

Designing a digital inhaler

Master's Thesis by
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Preface

For patients to gain control of their asthma, health care often expect them to take responsibility of their illness. On the other side asthma patients often lack the necessary knowledge of their disease and how to use their inhaler correctly to be able to take that responsibility - which in many cases leads to worse compliance with their treatment.

To help asthmatics take the necessary responsibility, we have designed an asthma inhaler which provides asthmatics with insights into their disease by correlating their asthma status with potential asthma triggers, such as weather and pollen. The developed inhaler is also designed to help the user improve their inhalation technique.

This report presents a master's thesis project assigned by Zenit Design AB in collaboration with Iconovo AB, at the Division of Product Development, Department of Design Science, Faculty of Engineering at Lund University.

We have received invaluable help from several people during this project, thank you:

Karl-Axel Andersson for being our supervisor at the university by providing us with inputs and ideas, both in the design process and the construction of the prototype.

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Lund, February 2017

Erika Axhed and **Kent Ngo**

Abstract

Untreated asthma limits the ability to live an active life, still many asthmatics does not have the level of control over their asthma as they could have. In addition, about 50% of the asthmatics use their inhaler incorrectly, which affects the result of the medicine negative. The asthma inhaler is central in an asthmatics living and has great potential for development towards a modern asthma monitoring tool and could possibly improve the user's overall asthma knowledge.

This thesis was done as a collaboration with Zenit Design AB and Iconovo AB and the object of the project was a generic inhaler from Iconovo's inhaler platform. The mission for the thesis was to explore possibilities, solutions and designs for a connected inhaler in order to increase and improve the asthmatics' use of asthma medicine.

The overall goal with the project was to localize user needs and discover ways to implement electronics into the inhaler in order to solve the needs and improve the user experience. In the initial phase, research was done through literature studies and interviews with asthmatics and asthma professionals, providing a broad understanding of asthma and how it is to live with asthma. By defining user needs and problems with today's asthma inhalers the design process was initiated.

Thinking entrepreneurial and developing the product by the Minimal Viable Product (MVP) approach, the function of the inhaler was initially designed with just enough features to solve the main user needs. Added to the entrepreneurial approach was an own method - to advance the MVP with additional functions in order to fulfil more user needs and improve the asthmatics inhalation technique.

When a superstructured MVP was set, the project evolved into a small system containing an inhaler with a detachable module and a belonging mobile application. The three components – the inhaler, the module and the app – was designed and developed in an iterative process.

In the end, through playing with light and sensors, a digital asthma/COPD inhaler was designed to aid the patient to use their inhaler correctly. When using the inhaler, the attached module registers and communicates data to the app. The app, in turn, processes the information and presents data and the numbers to users and caregivers to give them insights into the asthma conditions.

Sammanfattning

Obehandlad astma begränsar möjligheten för astmatiker att leva ett aktivt liv och många har inte den kontroll över sin astma som de skulle behöva. Runt 50% av alla astmatiker använder dessutom sin inhalator felaktigt, vilket påverkar transporten av läkemedlet till luftvägar och lungor negativt. Astmainhalatorn är central i en astmatikers vardag och har stor potential att utvecklas mot ett modernt astmaverktyg med möjlighet att hjälpa användaren till förbättrad följsamhet och rätt användning av sin astmamedicin.

Detta projekt är ett samarbete med Zenit Design AB och Iconovo AB och har genomförts med hjälp av lärare och professorer på Lunds Tekniska Högskola. Uppdraget för projektet var att undersöka möjligheter, lösningar och design för en uppkopplad/digital inhalator med avsikt att öka och förbättra astmatikers användning av sin astmamedicin. Iconovo utvecklar generiska inhalatorer och en av deras produkter stod som objekt för projektet.

Det övergripande målet med arbetet var att lokalisera användarbehov och hitta sätt att implementera elektronik i inhalatorn för att tillfredsställa behov och förbättra användarupplevelsen. I den inledande fasen av projektet genomfördes därför intervjuer med astmatiker och personer inom astmasjukvården samt litteraturstudier, vilket gav en bred förståelse för astma som sjukdom och hur det är att leva med astma. Designprocessen inleddes därefter genom att definiera användarbehov och de problem som finns med dagens astmainhalatorer.

Genom att tänka entreprenöriellt och utveckla en produkt med ett Minimal Viable Product (MVP) - tillvägagångssätt, var den ursprungliga avsikten med inhalatorns design att enbart lösa de viktigaste användarbehoven. Genom att själva göra tillägg till det entreprenöriella förhållningssätt genom en egen metod lades ytterligare funktioner till för att uppfylla fler användarbehov och förbättra astmatikers inhaleringsteknik.

Efter att alla funktioner för konceptet hade bestämts utvecklades projektet till ett litet system innehållande en inhalator med löstagbar modul samt en tillhörande mobilapplikation. De tre komponenterna; inhalatorn, modulen och appen, designades och utvecklades i en iterativ process.

I slutändan, efter att ha arbetat med olika ljusspel och sensorer, utformades en digital astma/KOL-inhalator för att guida till korrekt användande av inhalatorn. Modulen i konceptet registrerar när inhalatorn används och kommunicerar det till appen. Appen i sin tur, bearbetar information och presenterar grafer och siffror för användare och vårdgivare för att ge dem inblick i sin eller sin patients astmastatus.

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Chapter 1.
Introduction

1.1 Background

Asthma is one of the most common chronic diseases in the world, about 10% of the population in Sweden has asthma (Astma- & allergilinjén, 2016). Asthma stands for nearly 1% of the total medical expenses in Sweden and untreated asthma leads to unnecessary hospital visits for the asthmatic (Holmner and Sundberg, 2000).

Untreated asthma limits the ability to live an active life (Astma- & allergilinjén, 2016), still many asthmatics does not have the level of control over their asthma as they could have. A contributing factor is too poor adherence to the prescribed treatment plan. To attain the best result, the treatment plan should be followed regularly even on symptom free days, which is difficult to relate to for many asthmatics (Akdis and Agache, 2013)

Asthma is normally treated by inhaling long-term control medicine (controller) and quick-relief medicines (reliever) or a combination of both medication (combination medication) from asthma inhalers. In addition, asthma treatment usually involves learning to recognize your triggers and how to avoid these.

Monitoring; medication, asthma triggers and improvement, help asthmatics gain more control over their disease, but can be hard to accomplish. Tools for measuring these factors are up and coming and possible solutions for connected e-health devices are getting increasingly popular.

The asthma inhaler is central in an asthmatics living and has great potential for development towards a modern asthma monitoring tool and could possibly improve the user's overall asthma knowledge.

1.2 Zenit Design

The outsourcer of the project is Zenit Design Group AB, Malmö, Sweden.

Zenit Design is a design consultancy with a broad design portfolio, founded by four industrial designers in 1994. Zenit Design works with a mix of customers, from long-term collaborations with big companies and industry leaders to missions for smaller companies and start-ups. A good cooperation in the industry is important and product designers, graphic designers, interaction designers, CGI-artists and mechanical designers at Zenit Design works close to the customers to help them strengthen their brand and market position (Zenit Design, 2017)



Figure 1.3.1 parts of ICONOVO's product family (ICOres in the middle)

1.3 Iconovo

Iconovo is a Swedish privately funded device company with a business model to supply the market with unique, safe and cost efficient inhalation devices. Iconovo has long and unique experience and capability in the development of inhalation devices. Iconovo's products combine technical complexity with user friendly and attractive design. Iconovo's ambition is to become a leading supplier on a global market.

Iconovo started as a part of Zenit Medical, a business unit within Zenit Design since 2010. Zenit Design has for many years successfully worked with the development of inhalation devices. When AstraZeneca closed down the Lund site and relocated the inhalation R&D to Mölndal, two key individuals from AstraZeneca joined Zenit Design and formed Zenit Medical. Over three years several concepts have been developed making up a family of innovative inhalation devices. In 2013 ICONOVO AB was formed to develop and commercialize the inhalation devices (Iconovo, 2015)

1.3.1 ICOres

The object of the project is a generic inhaler from Iconovo's family platform called ICOres (Figure 1.3.1.1, Iconovo, 2015). ICOres, is a multidose dry powder inhaler with two reservoirs were two different drug formulations, or the same formulation in both reservoirs, can be used (Iconovo, 2015). A dose counter shows the usage and visual feedback is given by an indication on the side of the inhaler when loading and inhaling the dose. A clicking sound gives the user tactile and audible feedback when loading a dose.

1.4 Project description

The mission of the thesis was to explore possibilities, solutions and designs for a connected ICORES powder inhaler, as well as taking moral aspects and consequences of designing a connected inhaler into consideration. The aim was to create new opportunities for the users and health care providers of ICORES.

1.5 Goal

The overall goal with the project was to localize user needs and to discover ways to implement electronics into the inhaler in order to solve the needs and improve user experience.

1.6 Delimitations

The purpose of an open project description from Zenit Design was to encourage a creative approach to the task in order for the authors to develop their own limitations and ways of getting through the design process. If nothing else is stated, the limitations described were developed after speaking with Zenit Design and Iconovo or during the literature studies.

1.6.1 Technical delimitations and requirements

The developed product is to use the existing mechanical vessel as today's ICORES and use the same drug delivery functions. The lid of the inhaler should protect against moist. The developed product shall be able to connect to or communicate with internet in order to improve the asthmatics usage and experience (Lundgren, 2016).

Other product requirements for the new product, specified by Dr. Lastow (2016) includes:

- Possibility to measure the force of inhalation
- A dosage counter
- Ability to operate without internet connection



Picture 1.6.1 Illustration of some of the delimitations.

1.6.2 Target group

Market

Since the product will have integrated electronic components, it is expected to have a potentially higher market price than regular inhalers. The supposed target market will therefore be developed countries, where the required infrastructure is already developed (Lundgren, 2016).

Age

Children under five commonly have difficulties inhaling from a powder inhaler. Therefore, spray inhalers are more commonly used for children of this age group (Astma- & allergilinjen, 2016). However, interviews with parents with small children have been carried out in order to find and confirm user needs. The target group is therefore mainly focused on people above the age of five. People with low inhalation strength, due to age or other diseases may also have difficulties with their inhalation technique and are therefore also excluded from the target group.

Disease

Medication delivered by inhalers is used by people with asthma, COPD (Chronic Obstructive Pulmonary Disease) and chronic bronchitis. After initial literature studies a decision to focus the research on asthma patients was taken.

1.7 Scope and structure of the thesis

The project, with start in September 2016, was carried out during 20 weeks and presented in February 2017 at the department of Design Sciences at Lund University.

The product development of the thesis started with research, that mainly included literature studies and interviews, and was followed by research conclusions and identification of user needs. The user needs became the foundation of the succeeding design process and a function analysis was made to support future design decisions and concept generations. The result is presented as a final concept and is followed by discussions and reflections.





Chapter 2

Methodology

2.1 Approach

The scope of this project was never to design a fully functional product, but a meaningful concept. But for this concept to be truly meaningful it was decided that the solution should benefit many (**market size**), solve real **user needs** and have viable **technical solutions**.

To do so without limiting creativity, rapid **entrepreneurial**- and creative **design methods** were mixed. Inspiration to the design methodologies is first of all found in *Vilda idéer och djuplodande analys om designmetodikens grunder* (Landqvist, 1994), *Interaktionsdesign och UX* (Arvola, 2016) and in the design methods used at Zenit Design. Entrepreneurial methods are mostly focus on lean startup methodologies and can be found in the *Lean startup* (Eric Ries, 2011).

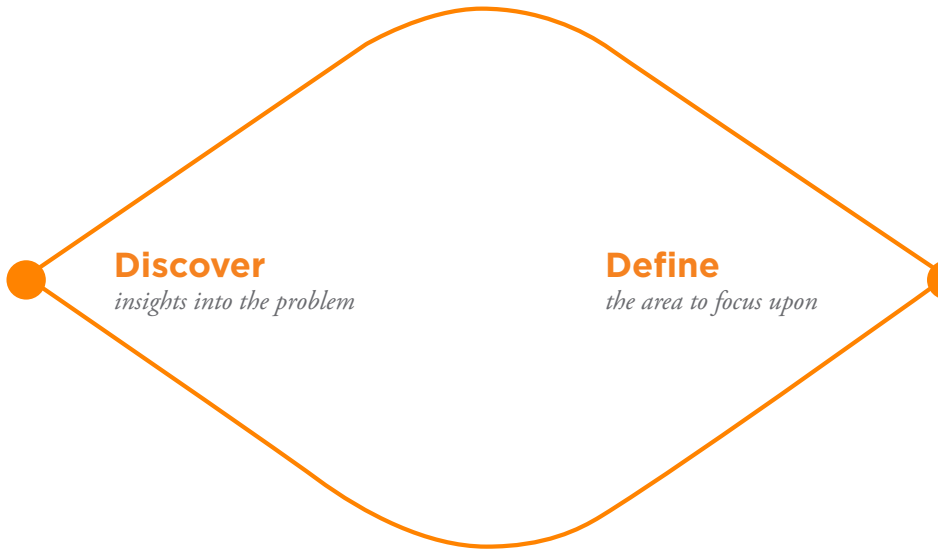
The overall method for approaching the project can be visualised through the Double Diamond Design Process see Figure 2.1. (also referred to as the double diamond method), developed by The Design Council.

The method is divided into four phases; *Discover*, *Define*, *Develop* and *Deliver*, which each represents the convergent or divergent stages of the design process. It illustrates how the different stages in the process either needs to open up to gather a wide range of inspiration and new ideas, or narrow down in order to find more concrete ideas and better focus (The Design Council, 2007). The Double Diamond Design Process presents the general activities that are common to all designers and opens up for creative thinking. The model gives concrete advices for appropriate tools and methods to use as frameworks during the process (The Design Council, 2017).

“Without a deep knowledge about electronical sensors, what they could measure, how specific they could be, their size and price - the development of the module was approached with an entrepreneurial mindset. A minimum viable product was to be developed first, an **MVP** - because in this way it could be determined if what we wanted to measure, even was measurable and at the same time applicable to an inhaler. So we asked ourselves:

If we could only measure one thing, what would that be?”

- early reflection about design methods.



2.1.1 Discover

The first quarter of the double diamond model was the start of the project and was about discovering new things, gather essential information, seeking inspiration and identifying user needs. Most of the Discover phase is presented in chapter three (and partly in chapter four) and mainly includes research regarding asthma and identification of user needs. The methods used to fulfil the phase in this project includes; literature studies, interviews, observations, stakeholder mapping and benchmarking.

2.1.2 Define

In the second quarter of the model the findings in the Discover phase were analysed and structured in order to channel actionable tasks. The findings were translated into user needs and problem statements. In the end of the design phase a new, clearer brief of the project could be composed. The methods used in the Define phase included brainstorming, function analysis and brief formulation.

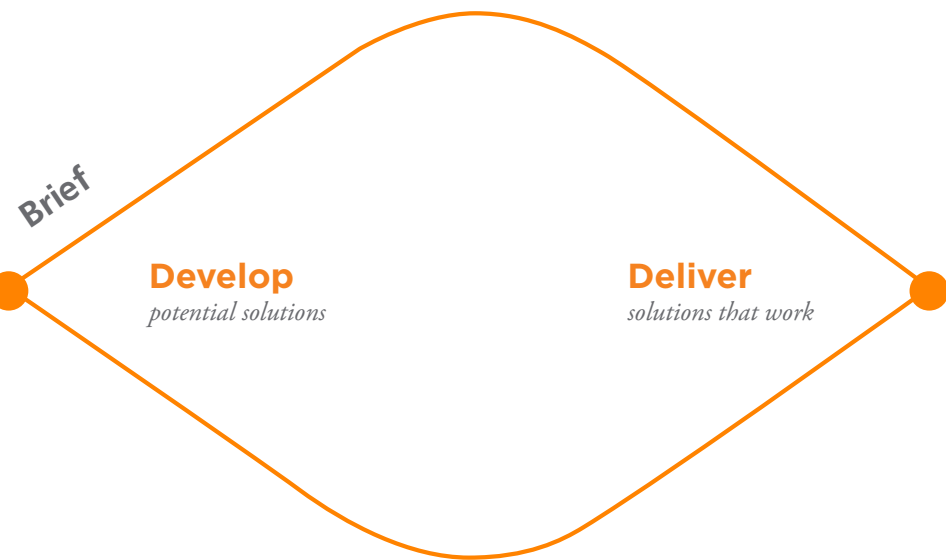


Figure 2.1. The double diamond process

2.1.3 Develop

After the project was narrowed down in order to be defined, the process was broadened again. In the Develop phase, the design brief was developed into concepts. The concepts were tested and research was done to verify their functions and validate them. All components that were needed for the final product were in this section developed until ready for implementation.

Design methods, such as rapid idea generation (brainstorming, brainwriting, sketching), storyboards, image boards and lo-fi prototypes were used. The Develop phase is first comprised in chapter five.

2.1.4 Deliver

The last part of the double diamond method explains all parts of the final concept, summarizes user tests and explains the final design. It includes a detailed, theoretical final concept, with renderings and explanations, and an actual prototype that shows some of the product features.

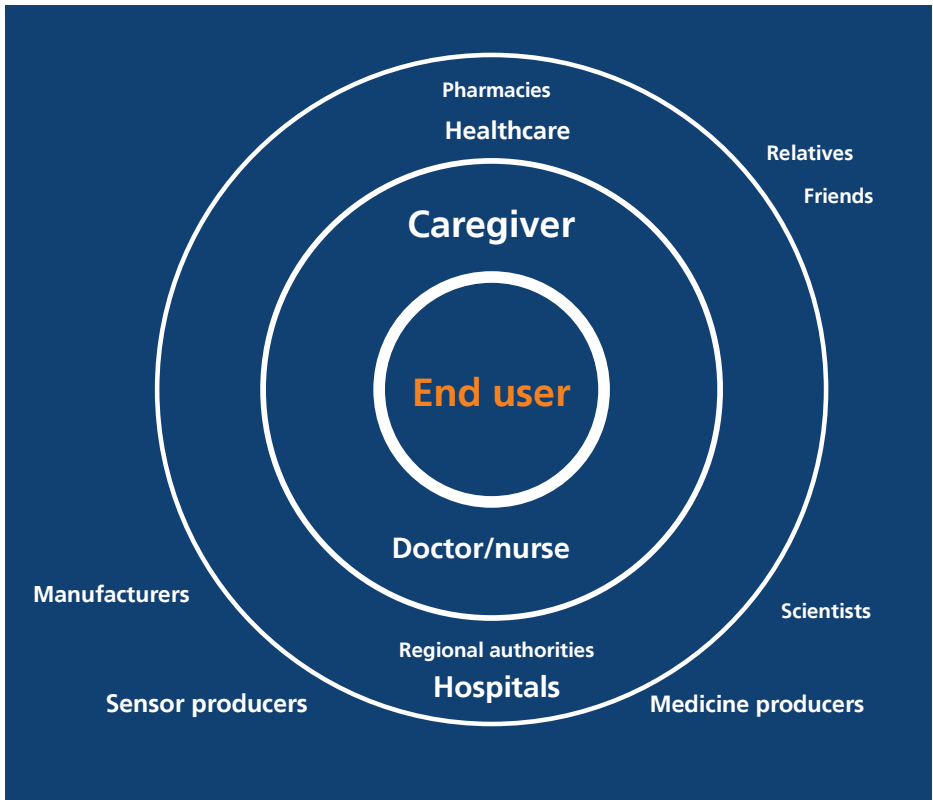


Figure 2.2.1.1 Stakeholder map with the end user in the middle.

2.2 Methods

2.2.1 Stakeholder mapping

The end users in this project are people with asthma. Stakeholder mapping contains a list of end users, those who depend on the end users, the ones that give the end user conditions or information, those who buy the product and those who pay for the product. In order to get a grip over different actors' involvement in the system around an asthma inhaler, and in order to build a network of contacts, stakeholders were mapped in the beginning of the project. See Figure 2.2.1.1.

2.2.2 Literature studies

Literature studies were carried out throughout the project to find facts and references. The literature included both books and electronic articles and web pages.

2.2.3 Brainstorming

Brainstorming was used in several parts of the project. The goal of brainstorming is to produce many ideas in a short time period and to combine ideas to get new ideas. No ideas can be criticized during the session and evaluation of the ideas is done afterwards (Jones, 1992). The ideas were often categorized, before evaluating, to get a better overview.

Brainwriting

Brainwriting, also called method 635, is a more structured form of brainstorming (Pahl and Beitz, 1988) and was used to gather more specific ideas and answering interesting questions. The original method was modified, so that only two people were needed for the performance:

Two participants, A and B, writes down five ideas each on a paper

- The papers are changed and A adds inspired notes to B and vice versa.
- The papers are changed back to the original author who finally adds new notes on the ideas in point 1 and 2.

2.2.4 Benchmarking

Benchmarking was used as a tool to get inspiration in the design process. It was used in different stages of the project to find strength and weaknesses in concurrent or similar products. In the beginning of the project, connected inhaler- products were excluded to not get caught up in existing solutions and functions. Later in the project, proof of concept was tested by benchmarking connected asthma devices.

2.2.5 Contextual study

In a contextual study interviews are combined with observations (in the context of the activity) with the intention to learn more about someone's living. The participants are the experts in the targeted context and explains what they do and about themselves (Arvola, 2016). Observations were made with asthma patients at the health centre Capio CityKliniken Lund Clemenstorget and at the asthma and allergy department at Lund University Hospital. The interviews with one of the men and one of the women in the age group 20-30, as well as both the two nurses, also included observations. During both interviews and observations, one of the authors asked the questions and the other one took notes.

2.2.6 Focus group and interviews

To gain insights in the asthmatics life and asthma treatment routine interviews and observations were performed in the beginning of the project. Open questions are preferable in an interview and it is important to listen to the participants without focusing on the next question. When doing telephone interviews, more effort is needed in order to get complete answers from the participants, it is therefore also important to have depth in the follow-up question (Arvola, 2016)

Some questions used in the interviews when talking to the focus group as well as individual end users, were collected from literature, (Hansson, 2007), (Arvola, 2016). Participants for the focus group were found at the university by reaching out in forums on social media connected to the university at Lund Technical University. The focus group was used (for the authors) to learn more about asthma, what to talk about concerning asthma and which questions to ask in following interviews, a more detailed version of the implementation can be found in Appendix A.

Interviews were held directly to end users and caregivers, through a focus group and telephone conversations, see figure 2.2.5.1. In addition, conversations were held to professionals; Two nurses and two doctors (one of them - Leif Bjermer - professor in respiratory medicine and allergology). A group meeting was held with Astma- och Allergiförbundet Skåne, eight men and women in the age 40 to 70 were attending (the group meeting and the professionals are not included in the figure). A more detailed picture of the interviews are presented in Appendix B.

2.2.7 User Journey

To get an understanding of the emotions patients go through when they are diagnosed with asthma, and which areas that could be improved upon when it comes to asthma treatment, a user journey was performed when the authors themselves *went to hospitals and acted as asthmatics*. In order to experience the same thing asthmatics goes through during their disease and hospital visits. Notes were taken of different touch points and emotional levels. A user journey template can be found in Appendix C)



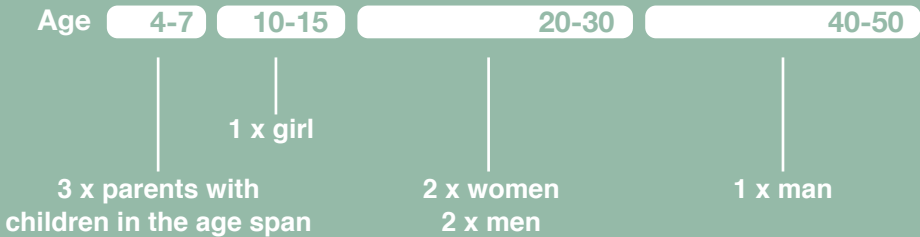
**2 Nurses & 2 Doctors
interviewed**

**1
x
Focus
group**

(5 people)

8 x professionals
(astma & allergiförbundet)

INTERVIEWS



...and we also did

1 user journey

Figure 2.2.5.1. Summary of the interviewed people.

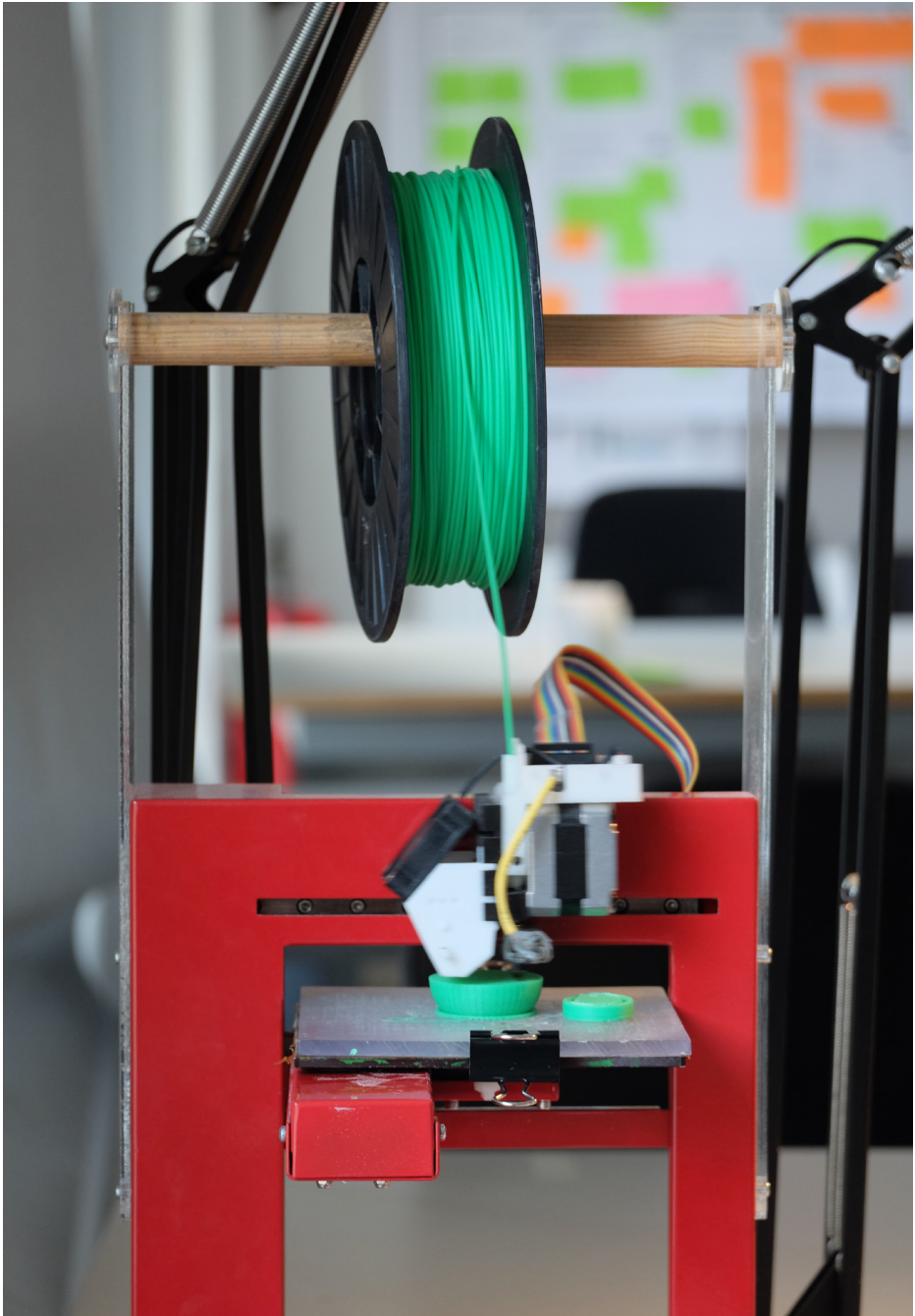


Figure 2.2.12. An Up! 3d-printer in action.

2.2.8 Function analysis

A function analysis was used for analysing and developing product requirements, list them as functions and in an easy way provide an overview of the intended product. The functions were later used to ensure that necessities are considered and to help select which concept to choose (Landqvist, 1994).

The function analysis in this project was built from the list of needs gathered from stakeholders and from the project delimitations. After being listed, one of the functions was chosen as the main function and the remaining were ranked as necessary or wanted.

2.2.9 Sketching

During the whole project rapid sketches were made to investigate functions and form.

2.2.10 Image boards

Image boards are used at Zenit Design to investigate aesthetics and form. In this project, image boards were created in the initial form studies and used throughout the project to assist design choices.

2.2.11 3D modelling and rendering

3D-modelling was made in Creo Parametric and Rhinoceros and rendering in KeyShot, to investigate form, material and colours.

2.2.12 Rapid prototyping/3D-printing

A 3D-printer (Figure 2.2.12) was used to get quick lo-fi prototypes and a better feeling of the form. Attributes, such as threads and magnet-attachments could easily be tested.

2.2.13 User tests

A network of asthmatics in different age groups were established in the beginning of the project so user testing could be conducted regularly and rapidly. Doctors and health care professionals were also consulted during the project to ensure (as good as possible) that the intended product would deliver the intended value. User tests were mainly conducted through observing users when they described prototypes and images - matching reactions and descriptions that were sought after with the intended design.

2.2.14 Design for manufacturing

Design for manufacturing was touched upon in this project through consultation with engineers, professors, design teachers and electronics professionals at Lundinova.

Lundinova

Lundinova is a product development company, specialized in electronics, software, industrial design and project management, based in Lund. Our contact person at Lundinova was Fredrik Bågenholm.

2.3 Project Plan

A time plan was conducted in the beginning of the project and was based on the four phases in the Double Diamond Design Process, with some parts of the phases overlapping each other. The Project Plan can be found in Appendix D.



In order to solve real problems, quantitative data from scientific reports and observations at the hospitals were mixed with open interviews and conversations with asthmatics, digital healthcare professionals and doctors.

Picture from WIKIMEDIA COMMONS



Chapter 3

Research

3.1 The Internet of Things

Connected things are creating more data than ever before. The internet of things (IoT), where physical devices are able to collect and exchange data, is evolving rapidly due to new manufacturing methods and advanced technology. The analysis company Gartner predicts there will be more than 20 billion connected products in 2020 (Geschickter and Moyer, 2016).

Internet of Things is a collective term for the ongoing progress which imply that machines, vehicles, household appliances, goods and other consumer products are equipped with small built-in sensors and computers. Characteristic for IoT is that the combination of smart unique sensors, mobile technology and cloud services creates a possibility to collect, process and communicate specific data. One can thus gain insight information of i.e. where the product is located, how it is used and whether it is functioning optimally or is in need of maintenance (Westergren, Saarikko and Blomquist, 2017).

3.1.1 The market for smart inhalers

The global market for digital dose inhalers for asthma and COPD will be worth \$3.56 billion in 2024, according to a prediction from Grand View Research (Comstock, 2016). Citing an aging population and a surge in the prevalence of chronic respiratory disease as two drivers. A rapid market growth is also predicted outside of North America in countries such as China, India, Brazil and Philippines due to a growth in the per capita income. Following is stated (Grand View Research, 2016):

Moreover, these technology-enabled respiratory devices are greatly sought after among the pediatric and the geriatric population so as to improve the patient medication compliance, dose tracking, and to enhance patient-health care practitioner connectivity that would enable real-time tracking of health care data; these serve as high impact rendering factors, significantly driving the market growth in the next nine years.

In a study by PWC 66% of the interviewed doctors believed that online video appointments could to some extent replace physical visits. And between 59-88% believed that it is very possible or pretty possible to determine the needed treatment through home-diagnostics-tests or do it yourself diagnosing (PWC, 2016).

The digital inhaler market is expected to **grow**

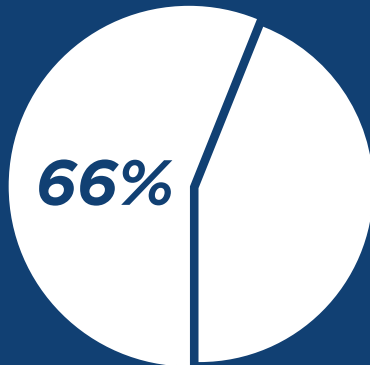
(Grand View Research)

\$3.56 billion (2024)



\$839.4 million (2015)

The future is **online**



Doctors believe that video appointments to some extent could replace physical visits.
(PWC)

59-88% **DIY solutions**

59-88% believed that it is very possible or pretty possible to determine the needed treatment through home-diagnostics-tests or do it yourself diagnosing.

(PWC)

3.1.2 Trust

In a world where more and more products become self-thinking or connected, people need to trust their devices. When things start to make decisions for the user it is central that the user feels like the decisions are inclined to their benefits. It is therefore important to focus on trust issues while designing new connected or self-thinking products. Trust issues may rise in the fear of being scammed or stalked, or fear of intrusion on personal information and privacy issues (Burnham, 2011).

A couple of notable findings regarding trust are following:

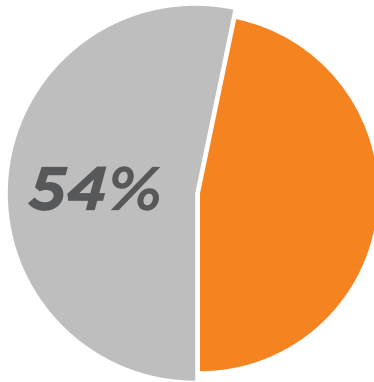
- A predictable behaviour is the key of trust in any relationship. If the behaviour of a product is random and unadaptable to its usual behaviour, user's reliance is reduced.
- When two things cannot communicate, trust ends very quickly. Therefore, in the future, internet needs to be ubiquitous and universal.
- If a product collects data about the user it is important that the user gets information and understands which data that is gathered, the content of the data and what the data will be used for.
- If the behaviour and character within the code are designed to benefit the device or company more than the user, the IoT works against trust not for it.

3.1.3 E-health

An important aspect when it comes to E-health in general is that a situation where the patient is inactive is bad (Bjerner, 2016). The patient needs to have personal contact with the doctor and be responsible for their own treatment. Big data can be collected from smart and connected devices and is needed to analyse patterns, but in the end the patient needs to be in focus and get relevant data which can lead them to better treatment.

Possibilities that information technology offers for an improved health situation are (Ruland, 2002):

- Communication
- Patient's allowance to be more involved in the decision making
- Documentation



Use their inhaler wrong

(journal of Aerosol medicine)

Figure 3.2 54% use their inhaler one month after receiving instructions.

3.2 Asthma

The disease state asthma means chronically inflamed bronchus that are extra sensitive for irritant or allergenic substances, causing respiratory distress. The dominating symptom is dyspnea, but wheezing, chest tightness and/or cough are also typical. 1 out of 10 person have asthma in Sweden (Bjermer, 2017).

3.2.1 Medication and treatment

Untreated asthma limits the ability to live an active life and leads to unnecessary hospital visits (Astma- & allergilinjen, 2017). Asthmatics medicate to prevent and treat their asthma by using anti-inflammatory control medicine (controller) for long term treatment on a regular basis and rescue medicine (reliever), to provide a quick relief of symptoms (Akdis and Agache, 2013).

3.2.2 Control

Medication shall be increased or decreased in relation to the level of asthma control. The level of control is divided in three conditions; controlled, partly controlled and uncontrolled. If no clinical symptoms are present and if the disease does not limit any daily activities, asthma can be deemed "controlled". In turn, frequent usage of reliever medicine may be a marker of uncontrolled asthma (Akdis and Agache, 2013).

3.2.3 The patient's responsibility

The patient's involvement is central to their treatment. Patients with asthma are provided with an individual treatment plan with instructions about PEF-measuring and how to change the medicine intake according to symptoms and eventual PEF-values. All patients with asthma need knowledge about what triggers the attacks, the effects of their medicine and how the treatment should be changed according to their asthma level, (Hansson, 2007), (Holmner and Sundberg, 2000, 12).

The role of the health care, on the other hand, is to engage patients in important information and motivate the patients to take responsibility in their illness and the treatment of the illness (Hansson, 2007). The main goal is for the patient to learn to live as symptom-free as possible by having as good control over the asthma as possible (Hedlin and Larsson, 2009). Further, it is important that the patient learns to find early signs of change to make correct risk assessments and know how to change the medication if exacerbation occurs.

In other words, the control needs to be in the hands of the asthmatic, but while striving for control and responsibility it is important to accept their own limits and not feel guilty about the condition (Holmner and Sundberg, 2000).

3.2.4 Monitoring

To assess control and an optimized treatment it is required for the patient to have an active monitoring, this is because asthma is of such various nature (Akdis and Agache, 2013), (Holmner and Sundberg, 2000, 21). Monitoring is a learning process and can be done in order to, for example, follow the compliance to the treatment plan or to localize asthma triggers. The monitoring helps the patient (or guardian) adhere to their (their child's) treatment plan. If compliance to the treatment plan has been documented, follow-ups at the health care can be made easier, medication can be regulated and new treatment plans can be developed considering the actual usage of asthma medicine (Holmner and Sundberg, 2000).

Electronic diaries are today used in clinical trials and may improve adherence to treatment. By monitoring the documentation automatically, the user can keep an eye on their compliance and their use of reliever medicine (Akdis and Agache, 2013).

3.2.5 Triggers in the external environment

Many situations in daily life can be prevented if the individual learns to pay attention and take action if any exacerbation occurs (Holmner and Sundberg, 2000). Asthma triggers irritates the airways and are the reasons asthma exacerbates.

- Asthma- trigger list (Asthma UK, 2017)
- Colds and flu
- Food
- Indoor environment (central heating, open fires, carpets and furniture, cleaning, building work)
- Pollution
- Smoking (and second-hand smoke)
- Alcohol
- Emotions
- Hormones
- Moulds and fungi
- Recreational drugs
- Stress and anxiety
- Animals and pets
- Exercise
- House dust mites
- Pollen
- Sex
- Weather (cold or damp air, hot weather, thunderstorms)

3.2.6 Irregularity in medication

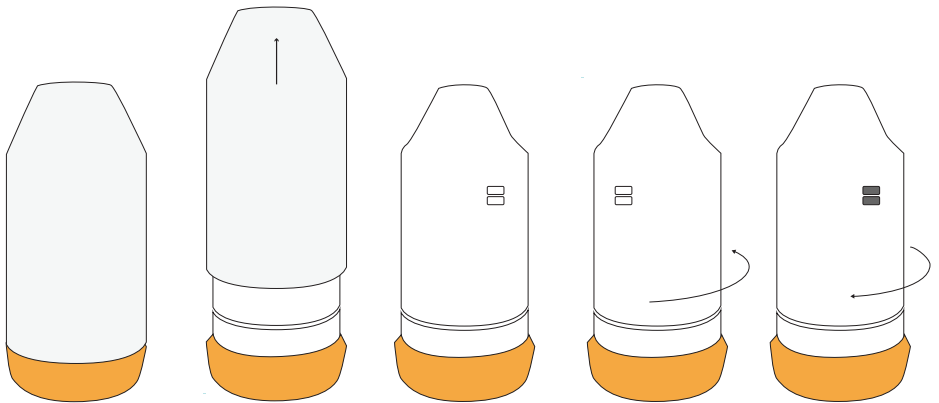
Too poor adherence to the prescribed treatment plan is one reason many asthmatics do not have fully controlled asthma today. For best result, the treatment plan shall be followed regularly, even on symptom free days. A french study showed that 54% used the turbuhaler (a similar inhaler to the ICOREs by function) incorrectly one month after receiving instructions on how to use it (Molimard, 2017).

Reasons for not taking the medicine:

- Symptom free (“I feel good today - I don’t need my medicine”)
- Forgetfulness
- Fear of side effects
- Psychological reasons (i.e. it makes you feel more sick if you take the medicine) (Akdis and Agache, 2013).

To prevent irregular medication, Holmner and Sundberg (2000) propose:

- Provide important information to the patient
- As uncomplicated treatment as possible
- The patient’s concurrence when determining the treatment
- Personalize the treatment and not generalize
- Make goals that are measurable



1

The lid is on.

2

The lid is taken off.

3

The inhaler is unloaded, no flag is shown in the window.

4

The inhaler is ½ loaded, no flag is shown in the window (the inhaler needs to be in vertical position).

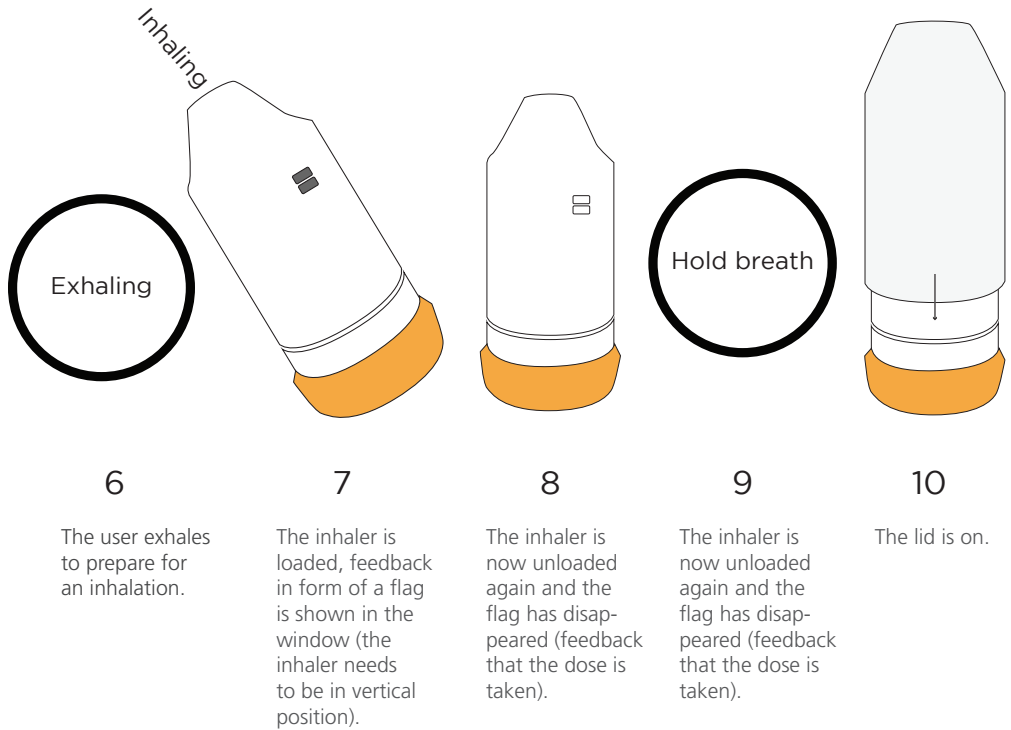
5

The inhaler is loaded, feedback in form of a flag is shown in the window (the inhaler needs to be in vertical position).

3.2.7 Inhalation Technique

Another reason to irregularity in medication is the occurrence of poor inhalation technique. According to Bjermer (2016), this is a common error derived from faulty demonstrations (from health care), a careless attitude or unawareness from the patient. Bjermer tells that it is common that pa-

Figure 3.2.7.1
The correct inhalation procedure with an ICOrs.



tients get a new inhaler without sufficient instructions how to use it which may lead to insecurity and negative placebo. It is therefore important that health care professionals provide an ongoing and correct inhaler technique (Figure 3.2.7.1) training (Ryan, et al. 2016).



Picture 3.2.8.1 A person who is not holding their inhaler in an upright position while triggering a dose.




3.3 Benchmarking

A benchmarking on regular inhalers was done in the beginning of the project to understand the different types of medications before talking to users and health care professionals. Figure 3.3.1 shows the turbuhalers, Bricanyl and Pulmicort - the most similar inhaler to the ICORes on the market today. The bricanyl is the reliever (relieves the symptoms but doesn't work preventive) and pulmicort is a controller (preventive). Another popular turbuhaler is the Symbicort which is a combination of both preventer and controller - the colour for combination medicines are mostly red and purple.



Figure 3.3.1 The Bricanyl and Pulmicort from Astra Zeneca.

A close-up photograph of a person's hand holding a small, white cylindrical container with an orange, ribbed cap. The person's face is partially visible on the right side of the frame. The background is a dark, pleated lampshade with a vertical wooden pole. The lighting is soft and focused on the hand and the container.

Displayed in this chapter, the second part of the research is presented and concentrated into user needs and a function analysis. The conclusions made in this chapter are based on people's expressed opinions and feelings and conducted through interviews, observations and hospital visits.



Chapter 4

User Needs

4.1 Key findings

After interviewing and observing asthmatics, parents to asthmatic children, doctors and nurses problems and needs relating to asthma was discovered. The key findings are the needs or problems that was brought up more frequently than other or, in some way, stood out from the rest, was important for the project and in need of notice.

4.1.1 When speaking to health care

Compliance

It is important that the inhaler is used correctly, otherwise the patient do not receive full potential of the medicine. To do that, correct inhalation technique is central. Continuous usage of the controller medicine is also fundamental for good compliance. For many people, this is difficult and leads to more symptoms and an overconsumption of the reliever medicine.

Responsibility

it is the patient's responsibility to maintain the treatment plan and asthma status, but the health care helps to inform and support.

4.1.2 When speaking to end users (age 20-45)

Motivation

A lot of motivation is needed to stick to the treatment plan and the prescribed ordination.

Own responsibility

The user has a great own responsibility in order to follow the treatment plan. There is also much to keep in mind, in order to brief the nurse/doctor you need to remember your case history and where and when the asthma exacerbates.

Feedback

Correct feedback from the inhaler is important, the user wants to know if the medicine was taken correctly or if the medicine is running low.

Steady contacts

It is hard to establish good contacts within the health care and if you change clinic your journal is not always transmitted. The same applies for emergency visits, where not always suitable acute medicine is prescribed.

Feel ashamed

Lastly, an additional finding was that some of the interviewed asthmatics does not like to show their medicine to friends and surrounding people. It can be because they do not want to show that they have asthma, that they think that the inhaler is ugly or that they want to avoid embarrassing question.

4.1.3 When speaking to parents/guardians

Am I doing the right thing?

For parents who helps their child with the medication it is hard to know if the child inhaled strong enough, if the medicine really suits the child or if it something else that should be better to do.

However, when the child is older and handles the medication alone the parent cannot be sure the child follows the plan.

Time

It takes a lot of time to take care of an asthmatic child, and there is much to keep in mind; when asthma exacerbations took place, hospital visits and new medication orders.

Feel ashamed

A child does not want to be different, she wants to be able to play just as much as the other children. Parents sometimes experienced that their child was ashamed of their asthma and did not want to tell their teacher that they needed their asthma medicine.

4.2 Identification of User Need

A map with the end user in the middle surrounded by three important relations (for an asthma patient), shows their main problems and needs. But also ideas from end users and conclusions from observation (Figure 4.2.1).

4.2.1 List of needs

After studying the list of key findings and the map of user needs three words was picked to explain the user needs in general: **control** of the disease and the treatment, **motivation** to follow treatment plan and an **understanding** for the disease (on an individual basis). All these are essential for good compliance and relevant for asthma patients. If the patient understands their disease it can increase their motivation to follow their treatment and thereby gain better control over their asthma condition (Hansson, 2007), (Figure 4.2.1.1).

Focusing on this and to summarize the research and get an overview of the user needs a list was constructed, (for original list see Appendix E). The list is illustrated in Figure 4.2.1.2 and the expressions in the figure are focusing on what the user needs or wants.



Figure 4.2.1.1 Key findings

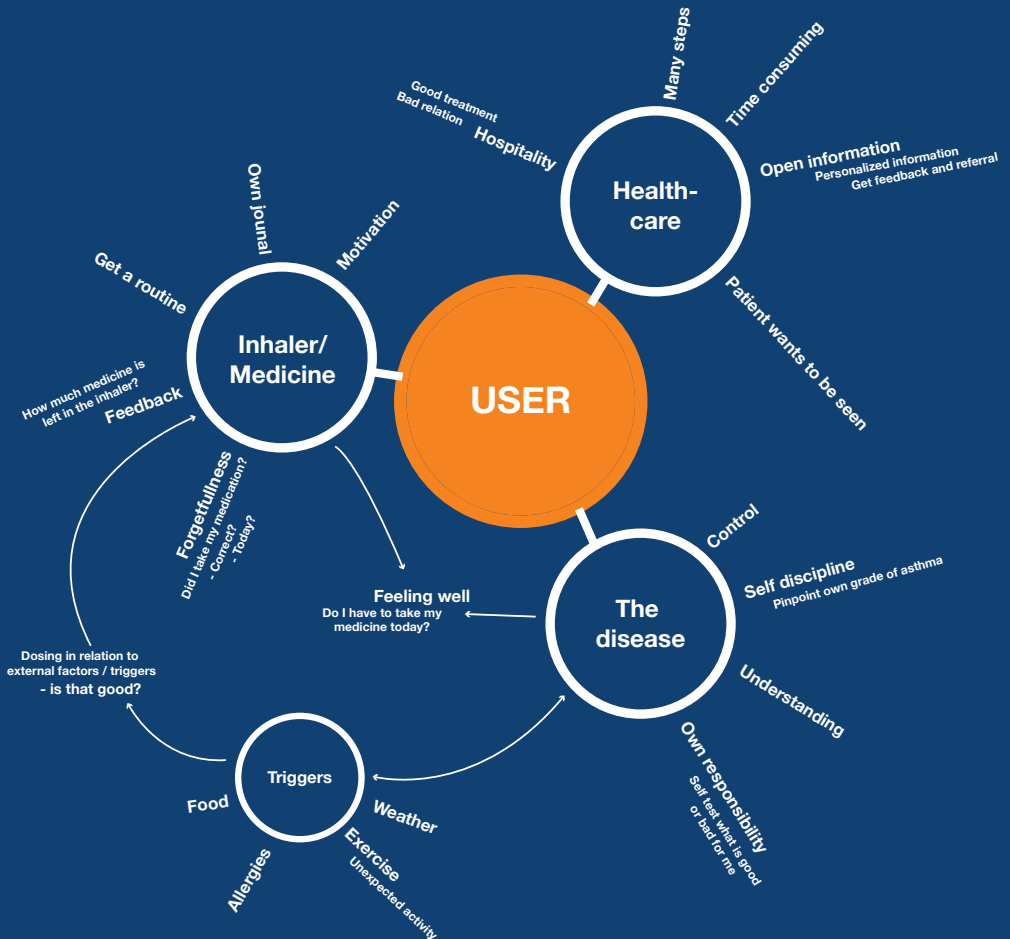


Figure 4.2.1. A map showing the end user's needs related to the inhaler, the health care and the disease.

4.3 Brief

To help patients gain more control, the task is to design a concept for the next generation ICORES inhaler, that gives an indication of the patient's asthma status by **registering when a dose has been taken, display the data and log the information.**

The goal is also to raise the level of motivation and understanding for asthma and what it is that **triggers the disease.**

Furthermore, the design of the inhaler is aimed towards removing the stigma around taking asthma medication.

4.4 Function Analysis

After researching and identifying user needs it was easier to know what product to strive for, a function analysis (figure 4.4.1) was therefore used throughout the project. In conjunction with design decisions, the list was modified along the way, but also used to motivate the decisions. In the end the headlines for the different parts in the function analysis were; Module, Size of Module, Inhaler and App.

All needed functions are implemented in the final concept, and so are most of the wished functions. (MF=Main Function, N=Needed, W=Wished)

Module

| | |
|----------------------------------|----|
| Register dose has been taken | MF |
| Transfer data to app | N |
| On/off indicator | N |
| Don't fall off easily | N |
| Indicate battery status | W |
| Register level of inhalation | W |
| Can be detached | W |
| Magnet attachment to the inhaler | W |
| Be placed under inhaler | W |

Module Size

| | |
|------------------------------------|---|
| Size fits the inhaler | N |
| Room for all electronic components | N |
| Room for battery | N |
| As small as possible | W |
| Not too fragile | W |

Module Resistance

| | |
|-------------|---|
| Dust | N |
| Temperature | N |
| Humidity | N |
| Water | W |

Inhaler

| | |
|-----------------------------------|---|
| Module stays in place | N |
| Allow inhalation | N |
| Feedback about if dose is inhaled | N |
| Room for module | N |
| Room for existing "motor" | N |
| Washable | W |
| Discover different medicines | W |
| In line with chosen image board | W |
| Ergonomic | W |
| Reminder to inhale | W |
| Reminder to order new medicine | W |
| Allow good grip | W |
| Look small and neat | W |
| Visible amount of doses left | W |
| Iconic | W |
| Visible LEDs while inhaling | W |
| Easy to transport | W |
| Simple (not look overworked) | W |

App

| | |
|--|---|
| Keep track of dosage | N |
| Gather API data | N |
| Register inhalation time (day) | N |
| Register inhalation location | W |
| Graphically in line with inhaler, module | W |
| Reminder to inhale | W |
| Reminder to order new medicine | W |

Figure 4.4.1 Function analysis





Displayed in this chapter, the second part of the research is presented and concentrated into user needs and a function analysis. The conclusions made in this chapter are based on people's expressed opinions and feelings and conducted through interviews, observations and hospital visits.

Chapter 5

Concept Generation & Selection

5.1 The overall concept

5.1.1 Starting points

From the brief in the former chapter following were stated:

- The inhaler will register if and when it is used
- Information will be logged and displayed for the user
- Reduce the stigma about taking asthma medication in public

The brief also said that the concept should give indications of the patient's asthma status, which was interpreted and following developmental starting points were formulated:

- Consult how triggers exacerbates asthma and link it with compliance
- Help the patient obtain correct inhalation technique
- Measure improvement of asthma status and/or pulmonary function
- Inform the patient about the disease, symptoms and medicine

5.1.2 Main concepts

The starting points above were boiled down to four main concepts for the inhaler. Each main concept was developed and focused on separately to find embodied ideas and concepts. The aim was to initially empower each concept on its own.

Concept 1: Documentation and compliance

Initial idea: Automatically monitoring the patient's compliance to the medication.

Every time an asthmatic uses the inhaler it is registered in order to document the asthma medicine usage. By doing this, the asthmatic can have better control over their treatment and easier remember when (and possibly where) the asthma was worsened.

The concept was aimed to be simple and already existing ICORes functions were therefore considered first to be possible solutions for registration:

1. A switch (or similar) that registers the loading of the medicine (the twist back and forth).
2. Sensors that use present mechanical functions inside the inhaler. The first of these solutions only registers that a dose is loaded, not that it is inhaled. The second could register both the loading and the inhaling.

Concept 2. Inhalation technique

Initial idea: Instruct correct inhalation technique and give feedback on performed inhalation.

The weak links in this procedure is step 4-9 in Figure 3.2.7.1. When loading a dose, the inhaler needs to be in upright position - which is something many users do not know or does not think of. The exhalation before taking the medicine needs to be powerful so that the forthcoming inhalation can be as strong as possible. The inhalation needs to reach at least a minimum flow-value (preferably over 60 l/min). After the inhalation, the user should hold the breath for approximately ten seconds, which easily becomes shuffled-off. How this technique could be attended to in the concept is developed further in the next chapter. Possible ways to measure the performed inhalation could be by using a pressure sensor or a flow sensor inside the inhaler. Today this is done mechanically and one solution could be to use that mechanism and connect it to a switch or sensor. This alternative would mean some reconstruction of the the exciting construction.

Concept 3. Asthma status (through spirometry)

Initial idea: Help the patient improve their asthma status by giving them feedback on their pulmonary function.

The pulmonary function is today measured by spirometry and PEF (peak expiratory flow) at the hospital, simple connected spirometers for home use are emerging on the market as well. If the same, or similar, results could be taken from a PIF (peak inspiratory flow) measuring while inhaling the asthma medicine it could help doctors analyzing the patient's asthma improvement. Possible ways to measure this could be by using sensors (as in the inhalation technique concept) but in this case more advanced and also more advanced data management than in earlier concepts. This alternative would probably mean some reconstruction in the exciting construction.

Concept 4. External factors and asthma triggers

Initial idea: Localize asthma triggers and map which external factors that affect the asthma status.

Asthma triggers such as pollen or weather conditions could be recognized by sampling API (Application Programming Interface) data and forecasts from weather or pollen stations. If using an app, this would necessarily not need to be performed by the inhaler, but collected to a software on the mobile phone instead. A complementary idea would be if asthma triggers

could be related to the usage of control medicine and with this combination improve the asthma status.

5.1.3 The Pyramid

A pyramid figure was invented (Figure 5.1.3) in order to arrange and illustrate how advanced the different concepts would be in terms of technicality (sensors), feasibility in production and level of work needed to create an effective user experience. The pyramid also illustrates that to reach the higher steps, the underlying part has to be solved first.

The foundation is based on the documentation and compliance concept because good compliance and adherence to the medication are essential in an asthma treatment. If a patient can show a documentation of their medication usage to the doctor it is easier for the doctor to prescribe correct dosage and update the treatment plan.

When the users have a functioning documentation, the next step for good adherence is to improve the inhalation technique. If correct inhalation technique cannot be accomplished the patient risks ineffectiveness of the medicine, the middle of the pyramid handles the inhalation technique.

The top of the pyramid consists of asthma improvement. Good adherence and correct inhalation technique are two steps in the right direction of improving the overall control of asthma status and pulmonary function. If the pulmonary function could be measured, the asthma patient could get direct feedback and data to present on the next visit with the doctor.

The concept that handles asthma triggers exists outside the pyramid, this is because this concept can be implemented in all three sections of the pyramid.

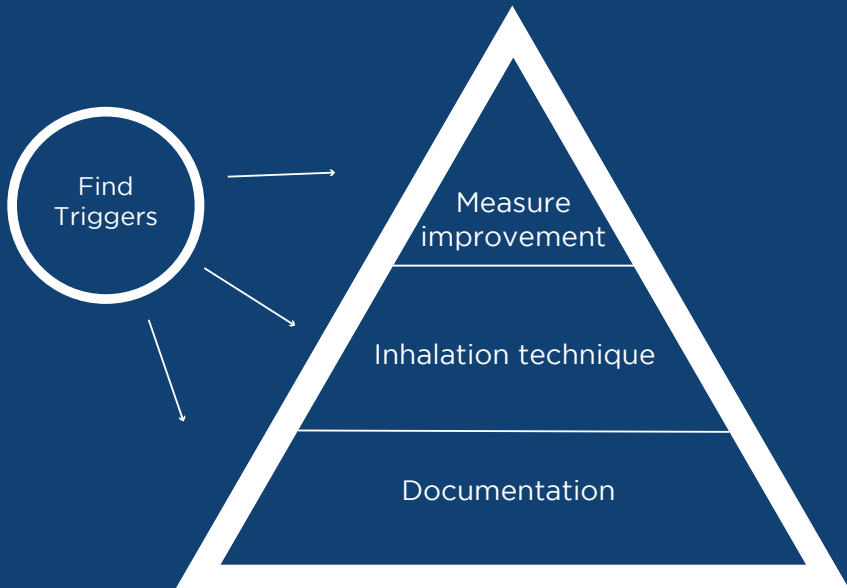


Figure 5.1.3. A foundation of documentation and compliance, a core of inhalation technique, a top with asthma improvement. The trigger concept (external factors) on the outside can be implemented in all sections.

5.1.4 Selection of main concept

As the pyramid suggests, all concepts could together build one concept, which was the decided way to go with the project. As seen in the pyramid, implementing documentation lays the foundation for the project and was therefore chosen to be implied first with the aim to reach better compliance amongst the users. The ambition was however to reach the top of the pyramid and to do that it was also required to explore the possibilities to improve the inhalation technique.

It would be a good compliment to the documentation to also register if the inhalation was strong enough, this could namely speak for good or bad compliance. Since feedback is given when a dose has been inhaled on the existing ICORes, through the "feedback flag" - it was decided that the connected inhaler also would register this and log the information. It was also decided to continue exploring the feedback on the inhalation procedure.

After some research it was found to be advanced to measure pulmonary function by inhaling from an asthma inhaler. In addition, peak inspiratory flow values are not used in the health care on a regular basis today. The idea to measure pulmonary function was therefore left outside the frames of this project but will be brought up again in the discussion.

Lastly, it was decided to collect API data and analyse if it could be combined with usage of control medicine in order to estimate good or bad asthma control.

5.2 Positioning of technology - the introduction of the module

Parallel to the overall concept generation, the technical solutions for the positioning of the electronical components were to be considered. After studying the construction of the ICORes, three possible solutions for placement were suggested: Integrated in the top part of the inhaler, integrated in the bottom of the inhaler, or as an external module to be attached somewhere on the inhaler.

5.2.1 Integrated concepts

The idea with an integrated concept means integrating all technology inside the original configuration of the inhaler. The ICORes consists of 180 doses and when they are finished the inhaler is thrown away and recycled. Therefore, fully integrated solutions were cancelled due to environmental considerations and bad recycling potentials.

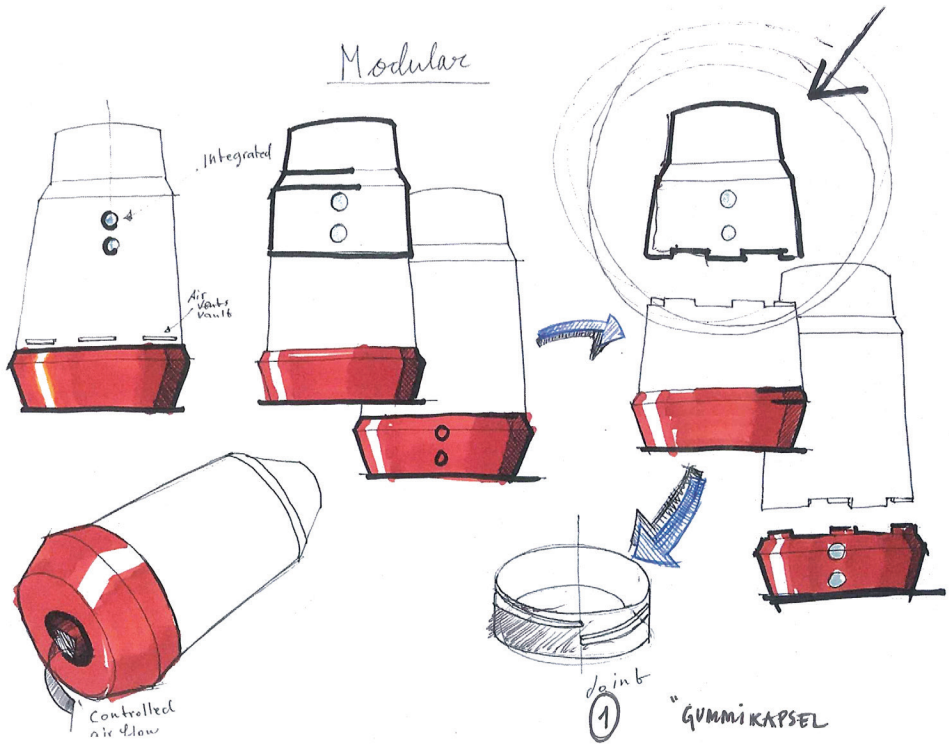


Figure 5.2.2. Early sketches of integrated modular concept.

5.2.2 Integrated modular concepts

The idea of an integrated modular solution was to keep the technology integrated within the inhaler's original configuration and in the same time be able to keep the technology when the medicine is finished. This means that you can use the module over again on the new inhalers (Figure 5.2.2).

With an integrated modular solution, the inhaler needs to be splitted into two parts, one to consume and one to keep. There is limited free space in the top of the inhaler, over the deliver construction where the module could be placed. The solution could also be placed as an extension under the medication deliver construction.

5.2.3 Modular concept

Two considered placements, if the technology was to be in a module, were; under the inhaler or in contact with the already existing openings for the number-wheel and “feedback-flag”. The modular solutions do not primarily need to affect the configuration of the inhaler. Sketches of potential solutions are shown in Figure 5.2.3.

5.2.4 Selecting the modular concept

All integrated solutions were declined due to described reasons. Since the inhaler, by itself, includes medicine that runs out when all doses are inhaled (about 180 doses), it is a consumable product. If it was to be replaced every second month it would be expensive and bad for the environment.

The integrated modular solutions were also declined with reference to the requirement that the inhaler should be able to be used even if the technology is not working. If the integrated modular solution is not attached, the inhaler would miss essential features (the mouthpiece or the charger).

The modular solution was best fitted to the purpose and after consultation with Zenit Design and Iconovo it was decided that it was preferable to have something that looked as it was integrated, but easy to remove. It was decided that a module on the bottom of the inhaler was to be further explored.

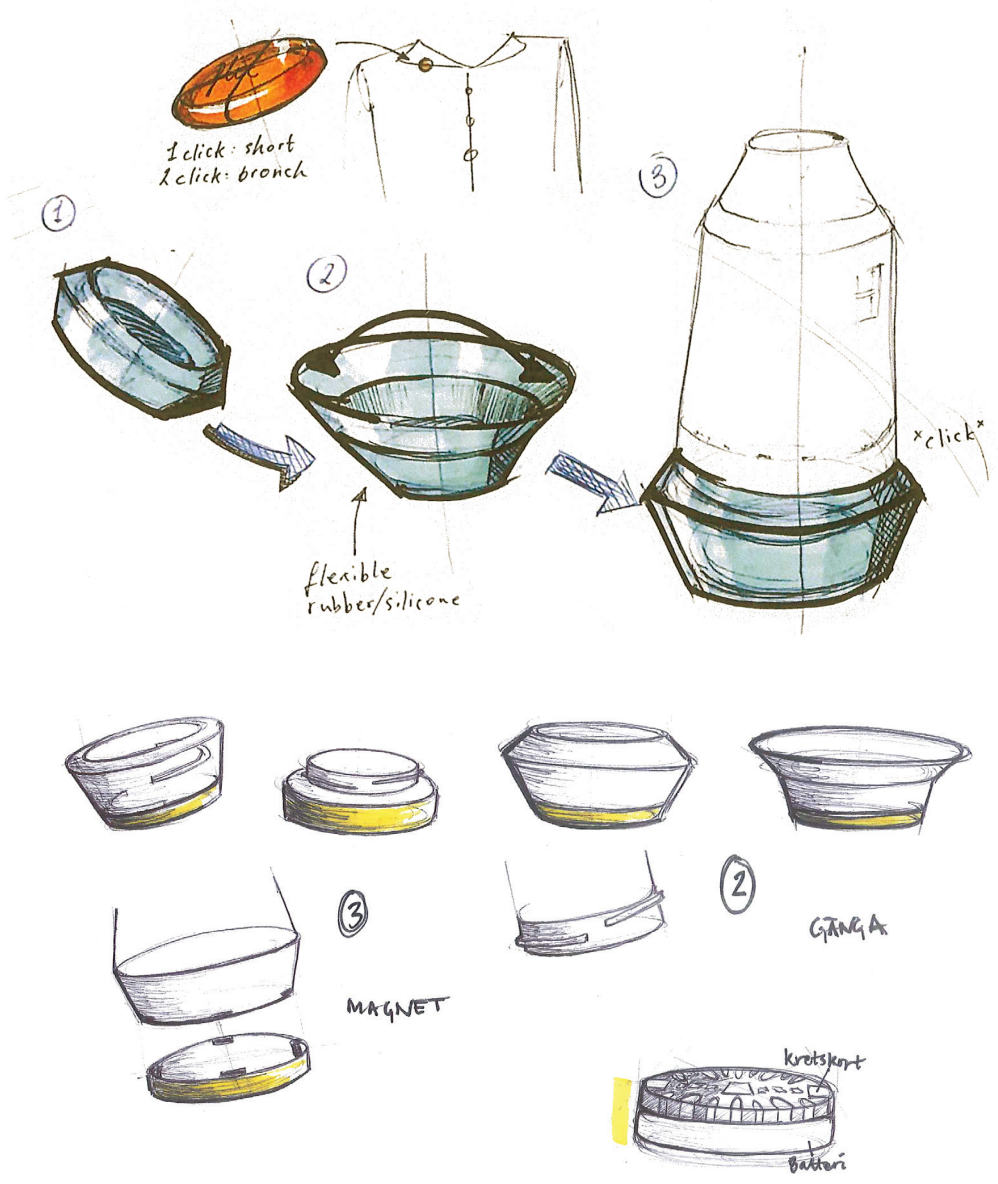


Figure 5.2.3 Sketches of how the digital parts could be attached to the inhaler through a module.



Figure 5.3. Early drawing of an inhaler with integrated display.

5.3 Displaying the data - the introduction of the app

5.3.1 Communicate registered data

Parallel to the overall concept generation and the positioning of technology ideas of how to present data for the user were generated. Two options for displaying and communicating data were concluded to be integrated in the inhaler or as an external solution (Figure 5.3 and Figure 5.3.1).

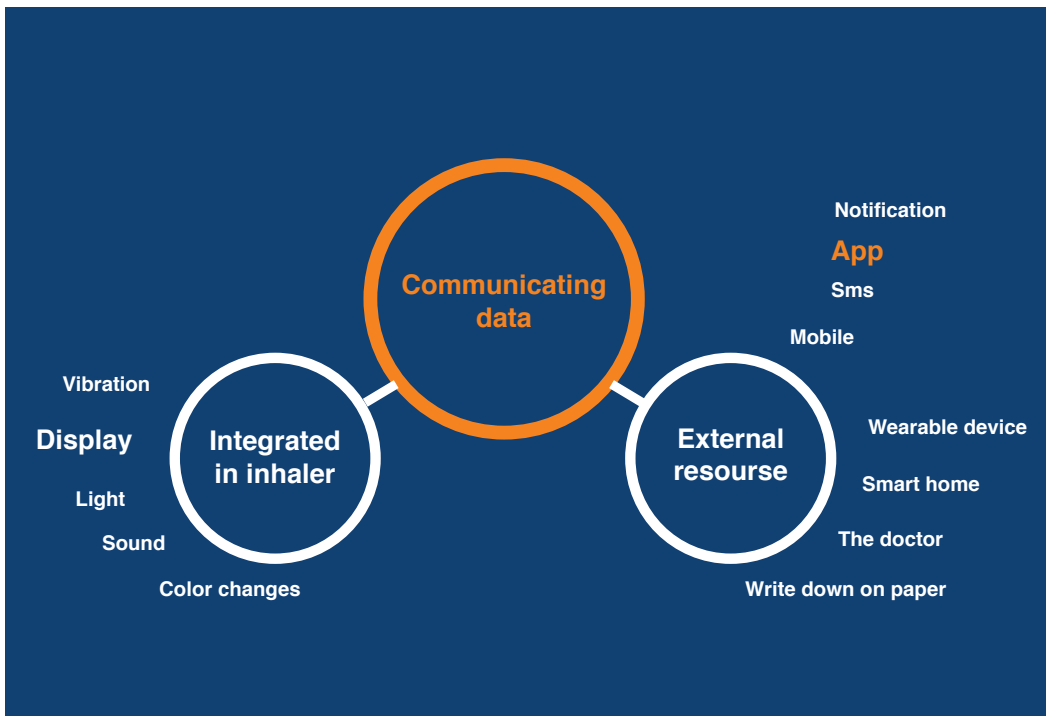


Figure 5.3.1. Thoughts of how to communicate data.

5.3.2 Additional information for display

Embedded in the main concepts were small-scale ideas and potential implementations found (using brainwriting) answering following questions:

- How can the user remember that she has taken the medicine?
- How can the user know that correct dose has been inhaled?
- How can correct inhalation technique be instructed?
- How can feedback on inhalation technique be delivered to the user?
- How can an inhaler help the patient improve their asthma status?
- How can the user be informed of external factors?

It was also found that most of these questions could more easily be processed if an additional mobile app was used in combination with the inhaler. The information that was supposed to reach the user, by using a connected inhaler/module, was very hard to fit inside the inhaler and since a majority (in the target group) are using smartphones today it was decided that the information should be displayed through an app.

5.4 Summary: The generated concept

A module is placed on the bottom of the inhaler (Figure 5.4.1), it can register when a dose is taken and upload it to an app (Figure 5.4.2). The app can also gather API data about external asthma triggers and link it to the usage of the different asthma medicines (Figure 5.4.3), by doing that conclusions about asthma control and/or asthma improvement can be made. The module can also register how good or bad the inhalation technique is by register if the inhalation reaches a high enough value.

In addition, the concept somehow guides the user to correct inhalation technique (inhalation procedure).

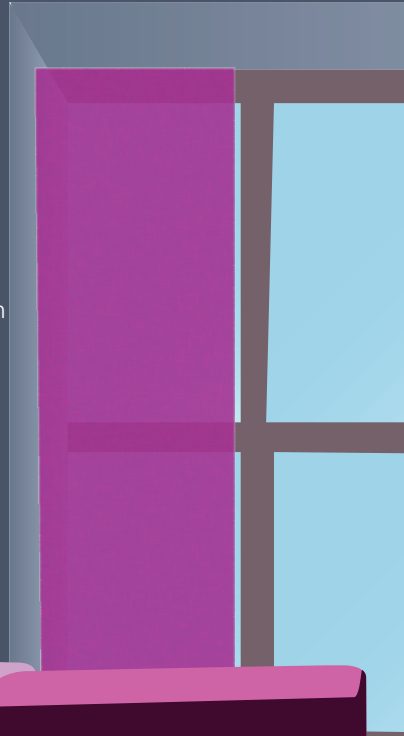




Figure 5.4.1. Scenario of a user attaching the module to an inhaler.



Figure 5.4.2. Scenario of the inhaler registering that a dose has been triggered.

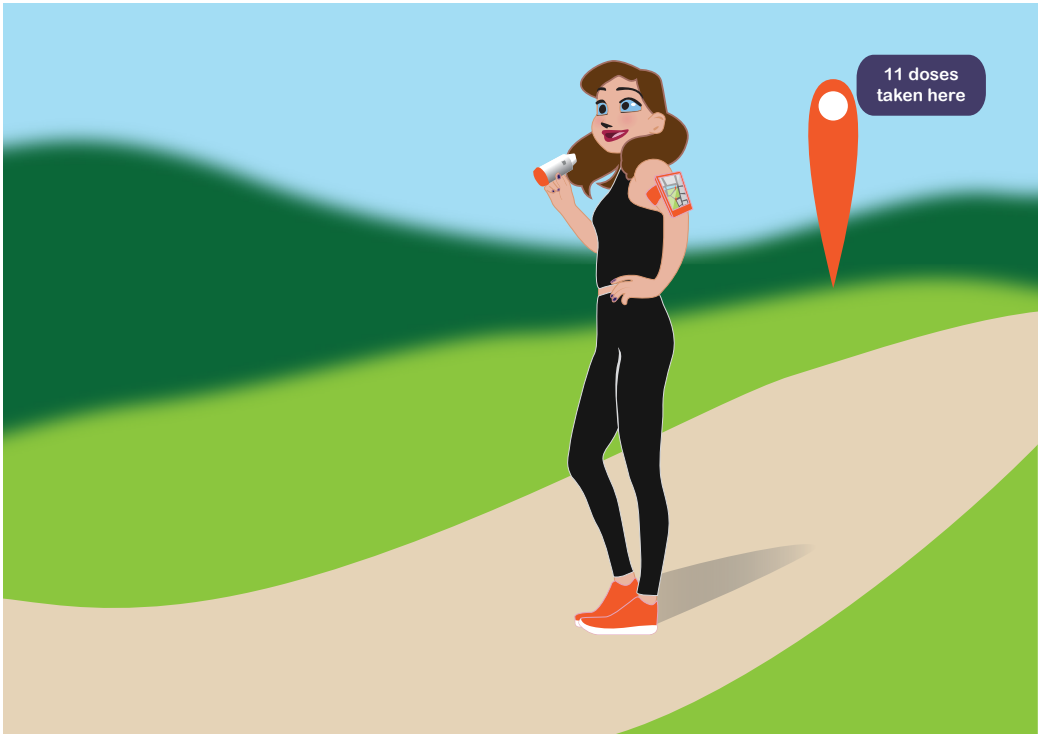


Figure 5.4.3. Scenario of the app registering where the inhaler has been used - to give an indication of their asthma status.

5.5 Proof of concept & Benchmarking

During the concept development phase, it was discovered that there were other companies developing similar concepts to measure the dosage with an inhaler and correlate the data with temperature, pollen and other available asthma trigger data (Figure 5.5.1). These companies have, with positive results, invested time and money to prove the concept. Hence the focus of this project was redirected to implement the concept with more focus on usability for the end user - something that was, according to our analysis, lacking in the existing concepts.

Smartinhaler (Adherium)

This modular solution by Adherium is attached to the Turbohaler (Astra Zeneca) and provides the user with data on when the medication has been taken. The smartinhaler comes with audio reminders and have a LED indicator which actuates medication taken and battery level. In a study where the Smartinhaler has been tried, following is stated (Chan, et al. 2015):

Use of the Smartinhaler platform improved adherence to preventative medication by 180% and reduced use of reliever medication by 45% in a study of 220 children conducted over 4 years.

Propeller Health

The most similar solution to the concept in this project is made by Propeller Health. Propeller Health has created a module which attaches to the top of a metered dose inhaler which activates when a dose is being activated. An additional app gathers data from various asthma triggers such as air pollutants and provides the user with insights into their asthma status. On October 26th 2016 Propeller Health announced that they were teaming up with IBM's answer to artificial intelligence, Watson, - to gain a deeper health analysis through combining population level health information with the individual's asthma inhaler (Farr, 2016).

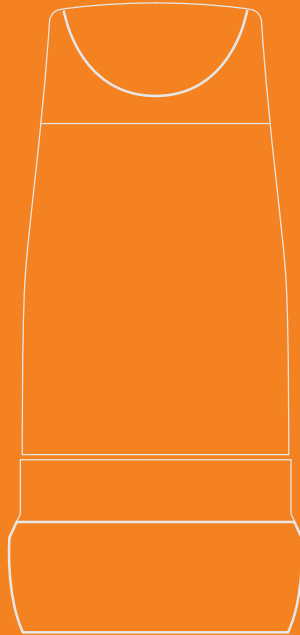
**Improve
inhalation technique**



Figure 5.5.1 Benchmark of other similar concepts. Our concept focus on improving the inhalation technique and user experience.

5.6 The system

Inhaler



Module





Chapter 6

The inhaler

To destigmatize a medical product

“Because the
inhaler is, apart
from something
that opens up a
person’s airways,
also is the object
which binds them
together with the
disease.

6.1 Normalizing the inhaler

With more than 7% of the population in the United states (CDC, 2017) and 10% of the population in Sweden (Astma- & allergilinjen, 2016) suffering from asthma - the disease and the medical products that follow, is becoming more and more an integral part of people's everyday life.

During the user studies many asthmatics said that their turbuhaler was ugly (one of the most used inhalers on the market), although, this is not the entire truth. Because the inhaler is, apart from something that opens up a person's airways and giving them the freedom to do many things, also is the object which binds them together with the disease. With this in mind, the aim was to design a more consumer friendly and emotional product, while trying to keep the dignity and respect a medical product should have.

6.2 Mood boards

To understand how users and the different stakeholders perceived different shapes and materials, three image boards were created: caring (Figure 6.2.1), dynamic (Figure 6.2.2) and medical (Figure 6.2.3). It was noticed that the dynamic and medical image boards sparked most discussions in conversations with people. Keywords people used in describing the dynamic concept were: Human and for the medical concept: Clean. Which were keywords that were pursued in the design process. In all the right bottom corner pictures of the image boards there are inspirational pictures for LED icons indicating that the product is electronic.

After discussions with the client it was determined that a mix between the dynamic and medical imageboards was to be pursued.



Figure 6.2.1 Caring image board

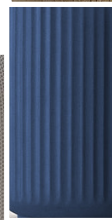
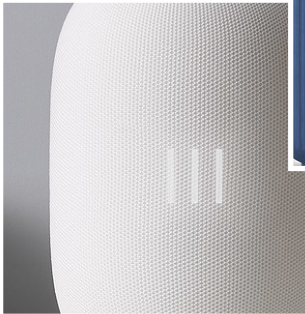
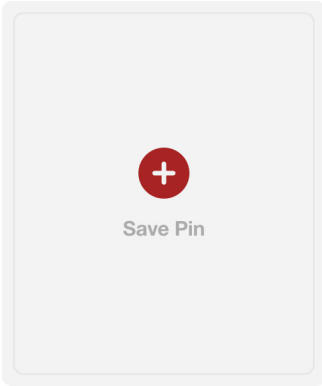


Figure 6.2.2 Dynamic image board with curved lines - described by users as human.





Figure 6.2.3 Medical image board which people described as *clean*.

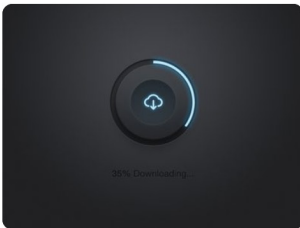


Objectify vase series, Isabell Gatzgen.

📌 585

mocoloco.com

👤 Saved by Erika Axhed



Nice reinterpretation of the boring old download button. But...

📌 686

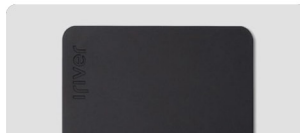
👤 Saved by Kent Ngo

iPhone 7 Plus 📌 1.9k ▼ 5
32GB Black (GSM) AT&T

iphone 7+ rose gold 32 gig(4)

Apple

👤 Saved by Kent Ngo



6.2.3 Hint of technology

To inform the user that the inhaler is a connected product, different light-icons to hint for technology were explored (see Figure 6.2.3.1). The main reason why light, as an indicator for technology, was chosen is because light is almost always found in other technical products. This is to build on natural mapping and the user's already taught understanding of product



the design labo inc. 238

Saved by Kent Ngo



Google - Google Home - 493 2

White/Slate fabric

Google Home speaker - \$130

Best Buy

Saved by Kent Ngo



leManoosh collates trends and top notch inspiration for... 47

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Looking for similar Pins? Follow me... 26

therewillbeeffects Saved by Erika Axhed



Whyd combines beauty, quality and simplicity to create an... 464

by Arthur Kenzo

Saved by Erika Axhed



Figure 6.2.3.1. Technology hints saved on Pinterest.

semiotics (Norman, 2013). In terms of functionality, light could also be used to let the user know whether the product is on or off. Later it was also realised that many more things could be communicated by using light on the inhaler, see section 7.5 (Using the inhaler correctly).

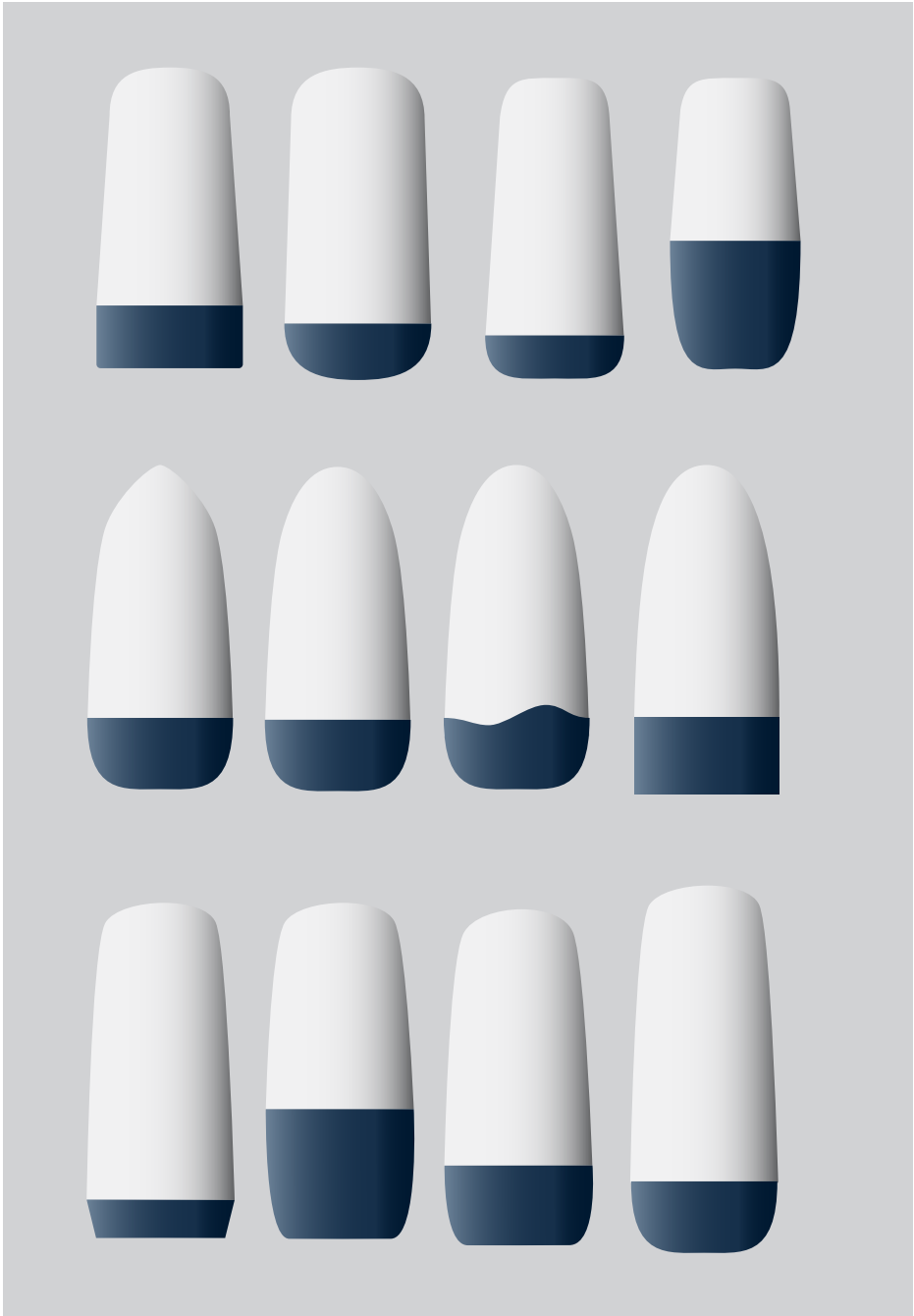


Figure 6.3.1 Early sketches of inhaler.

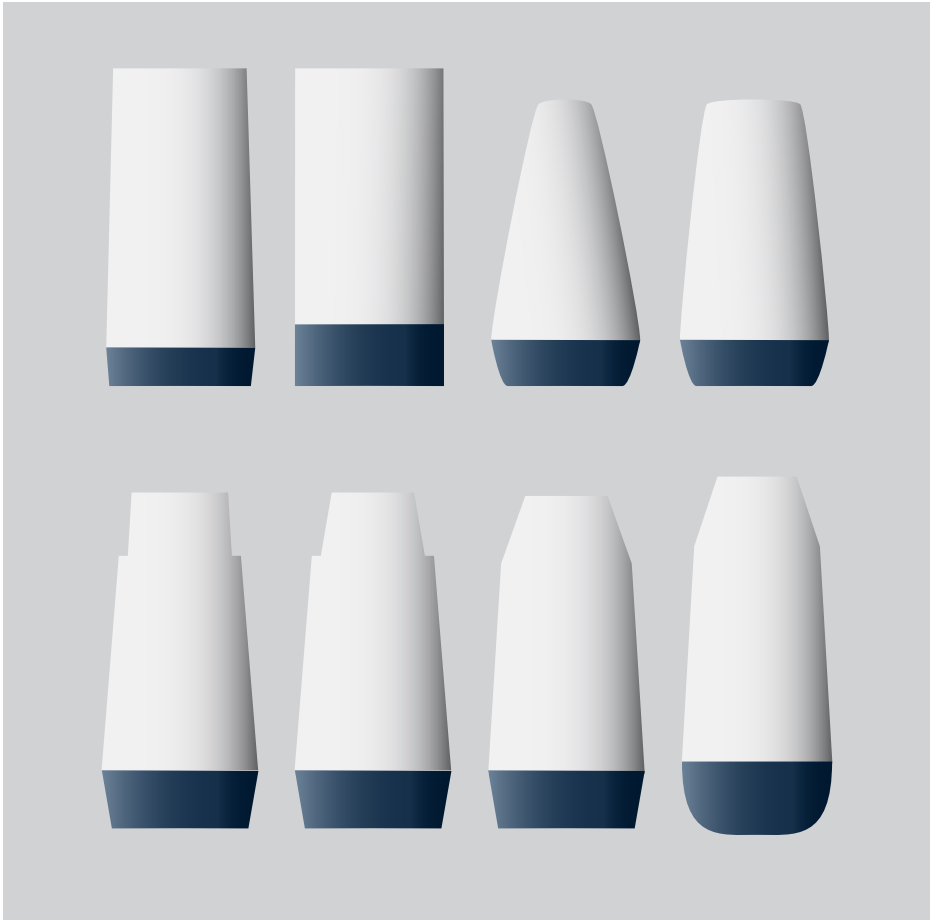


Figure 6.3.1 Early sketches of inhaler.

6.3 Fast sketches

To be able to evaluate the shape of the inhaler quickly, fast sketches, ranging from hard to soft shapes were drawn, see example in Figure 6.3.1. The shapes were discussed and the most interesting were 3D-printed.



6.4 Prototyping and rendering

After studying two dimensional form through sketches, forms studies were made through 3D-printing (Figure 6.4.1). The models were evaluated on mechanical aspects (if the parts of the inhaler would fit inside), ergonomic (grip size, visibility of module) and product semantics. The shapes with a curved profile were most looked at and discussed by potential users. They described the inhalers with curved shape as more human, interesting and thorough.



Figure 6.4.1. Prototypes were printed to understand what the inhaler would feel and look like.

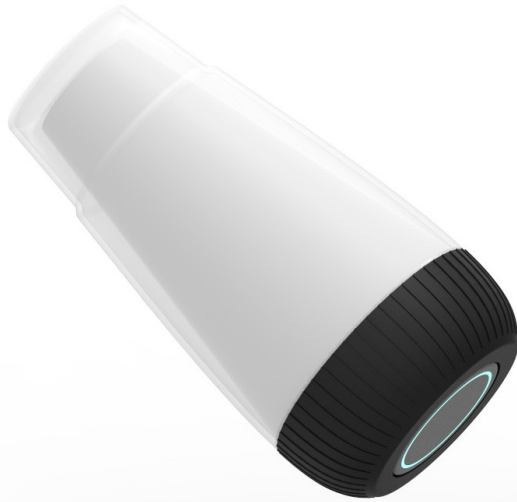


Figure 6.5 Early rendering of the inhaler, it was realized that the light from the module wouldn't be visible while inhaling.

6.5 Choosing form and material

Fast renderings were made in keyshot to simulate different colours and materials on the inhaler concepts. What the lid should look like and how the module should be displayed were also tested in this section.

Since the ICORes is a product mostly aimed towards medical generic companies, the colours of the inhaler very likely would be changed and aligned towards their product range in the future. The Iconovo-orange was kept on some renderings, while other colours were tested on asthmatics and with consideration to how they would be perceived at medical fairs (standing out from competitors) and also how well a generics company could imagine their colours on the actual product.

Throughout the entire process people of different age categories in the direct vicinity were exposed to renderings of the inhaler - so it could be observed if, and if so which inhalers got most attention from people. The users ranged from people at school (teachers, staff, students), friends that were visiting for dinner and uploading to snapchat to see which inhalers got most comments. This was not done to get a quantitative measurement of which inhaler was the most appropriate one, but to acquire a feeling for which shapes that made people express most positive emotions.

Body



Figure 6.6.1 The current ICores has a lid which doesn't have a planar top to restrain the inhaler from standing upside down, this was determined to be a good feature and was kept on the new lid designs.

The grip was also made larger to enable more surface area for gripping.



Lid

6.6 The perceived inhaler

If the asthma inhaler is viewed in terms of packaging for the medicine, the mechanical vessel which hold and deliver the medicine is the first packaging. The secondary packaging is the body and the third packaging layer is the lid (Figure 6.6.1). As a previous asthmatic (note one of the co-authors), the main perceived part of the inhaler is the body, so the focus was to develop a well perceived body with a lid that reflected what was on the inside.

Also in this case, the inhalers with shapes resembling the dynamic image boards were preferred by the authors and users. A downside to having a double-curved shape on the inhaler would be that it will be harder to apply a sticker or print on the surface. During the design of the inhaler this was a feature that was deemed less important than designing an inhaler which aimed to normalize asthma and increasing the user experience.



Figure 6.6.1.1 Standard colour

6.6.1 Choosing colour

To find out which colours that were in the border between medical and consumer products three palettes were made; one that was similar to the classic Turbuhaler Bricanyl (Figure 6.6.1.1), one used colours from a famous sports brand (Nike) (Figure 6.6.1.2) and one that was inspired by cosmetics (Figure 6.6.1.3). Initially a doctor with asthma and a student without asthma were asked to evaluate the colours, they ruled out the black one quite fast stating that it felt a bit dangerous. Some people said they would prefer the middle one but most people described the left inhaler as the one they think would be most trustworthy - something that was deemed the most important value for a medical product.



Figure 6.6.1.2 Sports colour



Figure 6.6.1.3 Cosmetic colours

6.6.2 Making the inhaler transparent

With the stigma related to taking medicine in mind, different options which followed the medical image board (transparent details) were explored. These concepts were made in an attempt to open up the inhaler and be transparent and honest about what was on the inside.

In the initial concepts, the lid was made transparent (Figure 6.5). Later, when an optical sensor was deemed the best solution for turning the inhaler ON/OFF the transparent material was moved to the body of the inhaler (see chapter 6.7).

6.7 Choosing inhaler

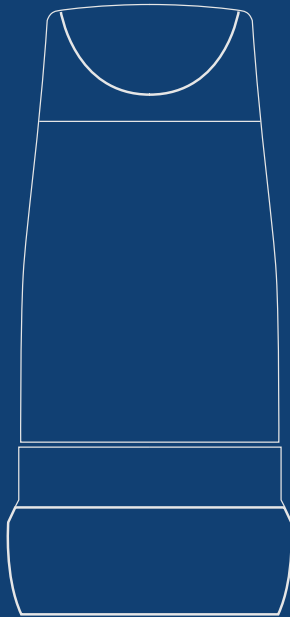


Figure 6.7.1 One of the designs for final inhaler selection.

In the end we had two inhalers to choose from - most people chose the right one (figure 6.7.2). And that was also the one we could see most people in the different age categories use.



Figure 6.7.2 The final inhaler design.



“What we aimed for during the entire design process was not for something that shouted I have asthma and I’m proud of it. But by designing an inhaler that felt a little bit more like a consumer product maybe we could take a few steps toward: I have asthma and it’s perfectly normal.”

6.8 The final inhaler

- named **ICOrest+**



Figure 6.8.1 The final mock up.

ICOres+
Budesonid 100 µg/dose





Figure 6.8.2 ICores+ from different angles.



Figure 6.8.3 Mock up of ICores+



Figure 6.8.4 User triggering a dose with ICore+

Figure 6.8.5 ICOres+ in ICONOVO orange. With the module inserted.



Figure 6.8.6 ICOres+ with the module to the right.

Figure 6.8.7 A rubber plug is inserted when the module isn't attached.



Figure 6.8.8 ICORES+ with parts of ICONOVOS existing product family.





Figure 6.8.9 Since Iconovo aims to sell inhalers to generic medical companies, in the end the different medical companies will put their own colours and brand on the inhalers. We decided to make some colour variations, ranging from darker and more luxury, to the standard colours found on many similar inhalers today to more poppy colours.



6.9 Surface Modelling

To give an indication of where the mouth should be and how far in the inhaler should go while inhaling there is a sharp edge on the front of the inhaler. The soft curvature on the side profile was chosen to give the inhaler a more continuous and dynamic and harmonic profile. The balance of these two "lines" were modelled in rhino (figure 6.9, figure 6.10), rendered, 3D-printed and evaluated until the right balance was found.

6.10 Injection Molding

Although full consideration haven't been taken to design a fully ready for manufacturing inhaler - the geometry will allow for injection moulding in terms of releasing the geometry.

The ICORes+ uses the same assembly process as the ICORes and has the same wall thickness.

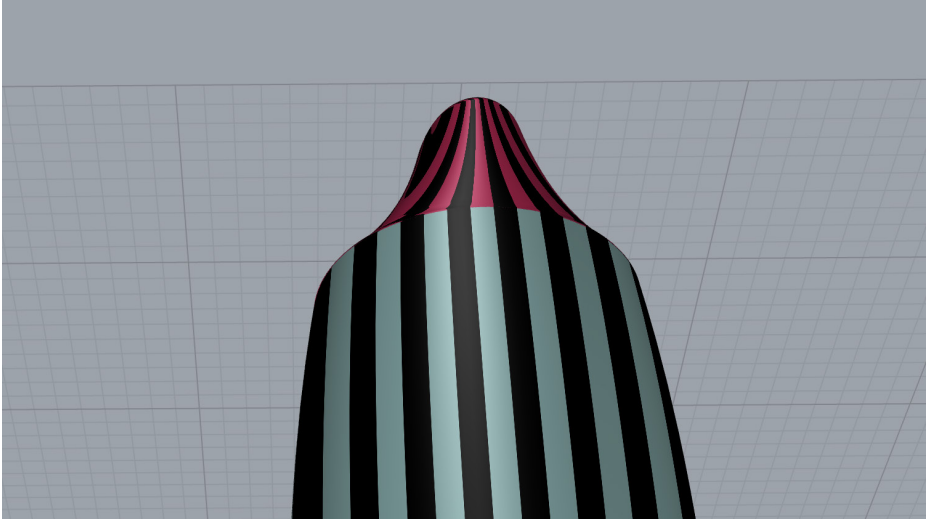


Figure 6.9 Side view, mouthpiece meets the body with a soft edge.

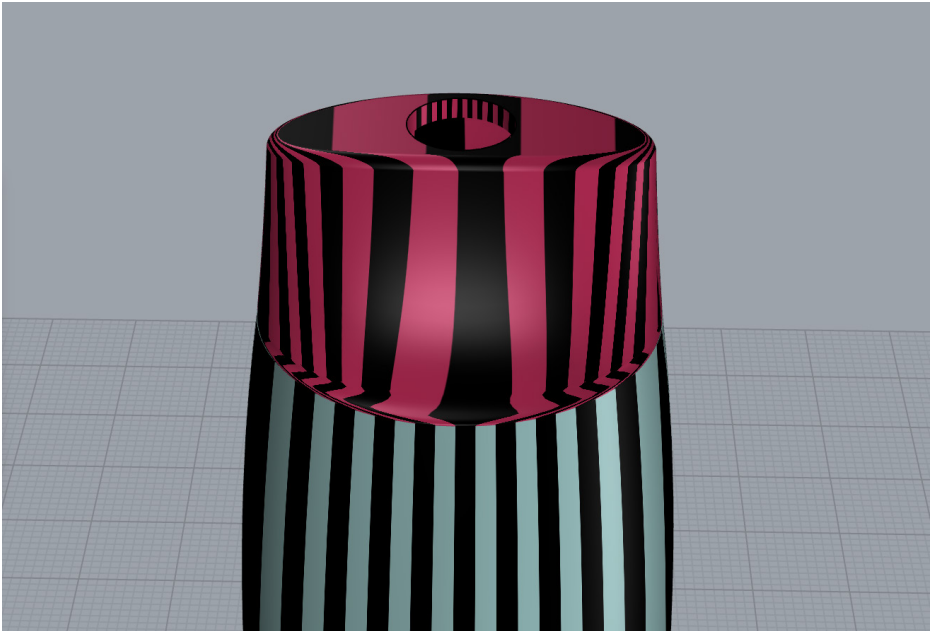


Figure 6.10 Front view, mouthpiece meets the body with a hard edge.





Chapter 7

The Module

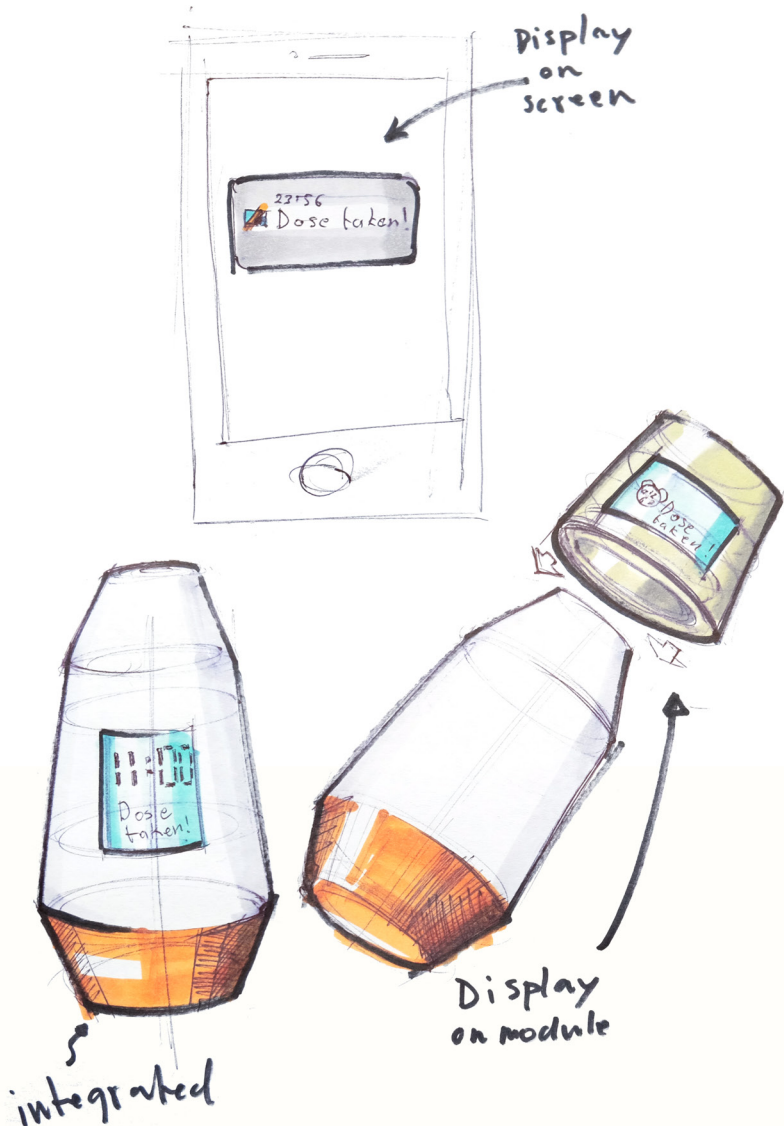
7.1 The Module

Since the inhaler is a consumable product which is replaced within a couple of months, a decision was taken to design and put all sensors and electronics into a module which will have a longer lifetime and can be used on multiple inhalers over time.

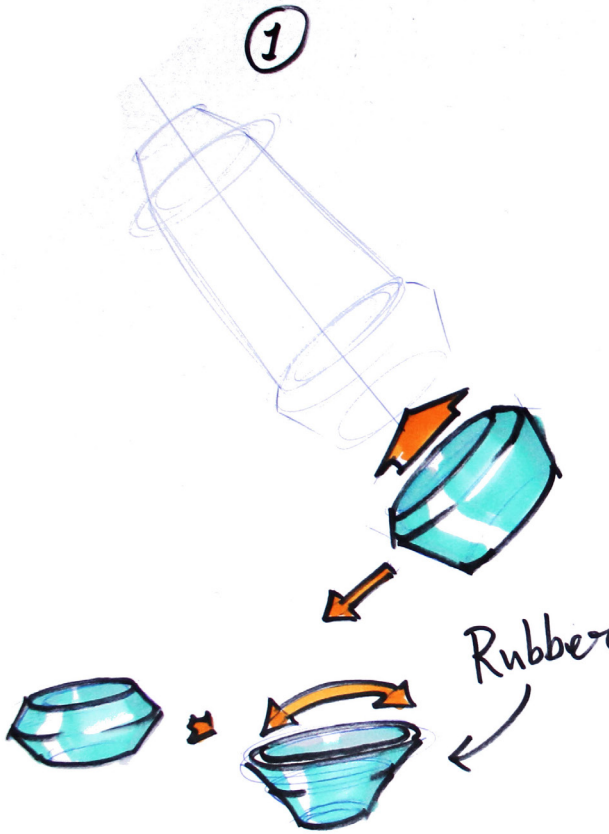
The first goal of the module was to register when a dose of medicine has been inhaled and send the information to a smartphone (the app). The second goal of the module was to provide the user with feedback - leading to correct usage of the inhaler.

To create a user friendly module following problems had to be solved:

1. How the module should be fastened and removed (when changing inhaler)
2. Form factor: Fitting all the electrical parts and sensors into the module
3. Using light to communicate and provide feedback to the user



Picture 7.1.1 Early sketches of whether the information should be displayed on the module or in an app.



7.2 Module concept selection

The modules were evaluated on six points: feasibility, durability, usability, how well the electronics would fit inside, how much larger the inhaler would be and coherence with the ICores design. The different concepts were tested through analysing products with similar fastening mechanisms. Zenit Design had for example designed a product with similar fastening mechanism as concept one, while concept three can be found on PET-bottles. Concept five was 3D-printed and tested on an inhaler.

Concept one, where the module is made of elastic rubber and concept five, where the module is fastened through a magnet were the most preferred options (by the authors) since these concepts would mean small mechanical alterations to the main inhaler. The magnetic alternative was considered more durable than the rubber and after consulting Iconovo, the magnetic concept, was decided to be further developed.

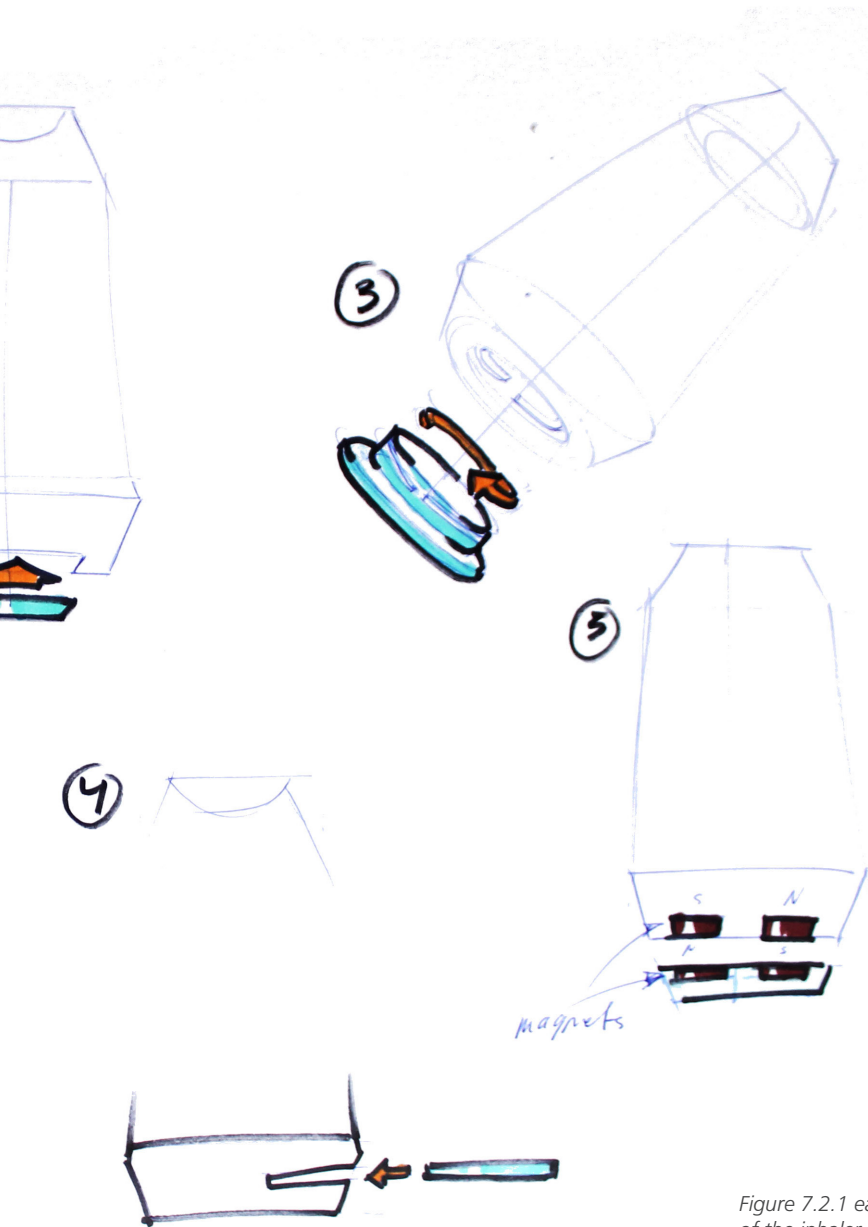


Figure 7.2.1 early rendering of the inhaler, it was realized that the light from the module wouldn't be visible while inhaling.

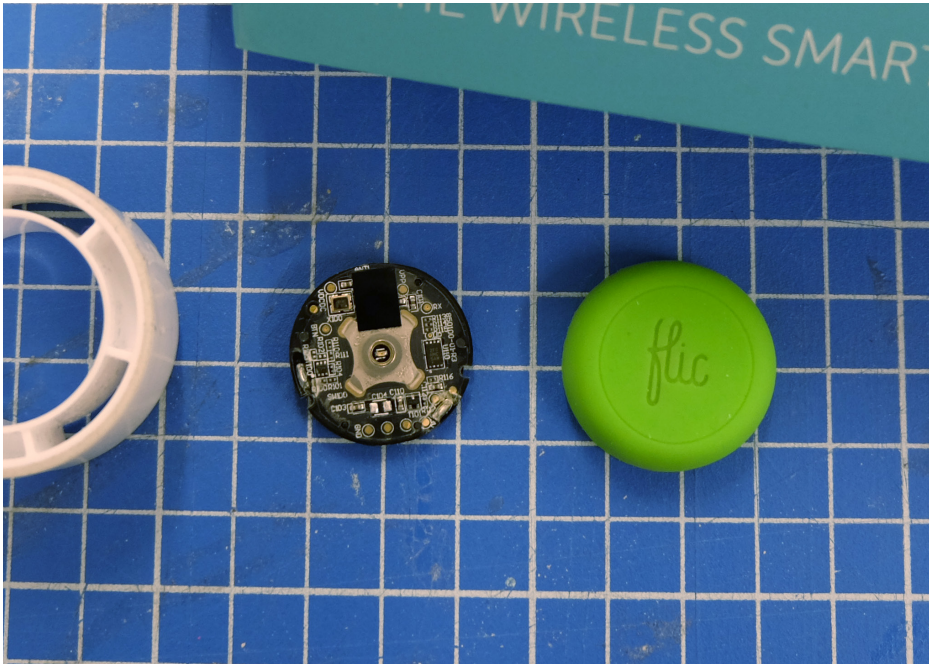


Figure 7.3.1 The flic button dissected.

7.3 Choosing electrical components

To understand which available sensors for the technology, their size and how they worked - research was made online and through reverse engineering small electrical products - one of them being a Flic button (Figure 7.3.1).

The components were then drawn up in Adobe Illustrator with their real proportions and fitted onto a plastic card to get an understanding of how small the module actually could be (Figure 7.3.2). Several modifications, with different sensors were tested and proofed with engineers at Lundinova.

Noteworthy is that a hall effect-sensor was being considered the optimal sensor for registering when a dose has been triggered, but due to the distance between the module and the rotation point a hall effect-sensor would not be able to register a magnetic signal, therefore a copper switch that leads electricity when a dose is being triggered was chosen instead (Figure 7.3.2).

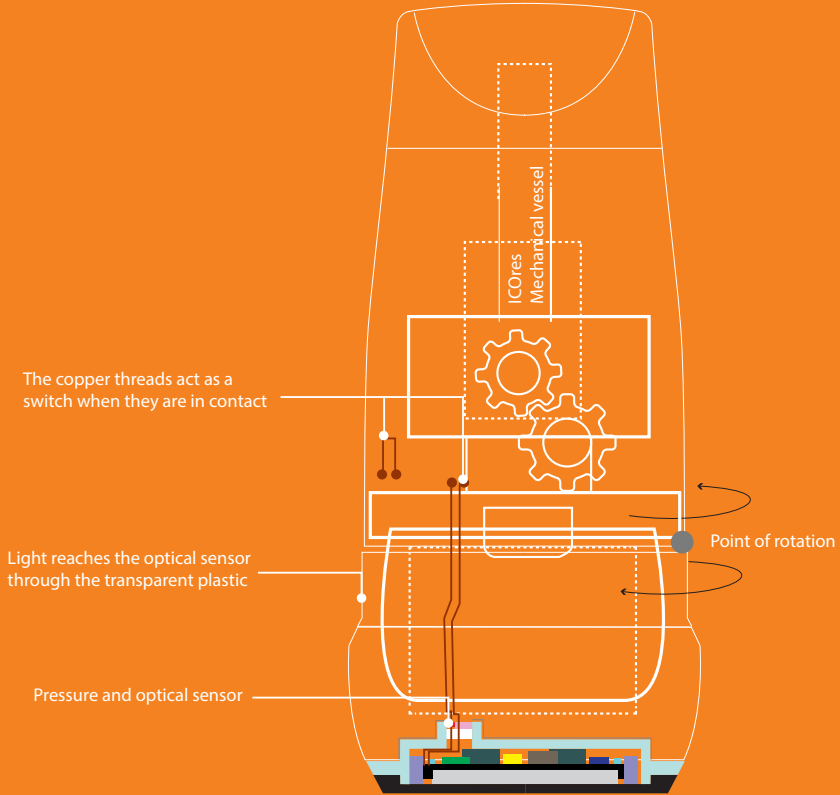


Figure 7.3.2 drawing of how the module would work when integrated with the inhaler.

Bluetooth (BLE, Bluetooth Low Energy to be specific) was decided the best communication method after discussing power management with Fredrik Bågenholm at Lundinova.

On the top of the module there are a pressure sensor and an optic sensor which are inserted into the inhaler. This allows the pressure inside the inhaler to be measured during an inhalation (Figure 7.3.2). The pressure sensor was added on later in the project hence the lack of it in the rendering in Figure 7.4.2.

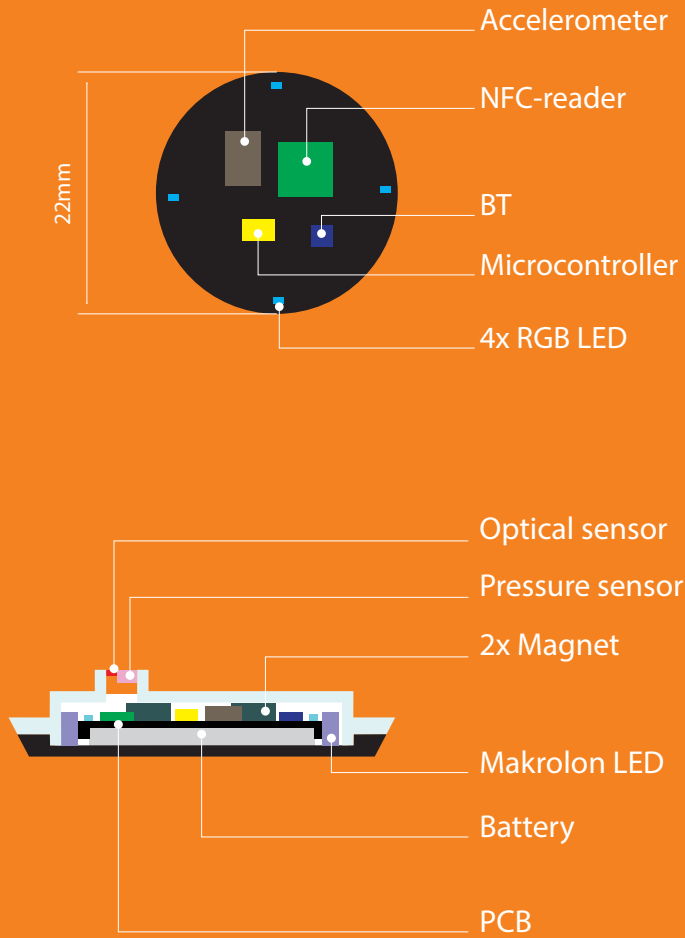


Figure 7.3.3 playing tetris with the components

7.3.1 Module components

-a theoretical solution

NFC-reader - registers which medicine the module is connected to, amount of doses, expiry date.

Copper leader switch - senses when a dose has been activated.

Accelerometer - determines when the inhaler is held correctly in an upright position.

Pressure sensor - determines a user's inhalation strength.

Photosensor - detects when the lid is off and the inhaler is ON.

Battery - powers the sensor (predicted to last about 1 year).

Magnets - allows for attachment to the inhaler.

Bluetooth - communicates with a smartphone which logs user data.

RGB LED - shows when the inhaler is on and provide usage feedback (customizable so different company's colours can be used).

Microcontroller - processes and saves the data (a smartphone might not always be available).

PCB - the components are soldered onto the printed circuit board.

Plastic card - to hold all the components and battery.

Makrolon - to diffuse the light

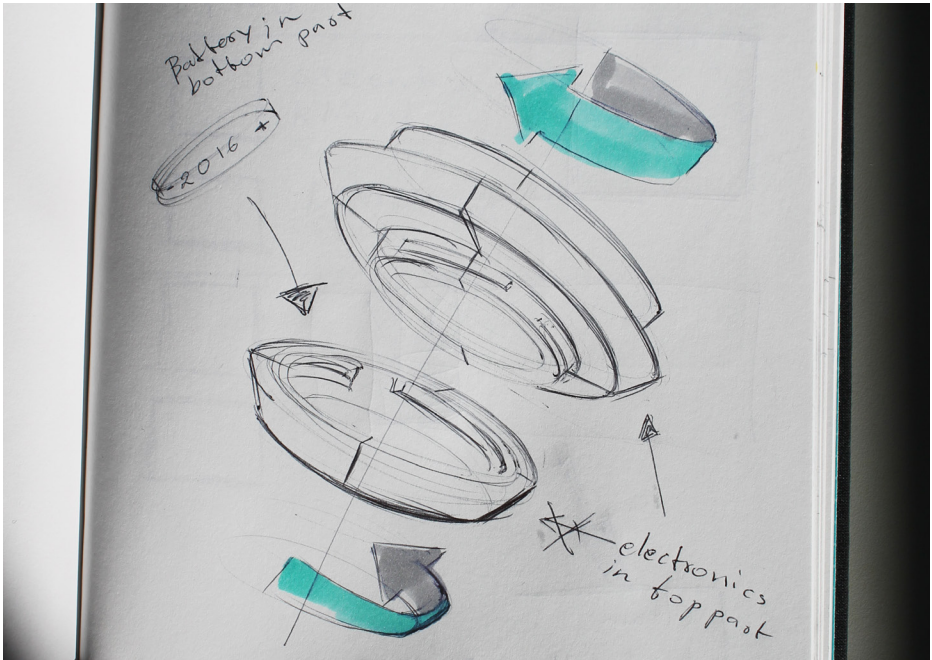


Figure 7.4.1 Opening solution for module - so a battery can be replaced.

7.4 Module form

The module's shape was heavily determined through following the positioning of the components and sensors inside and then using the bottom of the grip as a constraint to find a suitable form.

The aim was to create a module that felt like it belonged to the ICores, but did not feel as a product that was going to be thrown away after a couple of months (which is the case with the inhaler). The medical image board was followed when taking design decisions, for example, the top part of the module is transparent with matte plastic. The plastic is matte on the module (in comparison to the inhaler) to give it a hint of technology instead of exposing them completely, which would give the product a more technical feeling than intended. With consideration to the medical image board and the material selection the module was rendered (Figure 7.4.3) and prototyped.

To differentiate the module from the inhaler, the bottom part is made out of anodized aluminium, which will not conduct electricity. It will also make the part of the module that is most exposed to tear more durable. Figure 7.4.1 shows how the parts are separated.

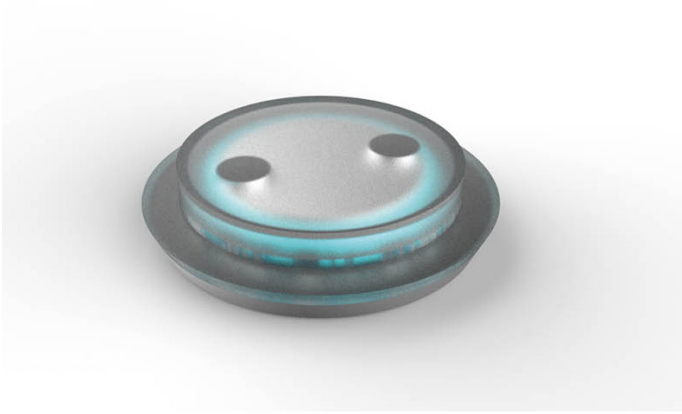


Figure 7.4.2 early rendering of module.

Clean & honest



Hint of tech



Transparent



Figure 7.4.3 parts of the clean mood-board.

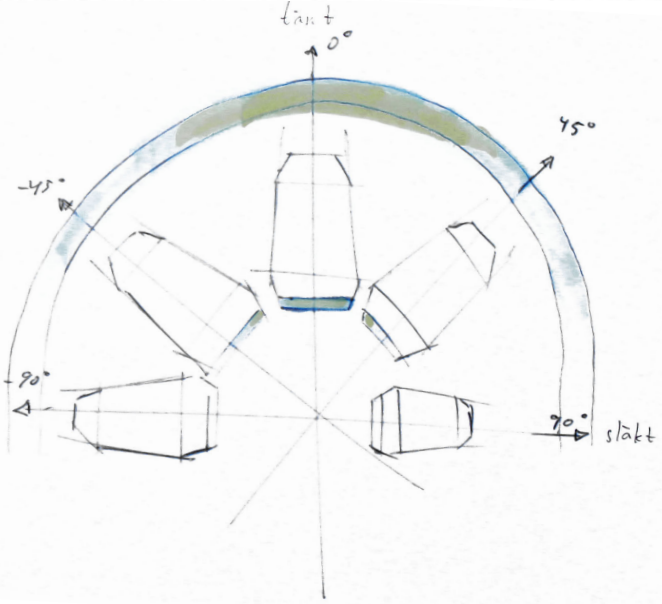
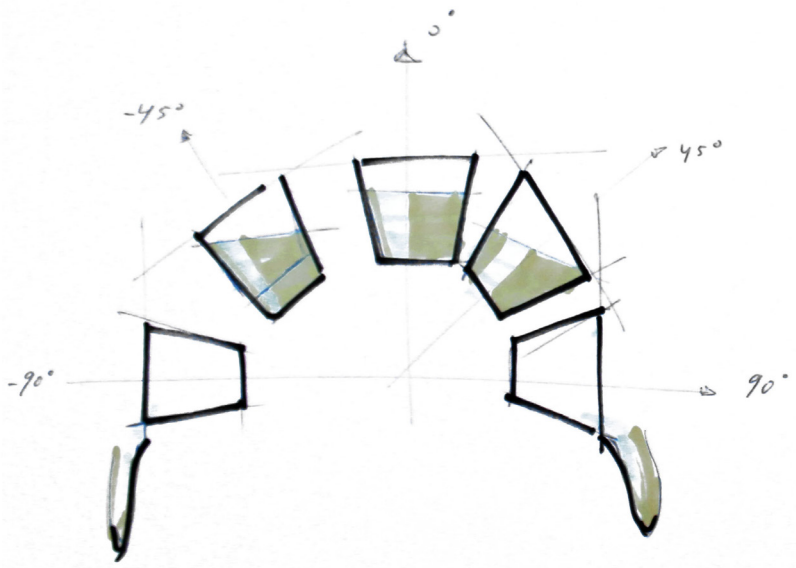


Figure 7.5.1 Early sketches of using light to communicate that an inhaler should be held upright while triggering a dose.

7.5 Using the inhaler correctly

We decided to focus on correct inhaler usage. Research shows that DPI's often provide good usage results during clinical trials, because the instructions are given directly - but many studies shows that after some time, many patients start to use the inhaler wrong. A french study states that after a months usage 54% used it wrong and 32% used the inhaler in a way which substantially affected the dose delivered to their lungs. With this in mind we started to think about solutions - not to teach the patient to use their inhaler correctly, but to remind them how to.

It all started during a coffee break. We were discussing how to solve the problem that many users do not hold the inhaler upright when they prepare a dose for inhalation. We realized how intuitive it was to hold a glass upright so the water does not spill and then we began translating the natural signals from a drinking cup to the inhaler.

Figure 7.5.1 illustrates how a glass of water can keep the water if it is held upright and that it does not "work" as a container if it is tilted too much. The idea that it is not working if it is not held upright was implemented in the inhaler by using light and different light plays, this is shown in Figure 7.5.1 where the inhaler is supposed to be as intuitive as the glass. The idea was initially tried by using a lamp as seen in Figure 7.5.3, 7.5.4, 7.5.5. After experimenting with different light plays with the lamp it was decided that the light should be there to guide and remind the user to correct inhalation technique, not berate or stress the user.



Figure 7.5.2 Using a glass of coffee to illustrate how natural it feels to hold a glass upright.



Figure 7.5.3 Experimenting with light. The inhaler is held in an upright position and the light is on.



Figure 7.5.4 The inhaler is tilted and the light turns off, since an inhaler should be held upright when a dose is triggered.

7.6 Light as a reminder for correct usage



Figure 7.6.1 The lights are off when the inhaler isn't held upright. Visit <https://youtu.be/PARRxuVbmjg> for a video.



Figure 7.6.2 The lights are ON when the inhaler is held upright.



Figure 7.6.3 The light is locked (ON) after a dose has been triggered (in this position the inhaler doesn't need to be held upright).



Figure 7.6.4 The light turns off when an inhalation is being made (the glass empties). Then the inhaler blinks for 10 seconds to remind the user to hold his breath.



Figure 7.7.1 Prototyping the first aluminium casing.

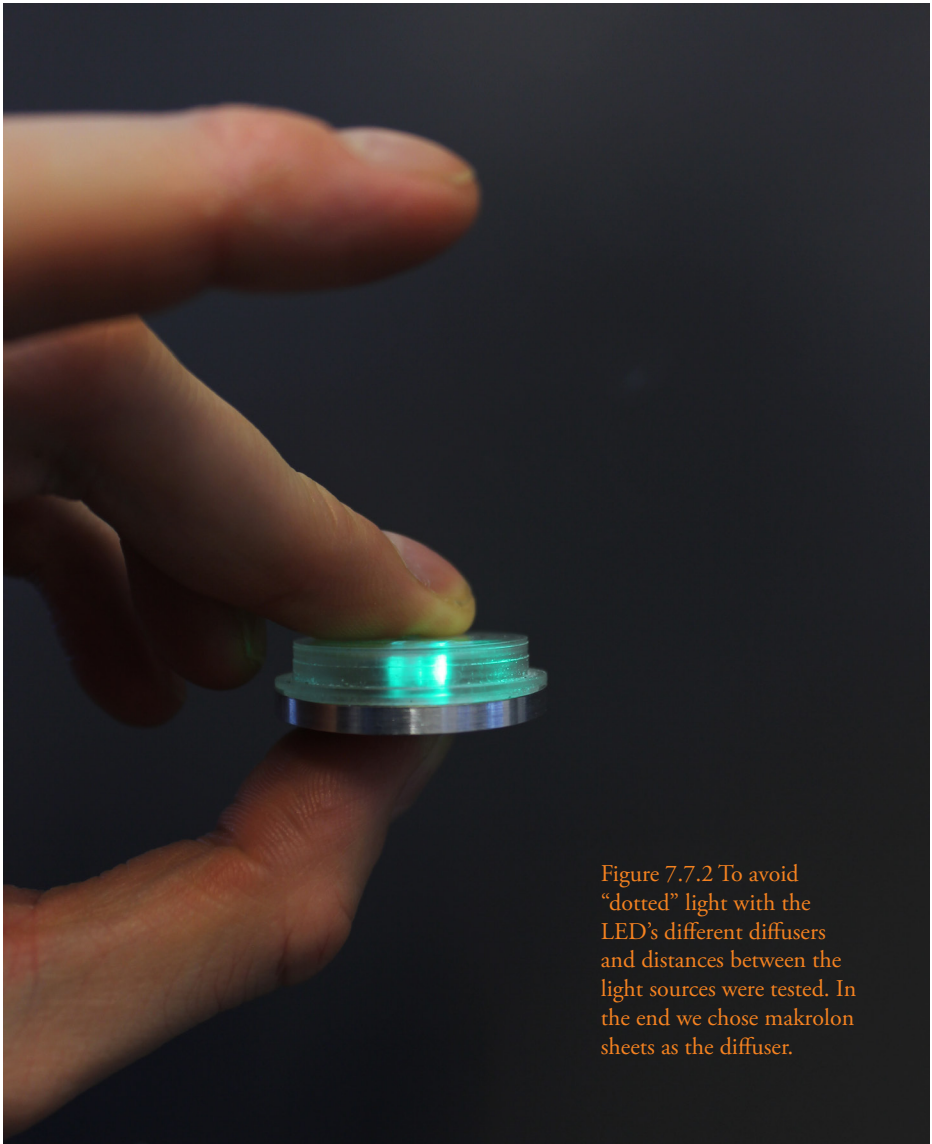
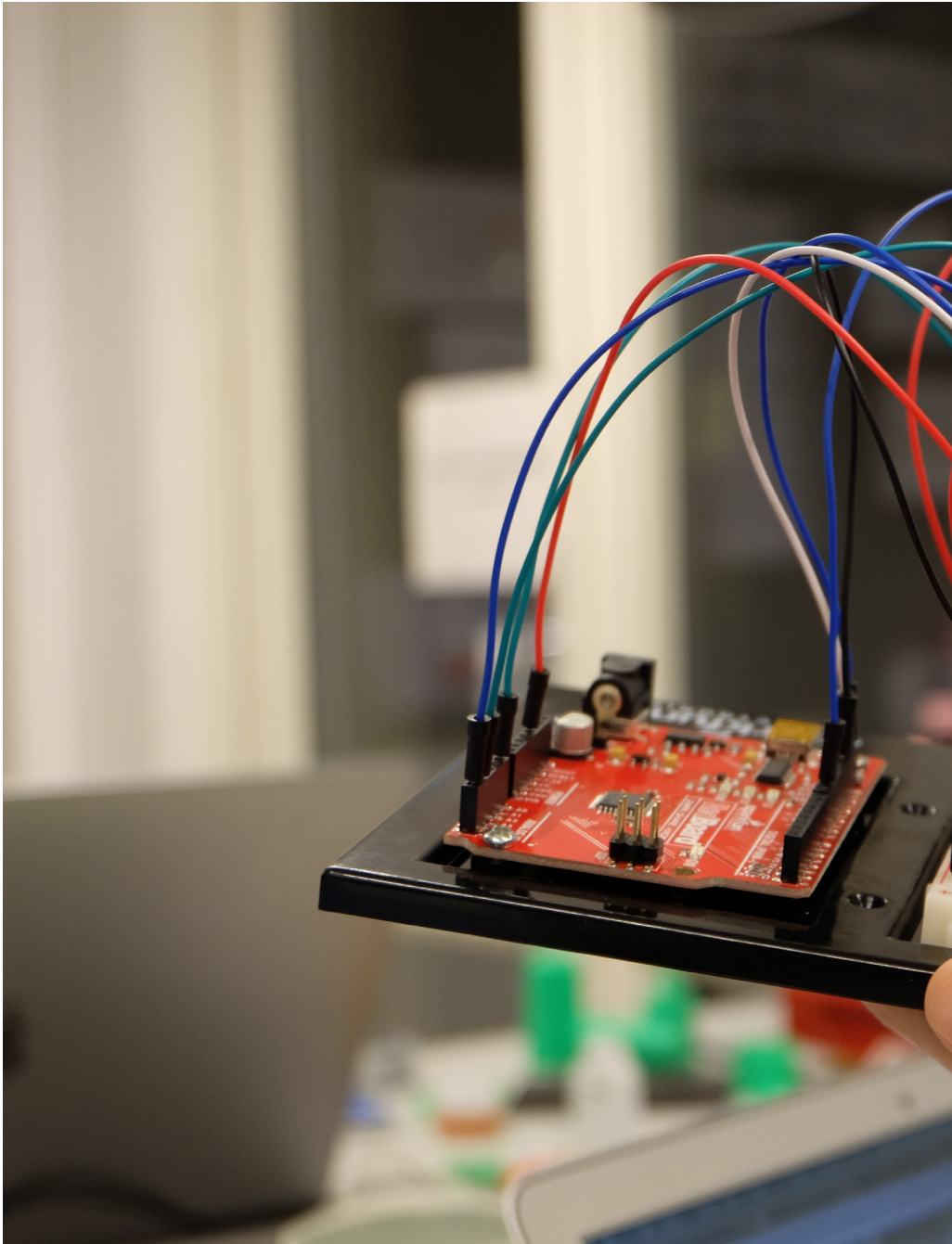


Figure 7.7.2 To avoid “dotted” light with the LED’s different diffusers and distances between the light sources were tested. In the end we chose makrolon sheets as the diffuser.

7.7 Prototype

Later in the project, an Arduino was programmed to demonstrate the functions in the final prototype, the result is shown in chapter seven. The sensors used in the prototype and the electronic schematics can be seen in Appendix F. The schematic and the sold were made by Lundinova.



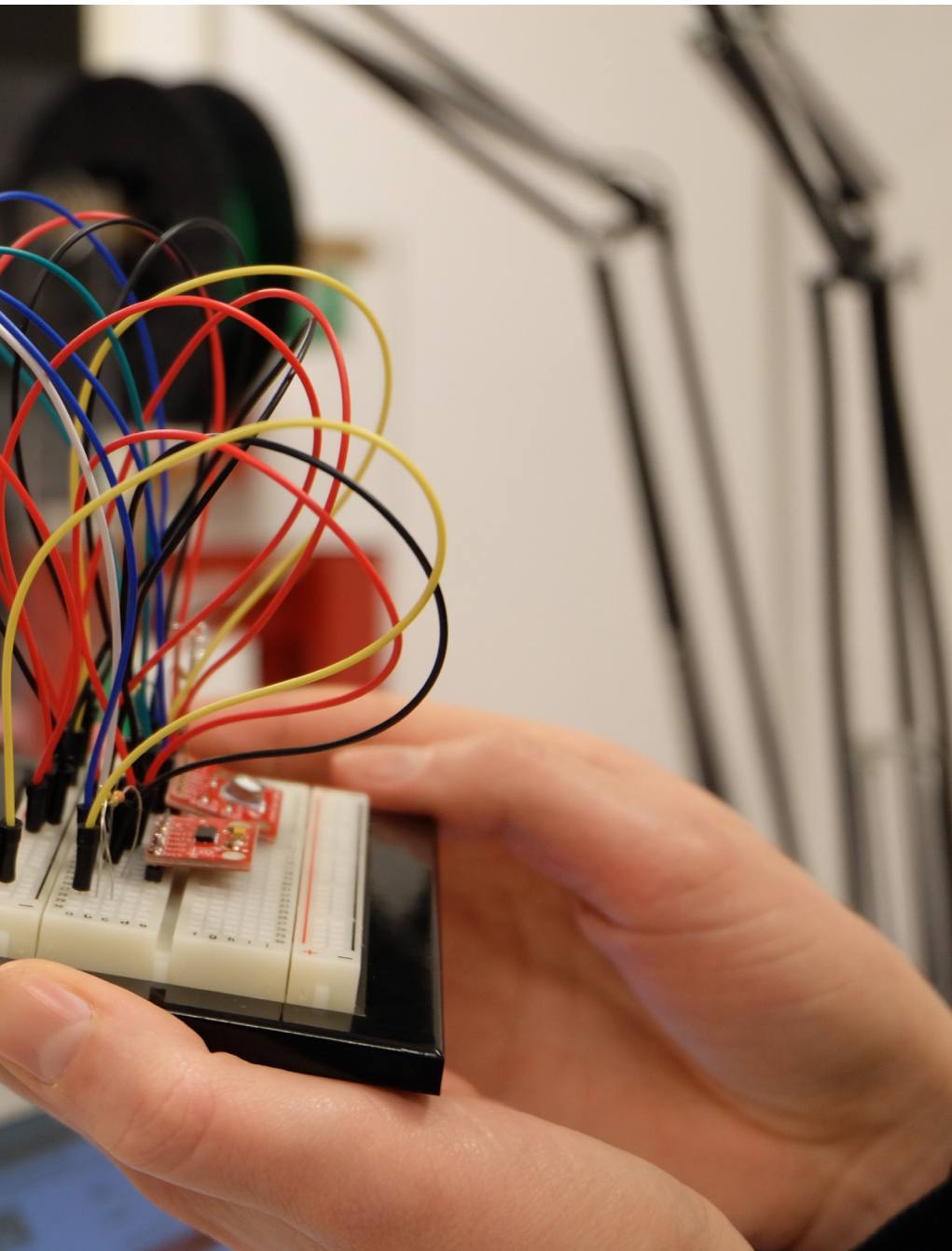


Figure 7.7.3 Testing the function of the light play, inhalation strength and optical sensor with an arduino.



7.8 The final module


-we named it ICOpal



Figure 7.8.1. the ICOpal.



Picture of sketching process



The app receives data from the module and saves the information for documentation. The app also receives selected API-data which is used to give a forecast over possible trigger conditions and document if asthma was worse during these conditions. All the data is translated into understandable graphs, displayed for the user.

Chapter 8

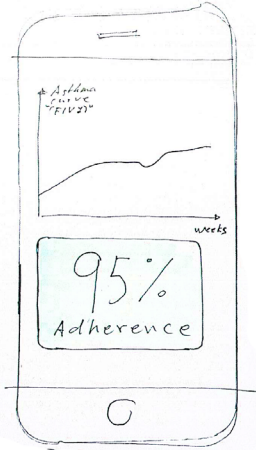
The App

8.1 The concept

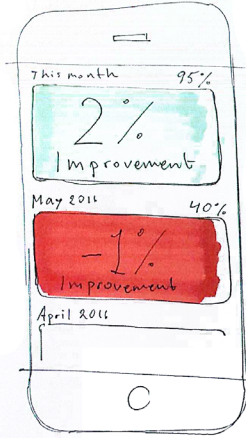
8.1.1 Developing the concept through the app

After deciding on an app, the first focus was to conclude the main concept within the interface; daily documentation (with weekly, monthly and yearly overview), reminders, a journal to follow compliance, information about the inhalation and a function to connect triggers with the usage of rescue medicine. Also analytics, that could be helpful for the doctor were included (Figure 8.1.1).

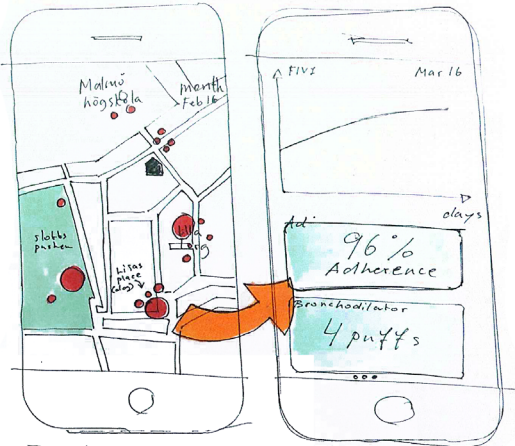
Improvement
over time



Motivation



Connecting the
dots...

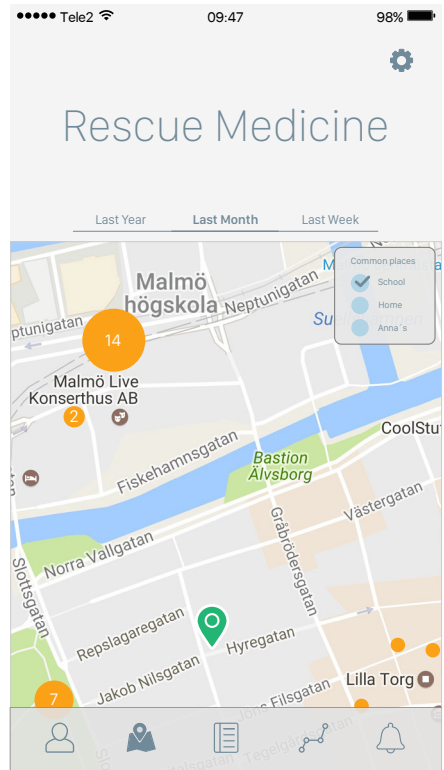
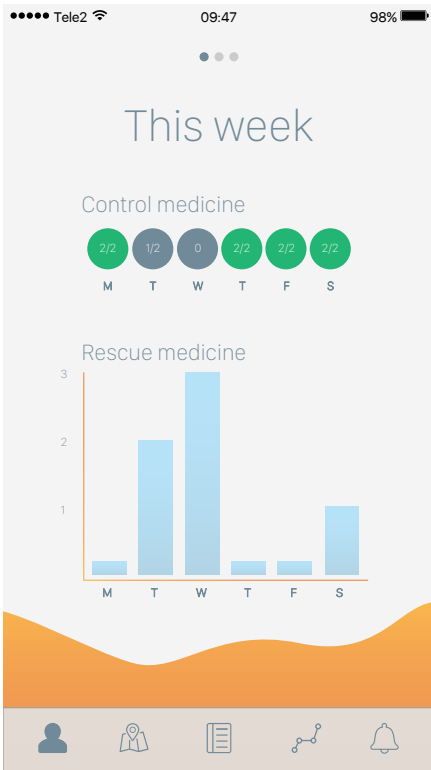


☒ High trigger locations



Didn't visit Lisa's
place this month

Figure 8.1.1. Initial sketches: overview, asthma status, trigger map.



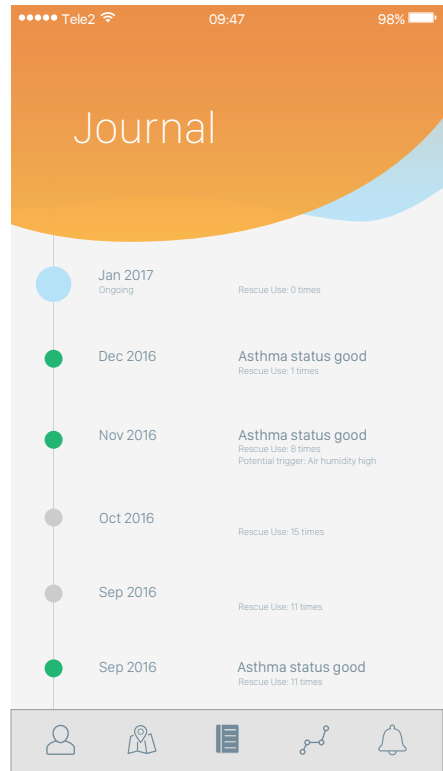
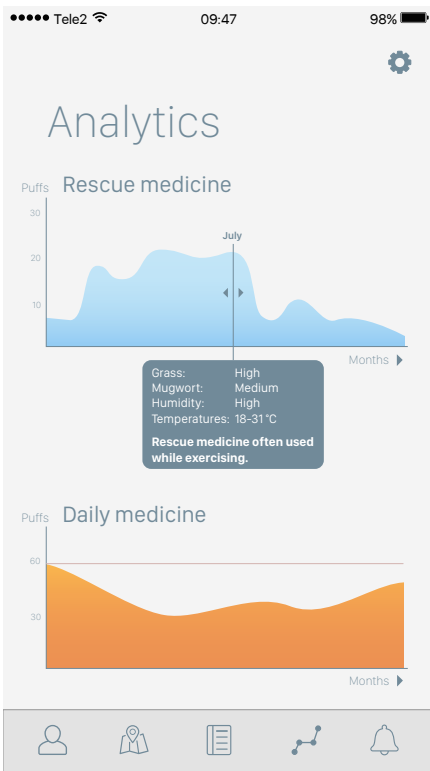


Figure 8.2.1 Initial app design.

8.2 Initial app design

Initial designs were created to visualize the functions in the app (Figure 8.2.1). They are displayed above in following order:

- Overview over today (to know the present)
- Mapping of rescue medicine related to triggers (to see what happened in the past and ratiocinate the future)
- Analytics (to understand a patients adherence)
- Journal (to know the past)

8.2.1 Personalized treatment plan

It was decided to include a personalized treatment plan in the app, since it is given to the patient by the doctor. An example of a treatment plan is shown in Figure 8.2.1 (Asthma and Allergy Foundation of America, 2017) and explains what to do in three different stages of asthma; controlled (green), partly controlled (yellow) and uncontrolled (red). A journal is today kept at the hospital but the patient does not necessarily fill in one at home.

For further development, colours and graphics were better matched with the style of the inhaler and module and the user interface was improved.

Asthma Action Plan

| | |
|------------------------------|------------------|
| Name | Date |
| Doctor | Medical Record # |
| Doctor's Office Phone #: Day | Night/Weekend |
| Emergency Contact | |
| Doctor's Signature | |



The Colors of a traffic light will help you use your asthma medicines.

Green means Go Zone!
Use preventive medicine.

Yellow Means Caution Zone!
Add quick-relief medicine.

Red means Danger Zone!
Get help from a doctor.

Personal Best Peak Flow _____

GO

You have **all** of these:

- Breathing is good
- No cough or wheeze
- Sleep through the night
- Can work and play

Peak flow from _____
to _____

CAUTION

You have **any** of these:

- First signs of a cold
- Exposure to known trigger
- Cough
- Tight chest
- Mild wheeze
- Coughing at night

Peak flow from _____
to _____

DANGER

Your asthma is getting worse fast:

- Medicine is not helping
- Breathing is hard and fast
- Nose opens wide
- Ribs show
- Can't talk well

Peak flow reading below _____

Use these daily preventive anti-inflammatory medicines:

| MEDICINE | HOW MUCH | HOW OFTEN/WHEN |
|----------|----------|----------------|
| | | |
| | | |
| | | |
| | | |

For asthma with exercise, take:

| | |
|--|--|
| | |
|--|--|

Continue with green zone medicine and add:

| MEDICINE | HOW MUCH | HOW OFTEN/WHEN |
|----------|----------|----------------|
| | | |
| | | |
| | | |
| | | |

CALL YOUR PRIMARY CARE PROVIDER.

Take these medicines and call your doctor now.

| MEDICINE | HOW MUCH | HOW OFTEN/WHEN |
|----------|----------|----------------|
| | | |
| | | |
| | | |
| | | |

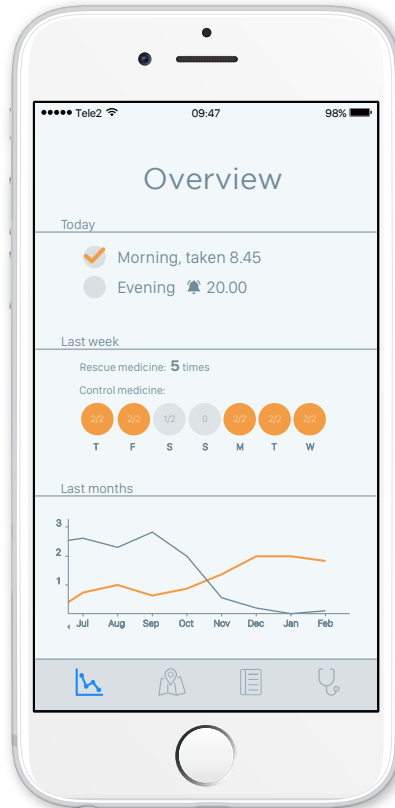
GET HELP FROM A DOCTOR NOW! Do not be afraid of causing a fuss. Your doctor will want to see you right away. It's important! If you cannot contact your doctor, go directly to the emergency room. DO NOT WAIT.

Make an appointment with your primary care provider within two days of an ER visit or hospitalization.

Figure 8.2.1. An example of a personalized asthma treatment plan (<http://www.aafa.org/media/asthma-action-plan-aafa.png>).

8.3 The final app

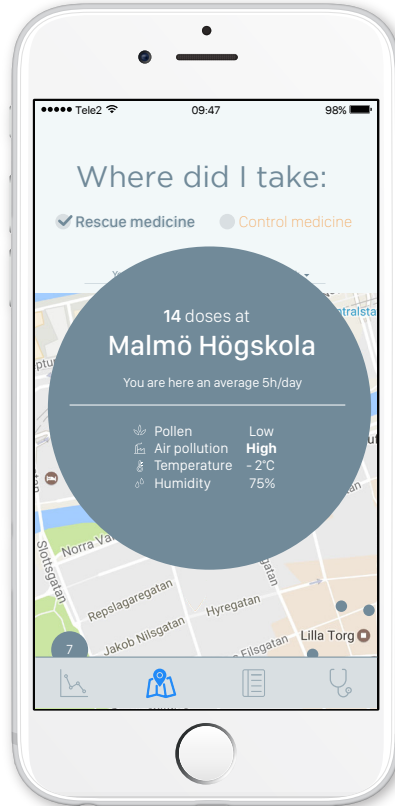
Figure 8.3.1 This example shows how it could look like for an asthmatic who takes two doses of medication a day, one in the morning and one on the evening.



Overview

The user gets an overview of the day and the medication usage the last week. The user also gets an overview of the last couple of months, with the y-axis showing an average of doses per day (Figure 8.3.1).

Figure 8.3.2. Inhalations are marked as dots on the map. If clicking on a dot, more information of that inhalation is shown.



Trigger locations

To find places and possible triggers, the inhalations are registered and mapped (as a dot) on a city map. If clicking on a dot, more information, such as the surrounding conditions connected to that specific inhalation, are displayed (Figure 8.3.2)

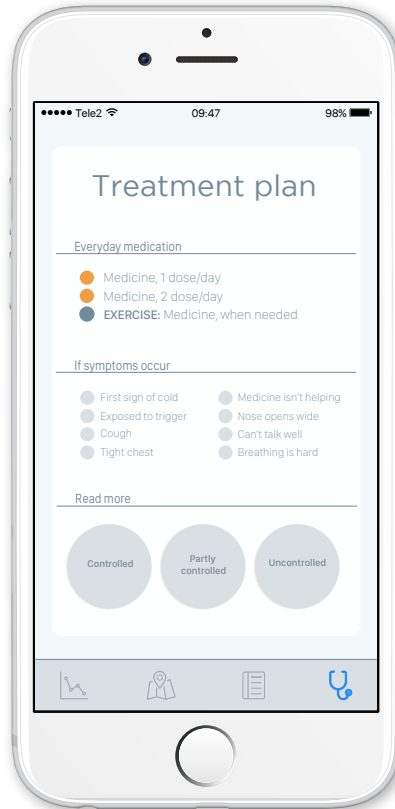
Figure 8.3.3 If clicking on a month in the journal, all data from that month is shown and average conditions.



Journal

In the journal, the user can go back and check usage and statistics for each month, which may help increase motivation to follow the treatment plan better (Figure 8.3.3).

Figure 8.3.4 The interface of the treatment plan shows which medicine to take each day if asthma is controlled and can be used when symptoms occur.



Treatment Plan

The treatment plan in the app gives the user quick and easy to understand information about the three stages of asthma control. The user can see which medicine that is expected to be taken each day (“When asthma is controlled”) and read about what to do if the asthma is controlled, partly controlled or uncontrolled (by clicking on the big grey dots in the bottom). Under “If symptoms occur”, emerging symptoms can be filled in and the asthma can be deemed partly controlled or controlled (Figure 8.3.4).



9. The (bonus) spirometer

At the end of the project, after realizing what modern sensors could do and having inserted all of them into a standalone module. We realized that a mechanical spirometer could be made and that all the thinking would be done via the module and the APP. This would potentially allow for a cheaper spirometer to be produced since it wouldn't require additional processing power or display.



This spirometer was designed after reverse engineering a spirometer that a professor had made. In theory the rotor fan that is inside will generate a specific current that is relative to airflow that a user generates. In this fashion a measurement can be given of a person's lung capacity. This spirometer is purely conceptual in form and function.

10. Discussion

To reach the final concept, possibilities and solutions for a connected ICORES inhaler, with implemented electronics, has been explored. Due to several reasons, including poor recycling potential, the technology was placed in an external module, not integrated in the inhaler. The inhaler has been redesigned to fit the module and the feeling of the overall concept. The aim to create new opportunities for asthmatics and health care providers has been fulfilled through an overall concept where data is gathered and processed to help the user get a better compliance to their medicine. If health care and scientists can access the data, results from asthma research can further help improve the asthmatics life.

By interviewing different stakeholders and analysing user needs, we have increased our knowledge in user centered design and the strive for an improved user experience. The design methods we used in the project were chosen along the way to fit the growing process. What could have been improved is the user studies during the middle of the project to better support the decisions. If something was to be changed, more time in the end of the project to test the final concept would be good.

Some design decisions were proofed by benchmarking other similar products, it would be interesting to further complement these results with own observations on, for example, how (or if) documentation really improves asthma status and helps find asthma triggers. This would on the other hand take a lot of time that we did not have.

Thoughts about how to measure lung capacity

The pressure sensor used in the concept is something we have discussed a lot. In the middle of the project, one of the ideas for the main concept was to measure pulmonary function, this idea was declined when it was deemed too large for the size of the project. Therefore, the function of the pressure sensor was narrowed to only measure if the inhalation reaches a minimum accepted value or not. When later testing the concept, a simple pressure sensor was used and it was found that fairly accurate values on the pressure could be read if the measuring was done in a defined, limited space. This fact would need further development but we believe a function like this is important for the future within asthma improvement and connected asthma devices.

Since the pressure sensor installed in the inhaler could measure pressure fairly accurately (0.2 mbar), there might be possible to perform a spirometry with its aid. Unfortunately, in this case, the scientific research for spirometry is mostly focusing on expiratory flows and volumes and a short inhalation might not be enough data to give a proper diagnosis. In addition, we believe that informing the user to exhale and perform a normal spirometry in the inhaler would heavily impair the user experience and be counterintuitive - also the inhaler would not allow a free flow expiration, which would give data that further deviates from the research already done on spirometry.

However, since the pressure installed in our prototype had such accuracy - we believe a standalone plastic tube (with a fan) for exhaling could be fitted to the module and allow the user to perform a proper spirometry test at home. This has to be further researched to be confirmed.

App development

Another area of development is the app; the interface is not optimized or user tested, the app was discussed with the clients and asthma professionals at Lund University Hospital. Exactly how the data should be presented in graphs and tables needs to be optimized so that the user gets a simple overview and a good seamless experience while using it. How to convert the data so that it gets useful for doctors and nurses is also needed to be considered. Furthermore, if the theoretical addition, to let the user fill a form of their current mood everyday, should be applied to the concept, it needs to be done with the user in focus. The user should not feel forced, but have the opportunity to use the function in order to improve their diagnosis by complementing the journaling.

Economical aspects

A thorough economic analysis has been outside the scope of this thesis, but consideration to the value the connected module delivers in relation to its costs needs to be considered. However, we think that by giving the user better control and understanding of their asthma, will result in fewer emergency hospital visits, fewer parents taking time off to accompany their children to hospitals and better adherence. We believe that this, together with the ability to gather valuable research data to improve asthma research in the long run - will be heavily beneficial for a society with a growing asthma population.

Design for manufacturing

The focus of this project has been to develop a valuable product for the user which solves a problem. But, to not solve one problem and in the same time create new problems, the design decisions for manufacturing have to be improved, this includes (but far from all problems): creating a module with suitable computational power (the Arduino used is overpowered), sensors (the pressure sensor used for the prototype covered pressure far wider than the range during an inhalation). Power management of the battery and the mechanical construction to be aligned with available production capabilities.

Testing, testing, testing

To take these concepts further clinical and user trials has to be performed. We believe that if the “light-concept” for using the inhaler correctly would prove good clinical results a very strong message would be sent across the room.



ICONOVO



End of thesis.

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Appendix A - Focus group

A focus group at the university was conducted for the initial interview phase. The focus group included four students at Lund University in the age group 20-25 and varying degrees of asthma. The goal was to guide participants to talk freely and focused about their asthma condition for one hour. Inspiration was found in *I ett andetag: en kulturanalys av astma som begränsning och möjlighet* (Hansson, 2007) and the conversation was held in Swedish. Below is the framework of the conversation, following by a summation of the discussion.

Conversation framework (in Swedish)

Moderator: Kent Ngo
Observer: Erika Axhed

Introduktion

Short presentation of interview participants 3 minuter

Kort presentation av de deltagande 4 minuter

Hur fick ni reda på att ni har astma? 10 minuter

Hur tar er astma sig form? 3 minutes

Vården - Skriv fråga (ta med lappar och pennor!) 10 min
Vilka delar i vården har ni upplevt som bra?
Vilka delar i er vården har ni upplevt som sämre?

Hur ofta kommunicerar ni med vården och vad sägs då? 5 min (31 minuter)

Beskriv hur er astma påverkar er vardag. 15 minuter
-Do you have any better or worse periods and do you know why?
-How do you notice it get better or worse?
-Hur allvarlig är din astma?

Hur upplever ni er astmabehandling? 15 min
Finns det något ni saknar?

Hur ser ni på er astma i framtiden? 10 min

Vilka är de allvarligaste problemen din astma har orsakat dig? 10 min
-Har ni någonsin skämts för att ni har astma?

Vilka är de viktigaste resultaten som du hoppas uppnå genom behandlingen? 5 min

Vilka mediciner och verktyg använder ni för att kontrollera er astma idag, och hur fungerar dem? 5 minuter

Är det några mediciner ni tycker mer om och andra ni tycker mindre om? Varför?

Summation

RELATIONSHIP WITH THE INHALER/MEDICINE

Feedback

- Feeling cheated that there is no medicine left (despite there is)
- Did I take my dose (properly / for the day)?

Reasons not to medicate:

- Lack of motivation
- Forgetfulness
- I feel good right now
- Hard to get into a routine

It would have been good to be able to track usage / have a journal

RELATIONSHIP WITH THE DISEASE

Emergence

- Unexpected effort
- External factors (food, weather, environment, sensitization, training)
- Poor knowledge of what impairs

You have to self test and find what makes you feel bad

Pinpoint "degree of asthma"

RELATIONSHIP WITH CAREGIVER

Treatment

- Patients must be in focus and "feel seen"
- Involved in their treatment plan
- Feedback (is not always as good as it seems)
- Know why (for example)
- Not withheld information
- Individualized information

Many steps

Visiting care for spirometry survey about once a year and / or to change the medication

Appendix B - Interviews

Telephone interviews were held with three end users in varying age (12, 24 and >40) and three mothers to children in the age 4-7 years. Observations were made two times on different occasions, one at Capio City Klink in Lund and one at the asthma and allergy department at Lund University Hospital. A part-time presentation of the concept was held for Astma- och Allergiförbundet Skåne and discussed with the eight participants (40-70 years old). Conversations were held with two asthma nurses, one asthma doctor and Leif Bjermer, professor in respiratory medicine and allergology. Below are questions for parents/guardians and end users followed by a summation on the interview with Leif Bjermer.

Framework for questions to parents/guardians (in Swedish)

Inledning

Kan du berätta lite om ditt barn och vilka mediciner den använder?

Hur tar astman sig form?

Har barnet fått några astmaattacker - vet du vad det beror på?

Beskriv hur en vanlig dag ser ut, för dig och för ditt barn, i relation till astman.

Rutin för medicinering

Hur fungerar medicineringen under dagen? På dagis/skola

har ni fått förklara för skolan om barnets astma

Hur påverkar astman barnets vardag?

Hur påverkas din vardag?

Hur upplever du att medicineringen fungerar?

Vad upplever du som bra, respektive dåligt med medicineringen?

Förstår barnet varför hon/han behöver ta medicin?

Är det några problem med att ge medicinen?

Glöms medicinen bort ibland?

Har du möjlighet att demonstrera hur inhalatorn medicinen ska användas? (filma)

Känner du dig säker på hur inhalatorn ska användas?

Får barnet i sig rätt dos medicin?

Finns det något mer positivt respektive negativt med inhalatorn/medicinen?

Håller ni koll på barnets astma, om det blir en förändring?

Dokumenterar ni barnets astma på något sätt?

Hur följs astman upp?

Använder ni några digitala hjälpmedel

Hur ser ett besök på sjukhus/vårdcentral ut?

-vad upplever du som bra/dåligt?

-inhalatorn

-behandlingsplan

-medicinering

Hur är din uppfattning av vården?

Hur mycket har ni som anhörig behövt läsa på om astma/behandlingsmetoder/osv , hur mycket information får man från vården?

Får ni några rekommendationer utöver själva medicineringen?

Framework for questions to end users (in Swedish)

Inledning

Beskriv din astmahistoria.

- Hur länge har du haft astma

- Vilka mediciner använder du och när använder du dem?

- Hur fungerar respektive medicin?

Har du möjlighet att demonstrera hur inhalatorn ska användas?

Beskriv hur en vanlig dag ser ut för dig i relation till astman.

Hur påverkas din vardag?

Finns det tillfällen då din astma är bättre respektive sämre?

Träning

Hur upplever du att medicineringen fungerar?

Vad upplever du som bra, respektive dåligt med medicineringen?

Glöms medicinen bort ibland? - vad beror det på?

Dokumenterar du astman?

Hur följs astman upp?

(Använder du några digitala hjälpmedel)

Hur bra koll skulle du säga att du har på din astma?

Hur är din uppfattning av vården?

Hur mycket har du behövt läsa på om astma/behandlingsmetoder/osv , hur mycket information får man från vården?

Får ni några rekommendationer utöver själva medicineringen?

Uppfattning av inhalator

Beskriv hur din inhalator ser ut?

Hur förvarar du den?

Psykologiska aspekter

Hur påverkar din astma de i din omgivning?

Hur tror du att din astma kommer vara i framtiden?

Fysiska aspekter

Hur tar din astma sig form?

Har du fått några astmaattacker, beskriv dem! Vet du varför de uppstod?

Summation of interview with Leif Bjermer and Alf Tunsäter

Interview with Leif Bjermer (professor in respiratory medicine and allergology) and Alf Tunsäter (docent)

Berlin 1930 - treated asthma through both nose and lungs. Nowadays only lungs.

Other notable asthma researchers:

Dermot Ryan (usability) and Erika von mutier who mapped asthma-factors, the first 3 years of living heavily affect the effects of asthma on person.

Why develop inhalers

Today there's a big focus on developing new medicine and substances, but the medical devices are lacking in terms of good deposition and simplicity - which leads to the patients not receiving the full potential of the medicine.

E-health in general

"Flight mode philosophy" where the patient is inactive is bad. The patient needs to have contact with the doctor and be responsible for their own treatment. Big data is good to analyze pattern, but in the end the patient needs to get relevant data which will lead them to have better treatment.

General summary of bad medications

When people switch inhaler and not receiving instructions - not knowing how to use an inhaler leads to fear which inhibits the patient's motivation. Telephone recipe

Mentions of good inhalers

New on the market: Spiromax and K2-haler (good deposition and easy to use)

Respimat (very good deposition but hard to load and instructions is needed)

Old ones: Symbicort (revolutionary at the time)

Mentions of bad inhalers

Airflusal Forspiro (copy product?)

Novolizer - providing intuitive feedback that you have taken your dose. BUT: If you take the dose to fast, the medicine may get stuck in the throat and cause fungus.

The ideal inhaler

Minimizes the risk and increases safety of usage (this is coherent with what the nurse at capio said)

Simple to use <- second

Inexpensive

Good deposition <- definitely most important

Environmental friendly

Reliable

Dose counter

Multiple doses

Fit with the substance

Good deposition

It is important with an inhaler that suits the user

The breathing (inhaling) technique and how you use the inhaler is important

It is common that the you get a new inhaler without sufficient instructions how to use it - leads to insecurity and negative placebo

It would be good with a inhaler that gives feedback when you have inhaled correctly

Environmental friendly

A mix of materials makes it harder to recycle

I.e. respimat: Is used for about 1 month and is then thrown away

The ideal patient

Takes the medication according to ordination

Uses the inhaler correctly

Responsible for their own treatment

Reasons the patient don't follow their treatment

Motivation

Forgetfulness

Fear of cortisone

Using the wrong technique

Problem when inhaling

When Dermot Ryan asked caregivers to demonstrate how to use the inhaler correctly only 12% demonstrated it correctly.

"A dose for the doctor and the rest for themselves"

The most frequent usage problems for the turbuhaler are:

Patient not holding the turbuhaler in an upright position, with bottom facing down.

Patient twisting the turbuhaler, without twisting it to the original position.

Slow starter, dead space

Frequent problem with spray inhaler is:

Patient inhaling too fast (the substances sticks to the throat - which causes fungus infection).

Dream inhaler/care

Disease modifying care where the patient receives an intense treatment over a short period to extinguish the disease or stop it from getting worse. Maybe use an inhaler from

time to time to stabilize condition.

Why?

So the patient doesn't have to medicate every day - why not?

Risk of latent asthma bursting out again (1% heal rate)

50% of the patients receives complete control over their disease (meaning it still affects your everyday life) - factors involve wrong usage of medication and lifestyle.

60-70% avoids physical activities because of their asthma.

Other interesting functions

Reverse spirometri

Digital dose meter

"Flight mode" - Leif didn't like this because it felt inhumane, the patient should be in control of their care. And it would be too expensive.

Future of asthma medication

Much focus has been put into care of serious asthma care, but less effort has been put into mild asthma treatment - something Leif has been pushing for.

External factors

Car fumes

Authority problems

Wrong treated patients - the authority appreciate the drug much more than the device


"The drug decides the price"

It is common that the you get a new inhaler without sufficient instructions how to use it - leads to insecurity and negative placebo

Research project BIG DATA

The user gets a spirometer, activity pulse meter, checking amount of device and sent to a mathematician to analyse result.

Appendix C - User journey template

| | | | | |
|---|--|---------------------------|--|----------------------|
|  | | NAME <input type="text"/> | | |
| | | AGE <input type="text"/> | | <input type="text"/> |
| STAGES » | | | | |
| TOUCHPOINT NAME » | | | | |
| <input type="checkbox"/> STORYBOARD <input type="checkbox"/> TOUCHPOINT DESCRIPTION <input type="checkbox"/> JOBS <input type="checkbox"/> CHANNELS <input type="checkbox"/> STAKEHOLDERS | | | | |
| <input type="checkbox"/> STORYBOARD <input type="checkbox"/> TOUCHPOINT DESCRIPTION <input type="checkbox"/> JOBS <input type="checkbox"/> CHANNELS <input type="checkbox"/> STAKEHOLDERS | | | | |
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| <input type="checkbox"/> STORYBOARD <input type="checkbox"/> TOUCHPOINT DESCRIPTION <input type="checkbox"/> JOBS <input type="checkbox"/> CHANNELS <input type="checkbox"/> STAKEHOLDERS | | | | |
| EMOTIONAL JOURNEY | | | | |
| <input type="text"/> | | | | |
| <input type="text"/> | | | | |
| <input type="text"/> | | | | |
| <input type="text"/> | | | | |
| DRAMATIC ARC | | | | |
| <input type="text"/> | | | | |
| <input type="text"/> | | | | |
| <input type="text"/> | | | | |
| <input type="text"/> | | | | |

TITLE _____ PAGE _____

PROJECT _____ DATE _____



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Four horizontal sections for notes, each consisting of a solid top line, a dashed middle line, and a solid bottom line.

Appendix D - Timeline

| Week | 35 | 36 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 |
|---|----|----|----|----|---------|----|----|----|----|----|-----------|
| Research | | | | | | | | | | | |
| Inspiration | | x | | | | | | | | | |
| Research general design | | x | | | | | | | | | |
| Research medical design | | x | x | x | | | | | | | |
| Research & discuss moral/ethics | | x | x | | | | | | | | |
| read up on different diseases | | | | | x | | | | | | |
| Get connected devices | | | | | started | | | | | | |
| Test connected device | | | | | | x | x | | | | |
| Visit hospital | | | | | | x | | | | | |
| User studies | | | | | | | | | | | |
| Test inhalers | | | | | | | | | | | |
| User journey (kent) | | | | | | | | | | | |
| Write questions for end user | | | | | x | | | | | | |
| Contact end user | | | | | x | | | | | | |
| Interview/observe end user | | | | | | x | x | | | | |
| Contact relevant stakeholders | | | | | x | | | | | | |
| Write questions for stakeholders | | | | | x | | | | | | |
| Interview/observe relevant stakeholders | | | | | | x | x | | | | |
| Mapping core users lifestyle | | | | | | | | | | | |
| Creating personas | | | | | | | | | | | |
| Market | | | | | | | | | | | |
| Benchmarking | | | | | started | | | | | | |
| Stakeholder mapping | | | | | x | | | | | | |
| Pain points | | | | | | | | x | | | |
| Plan focus group dinner | | | | | x | | | | | | |
| Focus group IoT-asthma | | | | | | | | | | | |
| Design | | | | | | | | | | | |
| Formulate brief | | | | | | | | | | | |
| Function analysis | | | | | | | | | | | |
| Concept generation | | | | | | | | | | | |
| Concept evaluation | | | | | | | | | | | |
| User testing/feedback | | | | | | | | | | | |
| Refine concepts | | | | | | | | | | | |
| Form studies | | | | | | | | | | | |
| Sketch models | | | | | | | | | | | |
| Proof of concept | | | | | | | | | | | |
| Prototype (working?) | | | | | | | | | | | |
| Realistic mockups/rendering | | | | | | | | | | | |
| Graphics | | | | | | | | | | | |
| Product alignment with regulations | | | | | | | | | | | |
| Patentable? | | | | | | | | | | | |
| Part time presentation | | | | | | | | | | | 15/11 tis |
| Report & presentation | | | | | | | | | | | |
| Photography | | | | | | | | | | | |
| Book room for presentation | | | | | | | | | | | |
| Invite people to presentation | | | | | | | | | | | |
| Summarize report (copy) | | | | | | | | | | | |
| Layout | | | | | | | | | | | |
| Slides | | | | | | | | | | | |
| Practice presentation | | | | | | | | | | | |
| Presentation | | | | | | | | | | | |

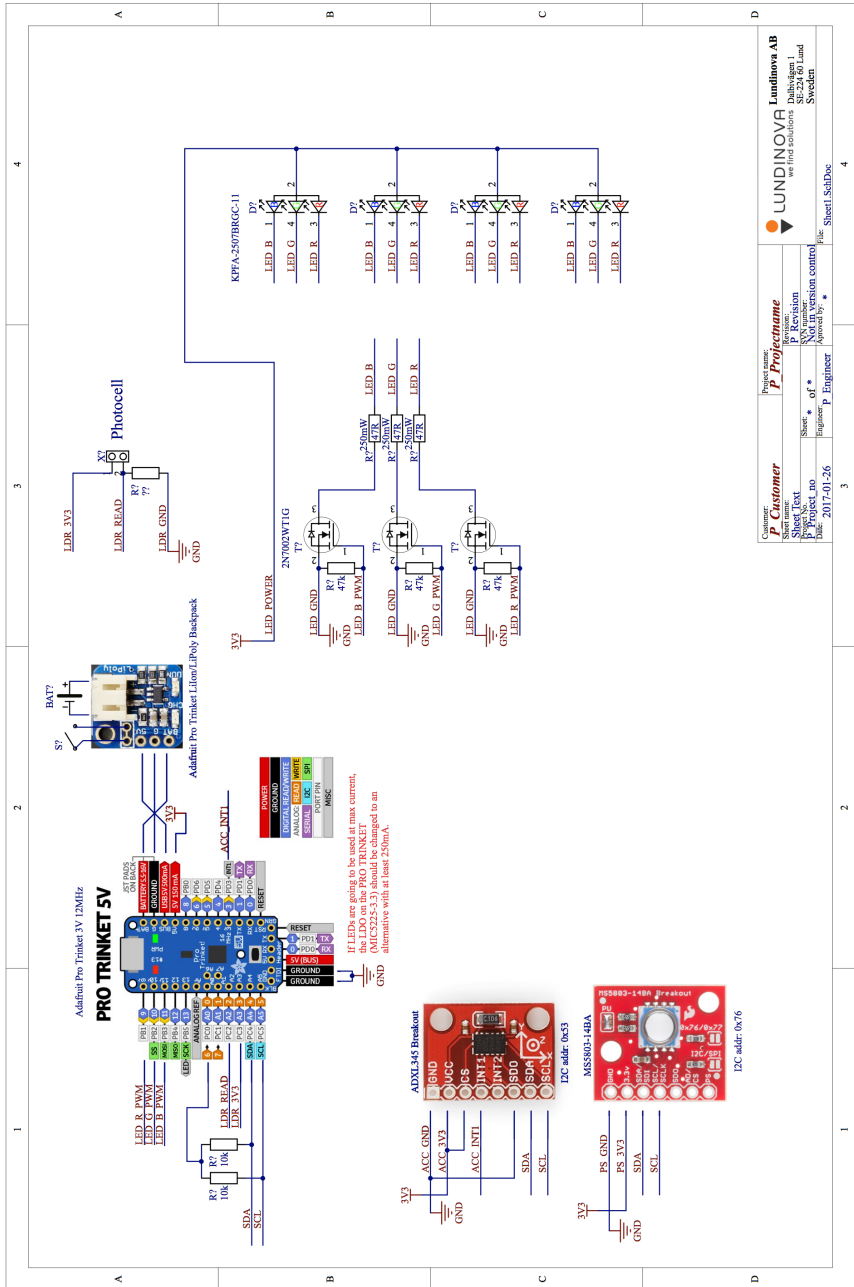


Appendix E - List of user needs

List of needs

| Verb: | What: | About: |
|--------------|---------------------|----------------------------------|
| Feels | Uncertain | Side effects |
| Feels | Hard to determine | Asthma status |
| Feels | Misleading | Feedback on medicine consumption |
| Feels | Good to help | Asthma Research |
| Feels | Hard to follow | Treatment Plan |
| Feels | Too much | Responsibility |
| Feels | It would be good to | Document asthma |
| Feels | Ashamed | Asthma |
| Misses | Knowledge | Asthma |
| Misses | Information | Effects of control medicine |
| Misses | Knowledge | Inhalation technique |
| Wants | Control | Asthma |
| Wants | Personal | Treatment |
| Wants | The best | Treatment |
| Thinks | Ugly | Inhaler |
| Inhales | Too often | Rescue medicine |

Appendix F - Electrical schematic



Appendix G - Work Division

The very nature of a master thesis and a design project between two students builds on collaboration. And as such, the work division has been inseparable.



zenit design
vision into value

ICONOVO