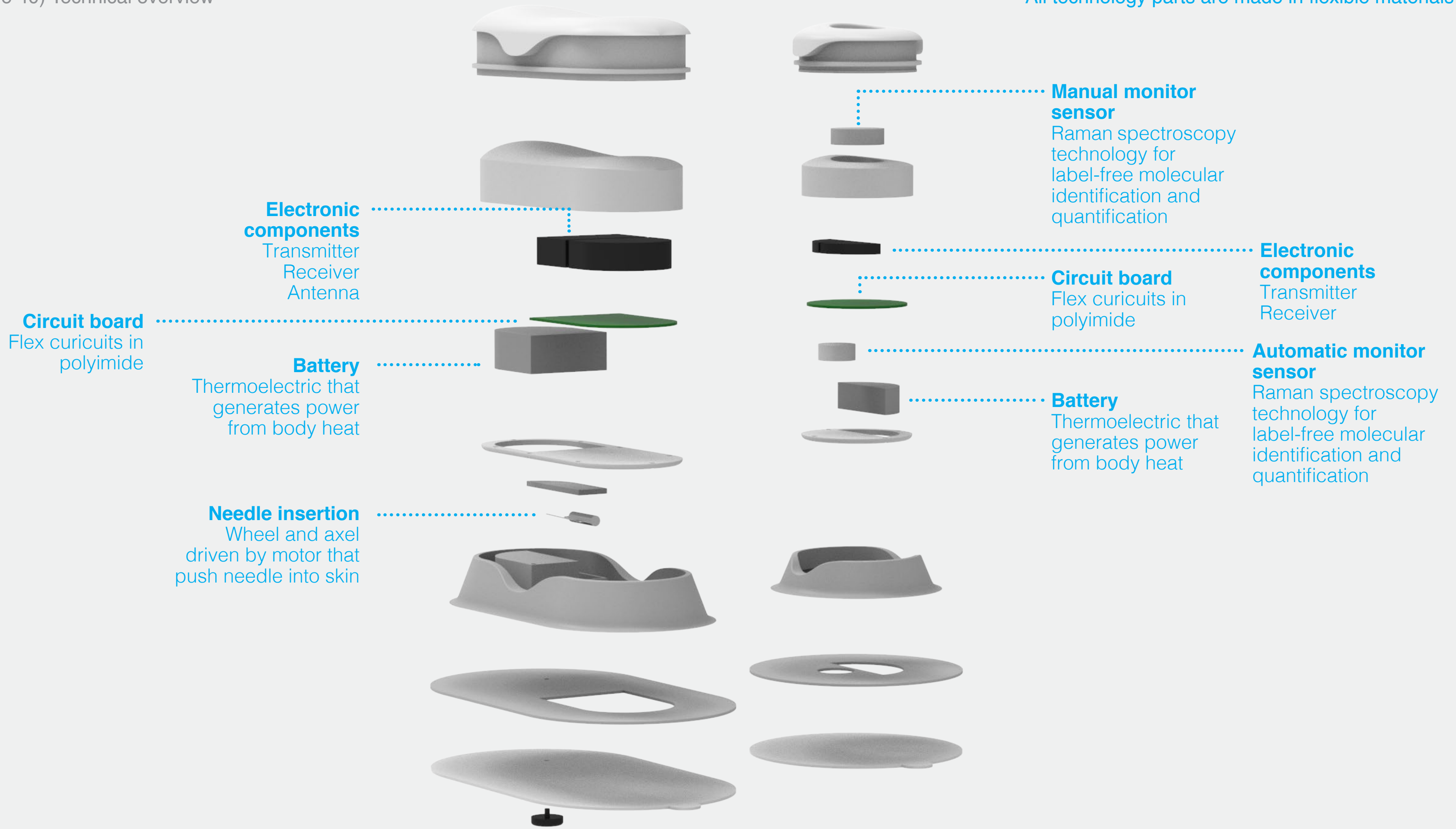


Image 159) Start device /insert needle

TECHNICAL DETAILS

Figure 40) Technical overview

*All technology parts are made in flexible materials



USER EXPERIENCE


Image 160) App

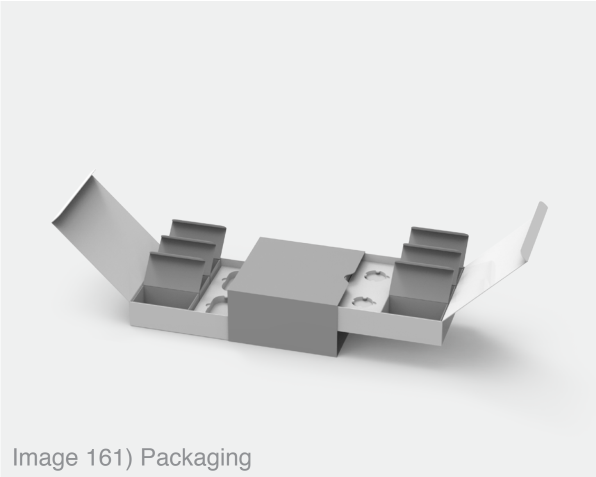


Image 161) Packaging

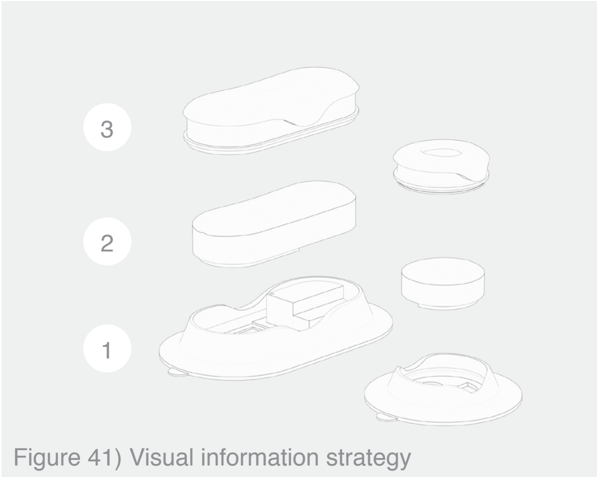


Figure 41) Visual information strategy

App

The current products on the market have a remote control that controls the products, but as I learned in my research, it was a problem for the users to have several products. Hence, I wanted to minimise the amount of products. Early on I worked with integrating a screen into the pump so it could be controlled from there, but as the users are often wearing the pump underneath clothing it was impractical. I therefore placed all controls and data storage in an app because I learned that the users always have their phone with them, and it was a opportunity for making it more simple and create less products.

Packaging

In the research I discovered that the experience of receiving the diabetes equipment was confusing and stressful and it has therefore been relevant in this project to consider the packaging and the experience the user is offered when receiving the products. I got inspired from packaging of consumer products, where I learned that simplicity and a clear communication of how the products are unboxed is important to create a good user experience. I also focused on organising the different parts in a way that is manageable for the user.

Information guides

As there is a lot of text in information guides for medical equipmen,t I also worked on creating a strategy for a more simple and visual ways of communicating information to the users. This part has not yet been developed.

The goal with this part was to create a pleasurable consumer experience.

PERSPECTIVATION

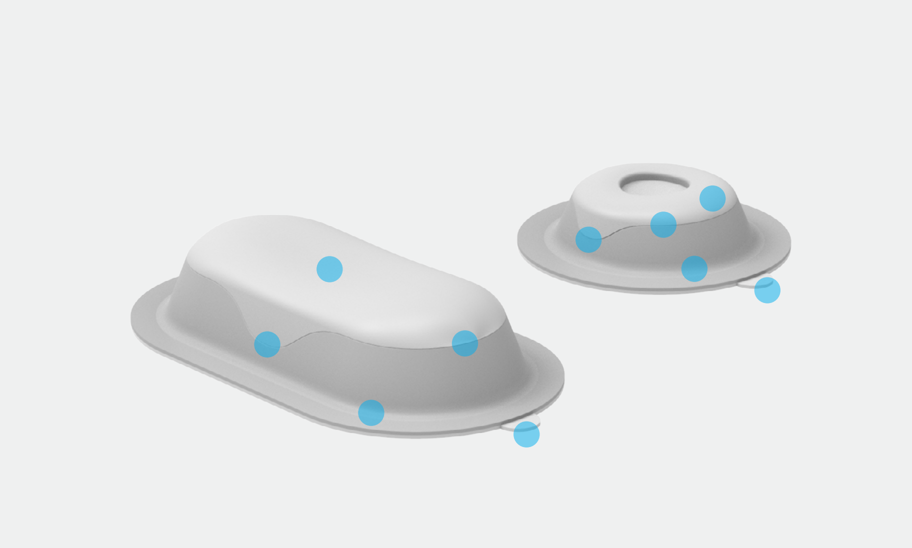


Image 162) Part that needs to be developed

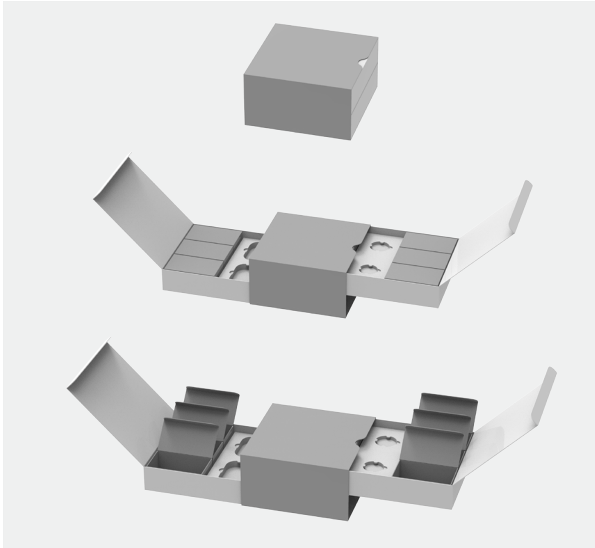


Image 163) Visualisation of unboxing experience

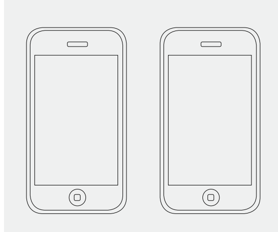


Figure 42) Framework

Figure 43) Guide strategy

REFLECTION AND FUTURE DEVELOPMENT

This thesis project has been challenging and complex with a large amount of knowledge. It has been key to the project to focus on both the physical and psychological problems the users have to be able to create a relevant design suggestion. The project is yet not finished and I will be working on refining the project until the exam date. In this part I will give an overview over the parts I will refine further in detail.

Product concepts

The product concepts overall shape is created but it has yet not been detailed. I will work further with the curves and the relationship between the two objects. I also think that the concept need to be simplified as it currently appears complex.

User experience concept

The user experience containing the app, packaging and information guides need development and have only been solved on a superficial level. I will develop the visual expression and the relationship between all elements of the project from the product to the branding, with the goal of creating a holistic project result.

EXECUTION

3D

Appearance model

I will create an appearence model, that clearly show the visual language of the end concpet.

Proof of principle models

To descripe the mechanical functions in the end concept I will create proof of principle models, mainly with the purpose of communicting.

2D

3D drawing & renderings

I will use 3D drawings and renders to communicate both form and function of the end design. I will use these renderings on posters.

Technical drawings

I will draw technical drawings to communicate the products dimensions and how it is supposed to be manufactured.

Digital

Digital presentation

I will create a digital presentation that summarize my project and explain my end result.

Project video

I will create a video that show a summary of the project process and the result.

Figure 44) Parts to execute for exam

REFERENCES & BIBLIOGRAPHY

Image list

Image 65) Visualisation of implantable monitor concept (2018) Julie Roland Sørensen

Image 66) User test 4 (2018) Julie Roland Sørensen

Image 67) User test 5 (2018) Julie Roland Sørensen

Image 68) User test 6 (2018) Julie Roland Sørensen

Image 69) User test – Modular patch concept (2018) Julie Roland Sørensen

Image 70) User test – Strap concept (2018) Julie Roland Sørensen

Image 71) User test – Double check monitor (2018) Julie Roland Sørensen

Image 72) Implantable concept (2018) https://www.youtube.com/watch?v=BtjD_75qfSw (Accessed 25. Of May. 2018)

Image 73) Selected concepts (2018) Julie Roland Sørensen

Image 74) 3D print testing snap size (2018) Julie Roland Sørensen

Image 75) 3D print testing interaction (2018) Julie Roland Sørensen

Image 76) 3D print testing grip shape (2018) Julie Roland Sørensen

Image 77) Patch test 1 (2018) Julie Roland Sørensen

Image 78) Patch test 2 (2018) Julie Roland Sørensen

Image 79) Patch test 3 (2018) Julie Roland Sørensen

Image 80, 81) User test – snap from top (2018) Julie Roland Sørensen

Image 82, 83) User test – Snap from side (2018) Julie Roland Sørensen

Image 84, 85) User test – Snap ring (2018) Julie Roland Sørensen

Image 86, 87) User test – Twist (2018) Julie Roland Sørensen

Image 88, 89)User test – Twist snap (2018) Julie Roland Sørensen

Image 90) Top view shape exploration (2018) Julie Roland Sørensen

Image 91) Human body mood board (2018) Julie Roland Sørensen

Image 92) Profile shape exploration (2018) Julie Roland Sørensen

Image 93) Organic shape exploration (2018) Julie Roland Sørensen

Image 94-100) Basic geometric shapes for insulin pump (2018) Julie Roland Sørensen

Image 101-107) Basic geometric shapes for monitor (2018) Julie Roland Sørensen

Image 107-119) Exploration of organic shapes in clay (2018) Julie Roland Sørensen

Image 119-128) 3D exploration of shapes with geometric proportions and organic curve. (2018) Julie Roland Sørensen

Image 129) Pump and monitor in same shape (2018) Julie Roland Sørensen

Image 130) Pump and monitor in different shapes (2018) Julie Roland Sørensen

Image 131) One colour (2018) Julie Roland Sørensen

Image 132) Device coloured (2018) Julie Roland Sørensen

Image 133) Attachment Coloured (2018) Julie Roland Sørensen

Image 134) Colour test underneath textile (2018) Julie Roland Sørensen

Image 135) Customizable cover (2018) Julie Roland Sørensen

Image 136) Pump in perspective (2018) Julie Roland Sørensen

Image 137) Pump in side view (2018) Julie Roland Sørensen

Image 138) Pump in top view (2018) Julie Roland Sørensen

Image 139) Monitor in perspective (2018) Julie Roland Sørensen

Image 140) Monitor in side view (2018) Julie Roland Sørensen

Image 141) Monitor in top view (2018) Julie Roland Sørensen

Image 142) Modular systems (2018) Julie Roland Sørensen

Image 143) The product communicates wirelessly (2018) Julie Roland Sørensen

Image 144) An app (2018) https://www.pexels.com/photo/apple-apple-device-blur-cell-phone-336948/ (Accessed 25. Of May. 2018)

Image 145) Attach to the body with a patch so it can be placed everywhere (2018) Julie Roland Sørensen

Image 146) A blood glucose monitor that monitors with sensor technology (2018) Julie Roland Sørensen

Image 147) A blood glucose monitor with two monitor sensors, one that monitor 24/7 and one that monitors when the user wants to double-check if the monitoring is correct. (2018) Julie Roland Sørensen

Image 148) Made of all flexible materials so it follows the body (2018) Julie Roland Sørensen

Image 149) Have a battery that are powered by the users body so it never needs to be plugged into a charger (2018) Julie Roland Sørensen

Image 150) The insulin pump has an automatic alarm if the blood glucose level is high, low or there is a error (2018) Julie Roland Sørensen

Image 151) Automatic insertion on needle (2018) Julie Roland Sørensen

Image 152) Attach patch to skin (2018) Julie Roland Sørensen

Image 153) Attach cover to device (2018) Julie Roland Sørensen

Image 154) Attach device to patch (2018) Julie Roland Sørensen

Image 155) Start device (2018) Julie Roland Sørensen

Image 156) Attach patch to skin (2018) Julie Roland Sørensen

Image 157) Attach cover to device (2018) Julie Roland Sørensen

Image 158) Attach device to patch (2018) Julie Roland Sørensen

Image 159) Start device /insert needle (2018) Julie Roland Sørensen

Image 160) App (2018) https://www.pexels.com/photo/apple-apple-device-blur-cell-phone-336948/ (Accessed 25. Of May. 2018)

Image 161) Packaging (2018) Julie Roland Sørensen

Image 162) Part that needs to be developed (2018) Julie Roland Sørensen

Image 163) Visualisation of unboxing experience (2018) Julie Roland Sørensen

Figure list

Books

Norman, D.A., (1998) The Design of Everyday Things. United Kingdom. MIT, London.

Michael Braungart & William McDonough (2009) Cradle to cradle. United Kingdom. Vintage U.K.

Donald A. Norman (1999) The Invisible Computer. United Kingdom. The MIT Press, London.

Joy. H. Selak. & Steven S. Overman (2005) You Don't Look Sick!: Living Well with Invisible Chronic Illness. United Kingdom. CRC Press.

Martz. E. & Livneh. H. (2007) Coping with Chronic Illness and Disability: Theoretical, Empirical, and Clinical Aspects. United States of America. Verlag New York. Inc.

Papanikitas. A (2013) Crash Course Medical Ethics and Sociology. United States of Ameraica. Mosby.

Paul. J. DOnoghue. & Mary. E. Seigal. (2000) Sick and Tired of Feeling Sick and Tired: Living with Invisible Chronic Illness. United States of America. W. W. Norton & Company.

Register. C. (1991) The Chronic Illness Experience: Embracing the Imperfect Life. Minnesota. Hazelden.

Royer. Ariela. (1998) Life with chronic illness social and psychological dimensions. United States of America. Praeger Publishers.

Stuckler. D. (2011) Sick Societies. England. OUP Oxford.
Turner. Bryan. S. (1995) Medical Power and social Knowledge. England. Sage.

Articles/journals

Blomquist, A., Arvola, M., 2002. Personas in action: ethnography in an interaction design team. In: Proceedings of the Second Nordic Conference on Humancomputer Interaction. ACM, Aarhus, Denmark, pp. 197e200

Crocker et al (1998) Crocker, J., Major, B., & Steele, C. (1998). Social stigma. In S. Fiske, D. Gilbert, & G. Lindzey (Eds.), Handbook of social psychology (pp. 504–553). Boston: McGraw-Hill

Dembo, T. (1964). Sensitivity of one person to another. Rehabilitation Literature, 25(8), 231–235.

Goffman, E. (1963). Stigma: Notes on the management of spoiled identity. New York: Prentice-Hall

Jones et al. (1984) Jones, E. E., Farina, A., Hastorf, A. H., Markus, H., Miller, D. T., & Scott, R. A. (1984). Social stigma: The psychology of marked relationships. New York: Freeman.

Lawrence Hsin Yang, Arthur Kleinman, Bruce G. Link, Jo C. Phelan, Sing Lee, Byron Good (2007) Culture and stigma: Adding moral experience to stigma theory. Social Science & Medicine 64 1524–1535

Lin. Laura. & Isla. Racquel. Doniz. Karine. & harkness. Heather. & Vincente. Kim. J (1998) Applying human Factors to the design of medical equipment. Available from: http://link.springer.com/article/10.1023/A%3A1009928203196. (accessed: 16. June 2014) copyright

Lupton, D. (1995) Medicine as Culture: Illness, Disease and the Body in Western Societies London: UK: Sage Publications
Magdalena Bergera, Todd H. Wagnera,b,c,_, Laurence C. Bakerb. Internet use and stigmatized illness. Stanford University School of Medicine. USA

Miller, N., Walker, C. (2000) Overcoming the stigma of chronic illness: Strategies for straightening out a 'spoiled identity'. Sociological Sights/Sites, TASA 2000 Conference, Adelaide, Flinders University. pp 1-11

Neuberg, S. L., Smith, D. M., & Asher, T. (2000). Why people stigmatize: toward a biocultural framework. In T. F. Heatherton, R. E. Kleck, M. R. Hebl, & J. G. Hull (Eds.), The social psychology of stigma (pp. 31–61). New York: The Guilford Press

Park, J. H., Faulkner, J., & Schaller, M. (2003). Evolved disease-avoidance processes and contemporary anti-social behavior: Prejudicial attitudes and avoidance of people with physical disabilities. Journal of Nonverbal Behavior, 27(2), 65–87.

Sawyer, D., 2009. Do it by Design: an Introduction to Human Factors in Medical Devices. Center for Devices and Radiological Health, United States.

Shaw. Brian. (1985) The Role of the Interaction between the User and the Manufacturer in Medical Equipment Innovation. Available from: http://onlinelibrary.wiley.com/doi/10.1111/j.1467-9310.1985.tb00039.x/abstract (accessed: 13. June 2014)

Struber, J. (2008) Stigma, prejudice, discrimination and health - Social Science & Medicine. Social Science & Medicine 67. Pp. 351–357 available at science direct

Ubel, P. A., Loewenstein, G., & Jepson, C. (2003). Whose quality of life? A commentary exploring discrepancies between health state evaluations of patients and the general public. Quality of Life Research, 12(6), 599–607.

Vincent, C., Li, Y., Blandford, A., 2014. Integration of human factors and ergonomics during medical device design and development: it's all about communication. Appl. Ergon. 45, 413e419.

Vincent, C., Li, Y., Blandford, A., 2014. Integration of human factors and ergonomics during medical device design and development: it's all about communication. Appl. Ergon. 45, 413e419.

Wright, E. R., Gronfein, W. P., & Owens, T. J. (2000). Deinstitutionalization, social rejection and the self-esteem of former mental patients. Journal of Health and Social Behavior, 41, 68–90

June H.Park, (2015). Health Care Design: Current and Potential Research and development. Massachusetts institute of technology. Design Issues: Volume 31, number 1 Winter 2015

G.M. Kane, C.A. Bakker, A.R. Balkenende (2017) Towards design strategies for circular medical products. Resources, Conservation & Recycling, http://dx.doi.org/10.1016/j.resconrec.2017.07.030

Hood Thabit, Romand Hovorka (2016) Coming of age: the artificial pancreas for type 1 diabetes. Diabetologia 2016 59:1795–1805
DOI 10.1007/s00125-016-4022-4

Gillian M. McCarthy, Edgar R. Rodríguez Ramírez & Brian J. Robinson (2017) Design Experiments. Identifying areas for intervention and designing medical technology for adolescents and young adults with type 1 diabetes, The Design Journal, 20:sup1, S2044-S2056, DOI: 10.1080/14606925.2017.1352723

Karen Alexander, John Clarkson, Duncan Bishop, Stewart Fox (2001) Good Design practise for medical devices and equipment. A framework. University of Cambridge Engineering Design Centre. ISBN 1-902546–08-3

MaryBeth Privitera (2017) Designing Industrial Design in the Highly Regulated Medical Device Development Process. Defining our valuable contribution towards usability, The Design Journal, 20:sup1, S2190-S2206, DOI: 10.1080/14606925.2017.1352735

Silvia Barbero, Amina Pereno & Paolo Tamborrini (2017) Systemic innovation in sustainable design of medical devices, The Design Journal, 20:sup1, S2486-S2497, DOI: 10.1080/14606925.2017.1352763

Lourdes A. Medina, Gül E. Okudan Kremer, Richard A. Wysk (2012) Supporting medical device development: A standard product design process model. Journal of Engineering Design, 2013 Vol. 24, No. 2, 83–119, http://dx.doi.org/10.1080/09544828.2012.676635

Websites

Diabetes foreningen (2018) Available at: https://diabetes.dk/ (Accessed 15. Of Feb. 2018)

UN goals (2018) Available at: http://www.un.org/sustainabledevelopment/sustainable-development-goals/ (Accessed 15. Of Feb. 2018)

Everyday health (2018) Available at: https://www.everydayhealth.com/diabetes/understanding/diabetes-mellitus-through-time.aspx (Accessed 15. Of Feb. 2018)

Whats next in diabetes tech for 2018? (2018) Available at: https://www.healthline.com/diabetesmine/diabetes-technology-excpectations-2018 (Accessed 8. Of Feb. 2018)

Diabetes mellitus trough time (2018) Available at: ttps://www.everydayhealth.com/diabetes/understanding/diabetes-mellitus-through-time.aspx (Accessed 19. Of Feb. 2018)

History of insulin (2018) Available at: https://www.diabetes.co.uk/insulin/history-of-insulin.html (Accessed 23. Of Feb. 2018)

Primary research sources

Line Bak Josephsen, 2018, Type 1 diabetes patient

Mille Molly, 2018, Type 1 diabetes patient

Pernille Gøhns Kristiansen, 2018, Type 1 diabetes patient

Amalie Bakmand, 2018, Type 1 diabetes patient

Joachim Elias Holgersen, 2018, Type 1 diabetes patient

Christina Kjær Pedersen, 2018, Type 1 diabetes patient

Simone Schubert Glumsø, 2018, Type 1 diabetes patient

Sisse Kappelgaard Bech, 2018, Type 1 diabetes patient

Karl & Marianne Jørgensen, 2018, Type 1 diabetes patient & pårørende

Thomas Brixen (2014) (Thomas Brixen, interview 1) (Coloplast interview) Denmark. (Julie Roland Sorensen)

Jakob Bendix (2014) (Jakob Bendix, interview 2) (Coloplast interview) Denmark. (Julie Roland Sorensen)

T // +45 42 74 41 84 M // juso1636@edu.kadk.dk W // www.julierolanddesign.com