MASTER THESIS

VEA - Personalizing the journey towards enhanced asthma self-management

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Acknowledgments

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Executive summary

Asthma is one of the most common chronic diseases worldwide, and it is expected that the prevalence of asthma will only increase in the coming years (Masoli et al., 2004). Medical self-management by asthma patients will be of essential importance to keep the burden of disease as low as possible.

Medical self-management is critical in obtaining asthma control. Research suggests that the majority of patients can obtain asthma control, yet most adults are still living with uncontrolled asthma. Both extensive literature research and qualitative research with asthma patients and healthcare providers were executed to uncover what the barriers are that asthma patients face in medical asthma self-management.

The research uncovered three main problems that form barriers to efficient self-management.: beliefs, low motivation, and inability. Each of these problems has its underlying causes. **Beliefs** are caused by (1) paternalistic care, (2) lack of stimulation, (3) shortcomings in knowledge sources. **Low motivation** is the result of (1) paternalistic care, (2) lack of awareness, (3) discouragement due to inadequate tools. At last, **inability** is caused by (1) lack of knowledge, (2) lack of skills (3) lack of insight.

Several opportunity areas to enhance the self-management of asthma patients were discovered: (a) patient education, (b) self-tailoring, and (c) increasing competence.

Patient education can be enhanced by creating awareness and providing a better knowledge source through (1) personalization, (2) spreading knowledge. Enabling the patient to **self-tailor** can induce more active participation of the patient. Increasing the asthma patient's **competence** can be done by (1) increasing self-knowledge (2) enabling action.

To overcome the barriers to self-management a design was proposed: vea. Vea consists of an app and a physical product.

The app enables the user to set goals and supports the user to achieve these goals. Through working on the goals, the app learns about the user and gets personalized. The physical device supports the app by measuring the air quality in the home of the user and gives feedback on this.

Key user benefits of the design are:

Personalization
Vea is designed to match the patients' needs. Through personalizing its approach and content, the app becomes relevant to the user.

Being in control
The user is in charge of the goals they want to achieve. The app assists them by making the once invisible complaints and effects of self-management explicit.

Increased capability
Vea provides structured tools that increase the capability of the user to self-manage their asthma. Through seamlessly collecting data and providing relevant feedback and tips, the user is motivated and capable of acting.

User evaluation demonstrated that the proposed design is undoubtedly promising. Both asthma patients and general practitioners indicated that the design could lead to increased insight, motivation, and enhanced competence of medical self-management.

The main limitation of this master thesis is, however, determining the long-term effect of the design. Although the design has shown to be promising, unfortunately, no statement can be made of the long-term effect of vea on the actual improvement of medical self-management. To be able to do so, the design should be further developed and tested in the long term.

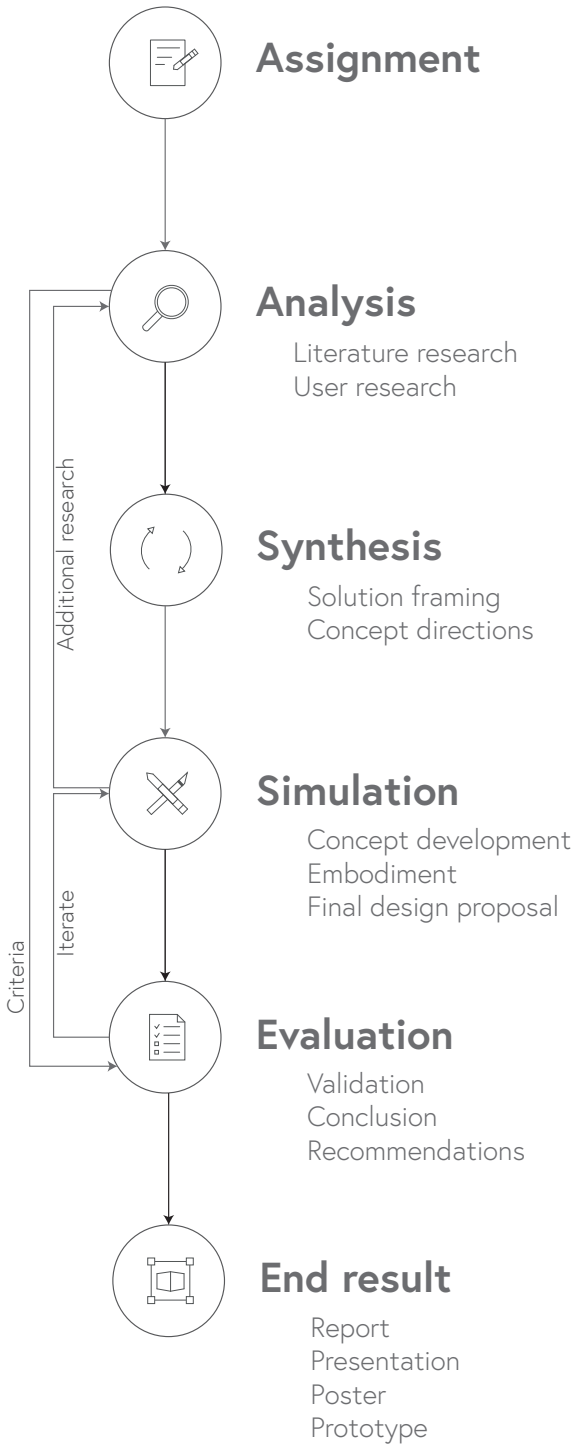


Figure 1. *Schematic representation of the different project phases*

Reading guide

Project & report structure

This project was executed according to the iterative design cycle by Eekels et al. (Eekels et al., 1991). An overview of this process can be seen in Figure 1. It is important to note that the design process was not as linear as this figure may suggest, because each stage contained multiple design iterations.

This report is written to present my 20-weeks graduation project. The report has been divided according to the five main stages mentioned above to obtain a clear reading structure.

The **assignment** section introduces the project objective, scope, and approach.

The **analysis** section presents the relevant literature research to answer the research questions. User research with asthma patients and treating physicians was conducted to get a better understanding of the project context. In this section, each chapter is concluded with its relevance for the project and a set of design implications. The design implications are recognized by a ✓. In Appendix 8 the list of requirements can be found including these design implications.

In the **synthesis** section, it is explained how the research findings led to six design proposals. This section is concluded with the selection of the final concept.

The **simulation** section describes the concept development process towards the final design.

In the **evaluation** section, the final prototype was tested with patients. Based on this evaluation, minor adjustments to the design were made, and the chapter is concluded with future recommendations and a personal reflection.

The **references** are presented at the end of the report, and the **appendices** are included in a separate "Appendix" document.

Glossary

Definitions

Adherence:
The extent to which a person's behaviour – taking medication, following a diet, and/or executing lifestyle changes, corresponds with agreed recommendations from a health care provider (WHO, 2003)

Asthma:
Asthma is a chronic inflammation of the airways which leads to hyperresponsiveness of the airways. When a person with asthma gets in touch with certain irritants this hyperresponsiveness can cause an exacerbation (GINA, 2006).

Asthma control:
The extent to which the effects of asthma can be seen in the patient, or, have been reduced or removed by treatment (GINA pocket, 2018)

Bronchodilator:
Bronchodilators, also called relievers, or rescue medication, fight the symptoms of an asthma exacerbation or can prevent the symptoms by relaxing the muscles around the airways (Longfonds, 2019).

Clinical manifestations:
Clinical manifestations in asthma are symptoms, sleep disturbances, limitations of daily activity, impairment of lung function and use of rescue medications (Bateman et al., 2008),

Collaborative care:
is a description of the patient-physician relationship in which physicians and patients make health care decisions together. (Bodenheimer et al, 2010)

eHealth:
Health services and information delivered or enhanced through the Internet and related technologies (Eysenbach, 2001)

Exacerbation:
Asthma attack

First line:
Treatment by the GP without referral

mHealth
The use of mobile phones and other wireless technology in medical care" (Rouse, 2018).

Morbidity:
The incidence of disease : the rate of illness (as in a specified population or group) (Merriam-webster.com, 2019)

Pathophysiology:
The functional changes that accompany a particular syndrome or disease (Merriam-webster.com, 2019)

Patient empowerment:
this concept holds that patients accept responsibility to manage their own conditions and are encouraged to solve their own problems with information, but not orders, from professionals. The paradigm views internal motivation as more effective for lifestyle change than external motivation. (Bodenheimer et al, 2010)

Self-knowledge
The extent to which a patient has insight in the level of asthma control, adherence and risk factors such as triggers and risk of exacerbations

Self-management:
Self-management refers to the individual's ability to manage the symptoms, treatment, physical and psychosocial consequences and life style changes inherent in living with a chronic condition. Efficacious self-management encompasses ability to monitor one's condition and to effect the cognitive, behavioural and emotional responses necessary to maintain a satisfactory quality of life. Thus, a dynamic and continuous process of self-regulation is established. (Barlow et al, 2002)

Sensitizing (booklet):
Sensitizing is a process where participants are triggered, encouraged and motivated to think, reflect, wonder and explore aspects of their personal context in their own time and environment. . A sensitizing package consisting of little activities or exercises is sent to the participants at home in the period before the session (Visser et al., 2005)

Paternalistic care
mHealth: the use of mobile phones and other wireless technology in medical care (Rouse, 2018)

Peakflow
The maximum volume of air that can be expelled from the lungs during a vigorous exhalation. Its measurement is used to determine the degree of respiratory impairment in patients with obstructive lung diseases (Medical Dictionary, n.d.).

Phenotypes:
Self-efficacy: the confidence to carry out a behaviour necessary to reach a desired goal (Bodenheimer et al., 2002)

Abbreviations

ACQ:
Asthma Control Questionnaire

AIS:
Asthma Instability Score

CMF:
Color Material Finish

DPI:
Dry Powder Inhaler

EMD:
Electronic monitoring devices (EMDs) are the optimal method for collecting objective data on inhaler use in asthma.

GP:
General Practitioner

Li-ion:
Lithium Ion

LOR:
List Of Requirements

PM:
Particulate Matter

pMDI:
Pressurised Metered Dose Inhaler

SMI:
Soft Mist Inhaler

VOC:
Volatile Organic Compound

WHO:
World Health Organisation

Table of contents

1 Assignment & approach

This section introduces the assignment and the project context. It also introduces the approach and objective of the project. Finally, the research questions which will be answered in the analysis phase are introduced.

1.1 Stakeholders

This project was initiated by CAHAG (COPD & Asthma General Practitioners Advisory Group) and involved multiple stakeholders. This section presents a short description of the different project partners and their role.

CAHAG
CAHAG is a group of general practitioners with a special interest in the diseases COPD and Asthma. CAHAG initiated this project because they want to stimulate the self-management of asthma patients. Besides that, they want to stimulate a better relationship between asthma patient and general practitioner.

CAHAG has set the initial boundaries for the assignment and was involved in all major decisions within the project. CAHAG was consulted for expert information on both asthma as a disease and the treatment in the first line.

VanBerlo
The project was done in co-creation with VanBerlo. VanBerlo is one of the most well-known design consultancies in the Netherlands. The role of VanBerlo is to guide the outcome of the project; their interest is to ensure a realistic result. VanBerlo acted as a consultant on design-related decisions and issues.

TU Delft
This graduation project was executed for the Delft University of Technology, department of Industrial Design. This 20-week project will conclude my master studies in Integrated Product Design.

The role of the TU Delft is to guide the project from an academic point of view. Natalia Romero and Sonja Paus-Buzink fulfilled this role.

NeLL & LUMC
The National eHealth Living Lab and Leiden Universitair Medisch Centrum are partners of CAHAG. These parties were consulted throughout the project.

Workgroup
Besides the parties mentioned above, there are four other main parties involved in the project; these are GSK, Boehringer Ingelheim, Astra Zeneca, and Novartis. These four pharmaceutical companies are the market leaders of asthma medication in the Netherlands. Their primary interest is in therapy compliance and improvement of asthma self-management.

1.2 Assignment

Problem definition and assignment

Asthma is a chronic infection of the airways that leads to narrowing of the airways. Asthma makes the lungs easily irritable and can lead to coughing, wheezing, and shortness of breath (Astma-COPD.nl, 2018). When suffering from asthma, self-management is of significant importance in treating the disease. Unfortunately, many asthma patients experience difficulties in self-managing their asthma.

The assignment for this project was therefore set to:

> *"Design an asthma self-management system that both empowers and supports recently diagnosed asthma patients and increases their competence of medical self-management."*

Expected outcome
The initial question of CAHAG was to develop a digital tool. As my studies are in Integrated Product Design, it was decided that in addition to the digital tool, I would also develop a physical tool that supports and complements the function of the digital tool.

Scope
Self-management is a complex and multidimensional concept with a lot of interrelated elements. To set clear boundaries for the project, the project was scoped towards a specific target group, time frame, and a focus within self-management.

Target group and timeframe
The target group of the project is young adults aged 18-25 who have recently been diagnosed with asthma. The focus will be on well literate patients who should be perfectly capable of self-management with the tools that are available to them, yet they somehow lack in doing so.

Medical self-management
Self-management entails many interrelated elements, yet the three main tasks of self-management are; medical management, behavioral management, and emotional management (Lorig and Holman, 2003). Figure 2 provides a schematic overview of self-management.

Because it is not possible to adress all issues related to self-management, it was decided to focus on one of the three self-management tasks, namely, medical self-management.

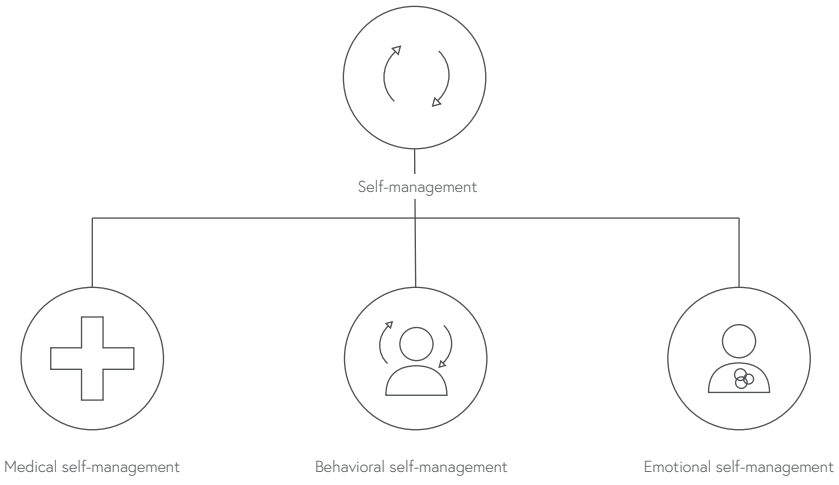


Figure 2. *Three self-management tasks*

1.3 Project approach

Research questions

Four main research questions were formulated to fulfill the project assignment. The research questions are structured according to the project phases as defined in the reading guide.

Analysis

How can design for increased competence improve medical self-management?

- *What does self-management in asthma comprise of?*
- *What are the reasons for poor medical self-management?*
- *How can asthma patients' competence in medical self-management be enhanced and supported?*

The main goal of the analysis phase was to get a good overview of the context of the project and the problems at hand. These findings were translated into design implications and used as input for the design phases.

Synthesis

How can design solve the problems as identified in the analysis, using one holistic self-management system that improves asthma patients' competence of medical self-management?

In the synthesis phase, the findings from the analysis are translated into design directions that together from the solution space. The most promising direction was chosen as the final design direction.

Evaluation

To what extent does the design fulfill its intended goals, and how can its functionality be further improved upon?

In this phase, a prototype was created to evaluate the design with the intended end-user. Based on this evaluation, several recommendations were formulated for concept improvements and future research.

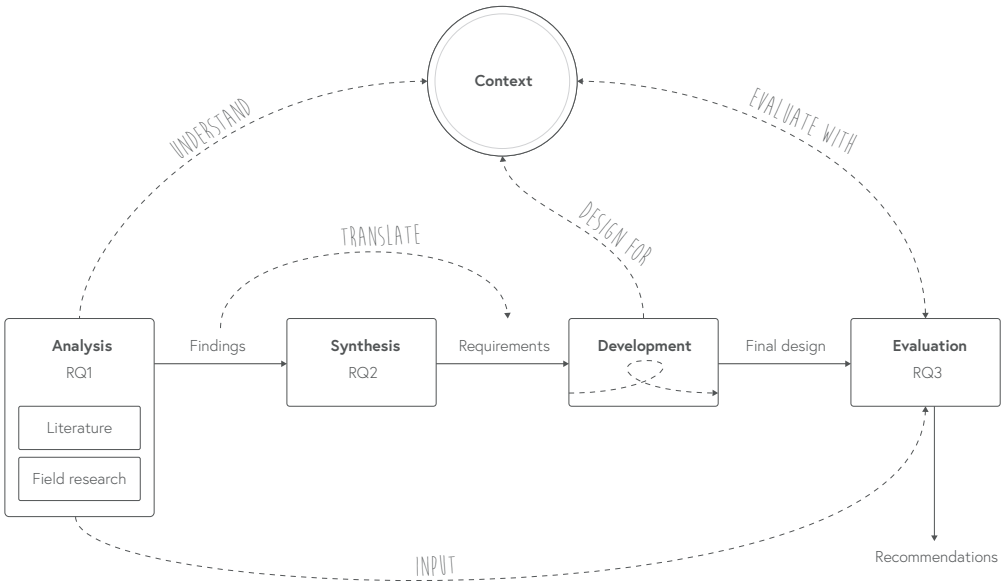


Figure 3. *Visual representation of the role of the research in the project*

Project approach

At the end of the assignment phase, the project approach was defined. This section describes the approach according to the phases of the project.

Analysis

The analysis started with *theoretical research. Literature research* was done to explore the context, existing frameworks, and to identify problem areas. Also, *market research* was performed to map out already existing solutions. This phase was followed by *field research.* The field research consisted of user research through organizing a *focus group* with asthma patients, preceded by a *sensitizing booklet.* The user research was conducted to confirm the literature research and to empathize with users. Specifically, the aim was to understand their current experiences and needs in daily life. The field research was complemented with *semi-structured interviews* with general practitioners.

A *creative session* with designers of VanBerlo concludes the analysis. This session was used to *cluster* the findings, *discover relations,* and to develop these into *problem areas.* Also, some early *brainstorming* was done on different design directions. After the session, the definitive design directions were further defined and presented in a mid-term meeting with the mentors of the project, in which one design direction was chosen.

Synthesis

The synthesis started with further crystallizing the design direction into a *solution space,* defining the *design context*, creating a *function analysis* and a *list of requirements.* Once these were clear, both *sketching sessions* and *brainstorm sessions* were done individually and with students, designers, and non-designers. *Experts* on specific elements of the design space were consulted for input to the concepts. The synthesis was concluded with the development of *three concepts* which were evaluated using de design criteria set at the beginning of the synthesis. One concept was chosen.

Simulation

The concept was further developed in the simulation phase. Different *scenarios* of use were created to get insight into the desired interactions. Next, the concept was further developed through several *iterations.* Iterative *sketches*, *visualizations*, and *prototypes* were made *tested*, *evaluated,* and *improved* upon. This section ends with the embodiment and prototyping, resulting in the *final design.*

Evaluation

In the evaluation phase, the final design was *evaluated* with patients and general practitioners through *observing* and *semi-structured interviewing.* In addition, the final design was tested using the list of requirements. The outcomes of the tests were used to define *recommendations* for future development by CAHAG. The report ends with a *personal reflection* and a *conclusion.*

2 Analysis

The main objective of the analysis phase was to gain insight into the disease of asthma and the concept of self-management. This chapter describes the key insights obtained from this research phase.

2.1 What is asthma?

Research on the pathophysiology of asthma, the diagnosis, and the treatment, was performed for a better understanding of the disease asthma. This chapter provides an overview of the key insights. Appendix 1 provides more in-depth information.

The prevalence of asthma

Asthma is one of the most common chronic diseases worldwide (Masoli et al., 2004). Worldwide 300 million people, and in the Netherlands alone 640.000 people, have asthma (Longfonds, n.d. b). It is expected that these numbers will increase, with a possible additional 250 million people suffering from asthma by the year 2025 (Masoli et al., 2004).

Figure 5 illustrates the burden of asthma for both patients and the society, a more in-depth description can be found in Appendix 1.

Due to inadequate treatment and a lack of self-management, there are many patients with unnecessarily uncontrolled asthm. Poor asthma control increases the burden of the disease drastically and leads to higher hospitalization rates, more emergency room visits, and increased personal limitations (Haugney et al., 2008).

The goal of this project is to support both asthma patients and healthcare providers towards increased medical self-management by asthma patients. With the aim to have more asthma patients obtain asthma control in the future.

Pathophysiology

Asthma is a chronic inflammation of the airways, which leads to hyperresponsiveness. When a person with asthma gets in touch with certain irritants, this hyperresponsiveness can cause an increase in complaints or an exacerbation (GINA, 2006).
There are three different kinds of asthma: allergic asthma, non-allergic asthma, and exercise-induced asthma. Asthma patients often suffer from more than one kind of asthma at the same time (Longfonds, n.d.).

Besides types of asthma, there are also different levels of severity that can be distinguished. This classification is based on the amount of medication that is required to treat a certain level of complaints (Khajotia, 2008). The four different levels of asthma severity are: mild intermittent, mild persistent, moderate persistent, severe persistent.

The symptoms of asthma are mostly present during an asthma exacerbation. An asthma exacerbation, or asthma attack, is a progressive increase in coughing, wheezing, shortness of breath, or chest tightness, or any combination of these symptoms (GINA, 2006). These events cause the bronchial tubes to narrow, making it difficult to breathe (Longfonds, n.d. b). Figure 4 provides a depiction of the airways during an asthma exacerbation. Asthma symptoms are often induced by specific *triggers*. There are many different triggers (see **Appendix** 1.2) each asthma patient is susceptible to different triggers.

At last, asthma is characterized by episodes of different severity of symptoms which change over time. However, asthma is a chronic disease, and the infection that causes asthma cannot be cured, even in times with little to no symptoms (Longfonds, n.d. b). For a more in-depth explanation of the pathophysiology of asthma, please refer to Appendix 1.

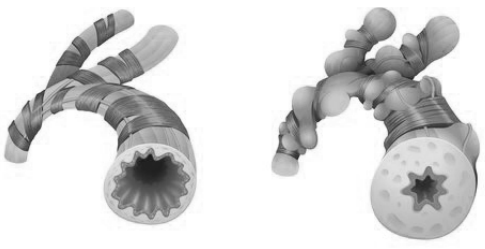


Figure 4. *Representation of the airways during an asthma exacerbation (Astma-COPD.nl, 2018).*

Figure 5. *The prevalence of asthma*

Diagnosis and treatment

A lung function test can be used to diagnose asthma; the general practitioner (GP) or pulmonologist can perform this test. Often this test is accompanied with listening to the lungs, and in some cases, an allergy test. Figure 7 provides an overview of the diagnosis process based on interviews performed with general practitioners.

Asthma is treated through inhaled medication and sometimes with medicines in the form of pills. There are two main categories of medicines; anti-inflammatory medicines and bronchodilators. Anti-inflammatory medication is applied for the long-term treatment of asthma. These medicines fight the permanent inflammation of the airways, which results in less sensitivity to triggers.

Bronchodilators, also called relievers or rescue medication, do not treat the inflammation of the lungs. Bronchodilators fight the symptoms of an asthma exacerbation or prevent the symptoms by relaxing the muscles around the airways (Longfonds, 2019).

At last, there are combination medicaments which both impede the inflammation and prevent the muscles around the airways from contracting. Figure 6 gives an overview of the different medicaments.

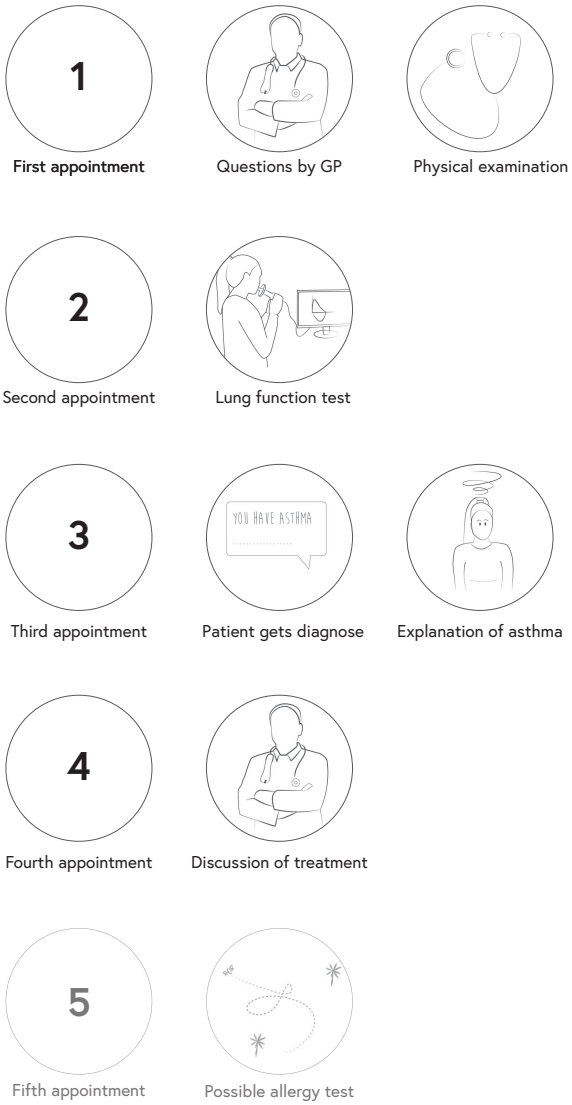


Figure 7. *The process of diagnosis.*

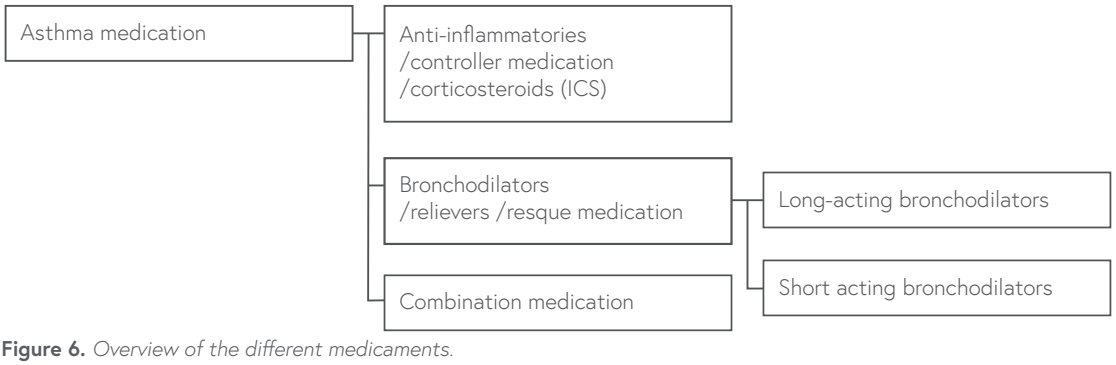


Figure 6. *Overview of the different medicaments.*

Conclusion

Asthma is a significant problem worldwide, which is expected to increase drastically in the coming years. Self-management is of crucial importance to keep the burden of disease as low as possible.

There are many definitions of what asthma means to a patient; there are many ways in which the disease manifests itself. Based on this finding, personalization of the design seems essential to improve self-management of asthma patients. In particular, this personalization should take into account the severity of asthma, asthma triggers, and level of asthma control.

Design implications

✓**Personalization**

Asthma is not a disease with one generalizable image of what it entails for a patient; there are different types of asthma, different levels of severity, numerous different triggers, and differences in complaints. Because of this highly diverse character of the disease, personalization of the design is decisive for a suitable solution for each patient. (R1)

✓**Insight**

Asthma changes over time, which makes it difficult for asthma patients to understand and interpret their complaints. The design should allow patients to keep track of changing conditions over a longer period of time. (R2)

✓**Adherence to medication**

The medication of asthma consists of three different types of medicine: anti-inflammatory medication, and reliever medication, or a combination of these. Each is essential for an optimal treatment of asthma. Therefore, the design should stimulate adherence to each of medication. (R3)

2.2 Asthma self-management

Central to the assignment of this project is the concept of self-management. Hence, an elaborate analysis of the concept of self-management in healthcare was performed. The focus of the project is on medical self-management. Nevertheless, self-management is a complex and multidimensional concept with many interrelated elements. This chapter provides a brief overview of the most important findings. More extensive information on self-management is given in Appendix 2.

Self-management as a concept

Self-management, as a concept in the treatment of chronic diseases, has been around and widely used since the mid-1960s (Lorig and Holman, 2003). It was chosen to adopt the definition of self-management by J. Barlow *et al.(2002)* to obtain a clear idea of self-management for this project:

> *"Self-management refers to the individual's ability to manage the symptoms, treatment, physical and psychosocial consequences, and lifestyle changes inherent in living with a chronic condition. Efficacious self-management encompasses the ability to monitor one's condition and to affect the cognitive, behavioral, and emotional responses necessary to maintain a satisfactory quality of life. Thus, a dynamic and continuous process of self-regulation is established." (Barlow et al., 2002)*

The topic of self-management becomes increasingly relevant in recent years. As the average life expectancy of people increases, there is an increase in the number of chronically ill people. This increase of chronically ill people puts a heavy load on healthcare services. The gap between the increased demand for care and the limited resources of healthcare can be closed adopting a collaborative care approach (Barlow et al., 2002).

In traditional, paternalistic, care models the patient is viewed as a passive receiver of care, whereas collaborative care represents a care system in which the patient is in control and becomes his or her primary caregiver. Healthcare professionals are seen as consultants supporting them in this role. A collaborative care system is essential for enhanced self-management as it enables patients to take a more active role in their treatment (Barlow et al., 2002), (Bodenheimer et al., 2010).

Unfortunately, less than one-third of the general practitioners (GP's) and only one-fifth of specialists have adopted collaborative care approaches. Thus, the majority of patients is not actively involved by their GP in their treatment (F. Braido, 2013).

Design implications

✓ **Stimulate collaborative care**

The design should emphasize collaborative care approaches and should thus stimulate collaboration between patient and caregiver. Taking into consideration that most GPs have not yet adopted collaborative care principles, the tool should create awareness on the patient side, such that they can actively participate. Examples of collaborative care are: asking critical questions, consulting the GP as an expert, or informing the GP on their point of view. (R4)

✓ **Active involvement of the patient**

Active involvement of the patient appears to be beneficial for self-management. For this reason, the patient should be encouraged to become a more active participant in their treatment. (R4.1)

Figure 8. *Roles in different care models.*

Self-management in asthma

For efficacious self-management patients must be capable of three main tasks: manage the disease on a medical level, role or behavior management, and emotional management (Lorig and Holman, 2003).

Medical management
Medical management refers to the management of medical aspects of the disease, such as adherence to the treatment, taking medication, correct use of the inhaler and knowledge of the disease.

Behavioral management
Behavioral management refers to changing behavior, to adjust to the disease, or, maintaining behaviors that are helpful to their condition.

Emotional management
Emotional management refers to the psychosocial health of the patient and the ability to cope with emotions.

Appendix 2.2 provides a more detailed description of concrete tasks of self-management in asthma based on the Dutch websites longfonds.nl and thuisarts.nl. Figure 9 provides a schematic overview of the three main tasks of self-management.

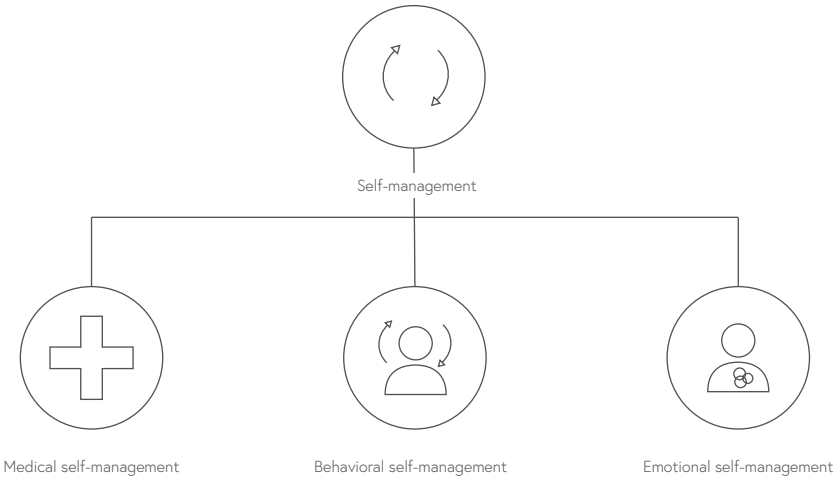


Figure 9. *Three self-management tasks*

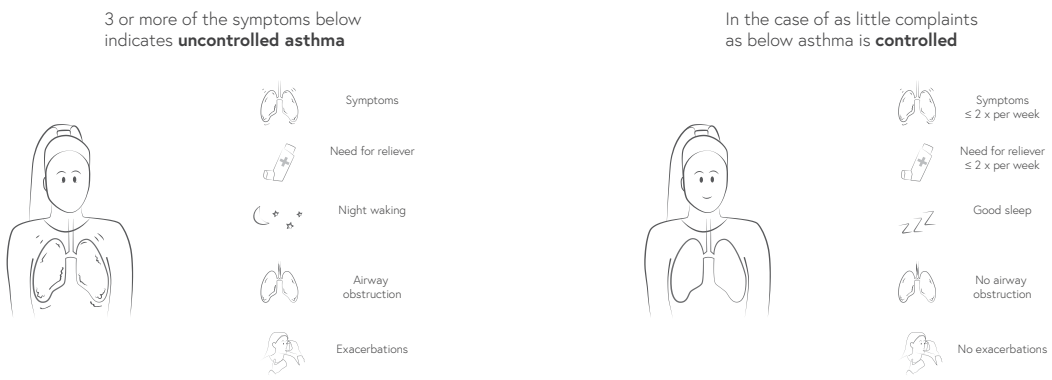


Figure 10. *Uncontrolled versus controlled asthma*

The goal: asthma control

The main goal of asthma treatment and asthma self-management is to achieve asthma control.

> *"Asthma control means the extent to which the effects of asthma can be seen in the patient, or, have been reduced or removed by treatment." (GINA pocket, 2018)*

Whether asthma control is achieved is the result of different factors such as the disease severity, the patients' knowledge, and behavior and the healthcare providers' knowledge and behavior (f. Braido, 2013).

Even though self-management consists of many different skills, actions, and behaviors, a key ingredient in obtaining asthma control seems to be the appropriate use of medication (Horne and Weinman, 1999). Unfortunately, medication adherence rates are low, with adherence to anti-inflammatory medication no higher than 26% (Braido, 2013).

Since medical self-management seems to be the key to obtaining better asthma control, it was decided to scope the project towards medical self-management. The next chapter explains medical self-management more extensively.

Behavioral change

Improving self-management of asthma patients beholds a need for behavioral change. Research on behavioral change theories was performed to understand how to design for behavioral change. One theory that emerged in literature is the self-efficacy theory by Albert Bandura. Self-efficacy is "the confidence to carry out a behavior necessary to reach a desired goal" (Bodenheimer et al., 2002).

According to Bodenheimer et al.(2002), self-efficacy is a central concept in self-management (Bodenheimer et al., 2002). Figure 11 provides a visualization of the four behaviors that are associated with improved self-efficacy: mastery experiences, vicarious experiences, social persuasion, and emotional management.

Another theory that is relevant to the topic of self-management and motivation is the self-determination theory by Deci & Ryan(2000), who state that there are three basic needs for intrinsic motivation; competence, relatedness, and autonomy (Ryan and Deci, 2000).

The design focuses on the individual asthma patient, which translates into incorporating the aspects of stimulating mastery experiences, feeling of competence and autonomy. For now, other aspects of the theories are considered to be out of scope.

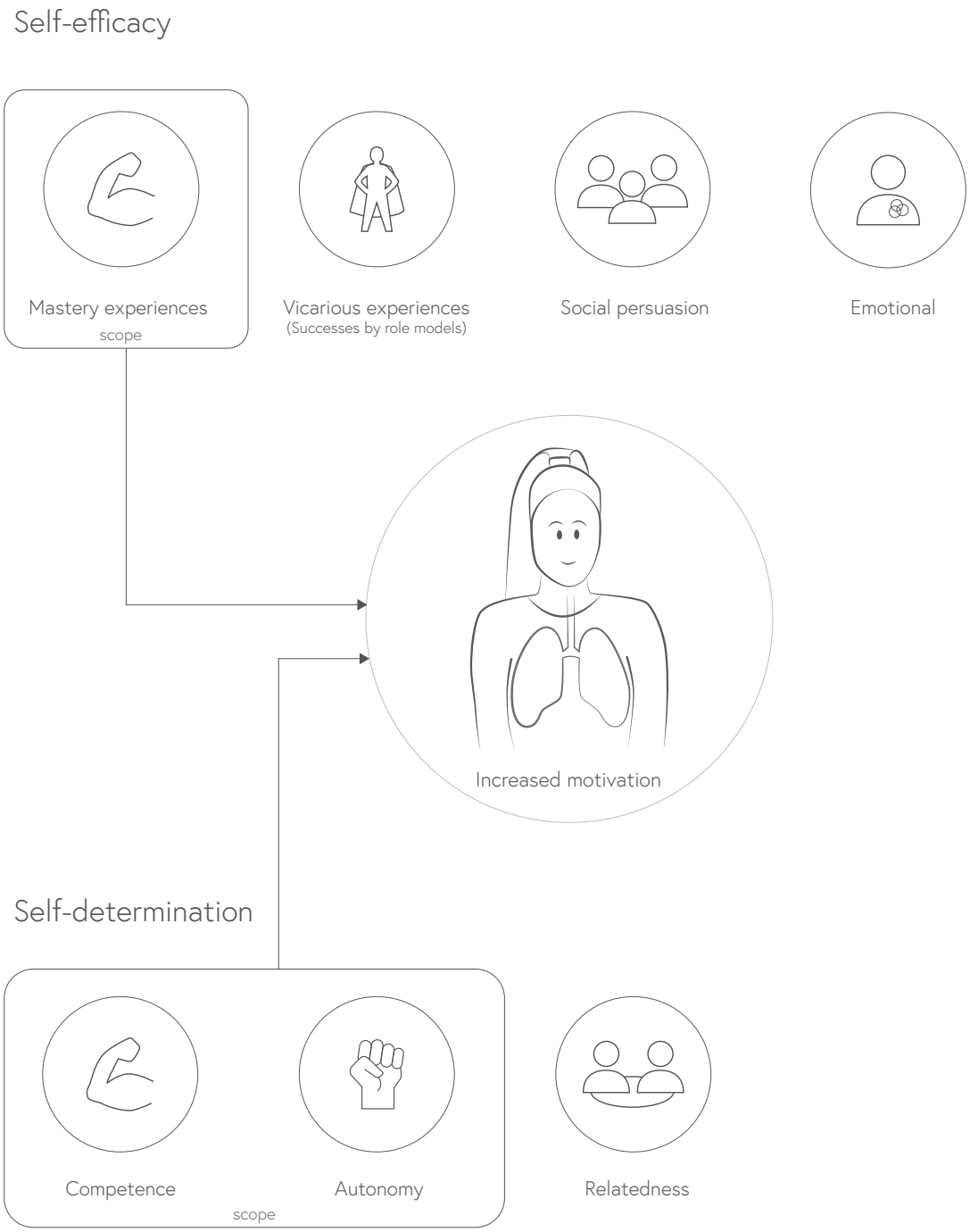


Figure 11. *Behavioral change theories*

Design implications

✓**Design for mastery experiences & competence: feedback, trends, and progress**

When designing for improved motivation and behavioral change, providing mastery experiences (a feeling of competence) is essential. The design realizes this by emphasizing achievements in the form of positive feedback and stimulating a feeling of progress. Also showing trends, especially positive trends, can be used to increase a feeling of competence. (R5)

✓**Design for autonomy**

When designing for improved motivation and behavioral change, the user must have a feeling of autonomy. By giving patients the options and freedom to make choices in their approach to self-management the design will give the patients a feeling of autonomy. (R6)

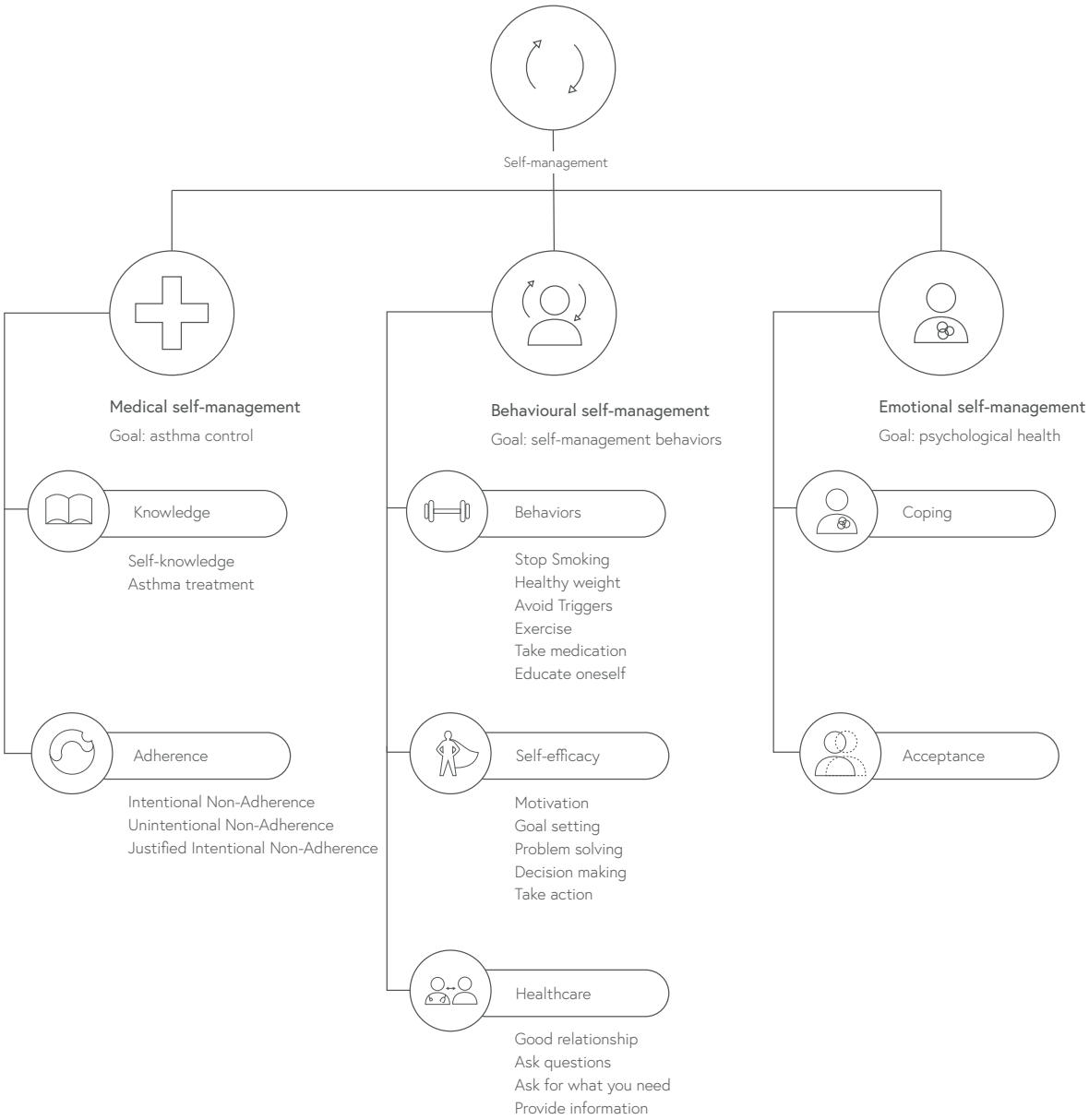


Figure 12. *Complete overview of self-management*

Conclusion

This chapter has explained the different aspects of self-management. Self-management consists of many different and interrelated elements. The project scope was set to medical self-management to keep the complexity of the project manageable.

Figure 12 provides a visual interpretation of self-management as presented in this chapter. For additional information on self-management refer to Appendix 2.

Design implications

✓**Medical Self-management**

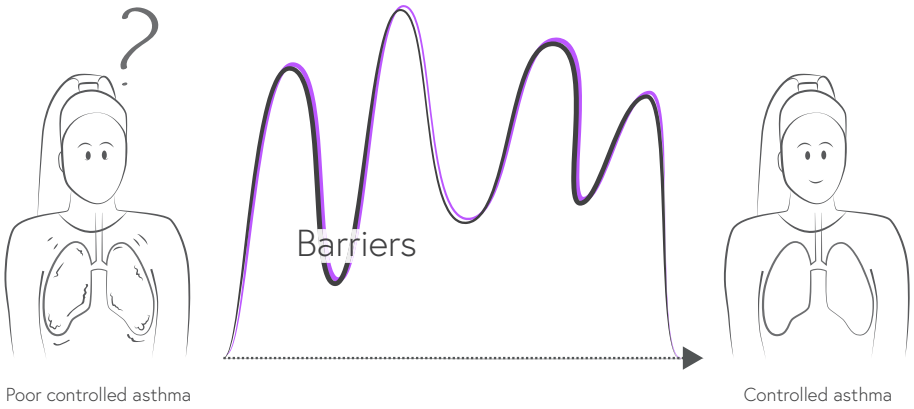
The focus of the project is on medical self-management. However, the different aspects of self-management are highly intertwined, and thus when designing emotional and behavioral self-management are considered as well. (R7, W1)

✓**Obtaining asthma control**

This chapter demonstrates that the primary goal of asthma treatment is to achieve asthma control. The design should support patients in obtaining asthma control through enhanced self-management. (R8)

2.3 Obstacles in medical self-management

Medical self-management is critical in achieving asthma control. Research suggests that the majority of patients would be able to obtain asthma control. However, most adults are still living with uncontrolled asthma. This chapter provides a deeper understanding of the role of medical self-management and the barriers that patients face when working towards asthma control.



The role of knowledge

Medical self-management has two main components; these are medical knowledge and adherence.

For optimal self-management, it is essential that patients develop knowledge about their disease. The role of knowledge about asthma and medication plays a significant role in adherence. Patients' beliefs on medication are strongly correlated with their adherence behavior (Horne and Weinman, 1999). Patients that are worried about possible adverse effects of medication or patients that perceive low necessity of medication, for example, are more likely to be non-adherent.

Along with knowledge about the disease, patients should also develop self-knowledge within asthma. Self-knowledge is the extent to which a patient has insight into his/her personal level of asthma control, adherence, and risk factors such as triggers and risk of exacerbations.

Research has shown that patients have difficulties expressing their level of asthma control and severity to their healthcare provider. Often patients underestimate the severity of their asthma, which could, in turn, lead to undertreated asthma (Simpson *et al.*, 2017). Patients with a lack of self-knowledge, who either under- or overestimate their complaints, are four times as likely to end up in the emergency department, five times as likely to end up in the hospital and six times more likely to have (near) fatal asthma attacks (F. Braido, 2013).

An even greater challenge to controlling asthma and providing optimal treatment is the fact that asthma severity may change over time, which leads to underestimation, inappropriate therapy and increased morbidity (Braido, 2013).

At last, it is crucial that patients develop an understanding of the triggers of their disease, so they can avoid possible irritants that lead to exacerbations. Getting to know these triggers can be an arduous process for asthma patients, as they must continuously be aware of their complaints, and they must discover the relations between their complaints and numerous environmental or internal aspects.

In summary, the three main problems concerning knowledge are: a lack of knowledge, lack of self-knowledge, or the development of (incorrect) beliefs that influence adherence to therapy.

Design implications

✓**Knowledge**
A good understanding of asthma and the treatment is vital for empowering patients to improve their (medical) self-management. (R9)

✓**Improve self-knowledge**
The development of self-knowledge should be supported. The design needs to give insight into the level of complaints and asthma control. (R9.1)

✓**Discover triggers**
As a part of improving self-knowledge, the support in finding a person's triggers is of great benefit to the self-management of an asthma patient. (R9.1.1)

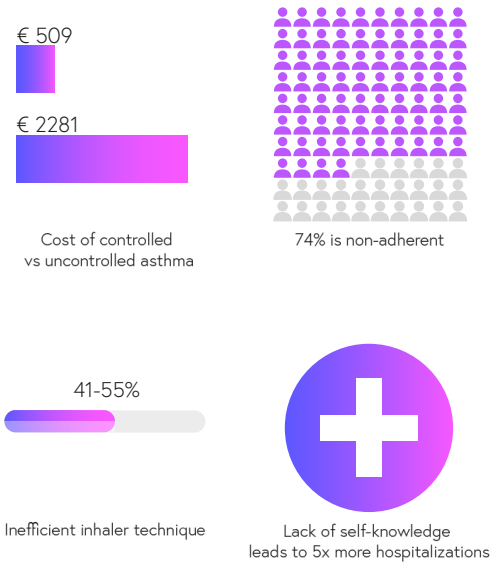


Figure 13. *Problems in medical self-management*

Adherence

Adherence to medication is one of the most essential elements of self-management and obtaining asthma control (Horne and Weinman, 1999). Adherence rates to anti-inflammatory medication in western Europe are no higher than 26% (Braido, 2013). A lack of therapy adherence leads to poorer health quality and lower quality of life (Price *et al.*, 2015).

Finding out about adherence is a challenging task as patients are reluctant to admit non-adherence. Besides that, in many studies, it was found that patients often overestimate their adherence when compared to objective measures. (Horne and Weinman, 1999).

Two kinds of errors lead to reduced- or non-adherence: intentional non-adherence and unintentional non-adherence.

Intentional nonadherence is a process in which a patient actively makes the decision not to adhere to treatment. This decision is often the result of a conscious or unconscious cost-benefit analysis by the patient based on their beliefs on the treatment. Examples of beliefs that may influence this decision are the perceived necessity of the medication, worries about adverse effects of medicines, skepticism towards drug dependency, a stigmatizing effect of medication and the wish not to be reminded that they are ill (Hugtenburg *et al.*, 2013). These perceptions link back to the importance of knowledge; a lack of knowledge may result in the beliefs mentioned above.

Unintentional non-adherence refers to a patients' ability to adhere to their therapy. Unintentional nonadherence can be the result of forgetfulness or patients not knowing how to use their medication (Hugtenburg *et al.*, 2013). Addressing routine, simplifying regimen, providing reminders (Hugtenburg *et al.*, 2013) and explaining how to use the inhaler (Haugney *et al.*, 2008) are means to be considered when addressing unintentional nonadherence.

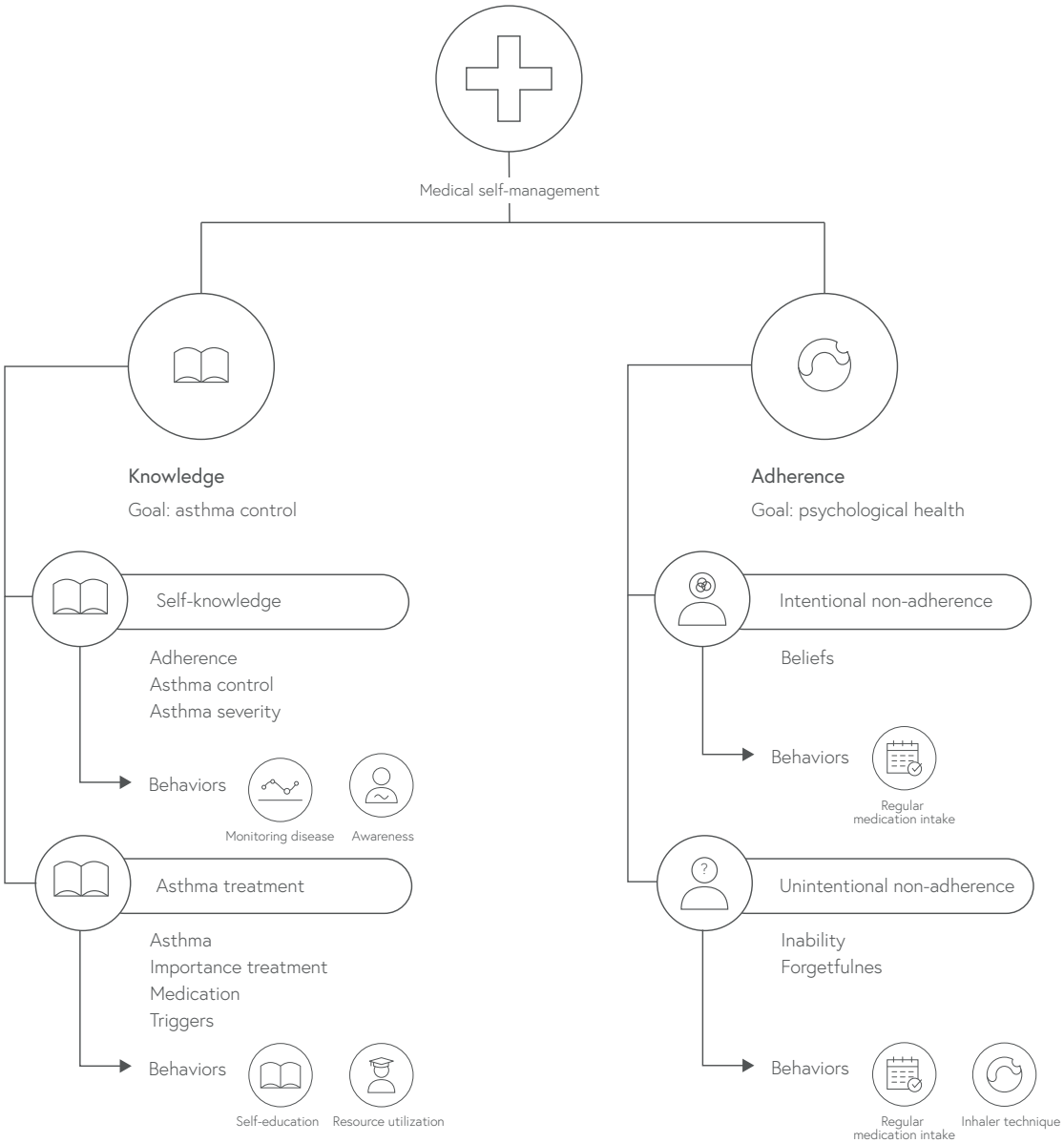


Figure 14. *Complete overview of medical self-management*

Design implications

✓**Beliefs**

It is decisive to prevent the development of incorrect beliefs about asthma; this can be done through proper education on different parts in medical self-management. (W2)

✓**Provide knowledge of medication**

Especially incorrect beliefs about medication seem to influence patients' adherence. Therefore, the design should address education about medicines. (R9.2)

✓**Reminders**

The design could make use of reminders to prevent users from forgetting their medicines. (R10)

✓**Inhaler technique**

Inhaler technique influences the level of asthma control substantially. Patients must be supported to use their inhaler correctly. (R10)

Target group

Attempts to improve patient's self-management, especially prove to be effective particularly in patients with severe asthma or frequent exacerbations. Less evidence can be found on the effectiveness in cases of less severe asthma (Thoonen *et al.*, 2003).

Patients with mild to moderate intermittent uncontrolled asthma perceive their disease as less severe, which results in decreased motivation for self-management. Patients in this group are likely to accept their complaints and remain uncontrolled asthma. This group of patients will be targeted in particular with the design, since they are especially difficult to motivate for self-management, but they have a good chance of achieving control.

Conclusion

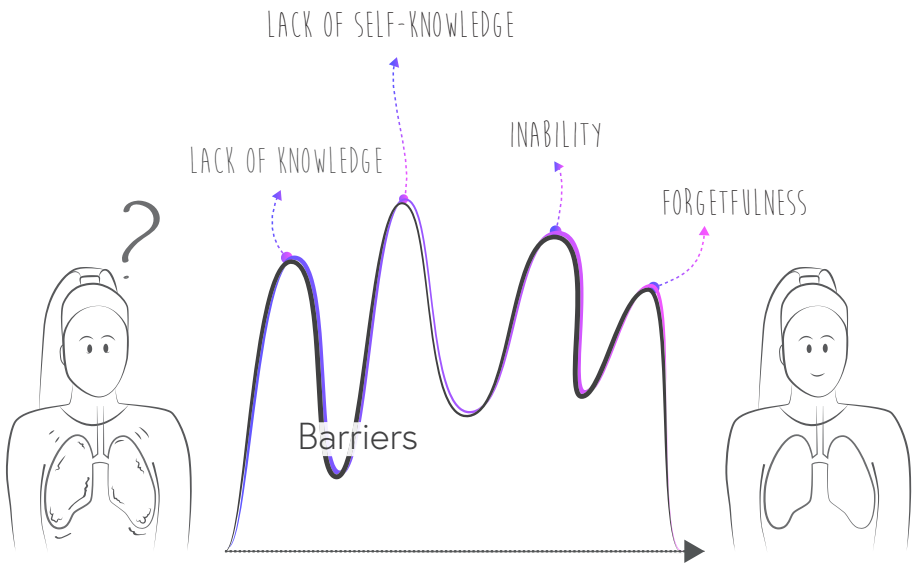
Several factors influence the medical adherence of asthma patients. Due to a lack of knowledge, asthma patients develop incorrect beliefs about asthma, leading to suboptimal self-management. Furthermore, the development of self-knowledge is an essential aspect of medical self-management. Incorrect estimates on the patient's complaints and adherence is a barrier to both the GP and the asthma patient for optimal treatment. At last, factors causing unintentional non-adherence are the inability to properly use the inhaler and forgetfulness.

F. Braido argues that, since many factors influence adherence, interventions solely focusing on one aspect struggle to demonstrate significant benefits (Braido, 2013). Hence, a promising way to increase the therapy adherence is a holistic approach, which addresses the knowledge, beliefs, and capabilities of patients.

Design implications

✓**Holistic approach to medical self-management**

An holistic approach addressing knowledge, beliefs, and capability at the same time is very promising to improve the self-management of asthma patients. (R9, W2)



2.4 Market analysis

Market research was performed to get a good overview of what is available on the market related to the treatment of asthma and self-management. This market research was divided into two categories: traditional care, and mHealth. Only products for adults that are available on the Dutch market have been included. To keep this report concise, only the main conclusions on mHealth are presented in this chapter. For a full overview of the research methods, results, and all conclusions, please refer to Appendix 3.

mHealth

The market for asthma care is heading more and more towards digital solutions. Concepts for smart inhalers are spread all over the internet, and there are numerous digital applications for asthma. A recent study published on January 15 of 2019 demonstrated that in the UK alone, 314 apps for Chronic Respiratory Diseases are available (Sleurs et al., 2019).

In this project, a distinction is made between the terms eHealth and mHealth. eHealth is an umbrella term that refers to "health services and information delivered or enhanced through the Internet and related technologies" (Eysenbach, 2001). mHealth refers to "the use of mobile phones and other wireless technology in medical care" (Rouse, 2018). The goal of this project is to develop a mobile application; therefore, it was chosen to adopt the term mHealth (mobile health).

Smart inhalers

A recent development in the treatment of asthma is the development of smart inhalers connected to mobile phones. At first glance, this development seems promising. However, when doing more thorough research, it was concluded that many inhalers do not make it much further than the concept phase or research tool yet. The smart inhalers that are on the market make use of smart add-ons that gather data on frequency and time of use. This data is sent to a connected smartphone app that collects data on the patient's adherence, sends reminders, and presents the data to the user. Self-claimed advantages by the producers of Propeller seem promising, mentioning up to 79% fewer asthma attacks, up to 50% more doses on schedule and 50% more symptom-free days (Propeller Health, 2019). On top of that, collecting objective data about patients' asthma increases patients' self-awareness (Merchant et al., 2016).

Another interesting feature offered by Propeller is connecting the date and location of medication use to some weather or air conditions, allowing them to predict certain triggers to users. A shortcoming and opportunity for this project is that they only support insight in measurable triggers. Triggers such as dust mite, exercise, or pets are not included.

A significant shortcoming in the smart inhaler market is the availability to asthma patients. There are three smart inhalers available to asthma patients in the Netherlands (see Figure 15). However, these inhalers are not being prescribed to patients by GPs yet. Also, MyAirCoach and Turbu+ are still in a research/development phase. Only the brand "Propeller" is accessible to consumers.

Design implications

✓**Tracking adherence and sending reminders**

Tracking adherence can help asthma patients to gain insight into their adherence. Also, it seems to increase adherence by up to 50%. The design should therefore provide the functionality to track adherence and to send reminders. Also providing insight in adherence will increase asthma patient's self-knowledge, which is beneficial for their self-management. (R3.3)

✓**Discovering triggers**

Helping patients to become aware of their triggers can help them to avoid unnecessary exacerbations. Supporting asthma patients in discovering (all types of) triggers and giving them tools to act upon these will be a useful addition to the design. (R9.1.2)

✓ **Turn data into insight & action**

The tools that are on the market merely gather data and present this to the user. At the moment, this data is not optimized for interpretation. Neither does the data support the user to take action. Supporting asthma patients to act upon their data (providing them with tips) will help them to become more competent in their self-management. ((R12.3)

Figure 15. *Smart inhalers top to bottom: Turbu+, MyAirCoach, Propeller*

Mobile applications

The market for mobile asthma applications (mHealth) is expanding at a high pace. To find out what current apps already provide, and to indicate possible market gaps, seven asthma self-management apps were compared (see Appendix 3.1 for a full overview of this research).

Most apps focus on self-monitoring of the disease asthma. Included functions are tracking ACQ, tracking adherence, measuring peak flow, and showing these results in graphs.

The apps that are currently on the market merely gather batches of data and present this back to the user. A shortcoming at the moment is that users are not provided with tools to interpret their data. For example, related data such as adherence and asthma control is presented separately, and no relationships are established, which makes it challenging to interpret the data.

An opportunity that I see here is to combine gathered data, for example linking a low asthma control score (ACQ) to poor adherence. This way, more conclusions can be drawn, and the insight and self-knowledge of the asthma patient is broadened.

Another opportunity is translating this data into action, what can the user do to improve? So far, the existing apps lack in providing actual tools for acting upon the data gathered. At last, all the gathered data is filled out manually, this combined with the fact that the user does not receive much output in return makes daily logging cumbersome to patients.

As a designer, my opinion is that the graphics of most of the apps are far from ideal, they convey much information and often the information is not presented in an easily understandable way (see Figure 18). As patients will want to spend as little time as possible on the app, the app should be made very accessible and allow for quickly obtaining an overview of the relevant data.

At last, it was noted that hardly any of the apps make use of gamification. Based on behavioral change theories, I argue that providing positive feedback or credits could help patients' motivation.

With over 300 different apps and the current legislation around health apps (see section rules and legislation), there is a lack of quality control. When designing a digital health application, it is crucial that CAHAG makes sure that this app will become the standard for General Practitioners. Having CAHAG as authority approving the app gives a guarantee of quality to its users. It is also essential that the app will be promoted nationally by the CAHAG. Otherwise, it will end up on the big pile of applications.

Design implications

✓**Ease of logging**

When collecting data through the design, it is vital to balance the input required by the user and the output obtained. The design should collect data as efficient as possible to minimize the effort required by the user. (W3)

✓**Provide Insight**

In order to keep the patient engaged and to support competence in self-management, it is essential to provide insights based on the gathered data. Providing just the data should be avoided. (R11)

✓**Translation to action**

For optimal improvement of the patient's self-management, and increasing patient empowerment/competence, translation of the gathered insights into executable actions is desirable. (R12.3)

✓**Easy to grasp**

The design should make efficient use of the patients' time. Therefore, the essential information in the app should be understandable at a glance. In-depth information should be available upon request, for example, by clicking a "more" button or by scrolling down. (W4)

✓**Gamification**

Gamification can be used to increase the user's motivation. Examples are; using metaphors, scoring points, or increasing in level upon achievement. (W5)

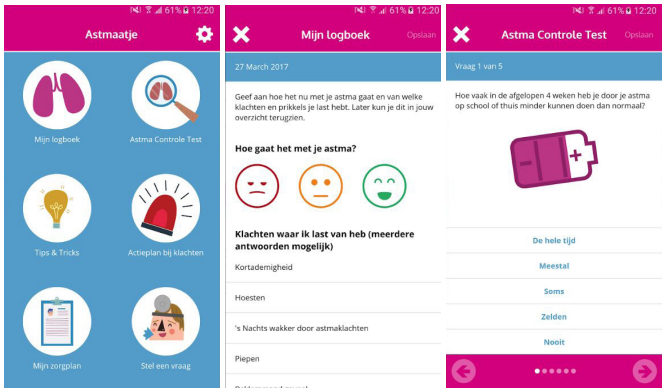


Figure 16. *Astmaatje*

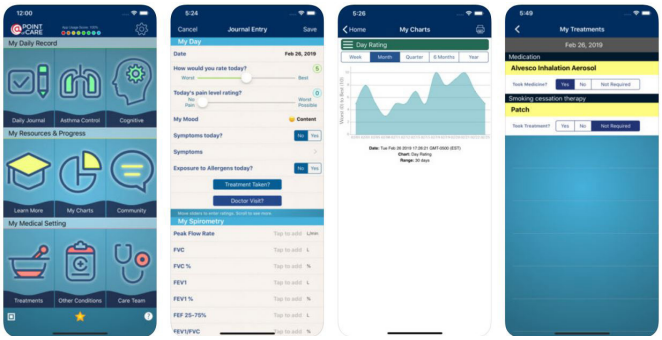


Figure 17. *Asthma manager*

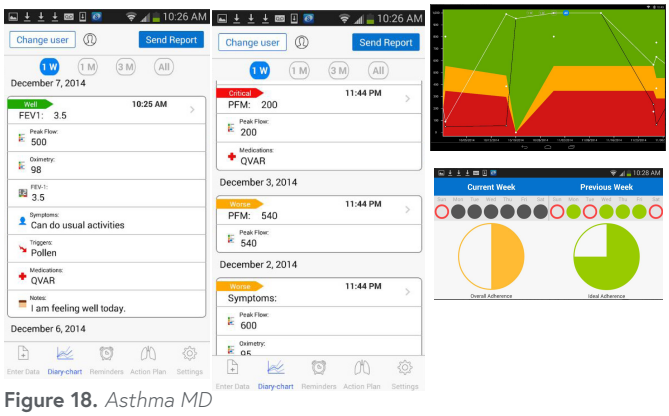


Figure 18. *Asthma MD*

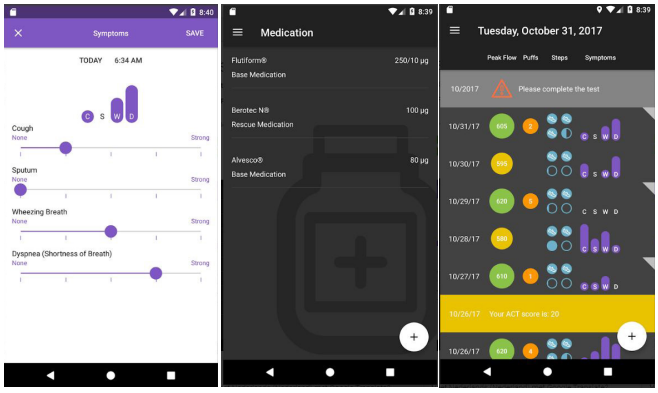


Figure 19. *Asthma tracker*

Discussion

Even though mHealth developments seem promising some critical questions arise regarding ethics, responsibility, and desirability. One of these questions, for example, is who is responsible? In the case that a smart application can predict that an asthma patient will have an exacerbation, who is responsible for interfering? In this case, it should be determined whether it is the app developer's responsibility, the users, or perhaps the general practitioner.

Another undesirable side effect of eHealth might be the extra time required by healthcare providers to examine data, which, instead of relieving pressure would increase the pressure on the healthcare system.

At last, when tracking medication, it is crucial to prevent a "big brother" effect. In which the patient might feel as if they are being checked. This effect could lead to decreased patient autonomy rather than increased patient autonomy.

Above mentioned critical notes have been evaluated in the discussion section of this report.

Conclusion

Multiple factors make asthma an interesting disease to work within mHealth. Asthma patients have difficulties tracking their adherence and expressing their level of asthma control. Tracking the use of reliever medication and controller medication using smart inhalers can increase asthma patients' self-knowledge and self-awareness (Merchant et al., 2016).

The current market of mHealth still shows some shortcomings that need to be overcome to enhance the medical self-management of asthma patients optimally. Also, the adoption of mHealth by healthcare provides is still low.
Making the design successful requires serious effort in promoting and standardizing the design by CAHAG.

Design implications

✓**Tracking both controller and reliever medication**

When tracking both the use of controller and reliever medication, the best insight is gained in a patient's adherence and level of asthma control. Therefore, the design should track adherence to both types of medication. (R3.1, R3.2)

✓**Give insight into asthma severity**

Asthma patients have difficulty expressing their asthma severity. The final design should be able to keep track of both adherence and asthma control. This will enable both the patient and the GP in determining the severity of the patient's asthma and therefore supports optimizing the treatment. (R2, R3.3)

✓**Increase self-knowledge**

Using the tool to track a patient's adherence and level of asthma control can facilitate increased self-knowledge. (R2, R3.3, R11)

✓**The patient is in charge of the data**

For the final design, a good look should be taken at the ethics of the design. One of the aspects that should be ensured is that the user of the app is in charge of their data and decides which data to share with their healthcare provider. (R6.2)

✓**Intentional non-adherence**

Current mHealth solutions only focus on unintentional non-adherence (forgetfulness). For optimal improvement of the adherence to treatment intentional non-adherence, based on beliefs and a lack of knowledge should also be addressed (design implications on beliefs in the next chapter). (R9)

2.5 Patient perspective

This section describes the main findings of the research with asthma patients. A focus group was organized, preceded with a sensitizing booklet to empathize with users. The goal of this research was to uncover the current experience and needs of asthma patients in daily life. The findings are presented as insights in medical self-management, personas, and a patient journey.

Research set-up

Qualitative research was conducted through a focus group to get a good understanding of the perspective of asthma patients. For the setup of this research, the context mapping method as described by Froukje Sleeswijk *et al.* (2005) was used. Appendix 4 provides a complete overview of the research objectives, methods, recruitment of participants, apparatus, and results.

Five asthma patients (P1, P2, P3, P4, and P5) participated in the research. To prepare the participants for the focus group, a sensitizing booklet was created (Appendix 4.2). The session itself consisted of a context mapping session with two assignments. Each assignment was made individually and presented and discussed afterward.

Key insights

In this report, only the key insights are explained and demonstrated with quotes. The full results of the user research can be found in Appendix 4.5. Besides key insights, four personas were derived from the research and are elaborated on in the section "personas". Additionally, the patient journey that was created based on this research can be found in Appendix 4.6.

Findings

A lack of knowledge leads to beliefs

Literature has shown that based on personal beliefs, patients make a cost-benefit analysis that leads to a certain level of adherence. Through talking to the research participants, several shortcomings in the knowledge gathering process were uncovered that lead to beliefs. Below shortcomings in knowledge gathering that cause intentional non-adherence are explained. Knowledge gathering is condensed.

First of all, most patients did their research about asthma only once, often shortly after diagnosis. In this stage, patients do not know much about their asthma, which makes it challenging to filter relevant information and to apply it to their situation. Besides that, after this research, patients think they understand the full concept of asthma, when actually they do not fully understand it, or they remember things wrong.

> *"They never explained to me what asthma exactly is. Probably also because if they ask, you say that you know, but that is never one hundred percent true." –P2*

Information is general and difficult to apply

Second, the available knowledge is rather general. Longfonds.nl is the primary source of information for patients. However, Longfonds.nl only provides basic information about asthma and describes the most common topics for patients. This way of presenting information has two consequences; first, there is much information at once making it difficult to process. Second, the information is difficult to apply for asthma patients, as it does not provide them with actions that apply to their specific situation.

Specific knowledge is difficult to find and understand
When patients want to research more specific information, they must rely on other sources, that are often using professional language, which is difficult to understand for them, even with a university level education.

At last, patients are often unaware of more specific information as there is currently no source to find this information. Often participants would accidentally hear about specific recommendations that might apply to them.

> *"General information can be found everywhere, but if you start searching more specifically, you end up with complicated pieces that are difficult to understand... Now that I have asthma for a while, I can look up more specific information, in the beginning, I really couldn't do that." –P2*

Asthma patients are not very investigative
The patients that were participating in the research have had asthma for a while. It was demonstrated that it is crucial to start proper education right after diagnosis. When missing this moment, patients have already developed beliefs, and their asthma has become such a given that they do not feel the need to develop any health literacy further.

> *"When you get diagnosed really young, and at some point, you don't really question it anymore, it is just a given... It's almost like looking up "how does a part of the body take up a vitamin", I don't know, I'm kind of interested, but I'm not going to research it, there is no reason. I just know vitamin is good for me, so I take it." -P5*

> *"I'm not very investigative these days... I don't have any questions or unclearness" –P1*

Lack of information on medication
To most patients, it is not clear what precisely the medicines do in the body. This unclarity creates misunderstandings and sometimes patients therefore do not see the need for taking medicine.

> *"What does this medicine do?" –P2*
> *"I do not know how the medicines work" –P4*
> *"Not understanding why I take medicine caused me to not taking it properly" –P4*

Skepticism towards drug dependency
Besides a lack of understanding, patients also feel uncomfortable being dependent on medicines. This feeling is a driver for them to try to lessen their medication.

> *"I do not always take medicines; I do not like the dependency"– P5*

Lack of feedback from medication
When taking the anti-inflammatory medication, patients do not notice an immediate benefit. Additionally, when stopping to take the medication, there is no direct indication of their condition lessening, which leads patients to believe that they do not need their medication, and therefore, it causes them to stop taking them. On top of that, when complaints do arise, they do not always link these to asthma or the fact that they have not been taking their medication. Interestingly one participant stated the desire to make these long-term relations visible in a graph.

> *"It goes very slowly, you don't take it for months, and you'll be fine, and then suddenly you are not fine." –P5*

> *"You don't want to take medicine in your body when you feel like you don't need to, that's why I would quit" -P4*

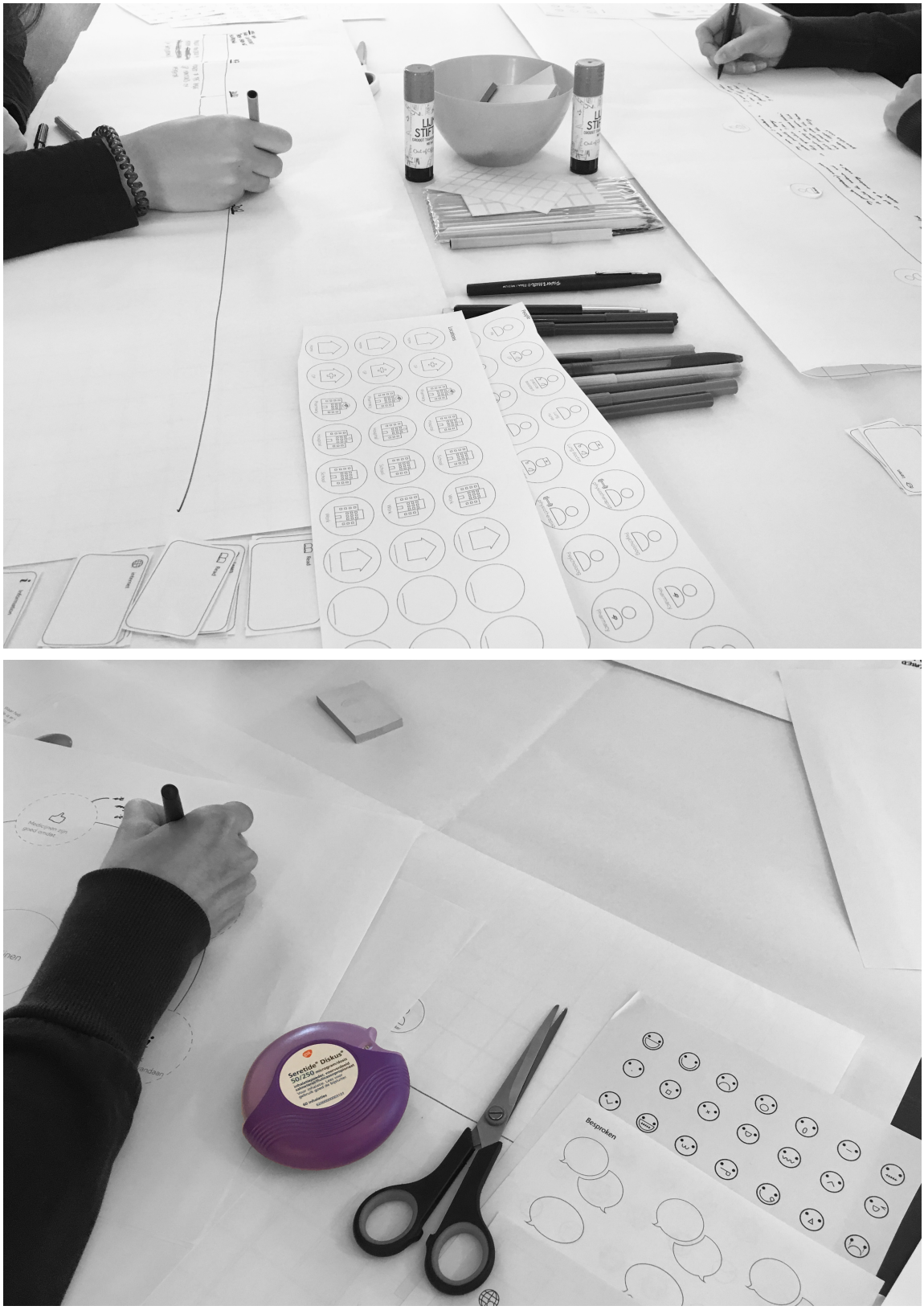


Figure 20. *An impression of a focus group session*

Patients are unaware and remain passive due to paternalistic care approaches

Literature shows that most healthcare providers still have paternalistic approaches to asthma care. The participants experience the same in their care. They see the doctor mostly as the prescriber of a regimen. Most asthma patients believe that it is not useful to go to the doctor to only hear the regimen. Besides that, they feel uncomfortable going to the doctor because they get the idea that they are being judged for not being able to get asthma control or for not taking their medicine as prescribed. At last, the patients feel like the doctor is in charge of the treatment and information, causing them to remain passive.

> *"It's the specialists' responsibility. The ones that are going to take care of you getting the medicine are fully responsible for making sure you understood why you are taking medicine, what for and what happens when you take it." – P4*

> *"I'm not going to go to a doctor just for them to give a regimen. There is no point" – P5*

Only one of the five patients has taken charge over her self-management, she said however that it took her a long time to realize that she can also be a more active participant in her care and that she would have wanted more handles or external motivation in the beginning.

Solving paternalistic care is out of the scope of the project, but a possible implication for the project could be to create awareness of the patients' responsibility, motivating them to become more active participants in their care.

> *"In the beginning, I thought the lung doctor probably knows it all, and the GP knows it all. After a while, I realized that I could also have an opinion on this, and I also have a say in this. I thought they studied for this, so they know, but there is also a responsibility for yourself"-P2*

> *"In the beginning, I was very passive, unconsciously though, that's not really your own fault … I think you are responsible yourself but I had wanted more handles in the beginning." P2*

Routine

One of the factors that seems to lead to unintentional non-adherence is the influence of routine. Most participants have a standard routine and location for taking their controller medication, but for the reliever medication, there is less of a routine. For this reason, patients forget to take their reliever medication. Also taking the medication becomes automated, causing them to be unable to remember whether they took their medication or not.

Conclusion

Many shortcomings in the knowledge gathering process indirectly lead to inefficient self-management. I believe that the accumulation of knowledge can be improved by spreading the knowledge gathering process and by increasing the relevance of information through personalization.

A secondary problem is the role of paternalistic care. Some patients are willing to become more active participants in their treatment, but they lack awareness of the possibility to do so. Also, they miss the tools to do so. Creating a design that makes patients aware of their responsibility, and that gives them action-oriented tools could get them over these barriers and facilitate asthma patient's self-management.

Design implications

✓**Stimulate awareness**

Asthma patients lack awareness of possibility and need to become active participants in their treatment. The tool should stimulate patients to become more actively involved for example by asking questions or sharing complaints and frustrations with their GP. (R4)

✓**Provide direct feedback**

Due to a lack of direct feedback, patients stop taking medication. The design should encourage patients to stay adherent by providing direct feedback on medicine intake, for example, compliments or positive quotes when taking medicine and more persuasive quotes or reminders when not taking medicine. (R3.5)

✓**Provide long term feedback**

Asthma patients do not always see the relationship between their non-adherence and an increase in asthma complaints in the long term. The tool should give long term feedback and insight into these relations, for example, through graphs. (R2, R3.3)

✓**Increase knowledge of medication**

It seems that within the target group of well-educated asthma patients, patients make conscious decisions based on their knowledge about whether to take medicine or not. Unfortunately, these decisions are often based on incorrect beliefs. The tool should provide knowledge on why medicines are needed an what their effect is. (R9.2)

✓**Beliefs**

When attempting to improve an asthma patient's medical self-management, the tool should tackle beliefs by providing knowledge on the topic at hand. (W2.2)

✓**Reminders**

The tool should provide the option to set reminders for medication, to prevent forgetfulness. (R3.4)

✓**Specific knowledge**

Patients stress that currently provided knowledge sources longfonds.nl and thuisarts.nl do not provide any specific knowledge on problems they run into. Patients need support in finding more in-depth information that applies to their specific need at that time. (w&)

✓**Making knowledge applicable**

Patients expressed the need for concrete tools or actions they can take to improve their self-management. Besides merely providing knowledge, the app should make this knowledge easy to apply using tips or actions. (R12.3)

✓**Spreading knowledge**

The current knowledge gathering process by asthma patients is very condensed, causing them to wrongly remember or forget information. The design tool should spread the gathering of knowledge and provide relevant knowledge at the right time. Spreading knowledge can be done by allowing the patient to determine the order of information, or by gathering data on the patient's asthma and playing into the gathered data. (R9.6)

✓**Improve health literacy (knowledge)**

Improving health literacy will enable patients to make more informed decisions. (R9.2)

Personas

Substantial differences in characteristics and approaches to self-management between asthma patients emerged from the patient research. Based on the data gathered, four different personas were identified (Van Boeijen et al., 2013). These personas are visualized in Figure 21. Each persona describes a different attitude towards asthma, asthma treatment, self-management, and varying needs from the future design. It is expected that when taking the different personas into account in the design, the design can optimally enhance the patients' self-management.

Design implications

Each of the four persona's has a different attitude towards asthma treatment and self-management. To optimally support each of these patients, a personalized approach will be required. The section personalization further explores what this means for the design.

✓ **Personalization based on persona**

Besides personalization of information based on different types of asthma (severity, type, and triggers), personalization based on patient attitude is also required for optimal stimulation of self-management. (R1.4)

Scope refinement: curious & passive

Unfortunately, it is not possible within the timeframe of this graduation project to develop a different app for each of the personas. Therefore, it was chosen to scope the further development towards two personas: the passive and the curious.

The passive and the curious were selected because they have the most open attitude towards change, and therefore, the design would be the most beneficial for them. The passive is unaware and needs a little push in the right direction, the curious is very willing to better self-manage his or her asthma, but misses the tools to do so. Both need some help to overcome paternalistic care approaches when applicable. The app can provide in these needs and thus open the road towards better self-management.

The curious

" When I hear something new I'm going to research it

Goal:
Treat my asthma as well as possible

Attitude:
Actively researches

Pain:
"In the beginning I was very passive, I wish someone would have told me that I also have a say in my treatment and that I can ask critical questions."

"General information can be found everywhere, but there is no way to find specific information"

Design space:
The curious is willing to take charge over their own treatment but misses the tools to do so.

Information approach:
Reads all the information there is, and wants some more specific information. Wants to be sure they have read all the information.

Functions:
- Tunnel: Information architecture
- Library: that is always accessible
- Goals: easy tools to adapt life
- Questions: save questions for the GP

Need:
Reassurance, we'll make sure you get to know everything

The passive

" The doctor is the expert "

Goal:
I let the doctor tell me what to do, and then I do that.

Attitude:
Passive

Pain:
The doctor never really explained to me what asthma is and why I take medicine. I think it is the doctors responsibility to make sure that you know why you are taking medicine, because why would you take it if you don't know what it is for"

Design space:
the passive takes medicines for asthma not knowing why they take them. They are non-adherent for longer times. The passive need help to see relations between non-adherence and complaints and motivation to become more active in their care.

Information approach:
The doctor should explain me how it works. He will make sure that I know what I need to know.

Functions:
- Physical: onboarding box
- Reminders: to learn
- Activation: through reminders
- Onboarding story: you are in charge

Need:
You are in charge and only you can achieve better asthma control

The expert

" I don't need explanation, it's obvious "

Goal:
I just want to live my life, I'm not that bothered by my asthma

Attitude:
It's not that big of a deal

Pain:
"I don't have any problems, I'm fine, I'll go to a doctor when there is a problem"

Design space:
The expert thinks they know it all, they avoid unnecessary explanations. This causes them to use their inhaler in the wrong way, and live with unnecessary uncontrolled asthma. The expert needs personalized knowledge that is relevant to their situation and feedback on their beliefs.

Information approach:
Reads parts of the information. Thinks it is obvious and does not continue reading

Functions:
- Feedback: on facts gathered
- Facts: that are undeniable
- Personalization: only relevant knowledge
- Tests: to intercept beliefs
- Matrix: information architecture

Need:
Trust, the expert needs to develop trust and feedback on their own beliefs

The sceptic

" I stopped seeing specialists, they were not helping"

Goal:
I just want to be normal

Attitude:
Sceptic

Pain:
"Asthma is not a disease with a solution for it, it's a disease with just treatment for it. All the doctor does is prescribing a regimen, I get the treatment, doctors are not going to solve my life. The type of medication is embarrassing too"

Design space:
The skeptic has been disappointed and does not want to see a doctor, it makes them feel different, judged and embarrassed and the doctor cannot improve their condition in their opinion. The skeptic needs a tool to help them self-tailor their treatment and to feel in charge, and they desire a more discrete inhaler.

Information approach:
This is not going to help anyway, my asthma is chronic and it cannot cure. I just want to be normal.

Functions:
- Positive feedback
- Progress: visualize progress
- Insight: into own asthma
- Onboarding story
- Self-tailoring
- Autonomy

Need:
Emphasize the benefit of learning about asthma, asthma is not a disease you can cure, but you can treat it.
Prevent skepticism by: self-tailoring, insight and tracking, facts

Note: this attitude comes into existence over time, after disappointment, the design can prevent this attitude

Figure 21. *The four personas*

2.6 Healthcare provider perspective

The field research with patients was complimented with two semi-structured interviews with GP's and with a visit to a GP practice. The goal of the interviews was to consult the GP's on their expertise in working with asthma patients. Their input was used to get a better insight into what problems they believe asthma patients encounter and what problems they run into themselves when treating asthma patients. At last, the interviews provided insight into the journey of diagnosing an asthma patient this journey is presented in the chapter "what is asthma".

Research set-up

Two GPs were interviewed during two individual sessions. The first session was combined with a practice visit, and the second session took place over the phone. The session consisted of a semi-structured interview of which the audio was recorded. After the session, the interviews were transcribed. The session started by asking about the diagnosis process of asthma patients, and from there on the discussion was guided through the other topics. The method, interview questions, and transcriptions can be found in Appendix 5.

Key insights

Underestimating complaints & acceptance

Both GP1 and GP2 see that most asthma patients underestimate their complaints. Reasons pointed out for underestimating complaints is that patients sometimes have had complaints for years and do not know any better. Also, patients think that having some complaints is not an issue. According to the GPs, it is important to make people aware of the fact that their asthma is not under control.

> *"patients usually accept it, but that is not ok" -GP1*

Insight in the use of medicines

Several times the importance of explaining asthma, its chronicity, and the reason for taking medicines was mentioned. The GPs stress that it is essential to ensure patients understand why they take medicine. Asthma patients need an explanation of what the different medicines do and that taking medicine once does not help. Both GP's pointed out they would like to have some information on medication in the tool.

> *"There are some misconceptions about it, that they are hormones, so it is bad for you, "its poison", the less you need, the better. So, I think there are a lot of misconceptions about medication" -GP2*

Recognizing complaints

Both GP1 and GP2 stressed that many patients have lived with asthma for several years before getting the diagnosis; for them, it is difficult to know what "feeling stuffy" entails as they are so used to it. Besides that, most patients have difficulty expressing their complaints to the GP as well. Often the GP has to find out through careful listening to how a patient feels.

> *Example: patients describe taking the bus instead of biking because biking does not feel very comfortable at the moment; the patient does not realize this is due to asthma complaints. -GP1*

Asthma is a varying disease meaning that patients have times with quite a few symptoms and times where their condition lessens. According to GP1 Patients often do not notice the decline in condition immediately, only when it is already quite late in the process and they start getting exacerbations. According to her, it is vital

for patients to start recognizing symptoms of their declining asthma condition so that they can increase their medication intake in time.

> *"I think the most important thing is that a patient knows what to do if he gets complaints. Because asthma is a disease that goes up and down. Someone can be good today and get complaints tomorrow. Then it is nice if such an app helps you further at that time."-GP2*

> *"What I would like. Is if the patient is working with the tool and that they get the message your asthma is not in control, this.., this.., this.., is important for you, try it, and otherwise go to the practice assistant or the GP. The patient is not allowed to accept that their asthma is not in control."-GP1*

Collaborative care

At last, the GPs also noted that many general practitioners do not have optimal approaches to asthma care, as it is not on top of their priorities list. They walk through the standard checklist and do not take enough time to get to know the patient and to discuss their approach with patients.

> *"Because asthma is different for every person and the way medicine should be taken as well, I really think it is the job of the caregiver to make clear to patients to make things negotiable; it's really working together." GP1*

Conclusion

The conversations with GP's and practice assistants confirmed several of the earlier made assumptions. The GPs agreed that self-knowledge should be stimulated. Additionally, the GPs mentioned that patients need to learn to recognize complaints. It is vital that patients develop knowledge of asthma and medication and that they have a good understanding of what the disease means and how it works in the body. At last, the GPs confirmed that collaborative care should be stimulated.

Design implications

✓**Recognize complaints**

Many asthma patients are so accustomed to living with asthma that they have difficulties recognizing and expressing complaints. The tool should support patients to recognize complaints and acknowledge that their asthma is not in control. (R9.1.3)

✓**Asthma Control Questionnaire (ACT)**

Asthma is a varying disease; sometimes, the condition of asthma patients goes down gradually without them noticing. The design should uncover these trends in time and provide the asthma patient with actions that can be taken to prevent further worsening of complaints. Examples that were mentioned are: contacting a healthcare provider or increasing medication. (R1.2)

✓**Role of medication**

It is vital that patients know how the medication works and why they take it. The tool could communicate this through education but could also do this by actively tracking medication use and giving feedback/ insight on the effects and consequences on different levels of adherence. (R9.2)

✓**Features**

The GPs mentioned several tools to be implemented in the design. The features that they mention as most important all belong to medical self-management; tracking adherence, knowledge of the treatment, and the ACQ. Also, the GPs mentioned some secondary features related to behavioral self-management; exercising or step counters. For now, these are out of scope, but they could be added to the tool in future development. (R3.1, R3.2, R2.1)

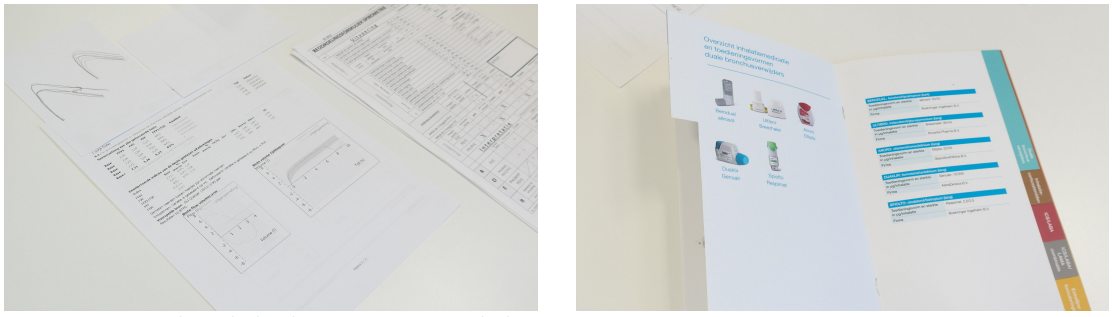


Figure 22. *Going through the diagnosis process with the GP*

2.7 Creative session VanBerlo

After the analysis was completed a creative session with four design experts of VanBerlo was held to synthesize all findings and to provide a new view on the findings. In Appendix 6, the complete setup of the creative session can be found, including the methodologies, materials, and outcomes. In this section, only the additional insights are communicated.

Paternalistic care

During the session, it was discovered that the doctor plays a vital role in the lack of self-management of asthma patients. For a large part, the origin of the problems lies in paternalistic care approaches in combination with a lack of appropriate tools. This realization has led to the final problem definition as defined in the next paragraph.

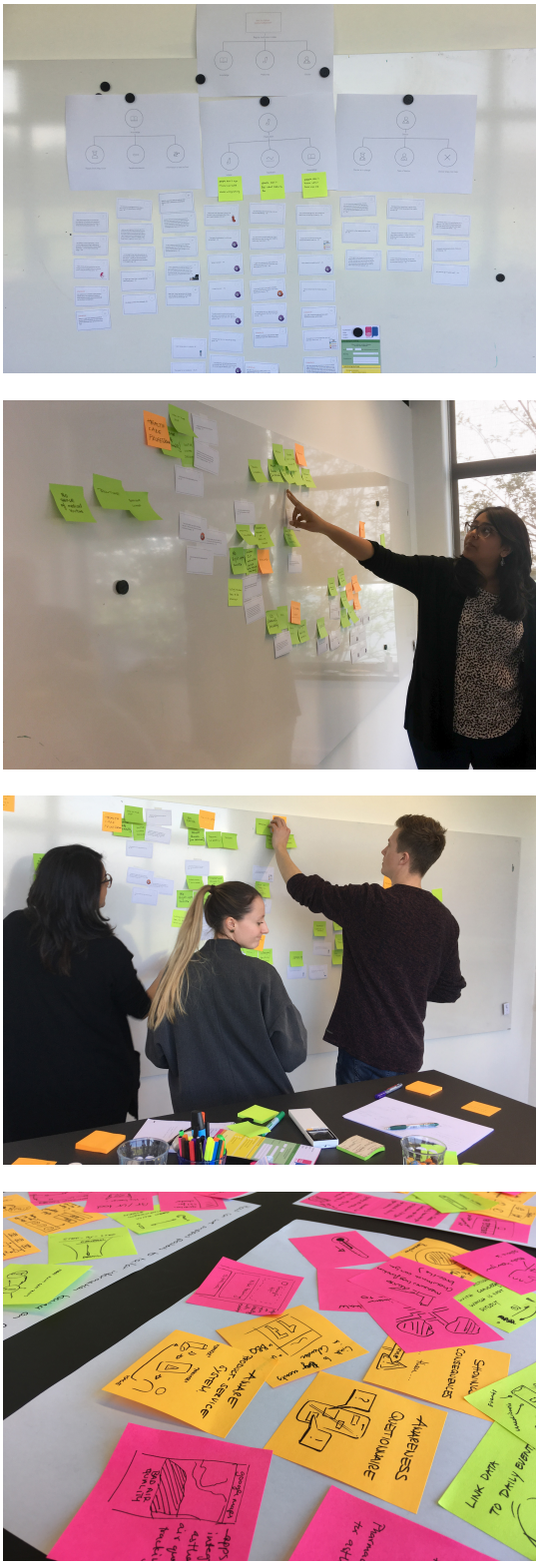


Figure 23. *Creative session at VanBerlo*


You have to inhale vigorously, I think I inhale vigorously enough, apparently, because I immediately feel it shoot down my throat ... I think that's where it belongs. -P3
Literature
non-adherence is related to the patients beliefs about the treatment, based on these beliefs patients consciously decide not to adhere to treatment.
They never explained to me what asthma exactly is. Probably also because if they ask, you that you know, but that is never one hundred percent true. -P2
Literature
"if you feel stuffy, it is difficult to take"
-P1, P2

2.8 Concluding the analysis

The analysis provided rich insights into the current problems surrounding self-management. This section summarizes the findings and presents them in the form of a problem definition and a solution space.

Problem definition

Figure 24 provides a complete overview of the identified problems. The problems are presented in a hierarchical order using the progressive abstraction method. It was concluded that the problems commence due to a paternalistic care approach. This approach leads to three underlying problems; the development of beliefs, low motivation, and inability. These three sub-problems are described below.

Beliefs

There are three aspects that form barriers to the development of a good body of knowledge about asthma. Together these cause the development of beliefs, which eventually lead to ineffective self-management.

1. Due to **paternalistic care** models patients get the feeling that the **doctor is in charge,** this causes them to remain passive and to not actively obtain any knowledge or ask questions.

2. Patients are **not stimulated** enough to **educate themselves.** This lack of stimulation is partly caused by a lack of awareness on the patients' side and partly by a lack of stimulation on the GP side.

3. Lastly, **current knowledge sources lack functionality.** The primary source of information for patients is longfonds.nl the information on this website is: very general, difficult to navigate, not personalized. If patients are curious, they refer to the internet themselves for more specific information, the information they find here is often professional language and difficult to understand.

Low motivation

Another problem is the lack of motivation by patients to perform effective self-management. Again, this problem has multiple origins.

1. Due to paternalistic care models patients feel like the **doctor is in charge**, and the doctor has the responsibility for proper treatment and information supply. This perception of responsibility induces a passive attitude towards the treatment.

2. Patients are u**naware of the fact that they can and should become an expert** in treating their disease and that the doctor is there to assist them rather than to instruct them.

3. Lastly, patients get **discouraged due to inadequate knowledge sources and poor inhaler tools.** The knowledge sources often do not match a patients' type of asthma, or their level of expertise, this works discouraging. Moreover, the inhalers are perceived as stigmatizing, embarrassing, and difficult to use.

Inability

The last problem that patients have to deal with is inability. Many patients are unable to effectively self-manage their asthma.

1. Patients do not have the **knowledge** to take optimal care of themselves.

2. Patients do not have the **skills** to take optimal care of themselves, i.e., they are forgetful or apply wrong techniques.

3. Due to varying conditions and long term relations patients have a **lack of insight** into their disease.

Altogether this leads to poor medical self-management, which in turn leads to poor asthma control. Which leads to an increased burden of disease, more (near) fatal asthma exacerbations and hospitalizations and increased costs for both asthma patients and society.

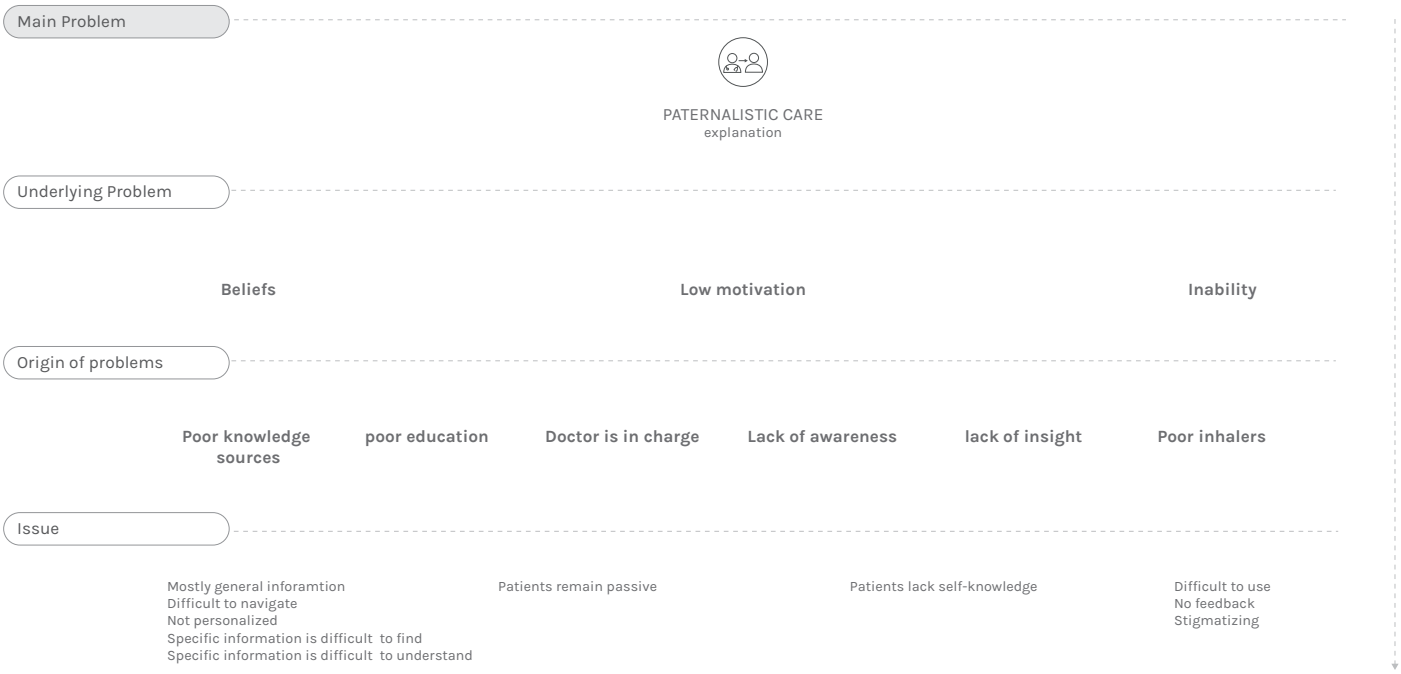
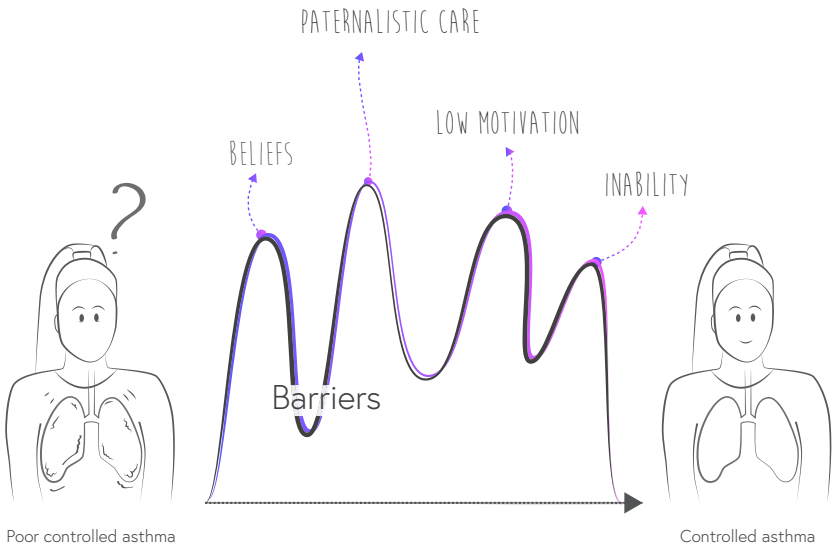


Figure 24. *Problem definition*



3 Synthesis

This chapter describes the development of the problem definition into a solution space. In the solution space, different design directions were identified, of which one direction was chosen. This chapter further describes the crystallization of the chosen design direction by defining the context, functions, and list of requirements. Consequently, it describes the first ideation phase, which consists of brainstorming sessions, and consulting experts. This chapter ends with six proposed concepts and the final chosen concept direction.

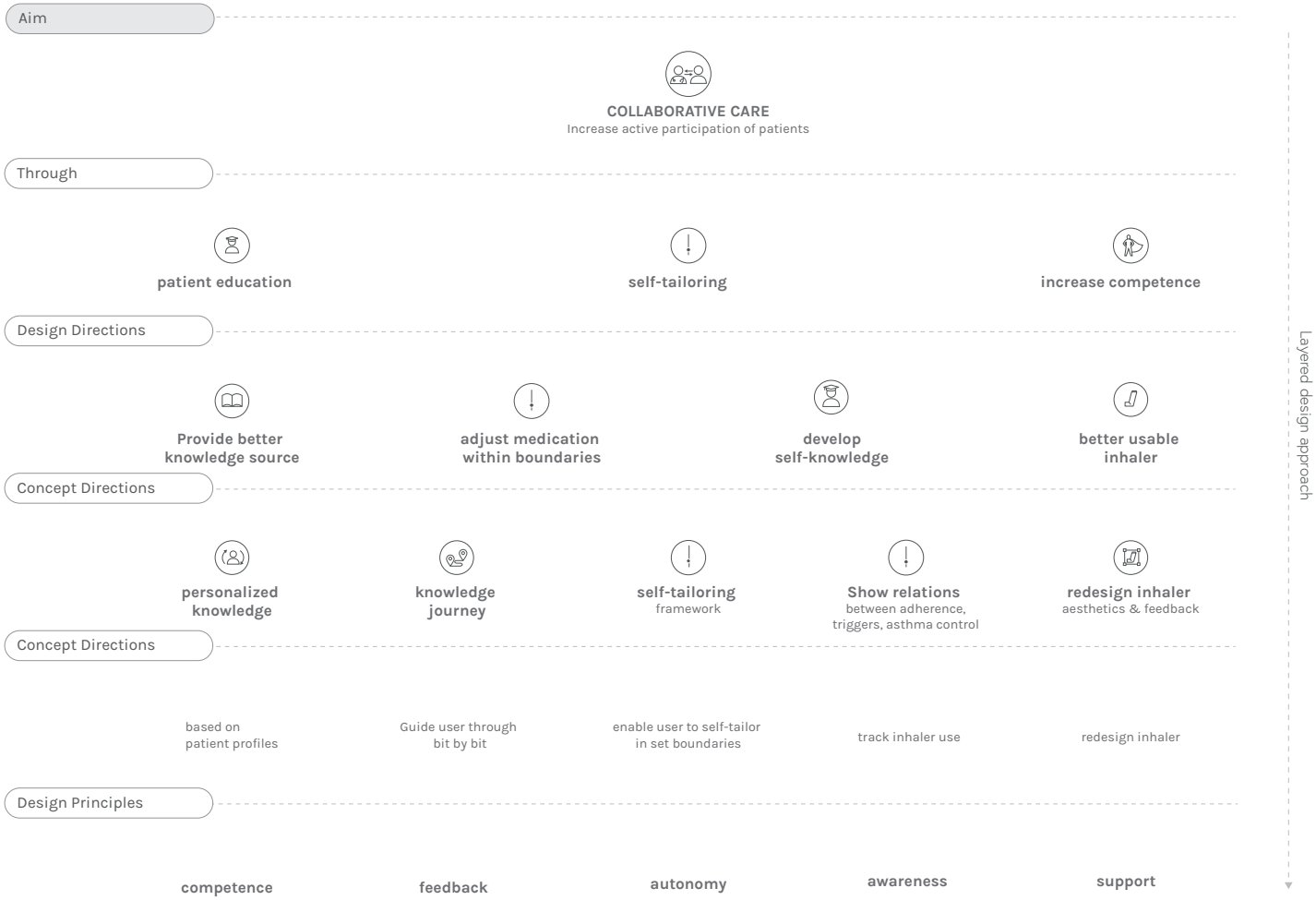


Figure 25. *Solution space*

3.1 Solution space

Based on the identified problems and previously identified design implications, different design solutions were identified and developed into the solution space. Three main solution areas that were defined are; Patient education, self-tailoring, and increasing competence.

Patient education
One of the solution areas is to improve patient education; this responds to the need for better knowledge sources and stimulation to educate oneself. For better patient education, several aspects are necessary.

First of all, it is important to create **awareness** about the importance of knowledge. Also, patients need to be motivated to educate themselves. Moreover, there is a need for a **better knowledge source**. Possible solutions are the *personalization of knowledge*, and the creation of a *knowledge journey*, which provides information bit by bit.

Self-tailoring
One of the core principles for efficacious self-management is a feeling of autonomy. Autonomy could be obtained through self-tailoring of treatment. Besides that, shared decision making about the treatment is an essential aspect of collaborative care. Enabling the patient to self-tailor can induce more **active participation** of the patient.

A possible design solution could be to support the patient to **self-tailor** their medication intake within *set boundaries by the GP*. Also, this self-tailoring, in combination with tracking of adherence, could be used to develop self-knowledge.

Increasing competence
Finally, it is crucial to support patients to become more competent in their self-management. For increasing the competence of asthma patients, two aspects need to be solved. These are increasing the patient's **self-knowledge** and enabling them to **better act upon gained self-knowledge.**

A solution for the development of self-knowledge could be to *track the use of the inhaler* and to show relations between adherence, triggers, and asthma control. For better use of the inhaler, the *inhaler could be redesigned* to provide use-indications and feedback on usage.

3.2 Chosen design direction

Based on the design space, three design directions were proposed to CAHAG. Appendix 7 demonstrates these directions. For the choice of the design direction, the initial project assignment was re-evaluated. Also, feedback from the client, CAHAG, has been taken into consideration.

Initial assignment

> *"Design an asthma self-management system that both empowers and supports recently diagnosed asthma patients and increases their competence of medical self-management."*

Chosen design direction

> *"Develop a personalized knowledge source that creates a journey of education, increased insight, and translates this into concrete actions for the patient. This will be done through design for increased competence and autonomy."*

Design direction explanation

The main barrier to good self-management is a lack of **knowledge** and a lack of **insight** which lead to inadequate competence. The design direction was set to "providing a better knowledge source" through **personalization** and creating a **knowledge journey**. The **patient's competence** will increase by providing **self-knowledge** or **insight** into asthma in combination with providing the tools to translate gathered insights into **action.**

Personalization of knowledge will be done based on the patient persona's (attitude) and a self-learning design that learns from the patient and personalizes to the user's type of asthma. Personalizing the knowledge will increase the relevance of knowledge and make it easier for patients to acquire and apply knowledge.

Creating a knowledge journey means that the knowledge will be spread over a longer time, keeping the process towards better self-management manageable and engaging. Design principles that will be applied are based on the behavioral change theories and will be to design for a feeling of increased **competence** and a sense of **autonomy.**

Design vision

At last, a design vision was created:

> *"To design a holistic self-management system that educates asthma patients on medical self-management and motivates and supports them to apply newly acquired knowledge to self-management to obtain asthma control."*

3.3 Defining the design space

This section further crystallizes the design space for the chosen concept direction by identifying the design context, the functions, and setting up a list of requirements.

Design context

First, the design context was established to set clear boundaries for the context in which the design will be used, see Figure 26.

1. Shortly after diagnosis: The design is intended for use by patients who have been recently diagnosed.

2. Independent use: The design is intended for patients to use independently in the context of their everyday life. This independent use means that the GP will not be involved with the daily interactions of the patient with the design.

3. Target group: The patients of the target group are recently diagnosed asthma patients that are well literate and have access to a smart phone and internet. Within the design, a distinction will be made between the curious and the passive patient as defined in the section patient perspective.

4. GP: The general practitioner can, upon the consent of the patient, view data obtained by the app.

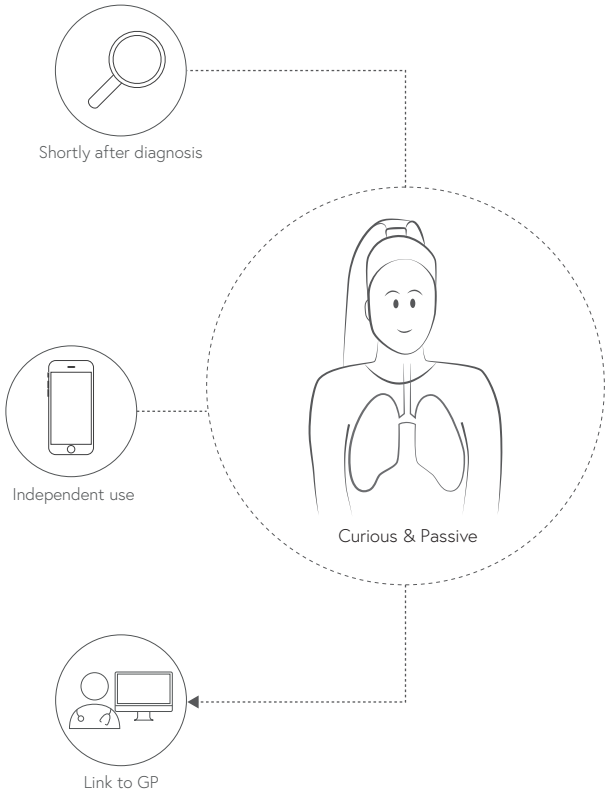


Figure 26. *The design context*

Function analysis

Next, a function analysis based on the design direction was performed as described by (Van Boeijen et al., 2013). The main goal of the design will be to increase the competence of the patient in medical self-management. According to the analysis phase patients are often passive; the design will motivate through giving a feeling of autonomy competence. Education of patients will be used to increase awareness of the disease and self-management strategies. Education will be made relevant to the user utilizing personalization. Insight based on personal progress and data gathered will be used to provide patients with self-knowledge. At last, these components will be presented with their relevance for the patient and in an action-oriented way, providing the user with the tools to act. In conclusion, combining the invitation to act with knowledge and personal relevance will increase motivation.

List of requirements

In Appendix 8, the list of requirements can be found. This list was set up using the design implications of the analysis phase, the design context, and the function analysis. The list of requirements was used to refer to during the development process and for the final evaluation of the concept.

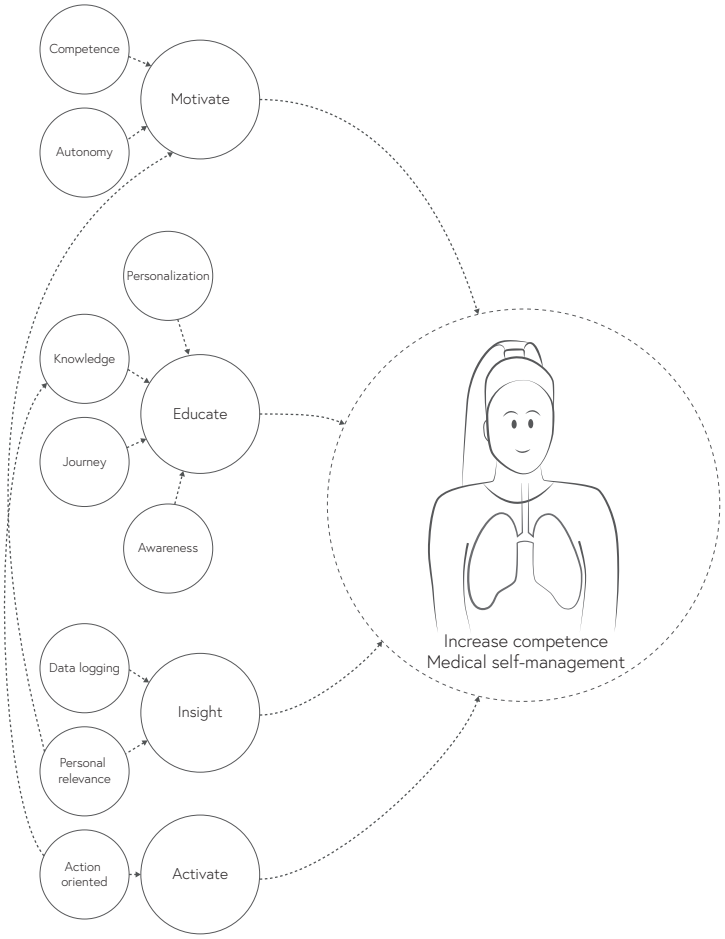


Figure 27. *The function analysis*

3.4 Ideation

This section provides an overview of different steps that were undertaken to come to the concept directions that are presented at the end of this chapter.

Brainstorming

The ideation phase commenced with individual brainstorming, as mentioned before the process of this project has not been entirely linear, meaning that throughout the project individual brainstorming sessions were done. Methods that were used were mind mapping, creating moodboards, brainwriting, and brain sketching. In Figure 28, some examples can be seen, in Appendix 9 some additional sketches can be found.

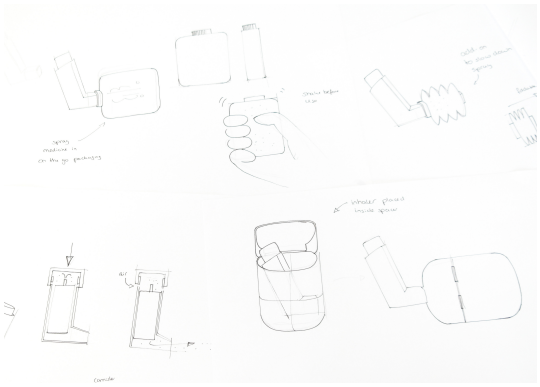


Figure 28. *An impression of the brainstorming phase*

Sketching sessions

In total two sketching sessions were organized with designers of VanBerlo. Both sketching sessions were done using the same method and input. Appendix 10 provides a full overview of the method and materials used for this session. Each session started with an introduction to the project assignment and the target group. Next, the design context and identified problems were explained using examples. After that, the participants were presented a "How might we.." question per identified problem. Below a few how might we questions are listed. For a full overview of these we questions please refer to Appendix 10.1.

How might we...

- Personalize knowledge based on attitude/ type of asthma/ asthma severity
- Motivate users to acquire new knowledge and keep them engaged
- Support patients to develop self-knowledge

For each how might we an individual brain sketching session of 10 minutes was held, after which each participant presented their results.

Outcome

Figure 30 shows some examples of the sketches that were made during the session. These sketches were used as inspiration for further brainstorming.

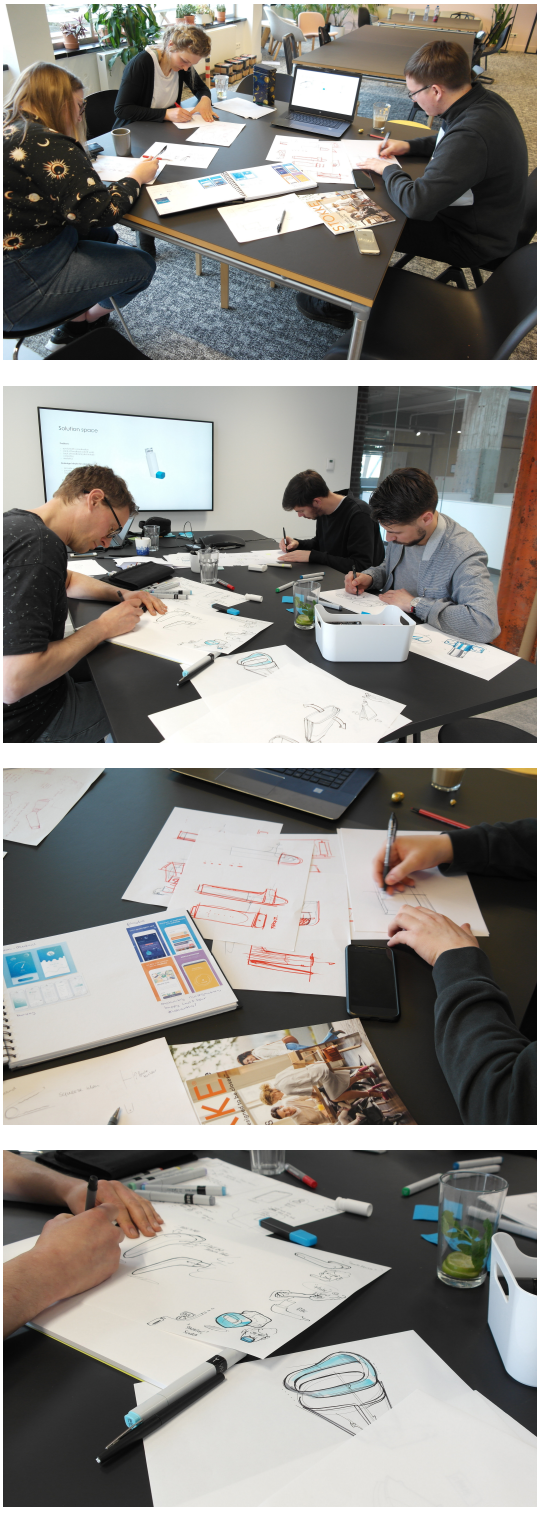


Figure 29. *Sketching sessions at VanBerlo*

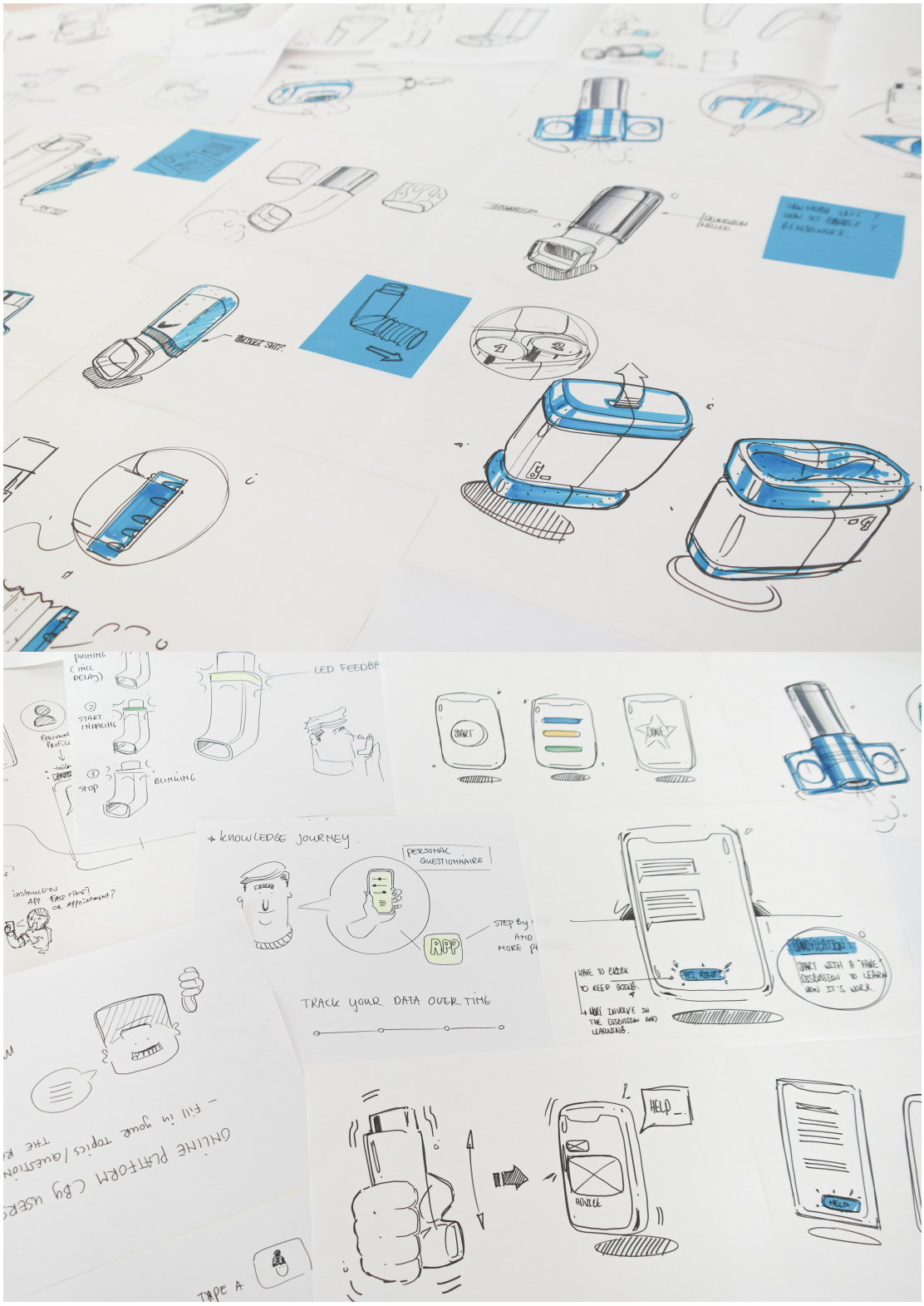


Figure 30. *Sketches (credits: Sjoerd Van Gerwen, Nicolas Schmitt, Taco Dietvorst, Oliver Sinclair, Jessica Castor, Christina Bauer)*

3.5 Concept development

The final concept will be a product service system combination consisting of an integrated physical and digital element. For the development of the concepts, the digital and physical part have been separated because they are interchangeable.

By placing promising sub solutions form the ideation phase on a morphological chart, three digital concepts were defined. For the creation of this chart, the method as described by van Boeijen and colleagues, was used (Van Boeijen et al., 2013).

Three physical concepts were created based on moodboards and using the ideas form the several brainstorming phases. The three physical elements were then designed to provide a useful add on to the digital concepts. On the following pages, the final six concepts are presented.

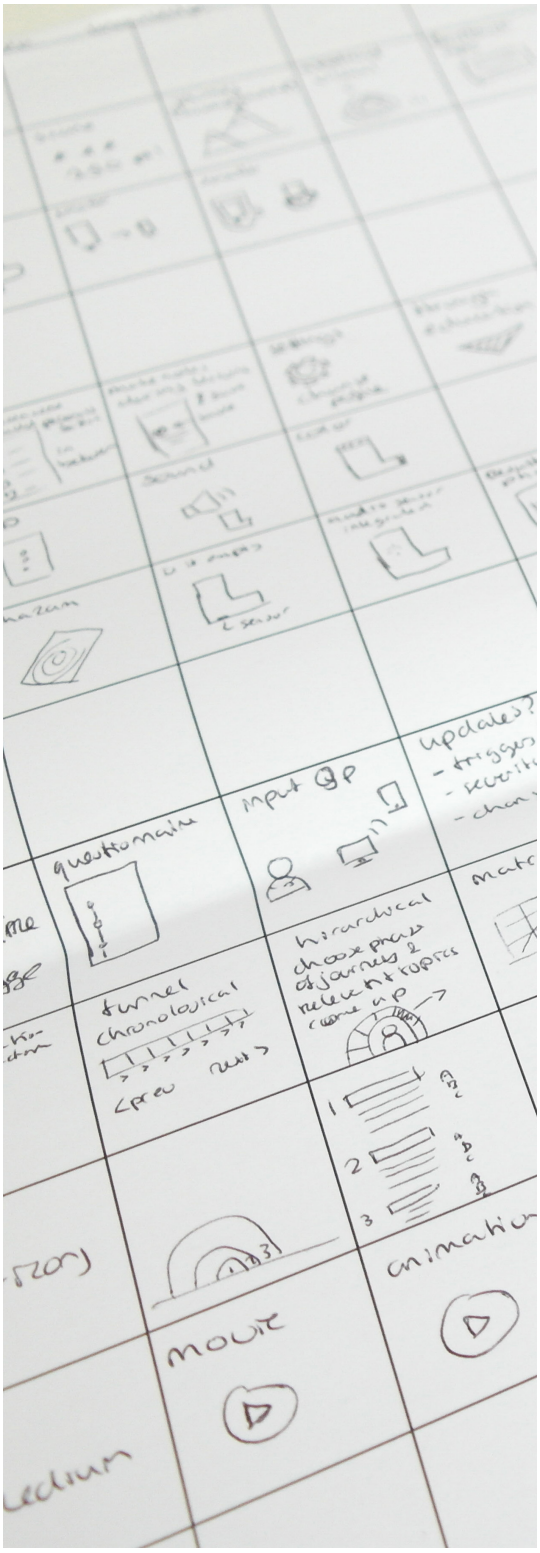
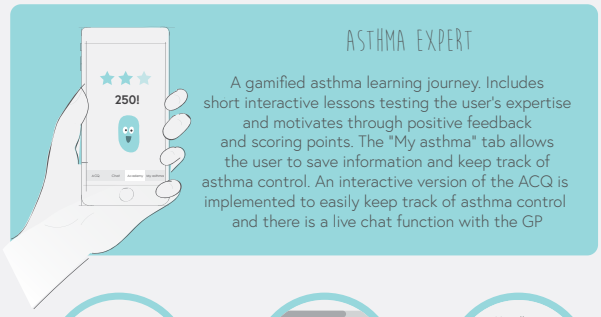


Figure 31. *Morphological chart*



ASTHMA EXPERT

A gamified asthma learning journey. Includes short interactive lessons testing the user's expertise and motivates through positive feedback and scoring points. The "My asthma" tab allows the user to save information and keep track of asthma control. An interactive version of the ACQ is implemented to easily keep track of asthma control and there is a live chat function with the GP

Asthma Academy

Asthma Academy

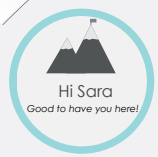
My Asthma

Asthma Control Questionnaire

GP Chat

MY JOURNEY

My journey takes the asthma patient on a literal journey towards better self-management. After an on-boarding story in which the app is personalized the user can set goals. Each goal has a different topic and educates and supports the user on the journey towards getting to know your asthma.

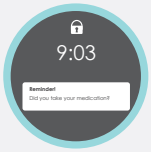


On-boarding Story

Goal Setting

Education

Personalization questionnaire



Reminders

Adherence

Save question

Asthma Control Questionnaire

KEEP TRACK

Keep track supports the asthma patient in keeping track of their asthma condition. Relations between exacerbations and external factors are automatically tracked. Also feedback is provided about the inhaler technique. At last, an abstract visual visualizes the level of asthma control

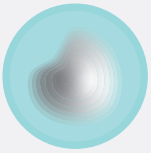
Adherence

Relations

Discover Triggers

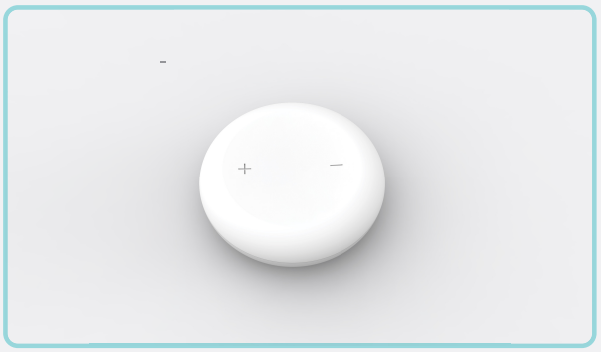
Accomplishments

Positive feedback



Me

Inhaler Technique



BLOB

Blob is a physical element for in the nightstand or on the go, or it could even be integrated into the inhaler. The user can track their adherence, asthma control and severity of exacerbations with the device. This will be done manually through pleasantly designed interactions e.g. turning, pushing, or twisting.

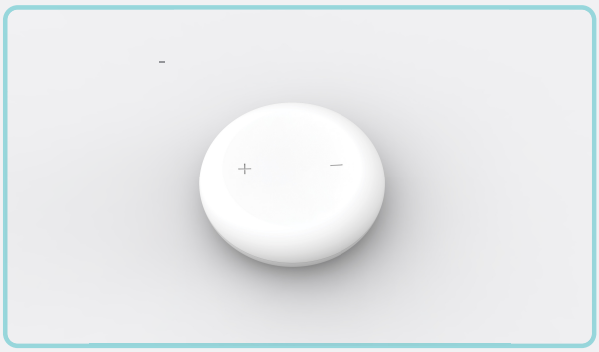
To track adherence (push when you took your medicines)

To measure asthma control (twist to indicate severity of asthma attack)

Could be integrated with inhaler

Pleasant interactions

Communicates findings to the app & helps to give insight



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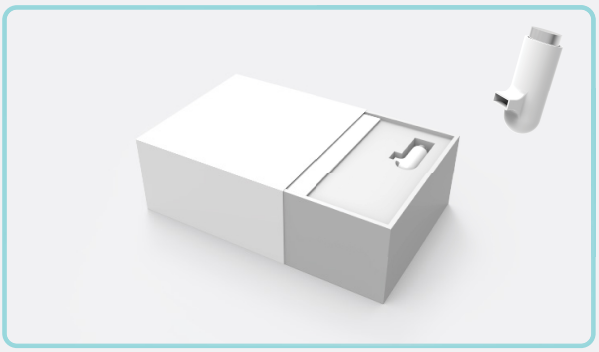
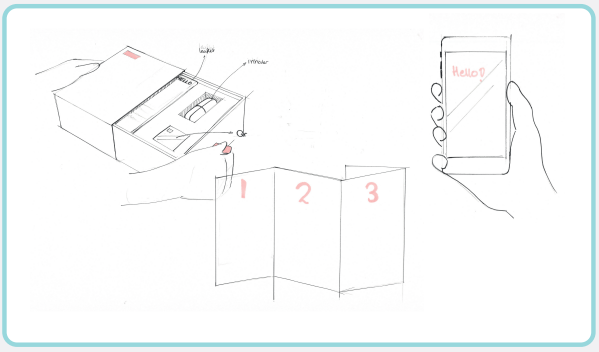


ON-BOARDING BOX

Keep track is supported by the development of a
smart inhaler. This smart inhaler could be given to the
asthma patient right after diagnosis. It contains a
leaflet that takes the user through the on-boarding process
step by step and contains a QR-code that links to the app.



3.6 Concept choice

This section describes the choice of the final concept. The main objective was to select the best solution for the assignment. It describes the selection criteria and methods that were used to make a choice. It was decided to separate the selection of the physical product from the selection of the digital product as the digital and physical element are both interchangeable.

Selection criteria

There were two aspects on which the concepts have been rated. First, the extent to which the concepts meet the determined functions from the "function analysis" was rated.

Besides being relevant to the assignment, it is important to determine whether the concept has any potential for future development. Therefore, the desirability, feasibility, viability, and innovativeness of each of the concepts were rated as well.

Function analysis

- Motivate: does the design motivate the user towards better self-management, through increasing competence and giving a feeling of autonomy?
- Educate: to what extent does the design educate the user?
- Insight: does the design increase the user's insight and to what extent does it support the development of self-knowledge?
- Activate: to what extent is the design action-oriented, and does it stimulate the user to act?

Relevance

- Feasibility: can it be done?
- Desirability: does it address the user's needs?
- Viability: will it survive in the longer term?
- Innovative: is the concept doing something new?

Selection method

Each of the criteria was set out in a table against the different concepts. Then each of the concepts was rated on the different criteria with a score from one to four, one meaning the criteria is not met at all, four meaning the criteria is matched perfectly. Based on the height of the total score, the final digital and physical concept were chosen. After that, this choice was evaluated with the client and workgroup for final approval.

The chosen concept

Based on the concept evaluation, it was decided to continue with the concepts my journey and wall.

My journey was chosen because it makes optimal use of personalization. The onboarding story addresses each persona, and the personalization questionnaire determines the best matching persona for the user. The function to choose goals increases competence and autonomy, and through education at the beginning of the goals, the user's health literacy will be increased as well. At last, the goals stimulate action.

The wall concept is an excellent addition to the design because it can measure the air quality indoors and communicate this to the user. This way, the user's insight into the influence of air quality on their asthma can be enhanced and even translated into action. For example, when the air quality is bad inside the user could open a window or decide to clean the house.

Vea

It was chosen to adopt a new name for the final concept: vea, pronounced as "veei". This name was chosen because of its symbolic meaning, translated from Latin vea means "road". Vea transforms the once invisible search for better asthma control into a clear road towards enhanced asthma self-management. The simulation section describes the further development of into the final design proposal.

	Asthma Expert	My Journey	Keep Track	Wall	Blob	On-boarding box
Function analasys						
Motivate	4	4	3	4	3	2
Educate	4	3	1	4	4	2
Insight	1	4	4	4	4	1
Activate	1	4	2	3	1	2
Design direction	3	4	1	4	3	1
Desirability						
Desirability	3	4	2	3	2	4
Feasibility	4	4	4	4	3	4
Viability	2	3	3	4	3	4
Innovative	2	4	1	1	4	1
Total	**24**	34	21	**31**	27	21
			4	*3*	*2*	*1*

Figure 32. *Evaluation of the concepts using the selection criteria*

4 Simulation

This section describes the further development of vea into a final design proposal. First, the concept is elaborated on by explaining the different features and functionalities of the design. Consequently, the digital and the physical development process are described separately. The development describes several iterations, tests, and evaluations with experts using mock-ups, prototypes, visualizations, and sketches. The chapter ends with the presentation of the final integrated design

4.1 Features and functions

The concept choice already predefined some of the features of the final design. This list of features is, however, far from complete. This section demonstrates the different features of the digital and the physical design and briefly explains why they are there. After that, it explains the integration of the concept.

Features of the digital design

Below the key features of the digital design are listed. Each of the features includes different functions as well. As there are many functionalities, it was chosen to demonstrate these using a visual.

1. Onboarding

The onboarding of the app is intended to both grab the user's attention and to start the personalization process of the app. The onboarding will consist of an introductory story that explains the goal of the app in a way that appeals to each of the personas. The onboarding story is followed by a personalization questionnaire in which the user is asked to fill out their name but also to reply to several questions that are used to determine their best matching persona.

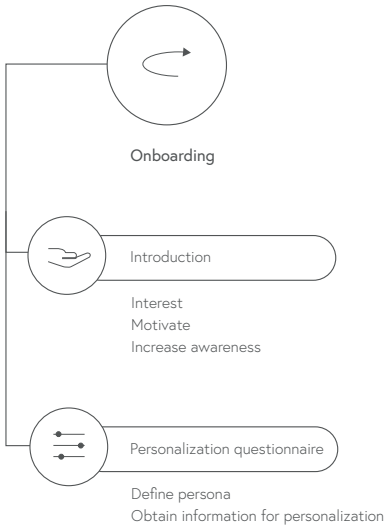


Figure 33. *Feature: "Onboarding" and its functions*

2. My home page

The homepage of the app is the central screen of the app, where the user gets an overview of goals they are working on, suggestions for next steps, and, most important, a prediction about their personal air quality for that day. Based on the goals, the app learns about the asthma patient. The app will learn what possible triggers are and how well the patients' asthma is in control. In combination with the physical device, identifying triggers allows the app to predict the air quality for the asthma patient specifically for that day. For example, if the patient is allergic to pollen, and there are lots of pollen, the asthma patient will be warned about this.

2.1. Air quality

As mentioned above the app predicts the air quality for the asthma patient. There are many apps that collect data about the air quality outside. However, all this data is spread over

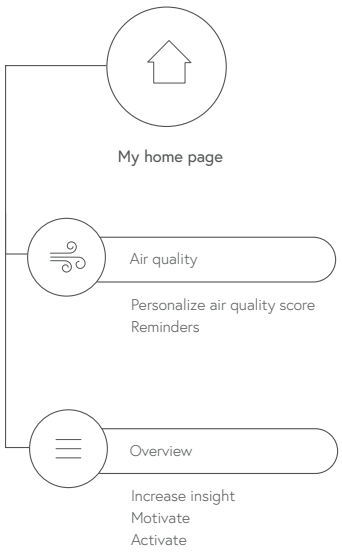


Figure 34. *Feature: "my home page" and its functions*

different apps and not personalized, meaning that the asthma patient needs to keep track of what influences their asthma themselves. What vea does is collecting all the data from these apps and presenting them in one overview that is based on the patient's triggers.

3. Setting goals

The main feature of the app is setting goals that support better self-management. Each goal supports a different aspect of self-management. The asthma patient can choose which goals to work on based on what is most relevant to them. Each goal will start with a short onboarding, intended to grab the user's attention and to educate them on the chosen goal. Then the goal can be set up according to the users' preferences, and together with the app the user can work towards achieving their goal. Some examples of these goals are "learning the basics" which will educate them on asthma and different elements of self-management. Another goal that will be implemented is the discovery of triggers. User research pointed out that asthma patients have some difficulties figuring out what triggers their asthma; this goal will keep track of possible triggers and uncover relations between them for the user.

3.1 Medication use

For some of the goals, it is beneficial or required to track the medication use of the asthma patient. The design of a smart inhaler is out of the scope of the project. For the further design process, it is assumed that the design will be connected to a smart inhaler. This could be any of the smart inhalers on the market, or a new inhaler could be developed to work together with the app.

4. Journey visualization

The "journey" supports the "goals" feature of the app. Each step that is set by the user towards better asthma self-management becomes a step on the journey. These steps are recorded on the journey, and upon achieving a specific number of steps, a new metaphoric "location" is discovered.

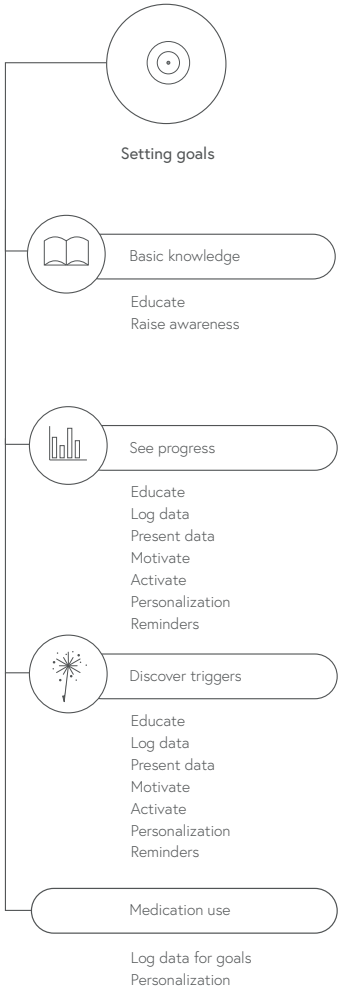


Figure 35. *Feature: "Setting goals" and its functions*

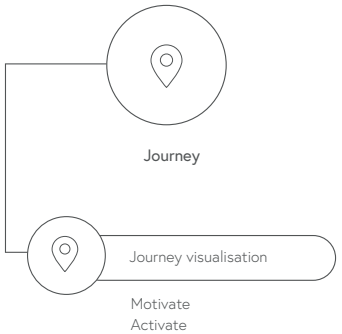


Figure 36. *Feature: "Journey" and its functions*

5. GP chat
The last feature is the GP chat. As the market is heading increasingly towards eHealth, live chat functions are becoming more standard. In consultation with CAHAG, it was decided to implement a chat function. Here the user can ask a question to their GP. The GP receives the questions at fixed times of the day and can answer the questions. For further development of the app, it was decided to focus on the other three features, as these are what makes the app truly unique.

Each of these features supports a set of different functions; below these functions are listed; each Figure 33 - Figure 38 give a visual overview of these.

- Personalization
- Reminders
- Educate the user
- Logging data
- Presenting data for increased insight
- Motivate the user
- Activate the user

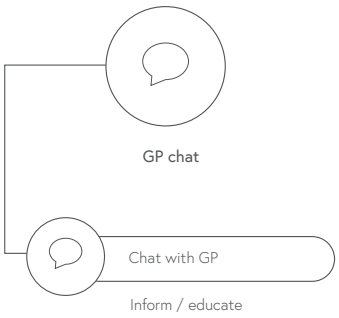


Figure 37. *Feature: "GP chat" and its functions*

Features of the physical design

1. Measure air quality
The main feature of the physical design is to measure the air quality inside the home of the asthma patient. As mentioned above, data of outside air quality is available everywhere, but data about the air quality inside is not. What the physical design does is measure the air quality inside the home and inform the user through the app. This way, the user can optimize the inside air quality. Besides that, the device allows the user to compare the inside air with the outside air, and thus helps determining, for example, whether to open a window or not.

2. Communicate
In general, the function of the physical design is to serve as a physical reminder for the user to use the app. It will display abstracted versions of information on the air quality inside and outside, and it will provide reminders for action. The display will be simple and should be understandable with one look at the device; more in-depth information is communicated through the app.

Figure 38. *Physical device and its features*

Product ecosystem

As explained in the features section, the final design makes use of data from other apps and a smart inhaler. This section briefly demonstrates the complete product ecosystem.

• GP
The GP can receive data about the patient's adherence, asthma control, and triggers upon approval by the patient.

• Smart inhaler
The smart inhaler notifies when it is being used and communicates this to the app.

• Apps air-condition
The digital design is collecting data from apps that track air quality.

• Physical device
The physical device contains sensors to determine the inside air quality. It communicates this to the app and receives data from the app about the air quality outside.

• Digital device
The digital device collects data from apps on air quality and communicates this to the physical device. Also, it receives data on the inside air quality from the physical device. Besides that, it receives data on the use of the smart inhaler, and upon approval by the user, it sends their data to their treating GP.

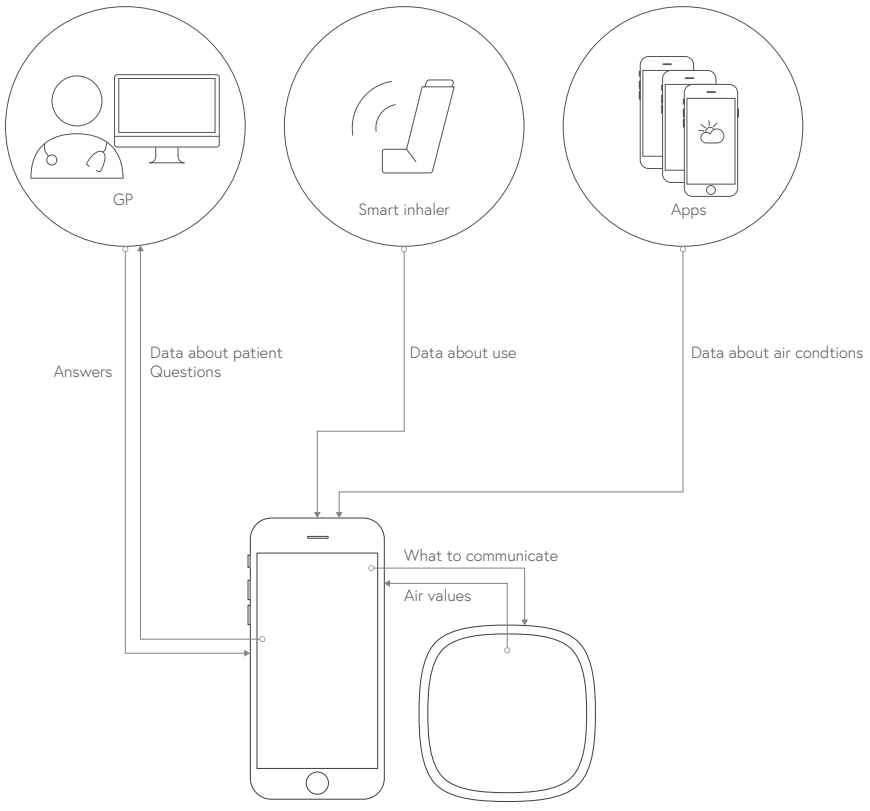


Figure 39. *Product ecosystem*

4.2 Digital design

The previous section explained the overall design. This section will give an impression of the development process of the digital design. It starts with some additional research to personalization and then illustrates the process and argues decisions. This section ends with a presentation of the final digital design.

Personalizing the design

In several instances in the analysis, the need for personalization came forward. Additional research was done on three types of personalization that could be applied in the final design: personalizing information architecture, personalizing content based on persona, and tailoring communication. Below the main findings are discussed.

Personalizing information architecture

Research was done on the effect of personalizing the information architecture (how to present information). For this research expert T. Dekkers was consulted. T. Dekkers and her colleagues are researching the effect of information architecture on knowledge gain and satisfaction with web-based patient education.

It was expected that the different personas might benefit from different information architectures. However, from the research, it was concluded that for the design of the app, each information architecture has its benefit in specific situations.

Based on our conversation, it was decided to use a combination of a tunnel and a matrix architecture to optimally employ their benefits for the user. The matrix architecture will be used in the main structure of the app; the user can decide which goal they want to work on and in what order. This choice increases their feeling of autonomy and the relevance of the goals for their situation.

Within each goal, a tunnel architecture will be applied, ensuring the user gets all the information and feels confident that they did not miss anything.

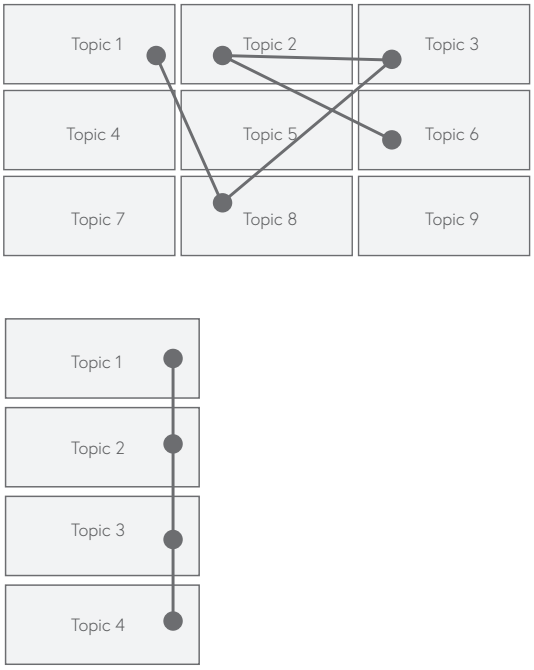


Figure 40. *Information architectures, Matrix (top) and Tunnel (bottom)*

The tone of voice and type of information
Based on the user research, it was concluded that for optimal motivation, each type of persona requires a slightly different approach within the app.

A scheme was set up illustrating how a different tone of voice, different level of information, and type of reminders can be used to appeal to both the curious and the passive persona. Appendix 11.1 provides a more elaborate scheme for further development of the app.

It is expected that the passive persona needs a slightly more persuasive tone of voice where the curious persona needs a soothing tone of voice. Also, the passive needs to get a clear overview of what must be done and why. The curious will be provided with more background information.

Chapter 5.1 demonstrates the outcome of this research using the final design.

	 Curious	 Passive
Reminders	1st reminder: friendly — Second reminder: more persuasive — Later reminders: persuasive	
Raise awareness	You can...	You should...
Focus	Autonomy You have the tools to...	Support Through offered toolsv
Tone of voice	Explanation	Argumentation
Identify severity	Mild intermittent	Mild intermittent

Figure 41. *Short version of the personalization scheme*

Tailoring communication
Besides tailoring the information architecture and tone of voice, the content of the app will also be adjusted to the different users.

According to Hawkins et al., message processing by patients can be positively influenced, utilizing three ways of tailoring information. These three are personalization, feedback, and content matching (Hawkins et al., 2008).

Personalization
Personalization can be used to increase the attention and motivation of the patient. The design will do so using identification, calling the patient by name. A second mechanism that will be used is "raising expectation of customization". This means, letting the user know that some content is created especially for them, for example, a discovered trigger (Hawkins et al., 2008).

Feedback
The design will also provide users with feedback based on their performance. One form that will be used is descriptive feedback. This is a form of feedback that is based on the patient's performance. It is based on the gathered data, for example, a patient's level of adherence. Descriptive feedback is known to improve self-referential thinking. The second form of feedback that will be included is evaluative feedback. This is feedback that notes a particular behavior or pattern and tells the user how to behave better (Hawkins et al., 2008).

Content matching
At last, a key factor in tailoring healthcare is content matching. As mentioned before, current information sources for asthma patients provide rather general information. All the information is there, but it is not explicitly written for the patient in question, which makes it challenging to apply the information. The app is designed to figure out what type of patient is using it, which type of asthma they have and which goals they are working on. Based on what is relevant at the moment, the app provides information that applies to the patient in question. The section *Final features of the app* displays some examples of how this is implemented in the digital design.

Design implications

✓**Personalizing in the onboarding**
During onboarding the app should prepare the app for personalization by defining the patient's name, defining the persona and asthma type. (R13)

✓**Self-learning**
The app is self-learning and further personalizes its content based on the data gathered from the patient. The input for this personalization is based on the Asthma Control Questionnaires (ACQ), medication schedule, triggers discovered, and adherence. (R2.1, R3.6, R3.3, R9.1.1)

✓**Reminders become more persuasive over time**
The reminders will be the same for each persona; they will become more persuasive over time if the user does not act upon the reminder. It is assumed that the curious persona will act on reminders faster and thus will not receive the more persuasive reminders. (R14)

✓**Tone of voice**
The scheme also demonstrates how the tone of voice needs to vary between the personas. (R1.4.1)

Scoping the digital design

The main goal that the app facilitates is setting goals. Based on the analysis phase, five goals related to medical self-management were defined; these are:

- Basic knowledge of asthma
- Discover triggers
- See progress
- Find the type of asthma
- Inhaler use

In the first instance, the app will focus on medical self-management, as this is the scope of the project. For further development, also behavioral self-management goals could be added, such as: exercising with asthma, quit smoking, etcetera.

After the goals were determined, the desired patient journey was envisioned. This journey can be found in Appendix 4.7. Based on this journey, the key touchpoints with the app were determined. These touchpoints were then developed into the features, as explained in the previous section.

Based on this journey also the most important goals for enhanced self-management were selected for further development. These are: See progress and discover triggers.

User Experience vision

Based on the patient research a user experience vision was defined. This vision was created with the patient in mind. In the patient evaluation this vision will be used to evaluate the design.

Figure 42. *User experience vision*

The app architecture

The next step of the development was to determine the architecture of the app based on the features. Figure 43 demonstrates this process. After an underlying architecture was determined, each of the features was further developed. The development of these features took several iterations. Below the main steps are explained.

First, the input and output for each feature were determined using block schemes. The next step was to create a scenario of use for each of the features. Hand sketches were made to create these scenarios. These sketches went from rough iterations to more and more detailed scenarios. At last, the final use-flows were defined by creating flowcharts in illustrator.

The created use-flows served as a basis for creating the wireframe in adobe Xd. This wireframe did not contain any real content yet and was merely used to asses the workflow of the app. Besides evaluating the wireframe individually, I also discussed it with an expert of VanBerlo.

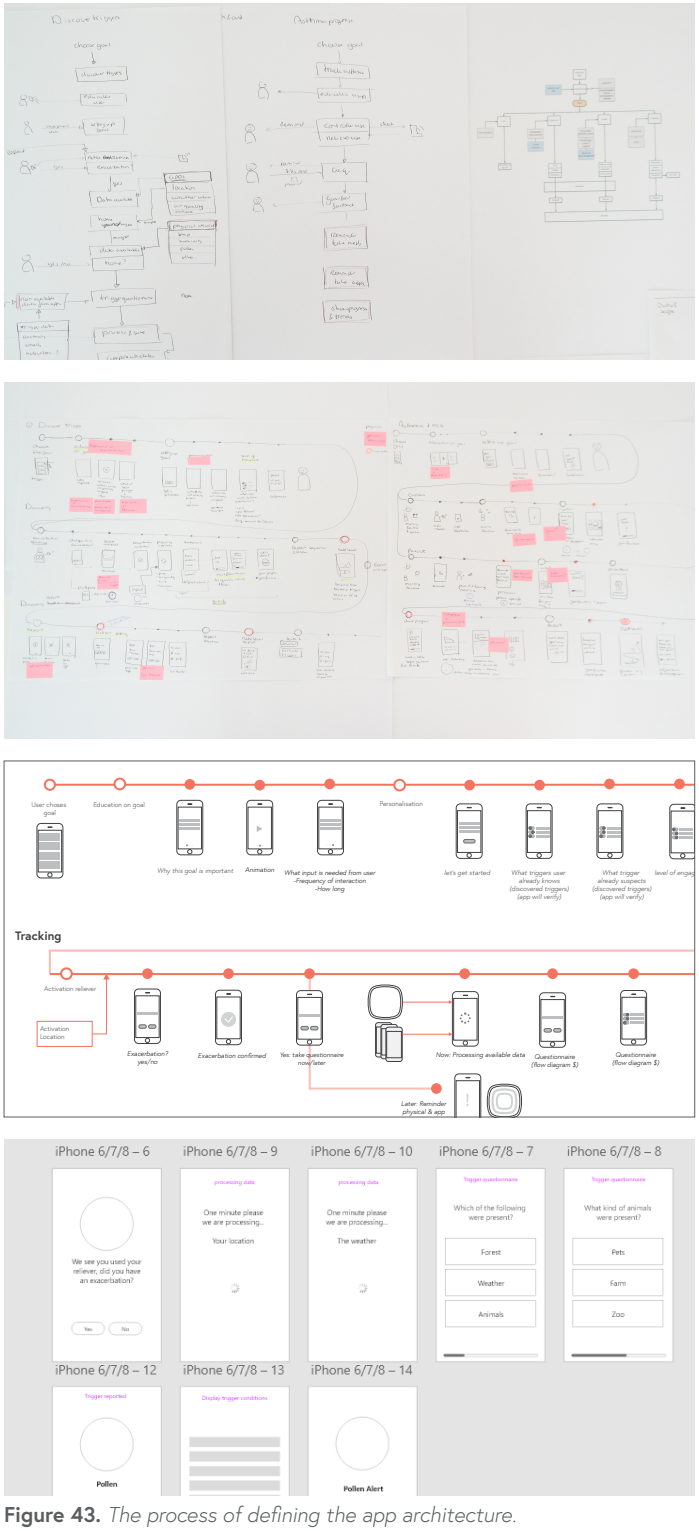


Figure 43. *The process of defining the app architecture.*

Brand personality.

Developing pleasant aesthetics for the app is essential to make the design inviting to use. Based on design implications, it was found to be essential to avoid stigmatization. Also, the app should be easy to understand and motivating.

To determine the brand personality of the app, a combination of the personality sliders method (Rijkers, 2019) and the brand personality tool of VanBerlo based on the theory of Jennifer Aaker (Aaker, 1997) was used. In total, ten determinants were created for the desired aesthetics (see Appendix 11.2).

Test

Next, three moodboards were created, each representing a slightly different set of qualities (medical, playful, serious, innovative, etcetera). These moodboards were evaluated with six potential users. They were asked to think out loud while rating each of the moodboards according to the ten determinants. The goal of this test was to see how different style elements from the moodboards were perceived.

Outcome

Based on the comments of users, it was decided to create a style based on the combination of two of the moodboards (see Figure 45). Participants perceived graphs very positively, as they give a clear and fast overview of information. Also, participants pointed out that they can keep track of trends, and the graphs are perceived as honest. The use of gradients and different colors in combination with some more playful context related images was perceived as exciting and motivating. A prerequisite, however, was that the images should not become too playful like in moodboard 3.

Design implications

✓ **Easthetics**

The use of illustrations and touches of color in combination with graphs and data will be used in the app. See Figure 45 for a visual representation of this design implication. (R29)

Figure 44. *Testing the moodboards with potential users*

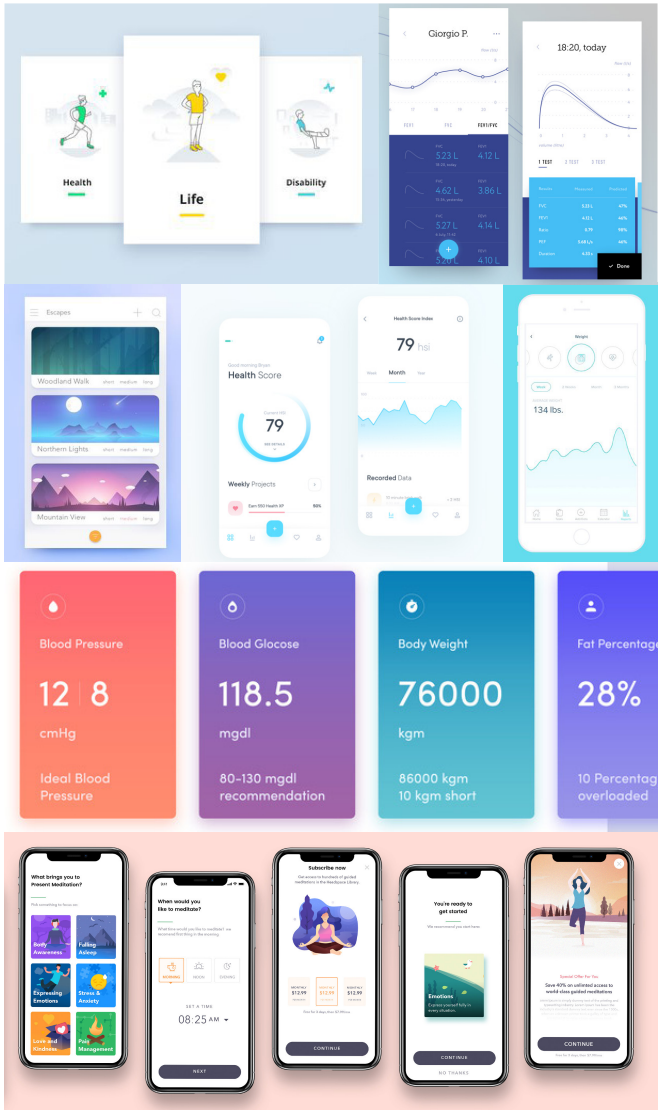


Figure 45. *The final brand personality moodboard (R29)*

Designing the features

Once the architecture, the use-flows, and the aesthetic style were determined, the real design work started. Based on the different use scenarios/use-flows, numerous screens were sketched in different aesthetics styles. Figure 47 gives an impression of the sketched screens. Appendix 11.5 displays a slightly bigger selection of the sketched screens.

Some key screens were further developed in illustrator, to get a good guideline for the visual style. This phase took several iterations. Each of these iterations was discussed and evaluated with experts of VanBerlo. Figure 48 shows a representation of the development of these screens. Below a few main steps of this process are briefly elaborated.

Example

As can be seen in Figure 48, the goals and journey screen developed quite a bit. In the first versions of the goals screen, the user could mainly see the title of the goal and a short subtitle. During further development, it was decided to divide the goals into little steps; each tile represents an action or step that a user can take. In the following iterations, I tried to make each step self-explanatory by adding short descriptions.

The tiles were integrated into the journey to create a more explicit link between the goals and the journey. In the final journey, the user can scroll sideways and see which steps they have taken, and how many steps they still need to take to reach the next level. Also, the timeline suggests actions (semitransparent).

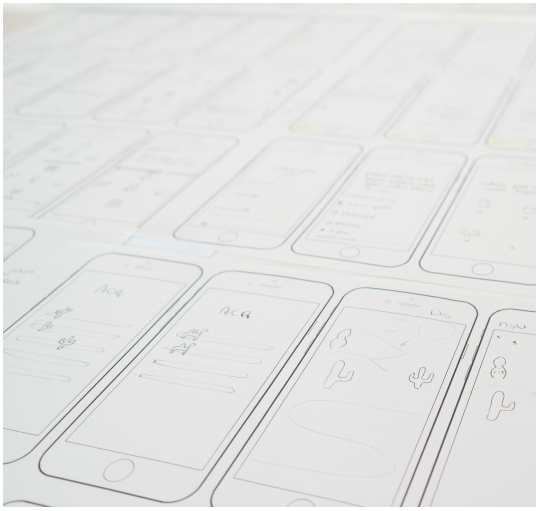


Figure 46. *Sketching screens*

Figure 47. *Further developed screens with feedback written on it*

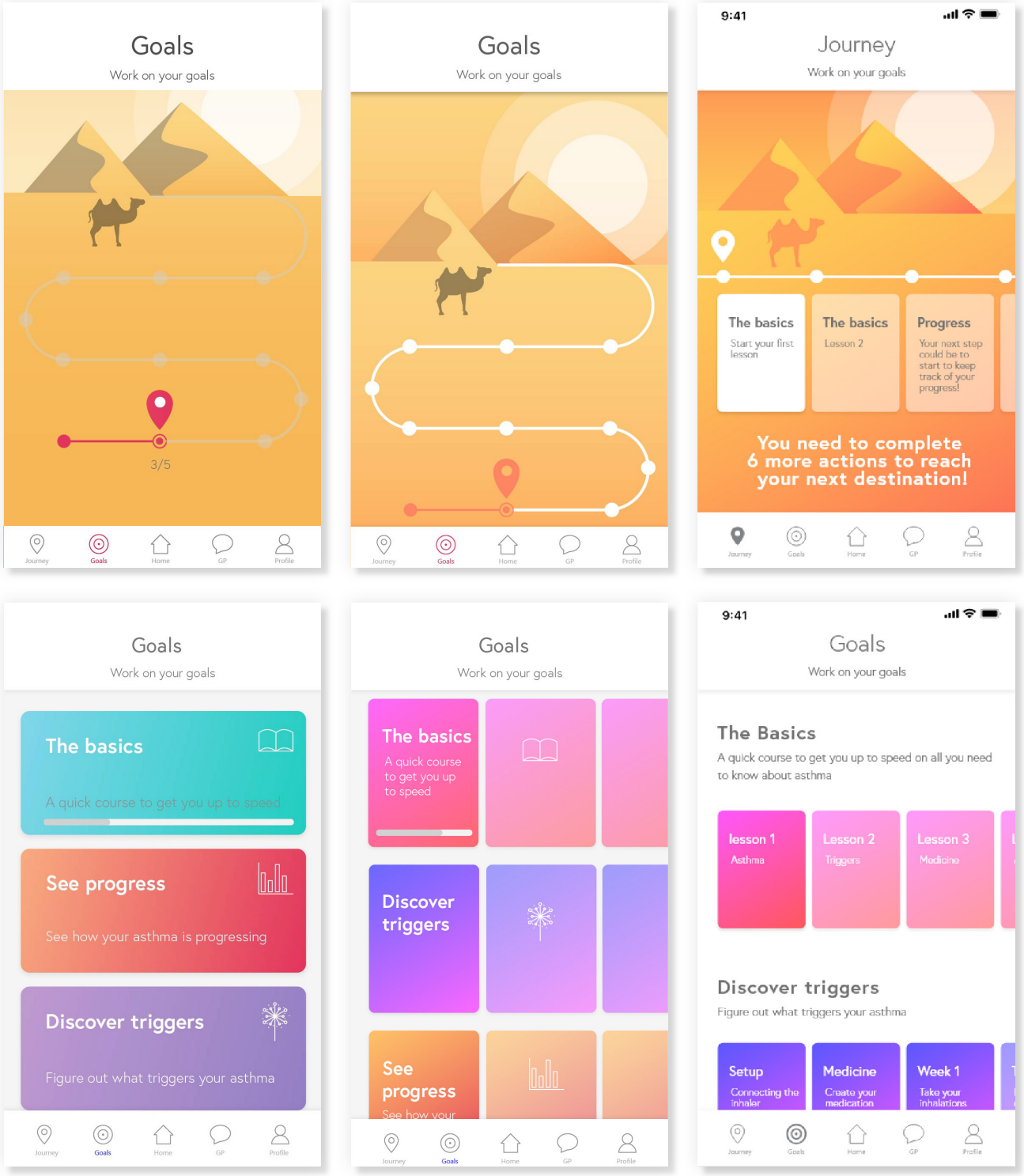


Figure 48. *Further developing the screens*

Testing interactions

Besides evaluating the screens with experts, small tests for usability were done with potential users. One of the features that was explicitly requested by the client was to integrate an ACQ (asthma control questionnaire). An ACQ is a set of six questions that can be used to determine the level of asthma control. This questionnaire can be found in Appendix 11.6. The ACQ is a rather static paper questionnaire. To integrate the ACQ in the style of the app, and to make it more efficient and dynamic, the layout of the test was redesigned.

In total, 9 versions were created and tested with both designers and non-designers on usability and desirability. In Figure 49, some examples of these screens can be seen; Appendix 11.6 shows all the test screens.

Test

Four participants evaluated the designed screens. They were asked to show how they would log their ACQ while thinking out loud. Then the screen was turned around, and on the back, the result after sliding was shown and users explained if this matched their expectation.

Outcomes

The tests provided useful insights for the usability of the app. For the ACQ in specific, the findings are communicated below:

- Each of the sliders should show a minimum and maximum value for reference.
- Icons help to quickly recognize the question. The questionnaire needs to be taken several times. Therefore easy recognition is beneficial for efficient logging.
- Horizontal sliding is perceived as more intuitive than vertical sliding.
- The questionnaire consists of 6 questions, and quick navigation between questions is desirable. Therefore, the choice has been made to slide horizontally between questions.

These findings resulted in the final design of the ACQ, as presented in Figure 50.

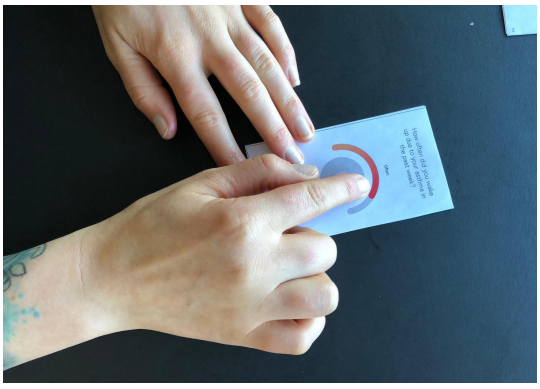


Figure 49. *Testing the interactions*

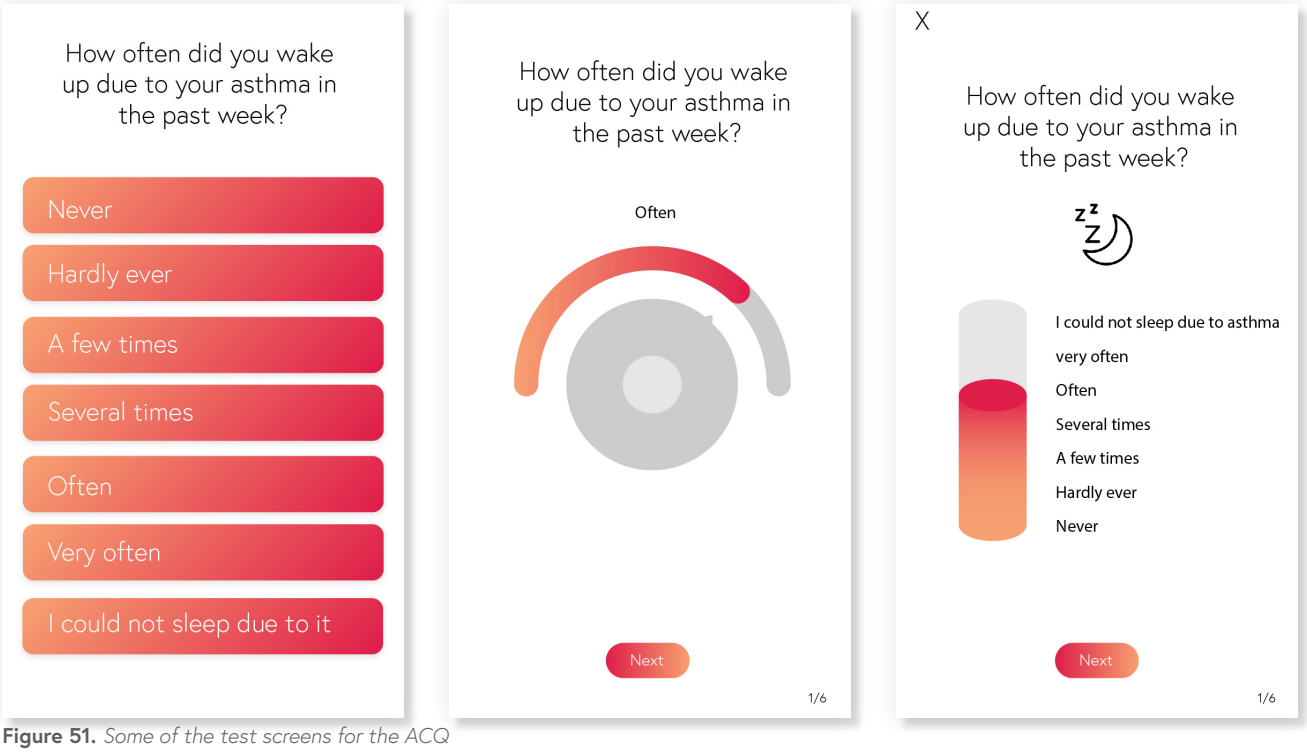


Figure 51. *Some of the test screens for the ACQ*

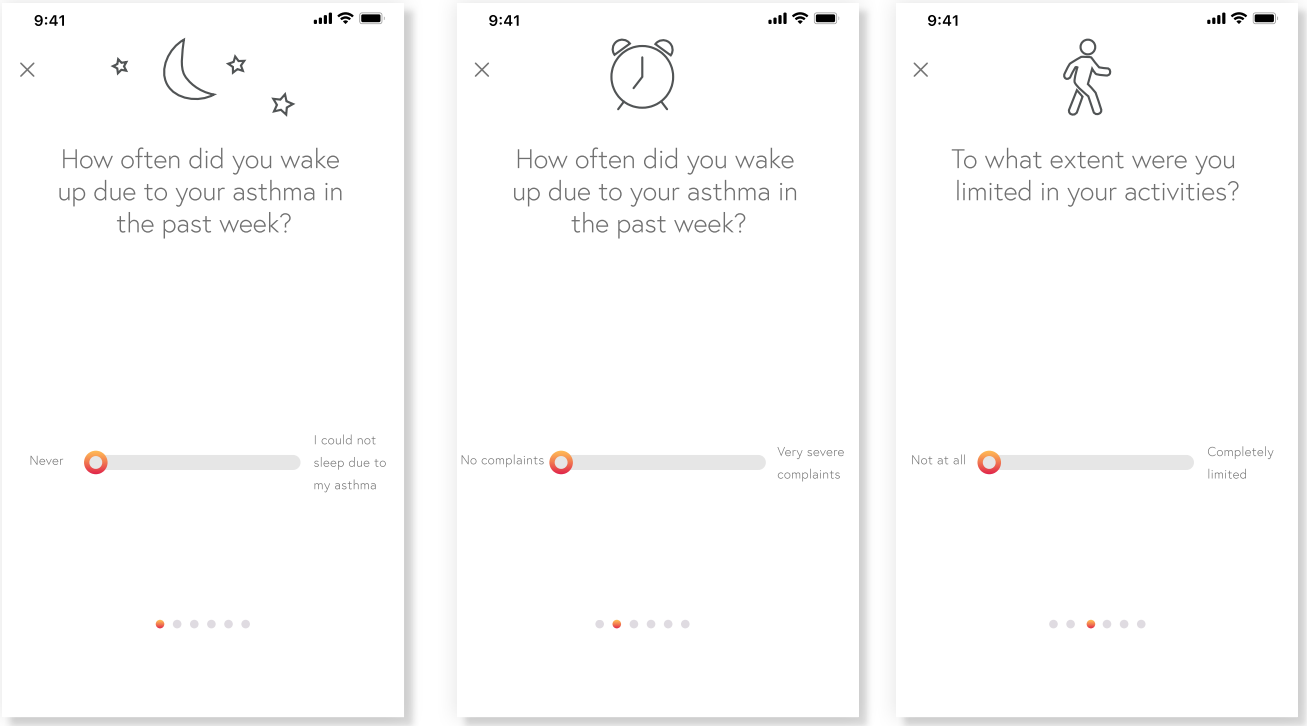


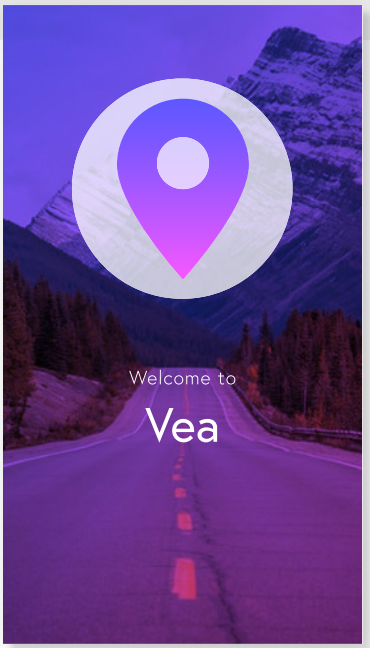
Figure 50. *Final design ACQ*

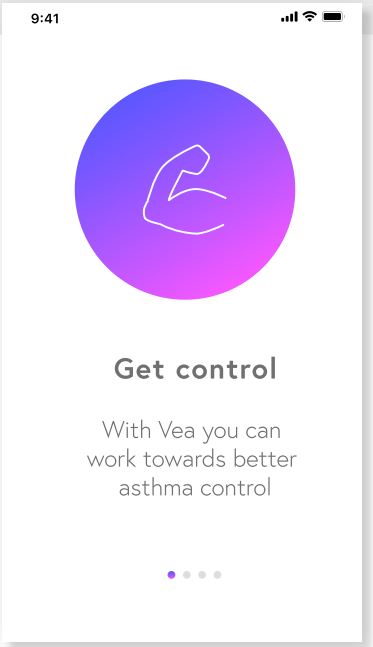
4.3 Final features of the app

The previously explained steps eventually lead to the final design. This section will demonstrate the main features of the app, using the final designs of the screens. For a complete overview of the features and designed screens, please refer to Appendix 11.9.

Onboarding process

When the user opens the app for the first time, they enter the onboarding feature of the app. This onboarding feature consists of two parts. In the first part, the goal of the app is explained in a short story; this story addresses the needs of the different types of persona, to make sure each user feels addressed.





The second part of the onboarding consists of a personalization questionnaire. Through this questionnaire, the app checks which persona best represents the user's attitude. Besides defining the persona, the app also collects some basic information about the user, such as his or her name. The app will use this information for personalization. For the full onboarding process and the personalization questionnaire, please refer to Appendix 11.7.

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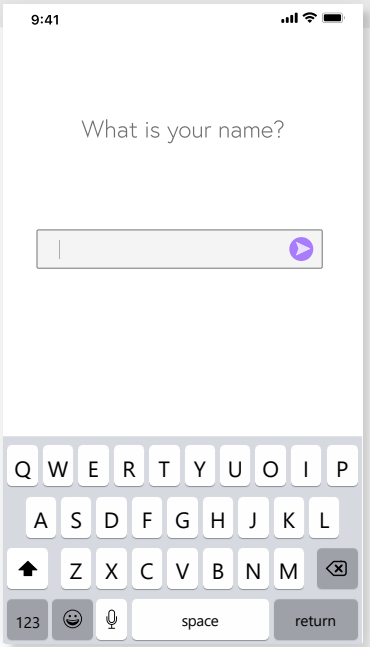
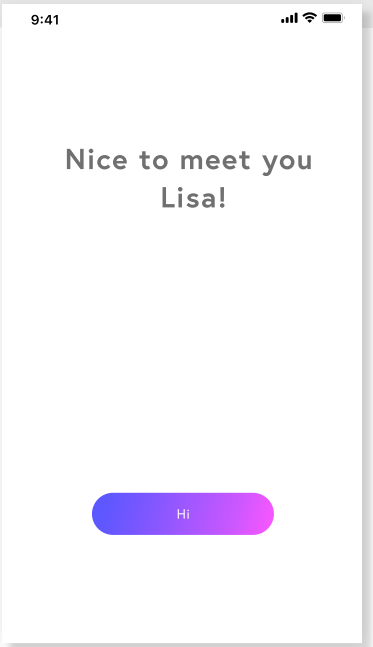
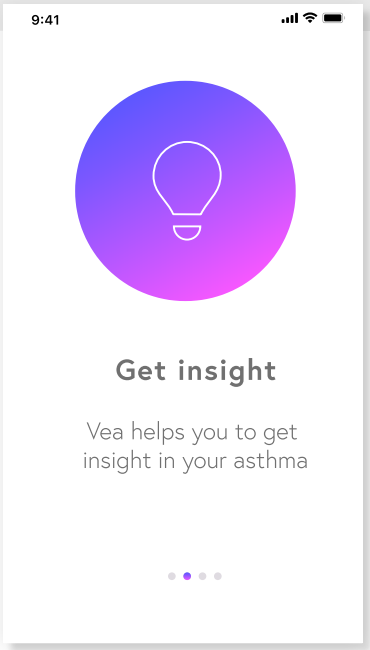
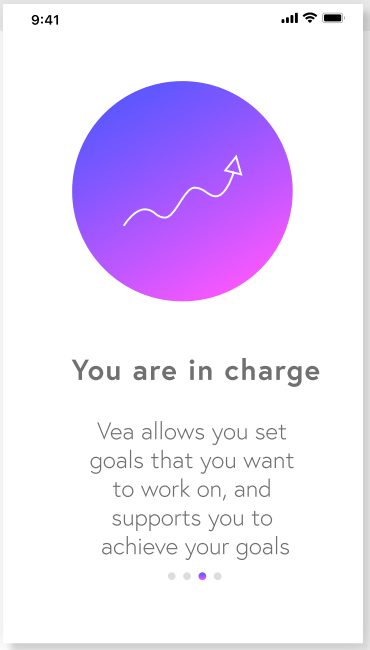
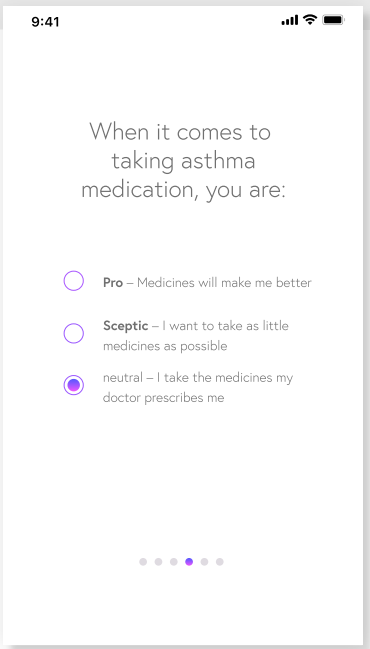
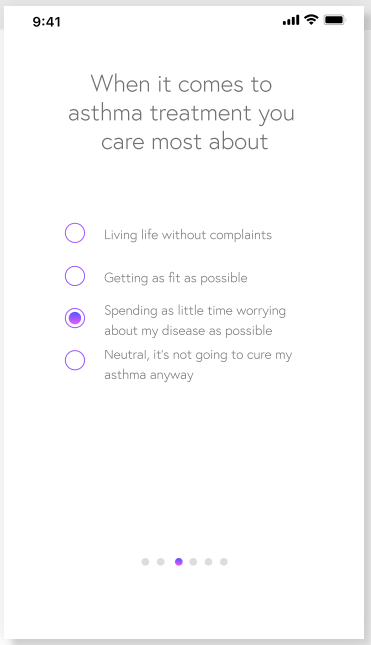


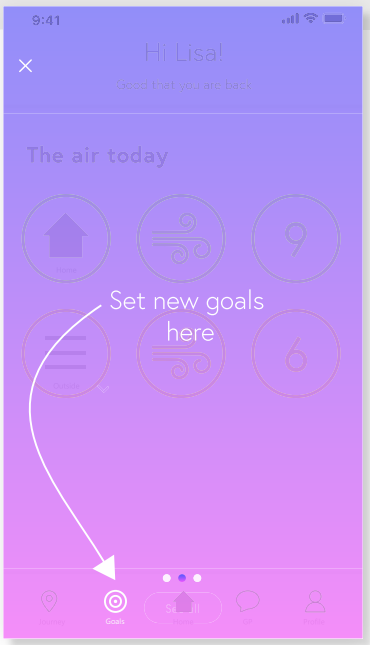



9:41
Get insight
Vea helps you to get insight in your asthma


9:41
You are in charge
Vea allows you set goals that you want to work on, and supports you to achieve your goals


9:41
When it comes to taking asthma medication, you are:
Pro – Medicines will make me better
Sceptic – I want to take as little medicines as possible
neutral – I take the medicines my doctor prescribes me

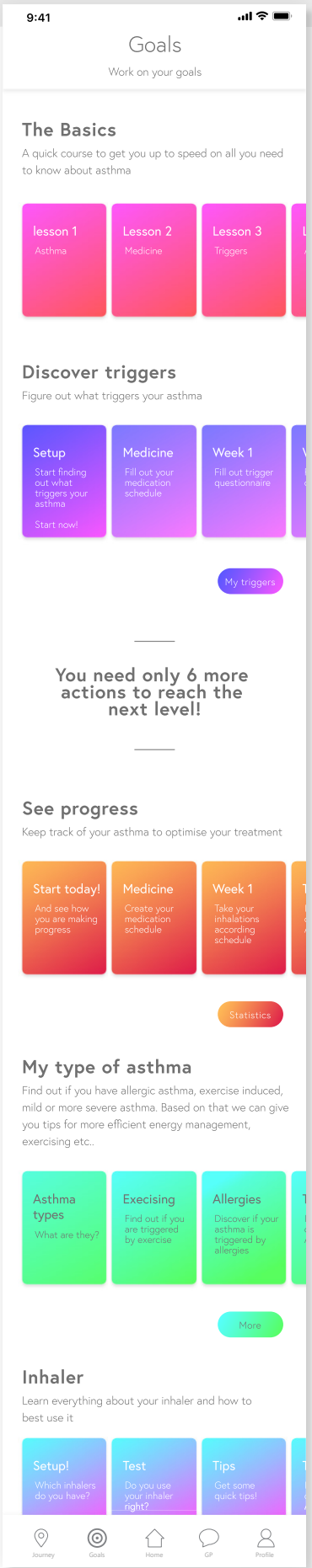

9:41
When it comes to asthma treatment you care most about
Living life without complaints
Getting as fit as possible
Spending as little time worrying about my disease as possible
Neutral, it's not going to cure my asthma anyway

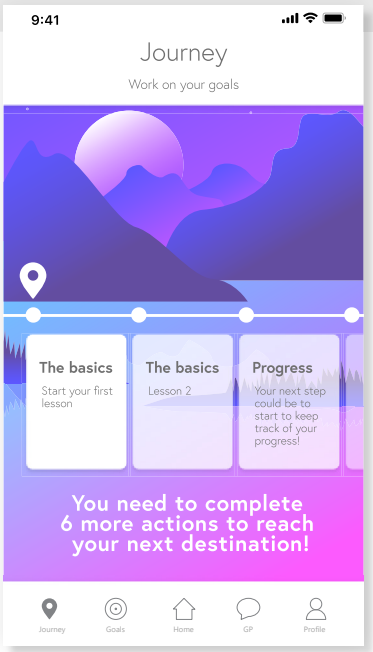

9:41
Hi Lisa!
The air today
Set new goals here

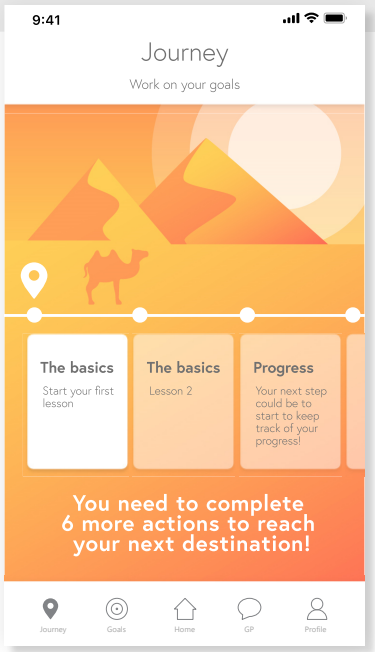
Setting goals and the journey

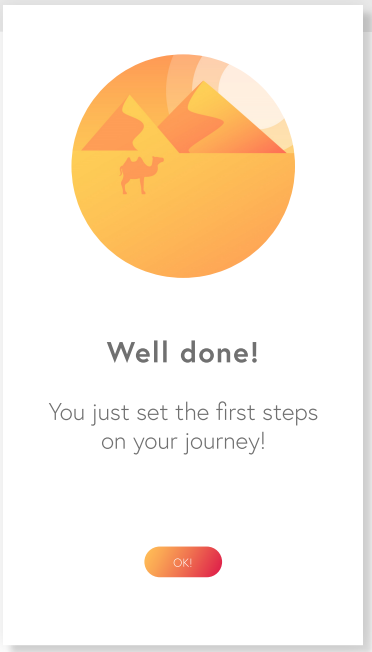
The primary function of the app is enabling the user to set goals. Under the tap "goals," an overview of the different goals that the asthma patient can work on can be found. Each goal is split up in little blocks, called action blocks. Each action block representing a small set of actions that are required when working on the goal. The user can scroll through the blocks to see the actions that need to be completed to complete the goal. The blocks that the user is working on and the blocks that he or she has completed appear on their "journey" in the journey tab. Here the user can see which achievements they have accomplished, and how many steps they need to take to reach the next journey location.

The journey is a metaphor for the road towards better asthma control, and each step is an achievement related to their self-management.






9:41
Journey
Work on your goals
The basics
Start your first lesson
The basics
Lesson 2
Progress
Your next step could be to start to keep track of your progress!
You need to complete 6 more actions to reach your next destination!
Journey
Goals
Home
GP
Profile


Well done!
You just set the first steps on your journey!
OK!

Discover triggers

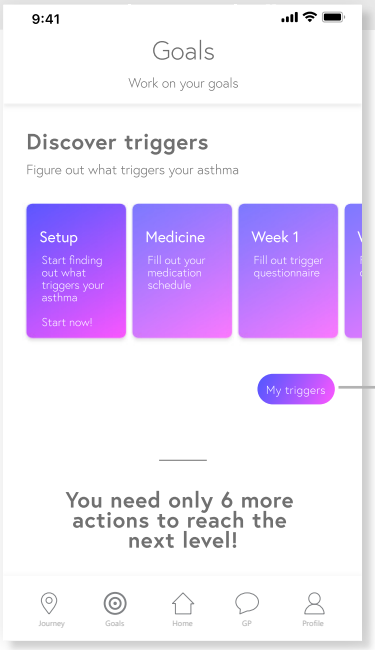
For asthma patients, it can be quite a hassle to discover what triggers their asthma. There are several reasons for this. First of all, this is because there are many different triggers, almost too many to be aware of (see Appendix 11.8). Besides a large number of triggers, triggers are also very personal, and different for each patient.

Furthermore, discovering triggers requires quite some awareness. However, most asthma patients do not want to think of their disease all the time, and have trouble remembering what triggered their asthma the last time. All this leads to frustration, unawareness, and acceptance of asthma complaints.

To solve these problems, the function "discover triggers" was designed. This function educates users about triggers, helps to discover triggers, and gives personalized advice and alerts based on the user's triggers.

Onboarding

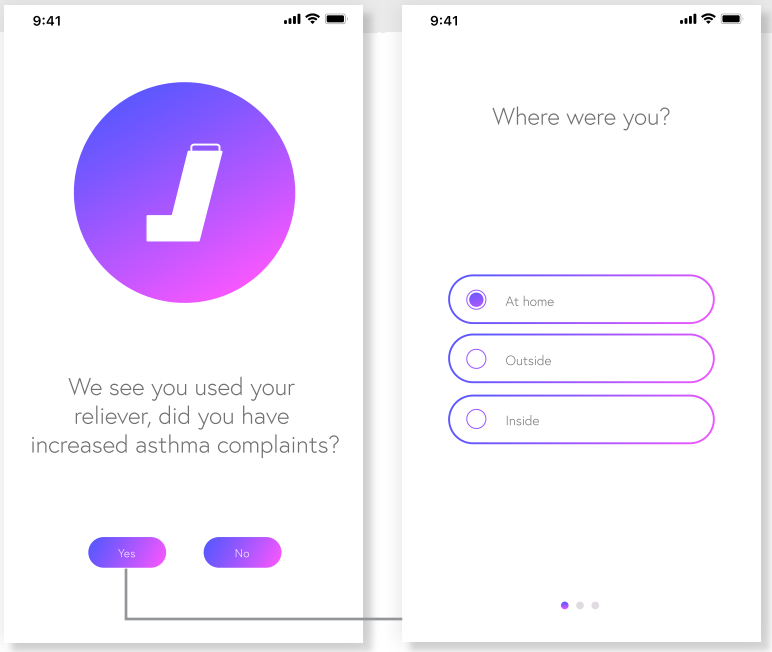
Upon first entering the goal, the user enters the onboarding process. In this onboarding, the user gets a little introduction to the goal; it explains why it is relevant to them, followed by an animation that educates on triggers. After that, the app tells the user what effort is required to achieve the goal.

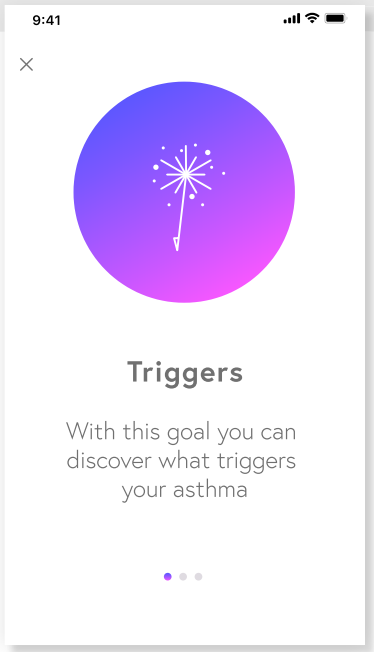


Scenario

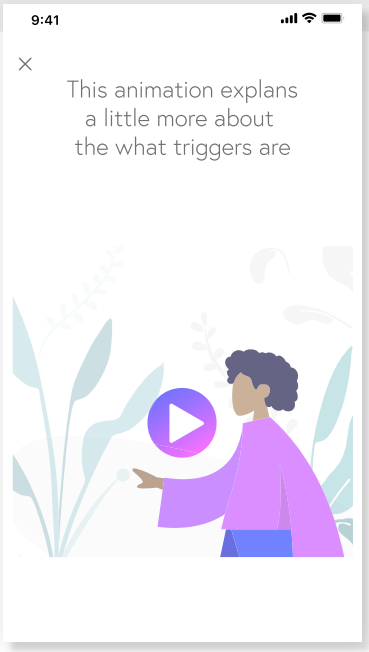
When setting up the app, the user can connect his or her inhalers and set up a medication schedule. By using this schedule, the app knows when the user uses the reliever medication off schedule. In the case of unscheduled medication use, the app will ask if the user had increased complaints. If this is the case, the user can take the trigger questionnaire to discover the cause of these complaints. The app identifies possible triggers based on the answers in the trigger questionnaire.

Additionally, the app imports data from air quality apps and the physical device. Appendix 11.8 shows the full flowchart that is used in the trigger questionnaire.

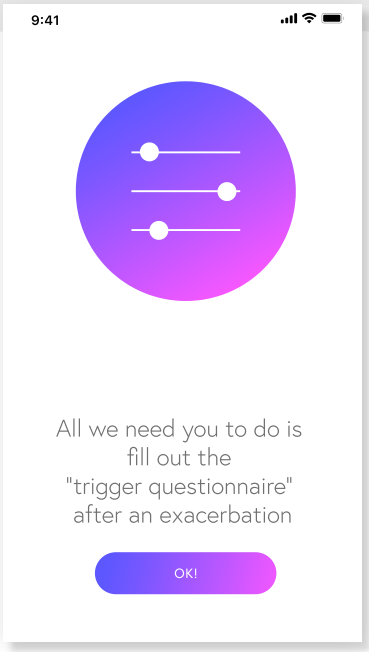




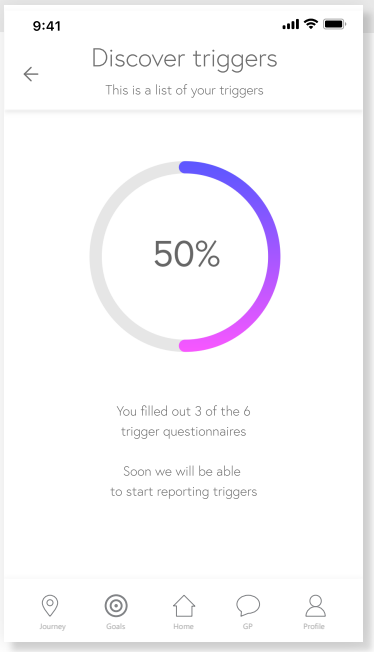
What & why

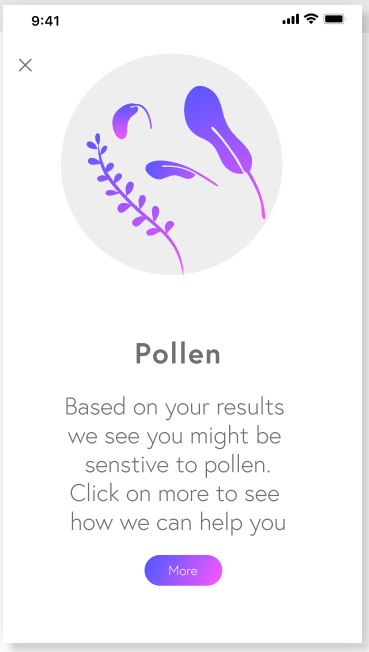


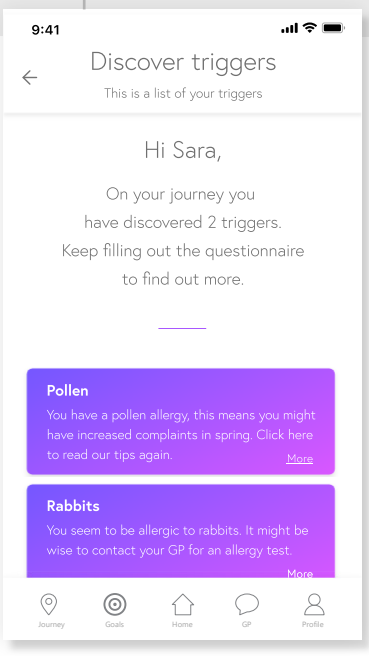
Education



How (what effort is required)







Discovering triggers

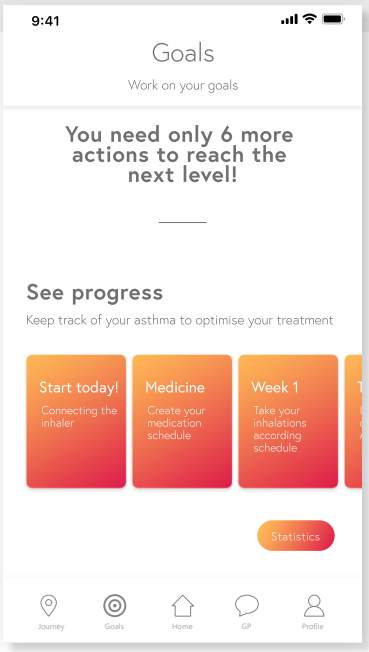
If the user has filled out the questionnaire five times or more, the app can start discovering triggers. Each reported trigger comes with some education and practical tips for actions that the user can undertake to avoid, or deal with the trigger.

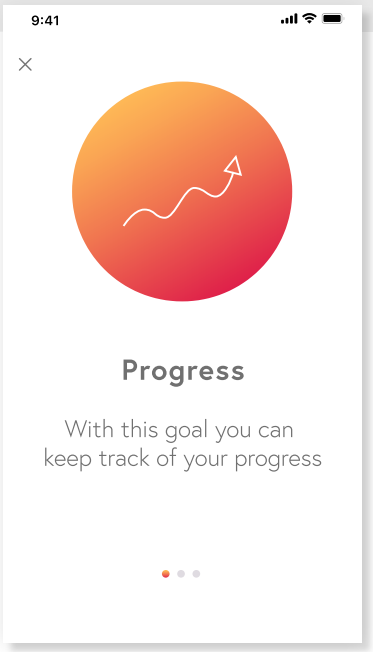
See progress

The analysis has shown that asthma patients often forget to take their medicine. Also, they have difficulties in estimating how adherent they are. On top of that, most asthma patients either under- or overestimate their level of asthma control. Together these errors can have severe consequences for the asthma patient.

In addition to the above mentioned unintentional errors, users also intentionally stop taking their controller medicine due to a lack of direct feedback, and a lack of long-term feedback.

The goal "see progress" was created in response to these problems. The goal educates the asthma patient on medication and it enables them to set reminders so they will not forget their medication. On top of that, it increases their insight through long- and short-term feedback.





What

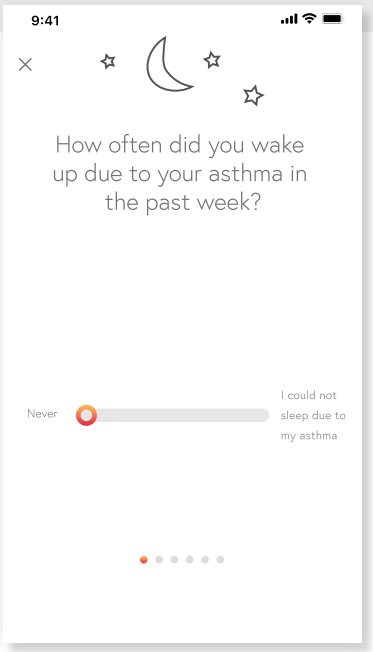
Onboarding

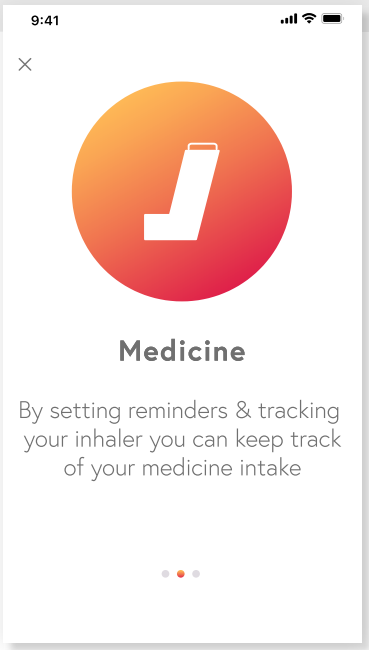
Upon first entering the goal, the user gets into a similar onboarding process to "discover triggers." The app explains what the goal is, why it is relevant, and the user is educated on the role of medication in asthma treatment.

Scenario

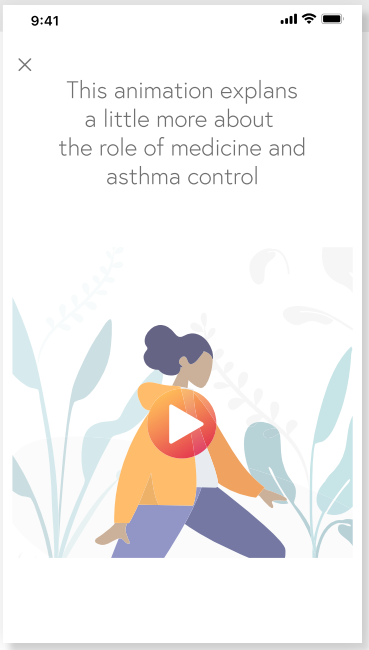
The app automatically tracks how adherent the user is. It provides the user with feedback on their adherence, and the user can see how adherent they are per day/week/month/year. Also, the user has the option to set reminders for their medication. The analysis phase demonstrated that providing these features can increase adherence by up to 50%.

In addition, the app asks the user to fill out the ACQ weekly. By keeping track of both the adherence and the ACQ, the app can demonstrate relations between non-adherence and decreasing asthma control (long term feedback). At last, the app will also provide the asthma patient with direct feedback on their adherence. It will reward the patient's adherence, and ten days of perfect adherence in a row will result in getting one step further in the journey.

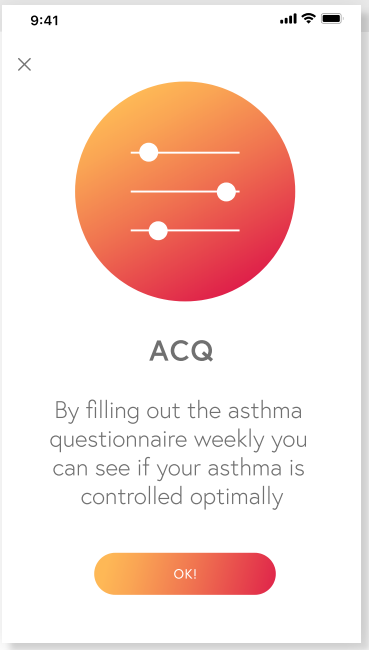




Why



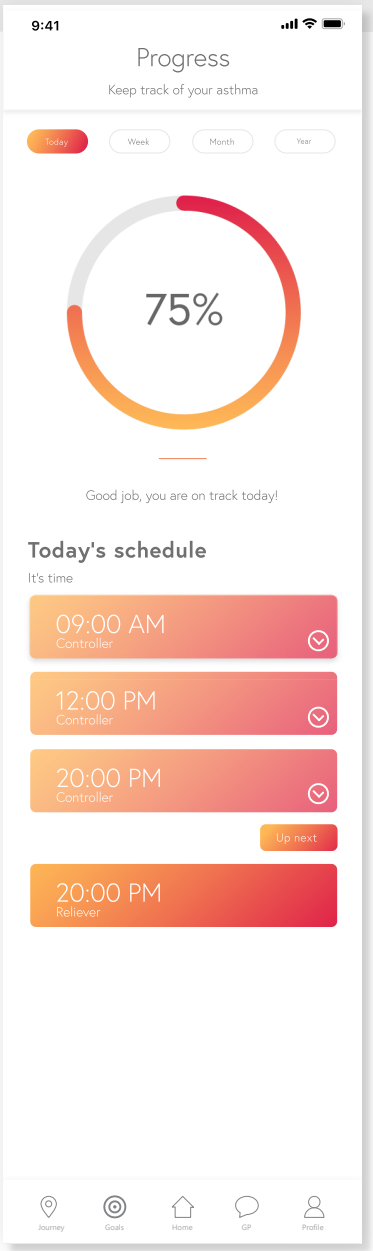
Education



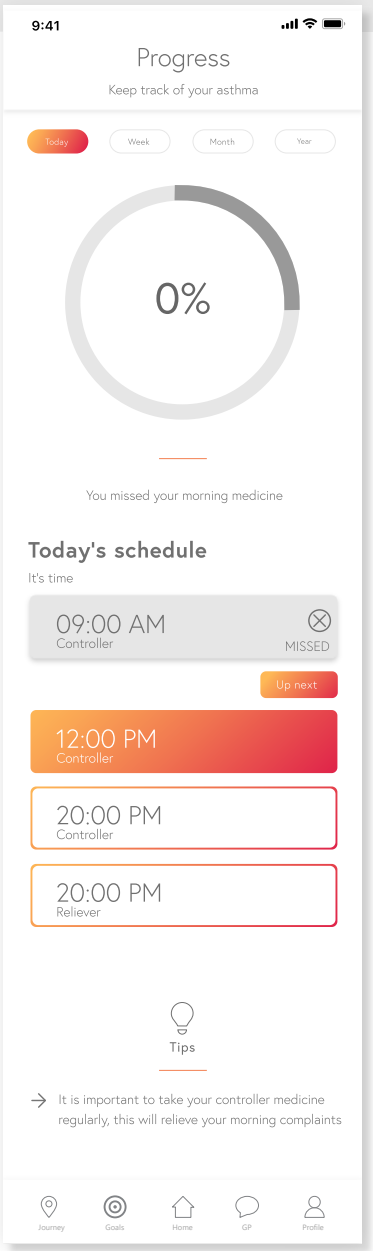
How (what effort is required)

Insight

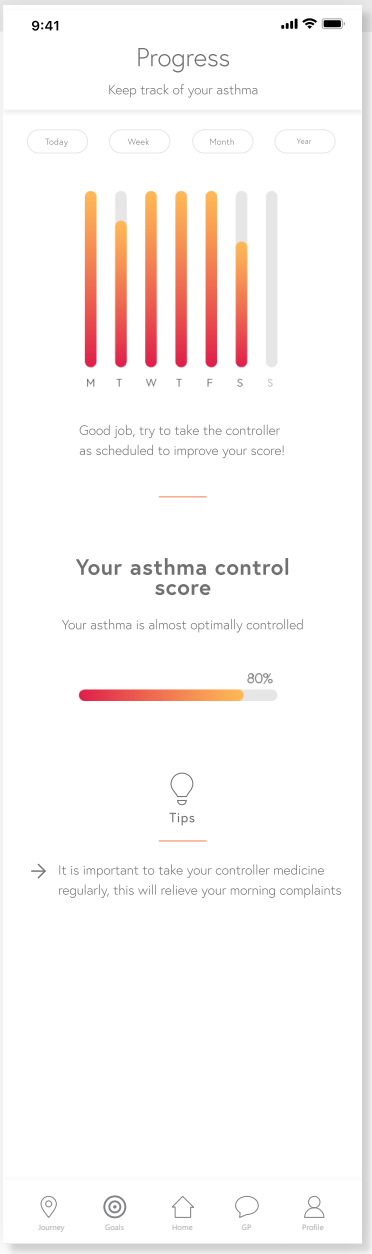
In order to optimally increase the user's insight, their data is presented visually, using graphs. The graphs are also translated into text that explains what they see. Using the results of the ACQ the personal relevance of the data is increased. For example, the app tells them, "your night waking due to asthma might decrease if you take your medicine as prescribed." At last, to increase the patients competence, they are provided with concrete tips on how to act on their progress (under the lightbulb icon).



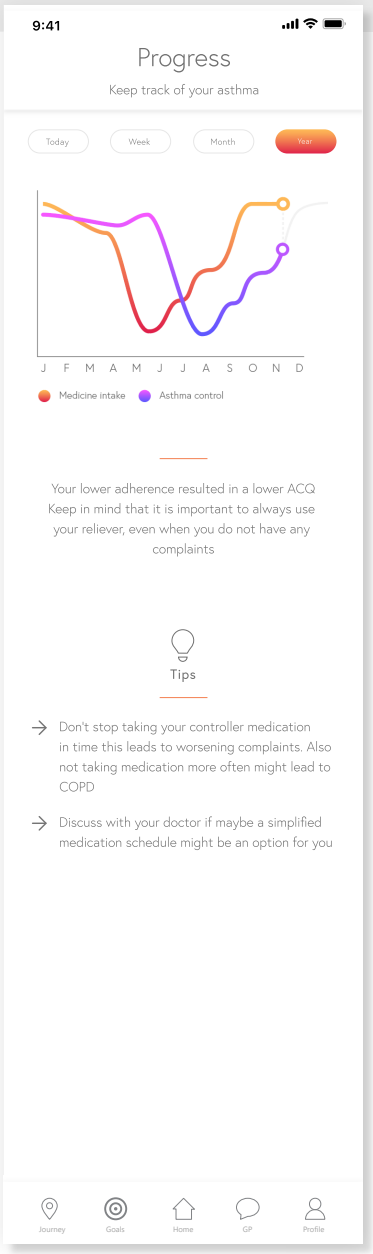
Direct feedback



Direct feedback



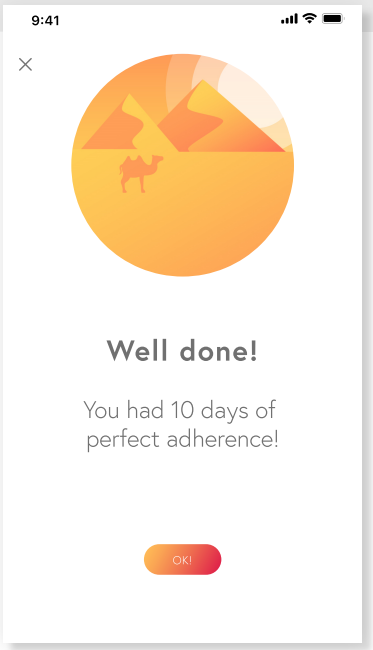
Direct feedback



Long term feedback

Increase insight through graphs & text

Increase competence by providing tips



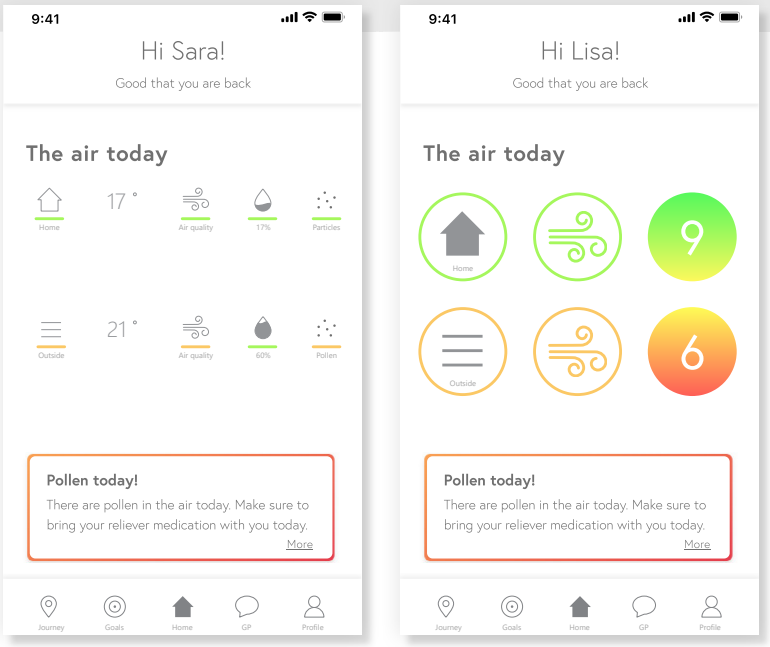
Direct feedback

Homepage

The landing page is the homepage of the app. The main goal of this screen is to give the user a quick overview of the essential information. On the top, it displays the personalized predicted air quality of that day, below that it shows tips based on the air quality, if applicable.

Further below, it shows suggestions for goal-related actions that can be taken, and on the bottom the user's next scheduled inhalation is displayed.

The homepage differs for the different personas. Below this personalization is further explained.

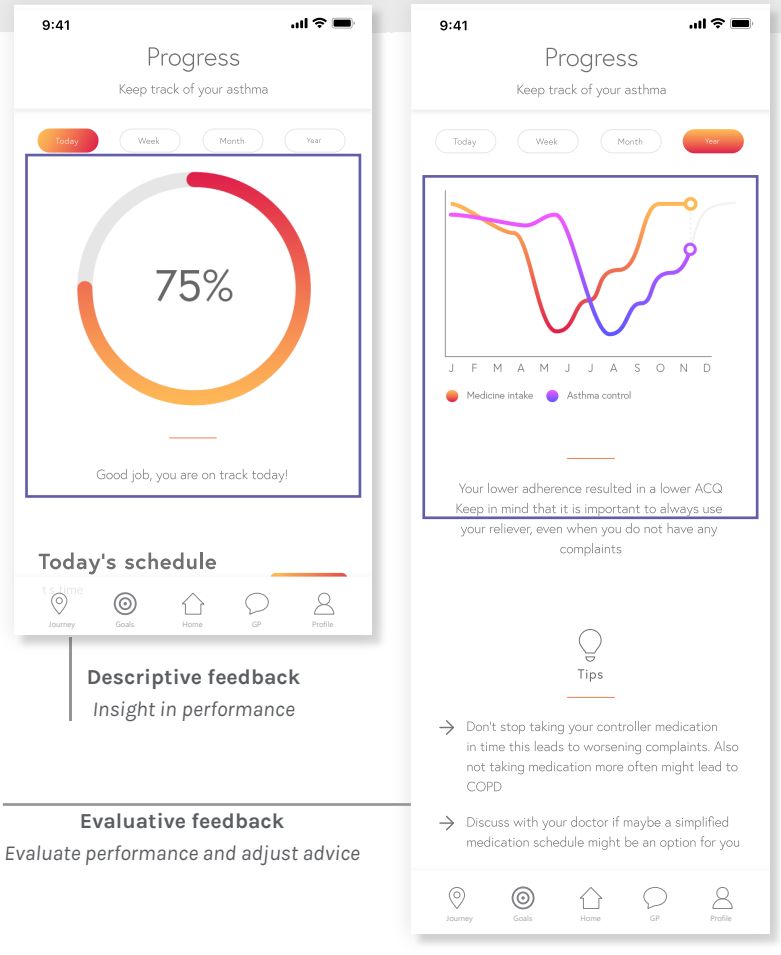


Personalization

At last, an essential feature of the app is personalization. As mentioned in section 4.2, the app applies two types of personalization; tailoring content and tone of voice.

Tailoring content

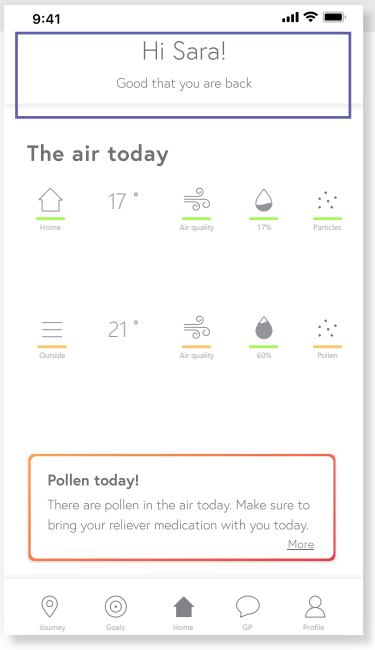
The content of the app will be personalized to optimally stimulate the information processing by the user. This content tailoring will be done using the three types of tailoring as described by Hawkins and colleagues; personalization, feedback, and content matching (Hawkins et al., 2008). On this and the following page these principles are demonstrated, for a more elaborate explanation, please refer back to the section *personalizing the design* in chapter 4.2.



Descriptive feedback
Insight in performance

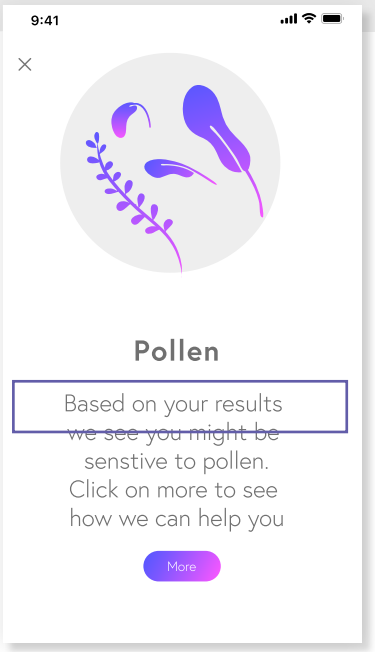
Evaluative feedback
Evaluate performance and adjust advice

Personalization



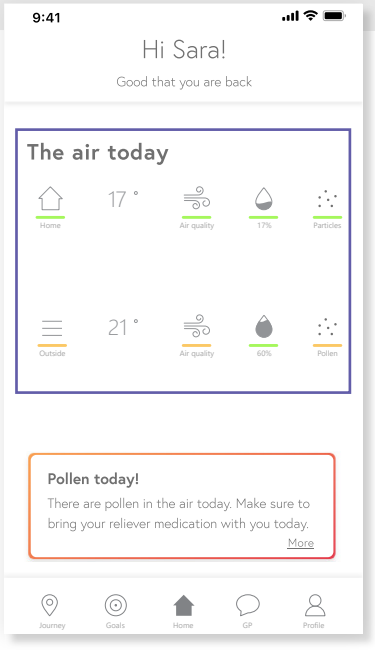
Identification

adressing user by name



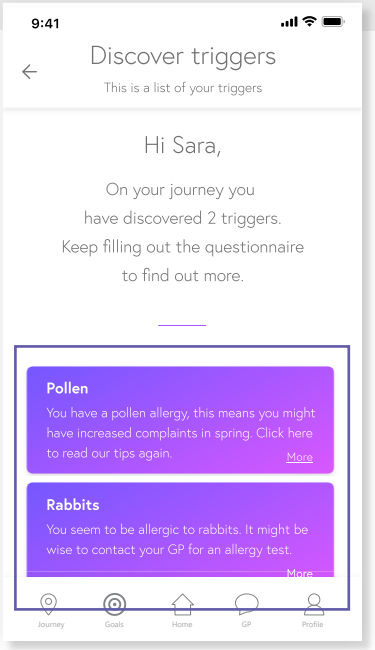
Raising expectation of customization

Letting the user know content is created especially for them



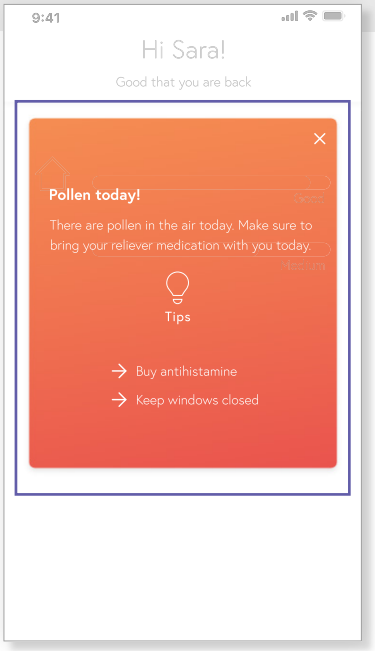
Content matching

Your personal air quality score



Content matching

Relevant information on your personal triggers

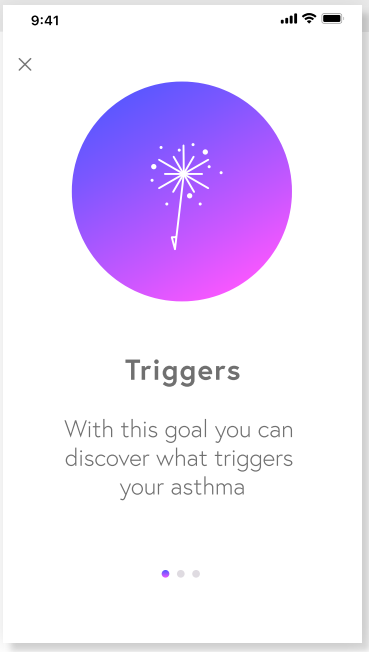


Content matching

Relevant information on your personal triggers

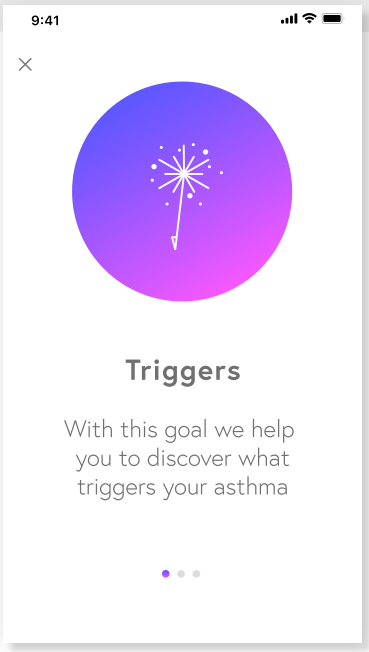
Tone of voice

As described in the section personalization, a table was made defining the different approaches for both the passive and the curious persona. On the right some examples are shown on how the tone of voice and depth of information varies between the personas.



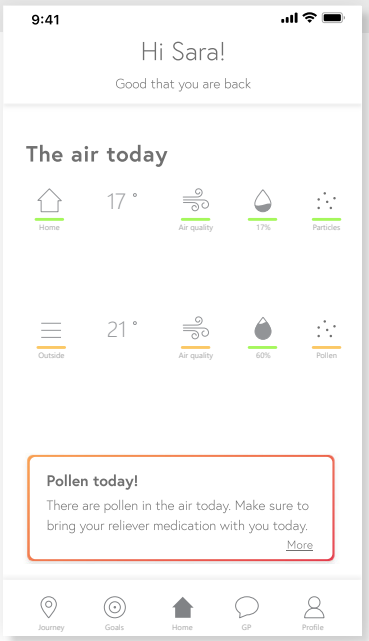
Curious: autonomy

You can...



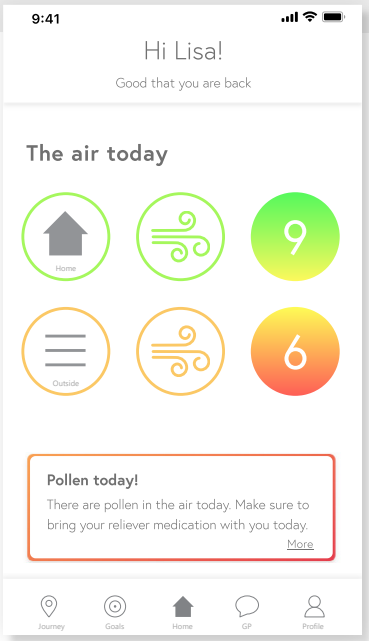
Passive: support

We will help



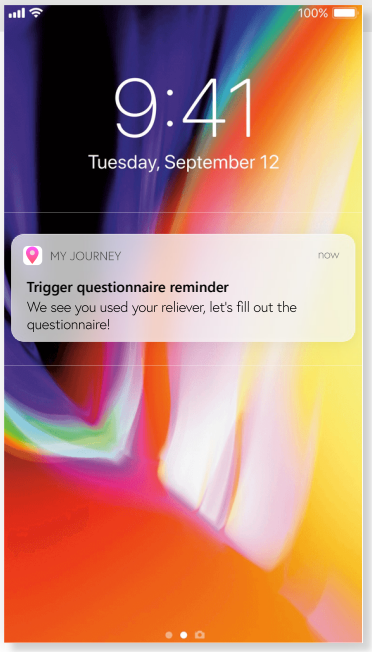
Curious: More detail

User is curious and wants to know all there is to know

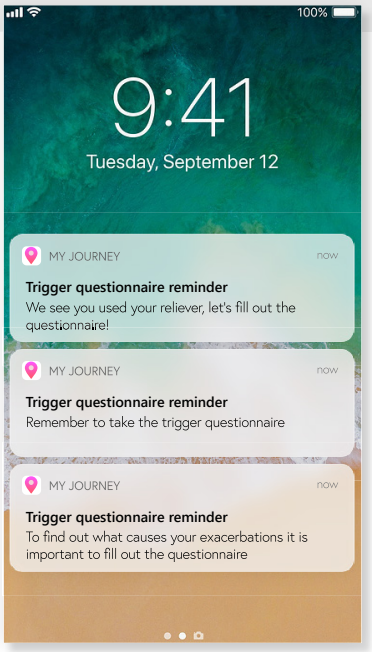


Passive: quick overview

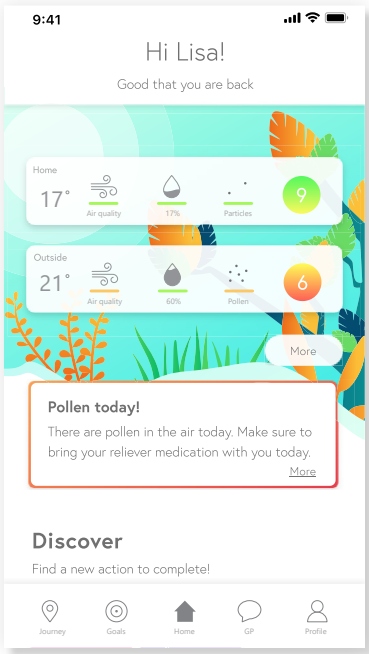
The passive prefers clear instructions, can click on more, if he/she wants to



Curious: *one reminder*



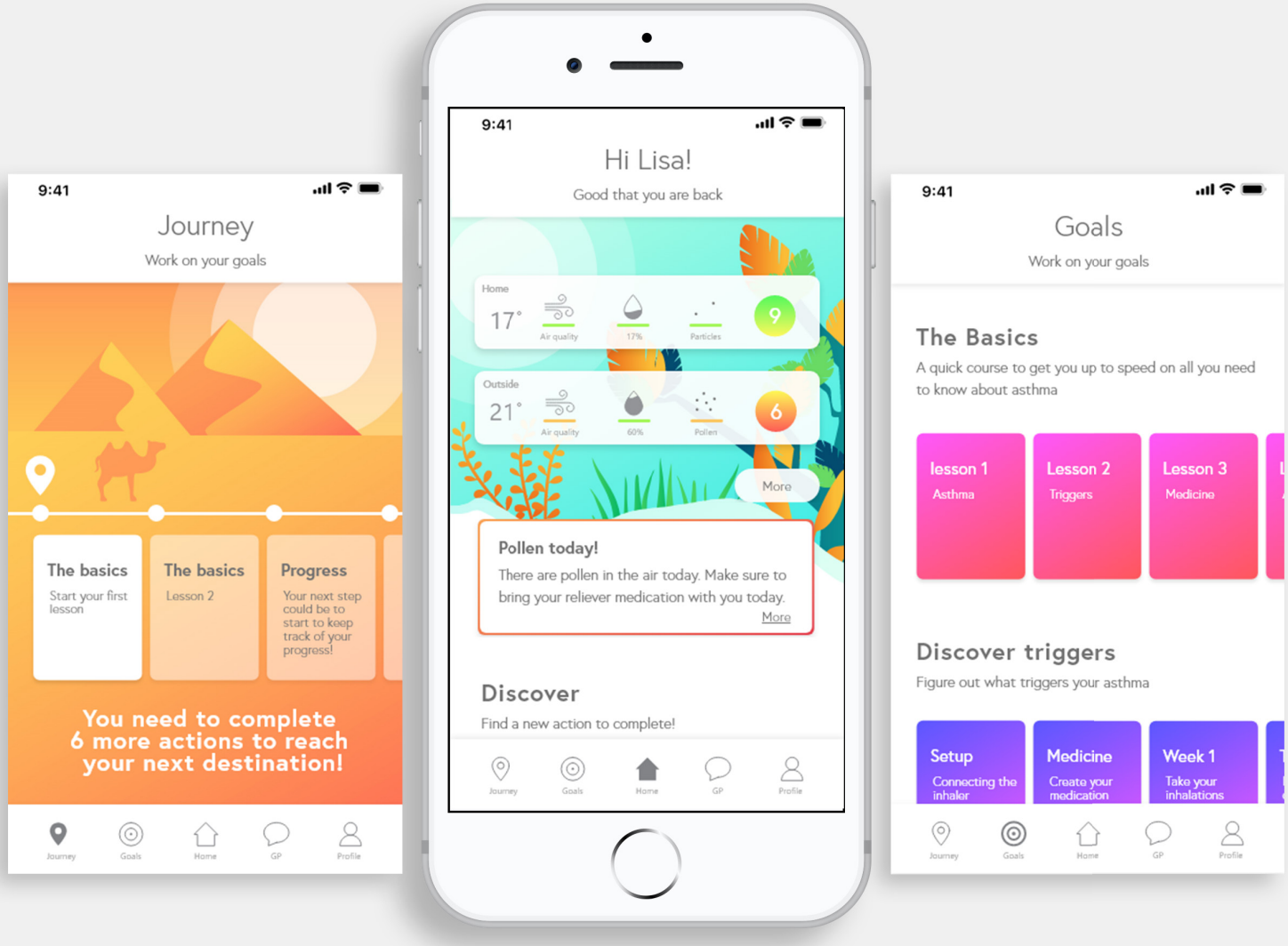
Passive: *multiple reminders*
Slowly more persuasive reminders are sent

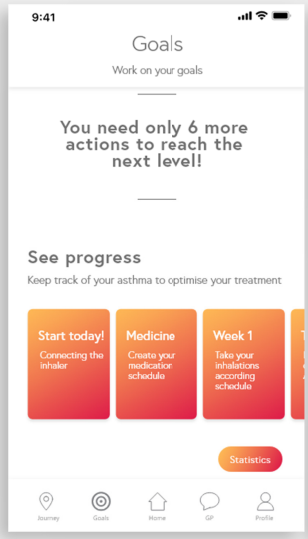


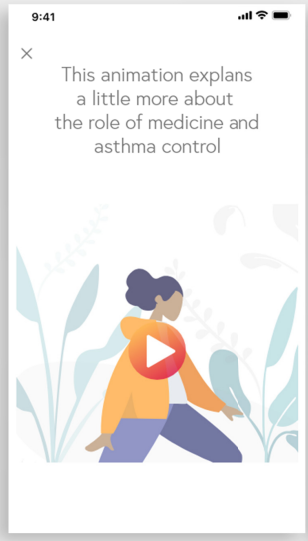
Final home page

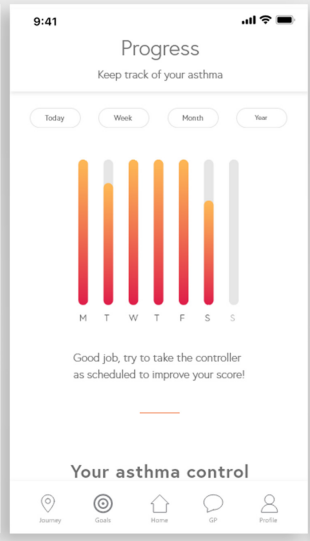
Based on the user research that was performed in the section "Patient evaluation" several changes were made to the home page.

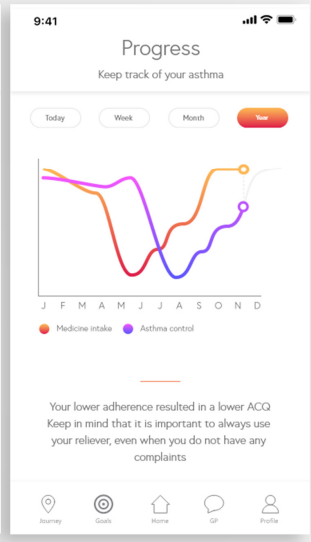
It was concluded that a combination of both screens was best. Patients wanted to see the number that rates the air quality at a glance. At the same time they want to be able to see at a glance why the air gets a certain number. Also the patients missed some color, as the rest of the app contains lots of visuals an colors.

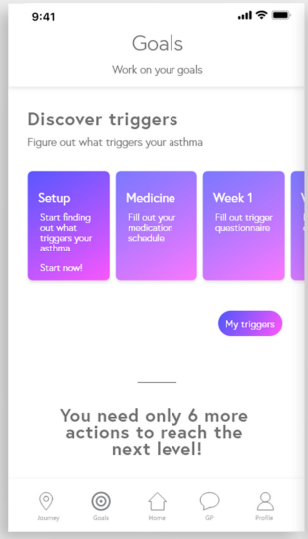

9:41
Journey
Work on your goals
The basics
Start your first lesson
The basics
Lesson 2
Progress
Your next step could be to start to keep track of your progress!
You need to complete 6 more actions to reach your next destination!
Journey
Goals
Home
GP
Profile
9:41
Hi Lisa!
Good that you are back
Home
17°
Air quality
17%
Particles
9
Outside
21°
Air quality
60%
Pollen
6
More
Pollen today!
There are pollen in the air today. Make sure to bring your reliever medication with you today.
More
Discover
Find a new action to complete!
Journey
Goals
Home
GP
Profile
9:41
Goals
Work on your goals
The Basics
A quick course to get you up to speed on all you need to know about asthma
lesson 1
Asthma
Lesson 2
Triggers
Lesson 3
Medicine
Discover triggers
Figure out what triggers your asthma
Setup
Connecting the inhaler
Medicine
Create your medication
Week 1
Take your inhalations
Journey
Goals
Home
GP
Profile

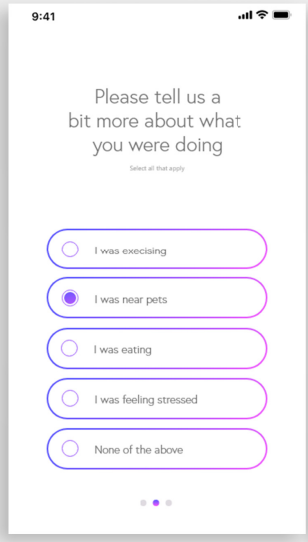

9:41
Goals
Work on your goals
You need only 6 more actions to reach the next level!
See progress
Keep track of your asthma to optimise your treatment
Start today!
Connecting the inhaler
Medicine
Create your medication schedule
Week 1
Take your inhalations according schedule
Statistics
Journey
Goals
Home
GP
Profile

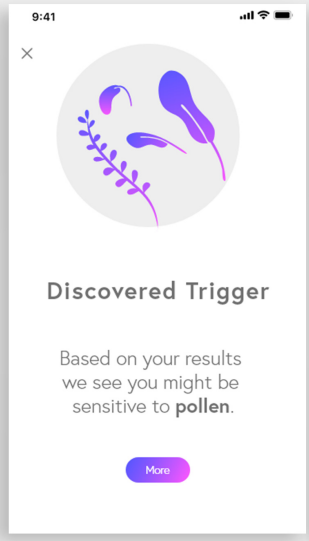

9:41
This animation explans a little more about the role of medicine and asthma control

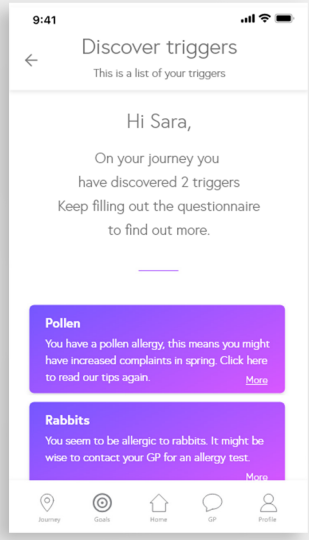

9:41
Progress
Keep track of your asthma
Today
Week
Month
Year
M T W T F S S
Good job, try to take the controller as scheduled to improve your score!
Your asthma control


9:41
Progress
Keep track of your asthma
Today
Week
Month
Year
J F M A M J J A S O N D
Medicine intake
Asthma control
Your lower adherence resulted in a lower ACQ
Keep in mind that it is important to always use your reliever, even when you do not have any complaints


9:41
Goals
Work on your goals
Discover triggers
Figure out what triggers your asthma
Setup
Start finding out what triggers your asthma
Start now!
Medicine
Fill out your medication schedule
Week 1
Fill out trigger questionnaire
My triggers
You need only 6 more actions to reach the next level!


9:41
Please tell us a bit more about what you were doing
I was exercising
I was near pets
I was eating
I was feeling stressed
None of the above


9:41
Discovered Trigger
Based on your results we see you might be sensitive to pollen.
More


9:41
Discover triggers
This is a list of your triggers
Hi Sara,
On your journey you have discovered 2 triggers
Keep filling out the questionnaire to find out more.
Pollen
You have a pollen allergy, this means you might have increased complaints in spring. Click here to read our tips again.
More
Rabbits
You seem to be allergic to rabbits. It might be wise to contact your GP for an allergy test.
More

4.4 General practitioner interface

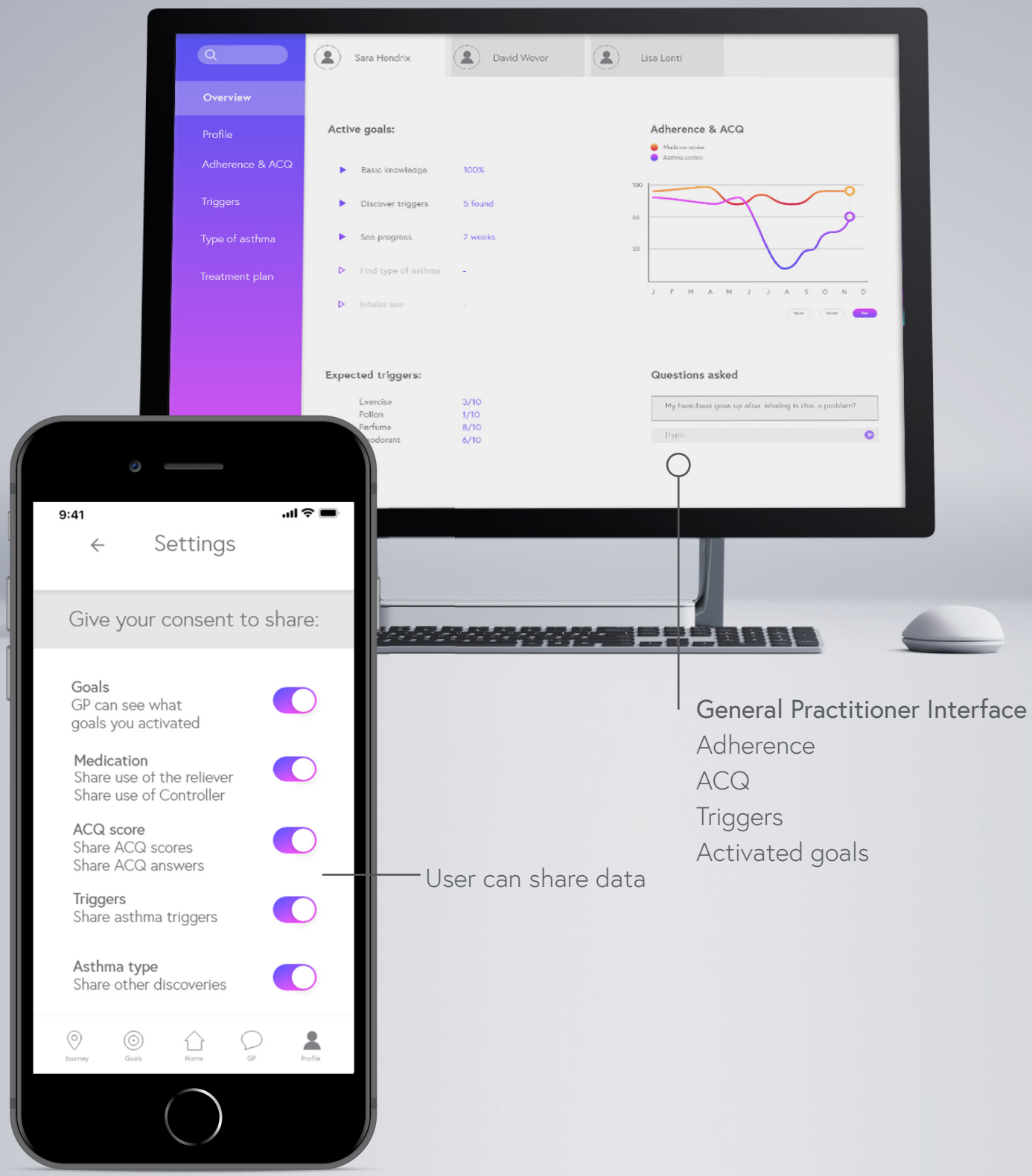
A specific request by CAHAG was to implement a link to the general practitioner into the design. Their wish was to enable the GP to better adjust the treatment of the patient.

To do so, it was decided to develop an interface for the GP as well. Upon approval by the patient, the data that the app gathers is sent to the GP interface.

In the screen, on the right page, this interface can be seen. The interface enables the GP to get insight into the patient's progress. The GP can see the level of adherence, the scores of the ACQ, and the discovered triggers.

Especially the graph that demonstrates the patient's adherence and ACQ scores could support the GP to adjust the treatment of the patient optimally. The graph can provide them with insight into the severity of the patient's asthma and their level of asthma control.

The interface on the right is a suggestion of what this interface could look like; the interface should eventually be integrated into the computer system of the GP to prevent the GP from having to download and login into a separate tool.



General Practitioner Interface
Adherence
ACQ
Triggers
Activated goals

User can share data

4.5 Physical design

This section describes the development of the physical design towards the final design proposal. The process of developing the physical design has not been linear and went back and forth in between iterations. For simplicity and to make the process understandable, this report portrays a linear representation of the development process.

Interface

In the section "features of the physical" design, the primary function of the physical design was established, and some requirements for the interface were set. These requirements are:

- The interface should be easy to understand.
- The interface should be readable from a distance.
- The interface should communicate inside air quality (good/bad).
- The interface should communicate outside air quality (good/bad).
- The interface should communicate actions required in the app.
- The interface should be able to alert the patient.

To develop an interface that satisfies these requirements sketches were made, also some small paper prototypes were made to test out the readability and possible interactions with the design. Figure 52 - Figure 55 give an impression of the design process. It was decided to go for a minimalistic interface, to enable reading the interface at a glance. For more in-depth information, the user can refer to the app. Figure 55 demonstrates the final interface.

The user research that was performed with the interface in Figure 54 showed that the participants liked the comparison between the inside and outside air quality. However, they wondered whether they could get a little more information than "good" or "bad". Therefore, another iteration was done on the interface. The final interface implements RGB LEDs that can display the air quality using a range of light from green to red. Figure 55 demonstrates the final interface.

Figure 52. *Paper mock-ups and sketches of the interface*

Figure 53. *First version of the interface*

Figure 54. *Version 2*

Figure 55. *Final interface, with RGB LEDs that indicate air quality, and more intuitive icons*

Sensors and technology

This section is intended to explain the technologies that will be used in the physical product. The feasibility of the product is demonstrated by selecting the sensors. It is important to note that the selected modules serve as a reference; in the final design, the sensors and technologies will be ordered separately and integrated into one PCB.

Interface

It was chosen to use a luminous interface. There are two types of functions that the interface needs to perform: 1. inform the user using small lights and 2. alert the user in case of urgent matters. For the first function, it was chosen to make use of an LED matrix.

For the second function, it was chosen to implement an RGB LED ring. The picture depicts a standard round version of this led ring, for the final design the led ring should be custom made to fit the dimensions of the interface.

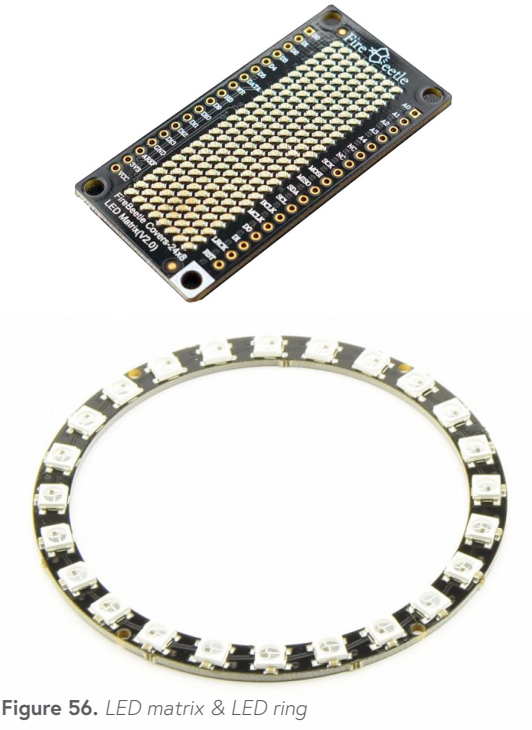


Figure 56. *LED matrix & LED ring*

User input

To give the user a sense of control and to be able to switch off the device, the user must be able to give input. There are different ways in which this input could be provided, for example, through using a capacitive sensor or a push button. It was chosen to use a push button as this gives the user tactile feedback on their actions, which is assumed to be more satisfactory than, for example, just using touch to detect input.

Figure 57. *Push button*

VOC

For the physical design, a VOC (Volatile Organic Compound) sensor will be integrated. VOCs are chemical contaminants which easily evaporate into the air. Examples of these are consumer products such as cigarettes, solvents, paints, and thinners (Tox Town, 2019). Asthmatic reactions can be triggered by high levels of VOC's in the air.

To detect these VOC's a CCS811 Gas Sensor will be integrated into the physical product. This sensor was selected because it is a very fine air quality sensor that can detect a wide range of VOCs and CO2 levels (Kiwi Electronics, 2019).

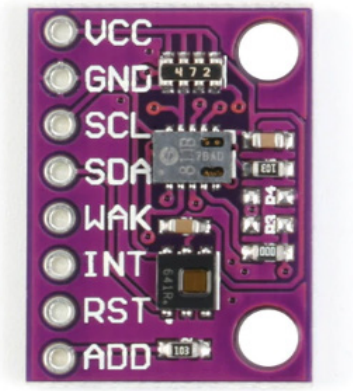


Figure 58. *VOC, temperature and humidity sensor*

Temperature & humidity sensor

The module in Figure 59 also integrates a humidity and temperature sensor. Humidity and temperature can support a healthy and pleasant environment. When suffering from asthma, possible triggers can be molds, dust mites, and pollen. Maintaining low humidity can decrease the presence of molds pollen and dust mites (AlerSense, 2019). Besides that, the integration of the humidity sensor can be used for compensation to get better accuracy of the VOC sensor (Kiwi Electronics, 2019).

Temperature can also be a trigger of asthma. Especially batches of cold air can trigger an exacerbation, but also rapid transitions in temperature, for example between inside and outside conditions. A temperature sensor was integrated to obtain insight into these triggers.

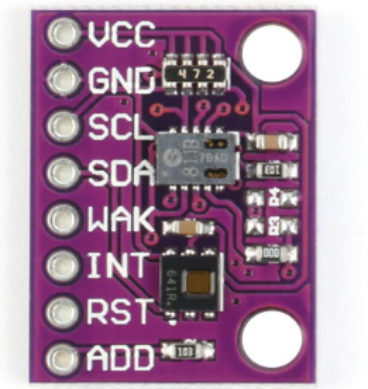


Figure 59. *VOC, temperature and humidity sensor*

Particulate matter

In addition to VOCs, the presence of particulate matter (PM) can significantly affect the air quality inside. PM can be solid particles or liquid droplets in the air. Many different airborne particles can trigger an exacerbation. Examples of these are dirt, smoke, pollution, and pet dander (US EPA, 2019). There are two main categories of particles:

- PM10: which are coarse particles with a diameter of 10 micrometers and smaller
- PM2.5: which are fine particles, with diameters of 2.5 micrometers and smaller

Coarse particulates can be molds, dust, ash, and smoke. Fine particles can be pet dander, dust mite, and other allergens.

A particle sensor was integrated that can differentiate between coarse and fine particles. It was chosen to use the GP2Y1010AU0F SHARP Dust Sensor, as it is relatively compact, and it can detect particles with a diameter of 0.8 µm and larger (Balance World Inc, 2019). A shortcoming of this sensor is that it will be challenging to identify the origin of different particulates (dust mite, pet dander, etcetera), as there are many different ones present in the house.

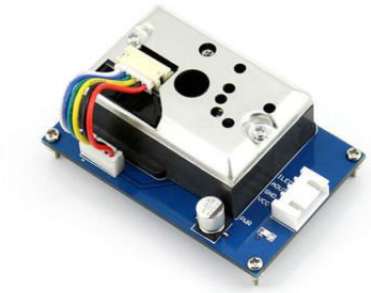


Figure 60. *Particle sensor*

Connectivity

The physical device should be able to communicate with the app to transfer the collected data. Also, it should be able to obtain commands from the app e.g., to communicate bad air quality.

For this connectivity, there are several options of which Wi-Fi and Bluetooth are the most promising ones. It was chosen to go for Wi-Fi because this allows the device also to work and communicate independently from the phone. Figure 62 provides a visual representation of the communication that will take place in the final design.

It was decided to use a Wi-Fi sensor integrated into an ESP32, as this chip is also able to collect all gathered data and to make sense of the data, additionally, it can control the LEDs.

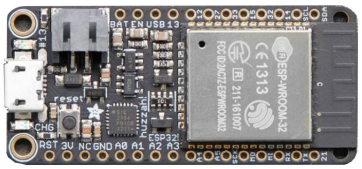


Figure 61. *WiFi & ESP32*

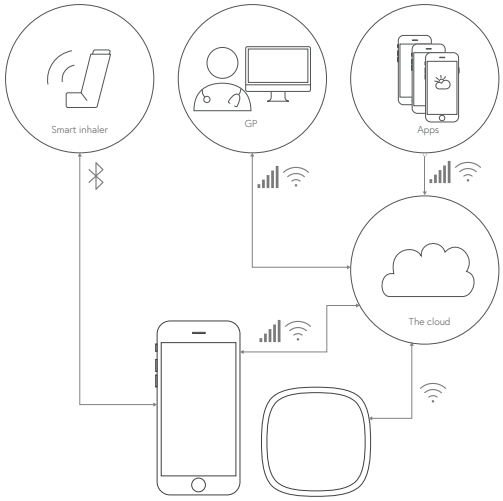


Figure 62. *Connectivity of the system*

Power

At last, the device should be foreseen with power. As the device must work wirelessly, it needs to have an integrated power source.

For this power source Li-ion batteries can be used (Figure 63) or rechargeable AAA (alkaline) batteries. The advantage of Li-ion batteries is that they can be smaller and produced at any size. For now it was chosen to use standard rechargeable AAA batteries. These batteries can be aesily replaced by the user. For future development it is adviced however to reconsider this choice, as the device can be made smaller when using a (custom made) Li-ion battery. The batteries will be charged using a micro USB-port.

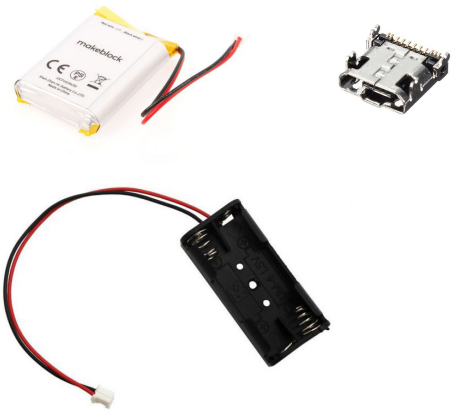


Figure 63. *Li-ion battery, micro USB-port, AAA rechargeable battery holder*

Product architecture and the final shape

Based on the selected technologies, a product architecture was determined in which optimal use is made of the space.

First, the sizes of the components were determined and cut out of paper 1:1. This was done to get a rough feeling of the size of the physical device. Next, the different components were modeled in solidworks using basic block shapes as placeholders. Based on this, the minimum required size of the physical device was determined. Based on the different configurations, shapes were sketched for the physical design. Several sketches were selected and developed into 3D models, and CNC milled on a 1:1 scale out of foam.

In total, 14 shapes were milled and used for a qualitative assessment of the forms. For this assessment, a few guidelines were set up;

- The shape should be compact.
- The shape should have a serious but slightly playful character.
- The shape should not be stigmatizing.
- The shape should match the brand personality as defined in chapter 4.2.

Figure 65 shows the CNC milled shapes and the selected shape in white. This shape(Figure 67) was used as the basis for further development.

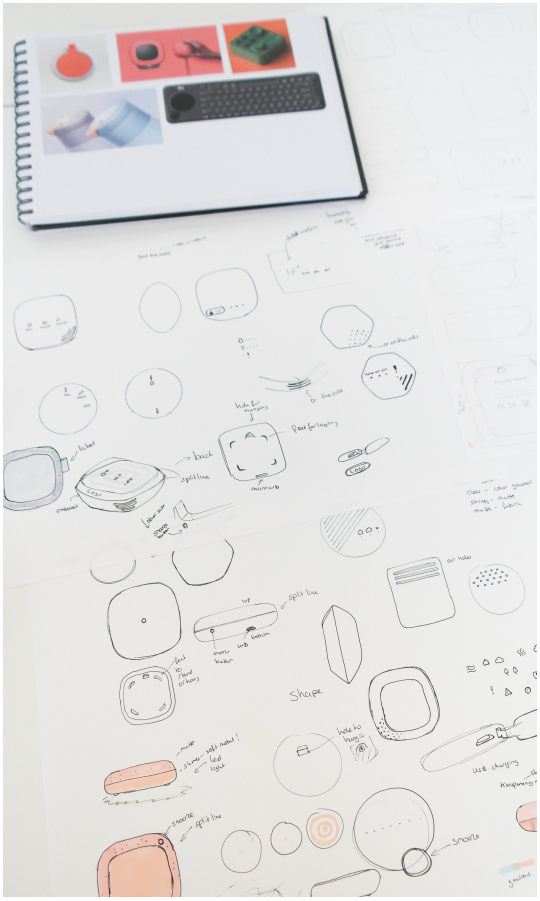


Figure 64. *An impression of the sketches that were made*

Figure 65. *CNC milled shapes and the final 3D printed shape*

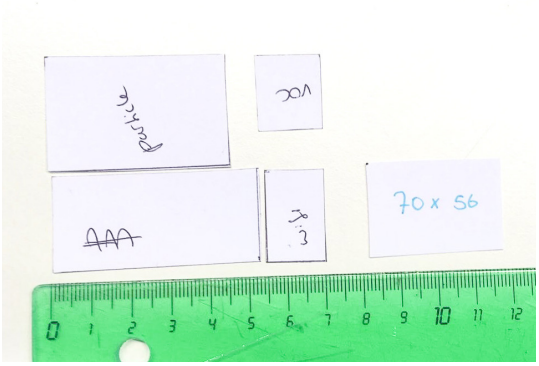


Figure 66. *Figuring out the product architecture*

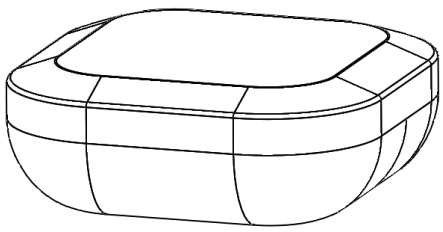


Figure 67. *The selected shape based on the foam models*

CAD detailing

After determining the shape and components, a more detailed CAD model was made for the final design. This CAD model includes the PCB and sensors. This section will discuss some details of the cad model.

Ventilation

The primary function of the physical device is to measure air quality. When doing so, there will always be some calibration time. To shorten this time and to make the device more accurate, some ventilation gaps were implemented. These allow for new air to pass the sensors.

Hanging on the wall

The device should be easy to move around the house. According to the user's preference, it can be hung on the wall or placed flat on a surface. To facilitate easy hanging a little gap was introduced to the back of the design, which fits over a small screw; this way, the device can easily be hung on the wall or taken down.

Closing mechanism

The device consists of a top and a bottom part that need to be connected. It was considered to use screws. However, the screws would be visible on the bottom, and the screws would need to be placed far to the middle of the design, which would interfere with the sensors. Therefore, it was decided to use snap-fits as these allow for easy and fast assembly and do not get in the way of the sensors.

Four snap fits were integrated. These snap fits are also used to lock the PCB into place. A disadvantage of using the snap fits is that the device is now difficult to open. However, opening the product by the consumer is not required as the battery can be charged using the micro-USB port.

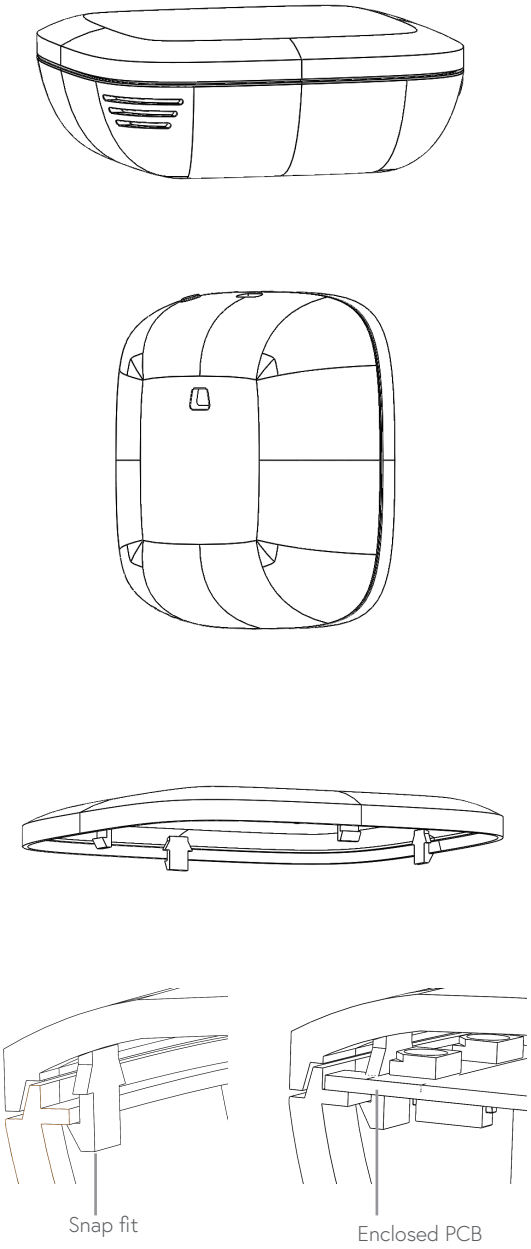


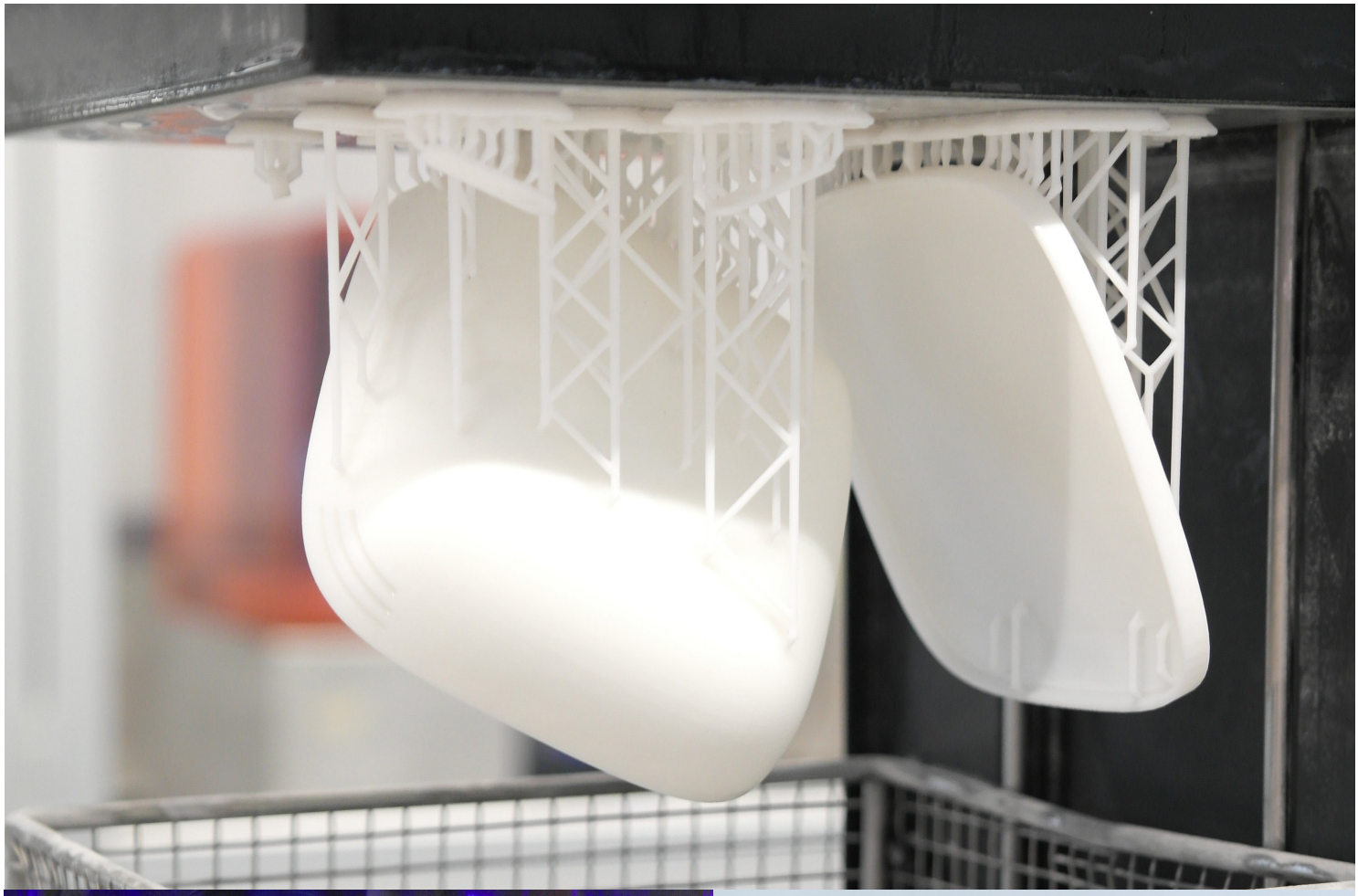
Figure 68. *CAD details*

Prototyping & CMF

Throughout the design process of the physical design, several models and prototypes were made to evaluate the shape, size, and fitting of the design (see Figure 70). For the user evaluation, also a physical model was built to give the participants a feeling of the physical object. The final prototype was made using a form 2 3D printer, and then sanded and polished.

At last, some CMF (color material finish) studies were done on the final model. The goal of these studies was to create a link between the app and the physical design and to give the design a pleasant look. As can be seen in Figure 69 several attempts were made to bring some of the gradient element of the app back in the physical product. Eventually, it was chosen to go for a white basis with an integrated logo that contains a purple gradient. It was chosen to go for white as this gives the product a rather neutral look that easily blends in into the home.

Figure 69. *CMF study*



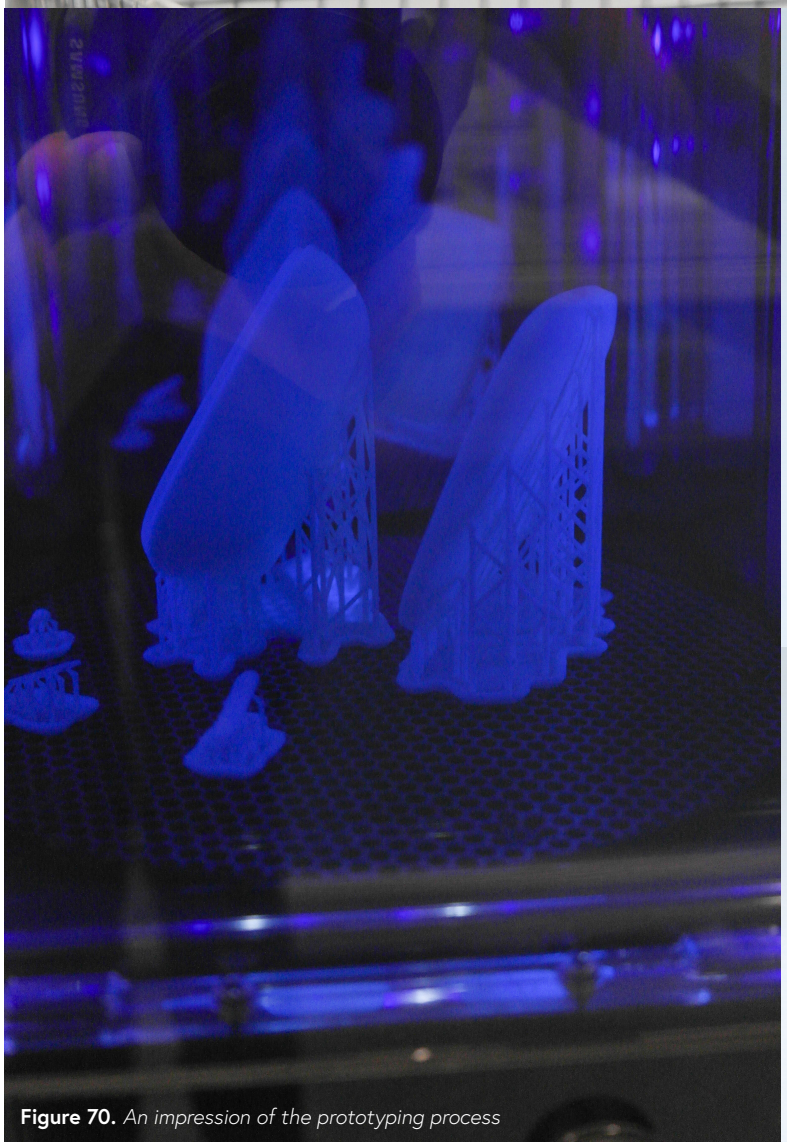


Figure 70. *An impression of the prototyping process*

4.6 Final physical design

Architecture

The architecture of the physical device is relatively simple. It consists of a top and a bottom part that are fit together using snap fits. A custom-made PCB that can be ordered separately is sandwiched in between and held down by the snap fits. For more detailed information on the parts, please refer to the technical drawings in Appendix 12.2.

The size of the design was determined by optimally placing the different elements as described in the section 4.5. When designing the product in more detail, it was noted that there is some empty space in the design meaning that the cover could be further optimized and decreased in size (see Figure 72).

Material and manufacturing

In addition to determining the technologies and product architecture, some attention was devoted to determining the feasibility in terms of manufacturing and material. As this is not the main focus of the project, this subject was briefly touched upon by discussing with engineering experts at VanBerlo.

The suggested material for the top and bottom cover is ABS. ABS is often seen in consumer products and has several advantageous properties. ABS allows for high-quality finishes, and it is relatively cheap. A disadvantage when comparing ABS to materials such as Nylon and PC is that it is a bit less strong. However, the design most likely does not need to withstand high forces in daily use. A recommendation for future development is to implement ribs in both cover parts to increase the stiffness of the casing. A detailed material study should be

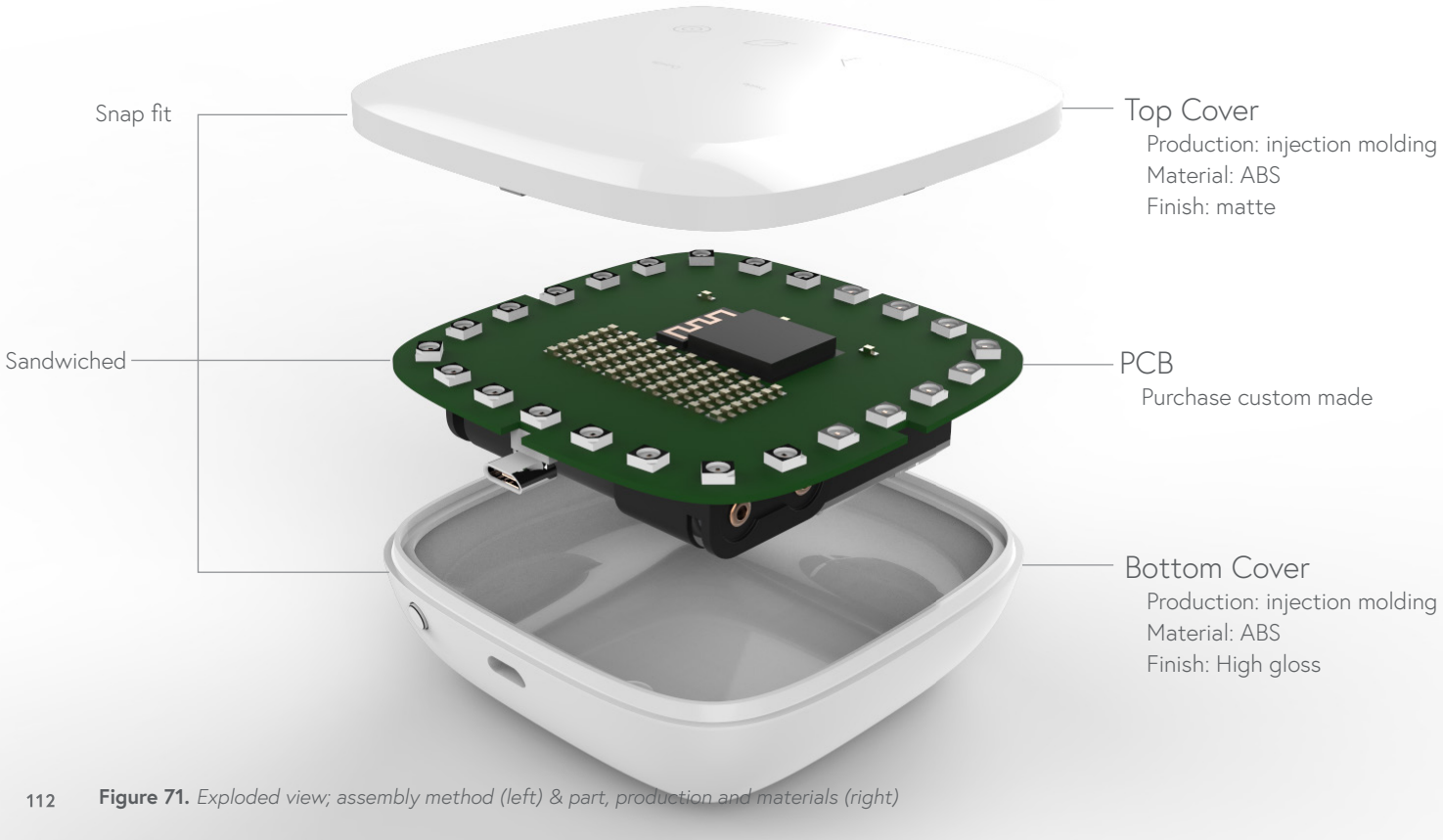


Figure 71. *Exploded view; assembly method (left) & part, production and materials (right)*

performed in further development to ensure that ABS is the optimal choice.

Considering that the casing is made of plastic limits the production methods. It is chosen to use injection molding as this will be the cheapest method looking at the production numbers.

It is assumed that the product will only be available on the Dutch market, which means that the purchase numbers will not be very high. It is estimated that in the first year, 10.000 devices will be made. The price of creating the mold is relatively high (estimated between 30.000-40.000 euro by experts of VanBerlo) but divided over 10.000 products this results in a production price of 3-4 euro per product (excluding material costs). A more detailed cost analysis can be found in the section 4.9 *Implementation plan.*

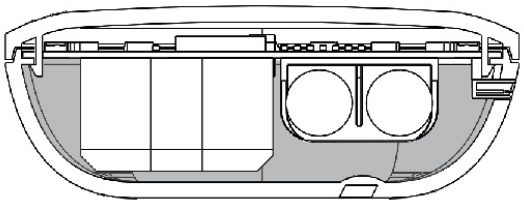


Figure 72. *Empty space (grey)*

Figure 73. *The final design*


vea


Inside
Outside
vea

4.7 Final design proposal

This section presents the final design proposal. First, the key features and user benefits are described, thereafter, the interaction is described in the form of use-scenarios. The end of this section describes an implementation plan, the rules and legislation, and a cost evaluation.

Design description

Vea consist of the combination of a physical design and an app. The app enables the user to set goals and supports the user to achieve these goals. Through working on the goals, the app learns about the user and gets personalized. The physical device supports the app by measuring the air quality in the home of the user and gives feedback on this.

Key features

Seamless logging

- Automatic medicine tracking through a connected inhaler
- Automated data collection on triggers using the cloud and the physical design
- Minimal input required by the user

Everything in one place

- Data about the user is stored and always available to the user for interpretation
- Integration of education, information & tips on self-management in one place
- Reminders and alerts can be set, both physical and digital

Translate data into action

- Relevant education based on interest (chosen goals)
- Providing feedback on performance
- Increasing insight by collecting data
- Concrete tools for action

Personalization

- Personalization of content based on patient data
- Personalization of tone of voice based on persona

Key user benefits

Personalization

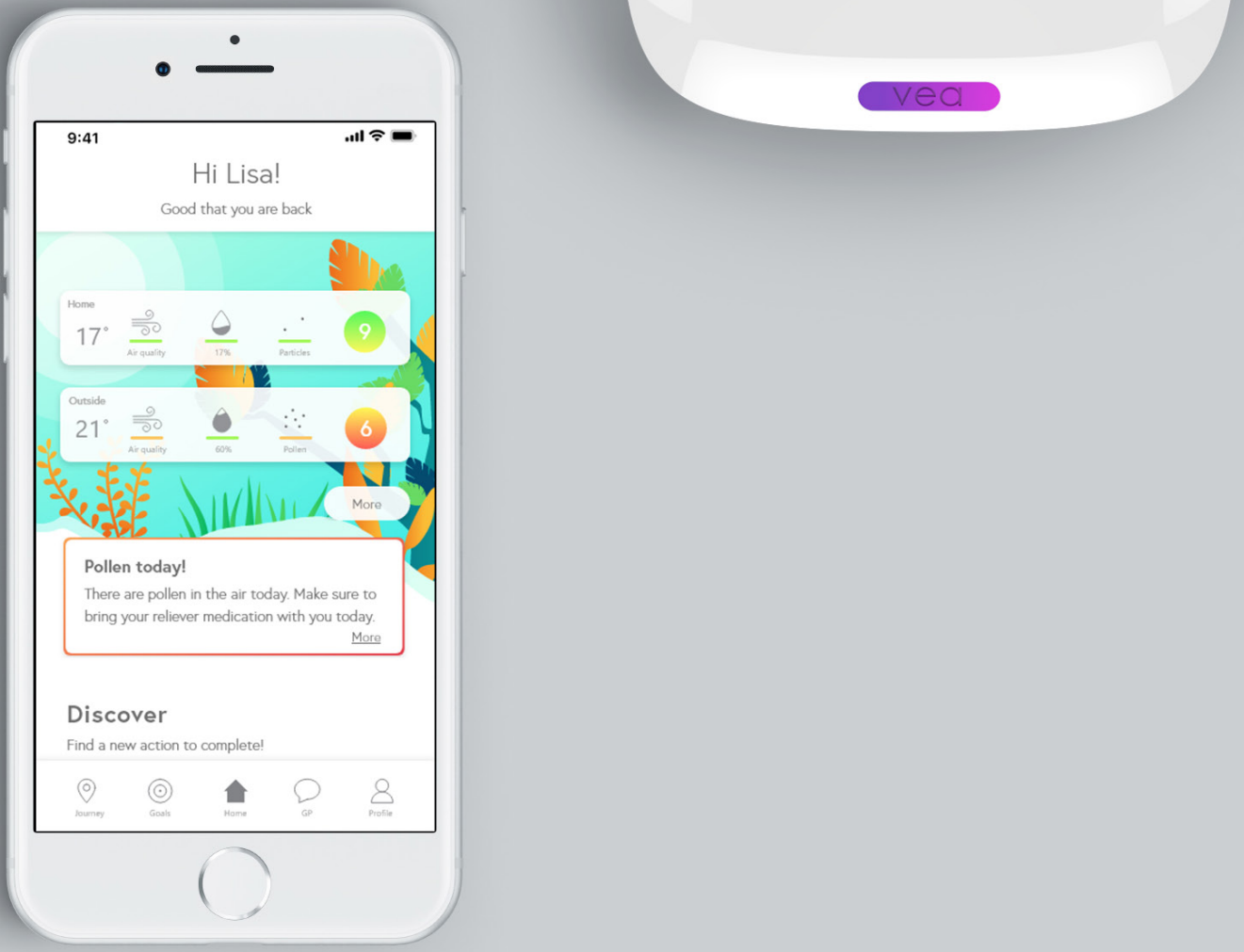
Vea is designed to match the patients' needs. Through personalizing its approach and content, the app becomes relevant to the user.

Being in control

The user is in charge of the goals they want to achieve. The app assists them by making the once invisible complaints and effects of self-management explicit.

Increased capability

Vea provides structured tools that increase the capability of the user to self-manage their asthma. Through seamlessly collecting data and providing relevant feedback and tips, the user is motivated and capable of acting.


9:41
Hi Lisa!
Good that you are back
Home
17°
Air quality
17%
Particles
9
Outside
21°
Air quality
60%
Pollen
6
More
Pollen today!
There are pollen in the air today. Make sure to bring your reliever medication with you today.
More
Discover
Find a new action to complete!
Journey
Goals
Home
GP
Profile
Inside
Outside
vea

4.8 Contextual scenarios

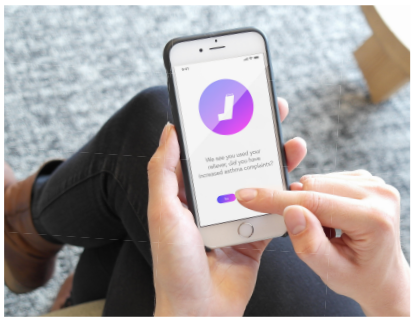
On the following pages four contextual use scenarios of the final design are presented to demonstrate the use of vea

Logging a trigger

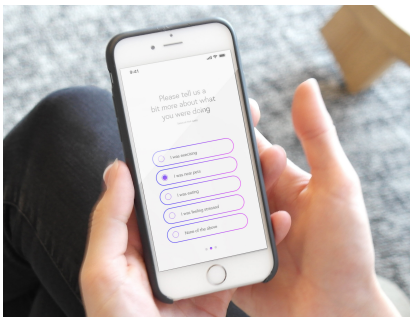
The patient feels a bit stuffy.

She decides to use the reliever to relief her complaints.

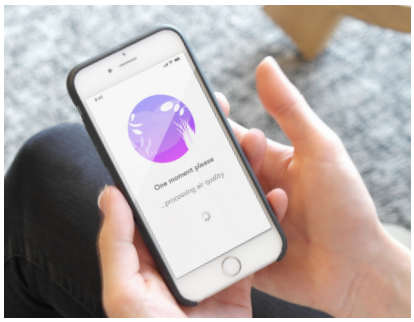
The app notifies the unscheduled use of the reliever.



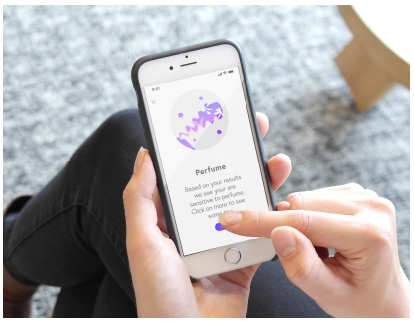
The app asks if the user had increased asthma complaints. the user responds with "yes".



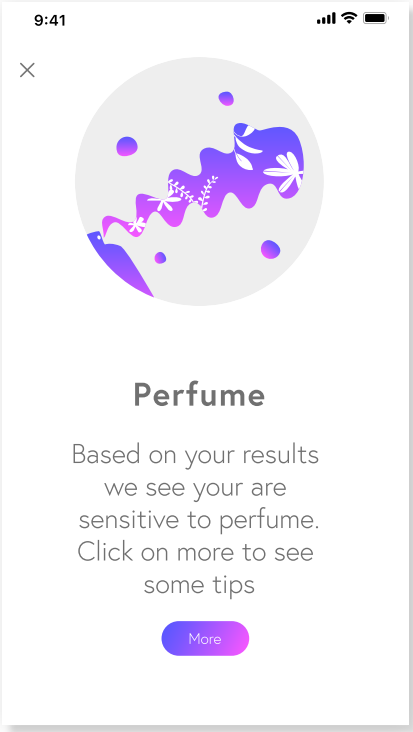
The user fills out the trigger questionnaire.



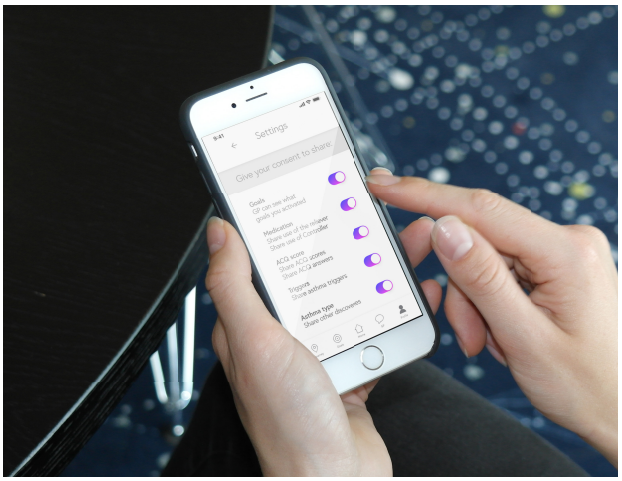
The app knows the user was inside and checks the air quality meter for possible triggers.



Based on the answers of the user in combination with high VOC rates in the air the app notifies that the user might be sensitive to perfume.



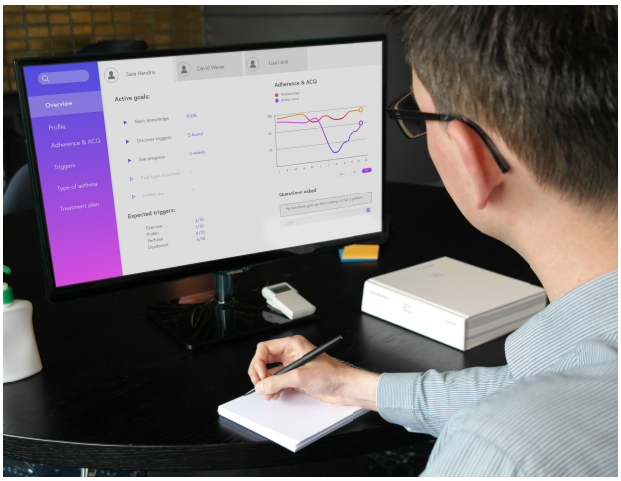
Visiting the GP



Upon installing the app the asthma patient gives consent to share the data that the app gathers with her GP.

When visiting the GP both the GP and the asthma patient have a good overview of how much medicine was taken and how well the asthma is controlled.

The GP explains that the patient has used her medicine as prescribed, but her asthma is still not optimally controlled.

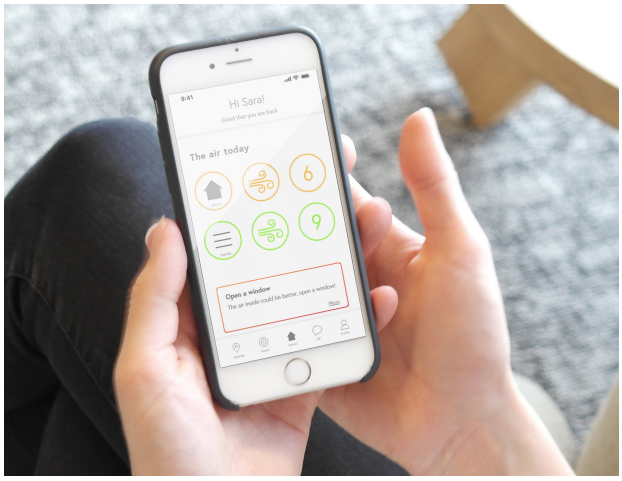


The GP wants to optimize the treatment and based on the data he decides to prescribe an extra inhalation of the Flixotide per day.

Bad air quality inside

Based on the asthma patients discovered triggers the physical device knows she is sensitive to VOC's. The physical device notices a high concentration of VOC's in the house and notifies the patient.

The patient sees that the air quality inside is not optimal and refers to the app for more information. The air quality score inside is a 6 and outside is a 9. She is curious and clicks on "more".



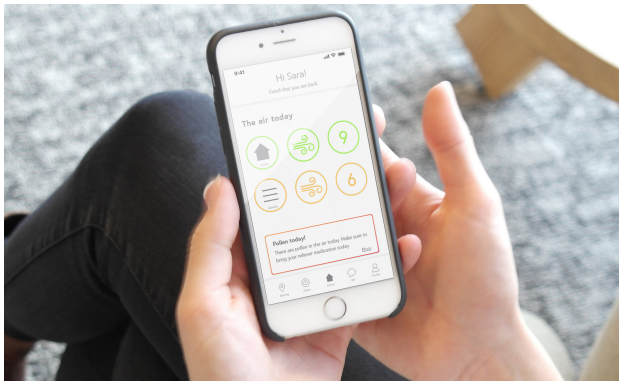
The app tells her that inside there is a high concentration of organic compounds (smells).

The asthma patient decides to open a window.

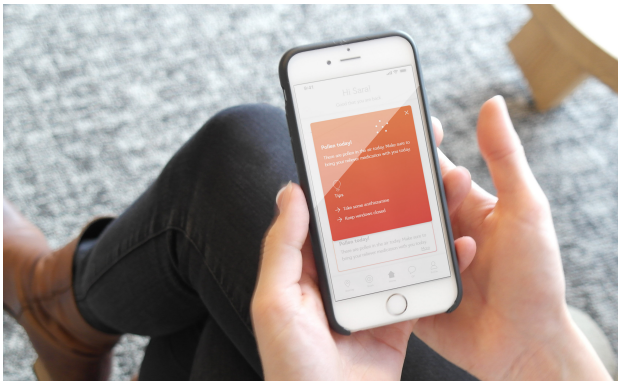
Pollen in the air

The app knows that the user is very sensitive to pollen. Today there is a high concentration of pollen and the user did not take her scheduled reliver medication yet. The device shows an urgent reminder.

The user sees that the air quality is really bad today, and that she forgot something.



She refers to the app and sees that there is a high concentration of pollen today and that she forgot to take her reliever.



The app also gives her tips on what to do: take the reliever medication and possibly take some anti histamine.

The user takes her reliever medication.

And she decides to take anti histamine today, to prevent an allergic asthma reaction.

4.9 Implementation plan

At last, an implementation plan for CAHAG was developed. This plan describes the following steps of the design process and how to get vea on the market. Besides this plan, some additional recommendations based on the evaluation can be found in the next section under "recommendations".

Key partners

This project was done with several stakeholders. CAHAG is the initiator and owner of the project with the responsibility for further development of the design. However, CAHAG will not be able to do so alone, they need additional funding. Before the project started CAHAG has set up a workgroup for the project consisting of both medical experts and four pharmaceutical companies, who are the main sponsors of the CAHAG. These companies are: GSK, Boehringer Ingelheim, Astra Zeneca, and Novartis.

The CAHAG will, together with the main sponsors, look for further financial support for the further development of the project. Besides these main sponsors, CAHAG will need to partner up with several other parties to be able to realize the design. Below the further development is discussed and some additional partnerships are proposed.

Further development

Digital design development

For the digital design, two main elements need to be further developed. First, the wireframe and aesthetics of the app (the front end) need to be further developed. Some additional screens need to be developed, and the design must be made intuitive to use. To do this, CAHAG could partner up with a design agency.

Besides the development of the front end, the back-end (programming) also requires some work. The app must be able to learn from the user, to support the patient in their road towards asthma control. The app will do so by collecting and interpreting lots of data. The app should also make suggestions based on the data and make predictions to a certain extent. To realize this machine learning will be used.

Machine learning means training a machine on how to learn. First, the system must be provided with examples of user data, based on these examples, it learns how to draw conclusions (Sas.com, 2019). For example, it learns to predict what might be a patient's triggers or what can be predictors of non-adherence. This can then be applied to the app, and the algorithm can be further trained with actual user data to become even more precise.

The third and last element of the app is ensuring medical correctness. As discussed in the section "rules and legislation," there are some set requirements for developing a medical device. Besides meeting these requirements, medical experts need to be involved throughout the project to ensure medical correctness.

Physical design development

The physical design will require some development as well. First of all, the design needs to be further optimized for production. Besides optimizing the design, the product also requires some programming. At last, the product will need to be manufactured.

For each of these elements, CAHAG could partner up with a design agency like VanBerlo. VanBerlo has engineers that could do the optimization for production, and they have the necessary partners for further manufacturing and programming as well.

Connected inhaler
At last the design is connected to a smart inhaler. Currently there is one smart inhaler on the market that could be connected to vea, this is propeller. However, the propeller smart add-on does not support inhalers of all pharmaceutical companies. Because the project will be financed by different sponsors the app cannot be developed to work together with inhalers of only some of the companies. This would lead to a conflict of interest and unequal market position for both CAHAG and the workgroup partners.

Therefore, it is adviced to first develop the app and to set universal requirements for a possible connected inhaler. The Pharmaceutical companies can then on their own develop smart inhaler devices for their products in a way that it could work with the App.

Implementation roadmap

To get the product ready to launch as fast as possible, CAHAG could consider dividing the development into steps. Below three suggested steps are described.

Version 1 – App
The first step could be to design the app to work stand-alone. Features as connecting the app to the GP, the physical device and smart inhaler can be left out in the first version of the app. The user research has shown that allowing the patient to manually log data about their asthma and enabling them to have all their data and personalized information in one location is already a significant improvement.

Version 2 – Physical device & general practitioner
During a second step, more advanced functionalities that require some additional development and investment can be implemented, such as the physical device. The app could get an update, and the physical device can be offered as an addition to the app.

Also, during the evaluation with GPs, it was discussed that a connection with the work system of the GP might require some time. Adjusting the computer interface of the GP is restrained by a lot of rules and regulations, which makes the process slow. CAHAG could consider implementing this feature in a later stage. In earlier versions, a function that enables the user to print their data or download a pdf could be used, for them to share their data with the GP individually.

Version 3 – Smart inhaler
The last step that would fully optimize the design is to connect the app to smart inhalers. Research has shown that this provides both patients and GPs with a lot of useful data and insights. The development of a smart inhaler is, however, beyond the control of CAHAG. It is recommended that requirements for the smart inhaler are set from the beginning on, so pharmacists can start developing smart inhalers right away. However, developing a smart inhaler entails some difficulties. Therefore it is expected that to get this feature on the market some time will pass.

Business plan

If the previously described development is completed, the product can go on the market. A good business plan will need to be set up, to make the product viable. This section describes a suggested business plan based on the estimated cost.

Cost structure
In the section cost evaluation, the main costs have been described. For version 1 of the app, the main costs will be the development of the app. However, some additional costs might be associated with the validation for CE-marking (see rules and legislation) and with already preparing the following launching phases (version 2 and 3).

For financing of the initial cost, CAHAG needs to address the members/organizations from the workgroup for sponsoring.

Revenue stream
For this type of medical innovations, the reimbursement of the invested cost is a different story than we normally see with consumer products. The revenue is not obtained through patients paying for the app, but through the decreased socio-economical costs associated with asthma. If the app is successful in supporting asthma patients to obtain better asthma control this leads to a decrease in hospitalizations, less emergency visits and in general more healthy asthma patients. As explained in the analysis the costs associated with controlled asthma are significantly lower than those related to uncontrolled asthma.

Besides investments of the sponsors and savings on the costs of asthma as a disease the app might qualify for reimbursement by health insurances. This will be the case if it has proven itself to be effective in increasing the level of asthma control is obtained. All this will be evaluated using a pilot study after further development.

Cost evaluation

It is quite challenging to make a cost estimation for a product service system like vea and to estimate how much revenue it will make. Nevertheless, an approximation of the final costs was made. For this cost evaluation, the cost for the development of an MVP, minimum viable product, for the app was determined, see table on the next page. Also, a cost estimation of the physical product was made, see table on the next page.

Appendix 14 provides an elaboration on the cost estimation. Also, Appendix 14.1 provides an elaborate explanation of the app development process and cost-structure to provide insight into the process for the client.

It is important to note that the prices mentioned below are susceptible to change according to requirements on the quality, unforeseen cost, and economic changes.

Cost estimation digital design

Main activity	Hourly rate	Estimated hours	Total cost price
Research	€ 130	64	€ 8.320
Creative direction	€ 130	80	€ 10.400
UX	€ 100	120	€ 12.000
Content	*	120	€ 12.000
App development	€ 120	240	€ 28.800
Project management	€ 120	70	€ 8.400
Total cost price:			**€ 73.820**

*see appendix

Main activity	Hourly rate	Estimated hours	Total cost price
SLA	€ 80	8 hours/month	€ 80 per month

Cost estimation physical design

Product	Cost price	Batch size	Total cost price
CASING	€ 7,82	10.000	€ 78.200
PCB parts	€ 34,76	10.000	€ 347.600
PCB assembly	€0,26	10.000	€ 2.600
Product assembly	€0,14	10.000	€1.400
Total cost price:	€ 42,98		**€ 429.800**

Rules and regulations

As vea has a medical purpose, it is restricted by special rules that ensure the quality and safety of medical devices. Vea also falls under these regulations. If an app is classified as a medical device, it requires a CE marking to make sure that it complies with European guidelines. Medical devices are divided into four different risk classes: class I (lowest risk class), Class IIa, Class IIb, and Class III (highest risk class). To which class a device belongs depends on different aspects (Van Dongelen et al., 2018).

To find out if and how the design should be classified two MEDDEV guidance documentations were consulted (EU Legislation on Medical Devices, 2016), (EU Legislation on Medical Devices, 2010). Appendix 13 further describes this process.

After carefully assessing both the app and the physical design, it was concluded that the physical design does not classify as a medical device. The app, however, should be classified in class 1, the lowest risk category. Appendix 13.3 further explains the steps that need to be taken in order to obtain a CE marking for the app. On a concluding note, it is important to note that in 2020 the rules for classification will be adjusted and tightened, this could result in the design falling in a higher classification (Van Dongelen et al., 2018). This change might complicate the approval process and increase the costs of this process.


Inside
Outside
vea

5 Evaluation

This section describes the evaluation of the design proposal against a multitude of factors. First the concept will be evaluated qualitatively. Then it will be evaluated using the list of requirements and eventually using the previously defined assignment and concept direction. This section ends with recommendations based on the evaluation.

5.1 Patient evaluation

Vea was created with the needs of the asthma patient as a central driver of the concept. Vea was therefore evaluated with asthma patients, to see it if the concept matches their needs. This section describes the evaluation with asthma patients.

Research set-up

Objective
The patient evaluation had three main goals. First of all, to evaluate if the design meets the requirements that were set in the function analysis. The second goal was to see if the concept is in line with the envisioned user experience. Third, the use-flow was tested for intuitiveness. At last to see what the possible limitations of the concept are and how these can be improved upon. Below the main research questions are listed.

Does the design enhance self-management?

- How are the different features of the concept perceived?
- Is the concept motivating?
- Does the app increase capability of self-management?
- Do the participants' preferences match their persona?

Method
The user research was performed in individual sessions. The participants were presented with a click-through prototype of the app, scenarios on paper, a prototype of the physical design and renders of the physical design. Through semi-structured interviewing and observing the research questions were evaluated. Appendix 15 provides a full overview of the research setup, including findings. It was chosen to use the same participants as during the focus groups, when possible. This was done because the initial research phase provided rich insight on the persona's that best matched the participants. These insights were used to research the personalization aspect of the app.

Below some main findings are elaborated on and demonstrated with some quotes, for all findings, please refer to Appendix 15.3. The recommendations by users that were implemented into the design are also highlighted. The ones that could not be implemented anymore can be found under the section recommendations.

Key insights

Insight in medication use and asthma control
The goal "see progress" was perceived with enthusiasm by all participants. The participants appreciated the level of insight it provides into their asthma. They state that being able to see their adherence and asthma control would increase their motivation to adhere to their medication for several reasons.

The yearly overview provides asthma patients with both insight and proof on the effect of medication. Having this insight and proof, the patients believe that they would become more adherent.

> *"It is a bit like if the doctor tells you to take medicine, but you don't experience if it is actually working, then I would rather not take it. But if I can see out of my own results and my own experience and what I fill out myself, if I don't take my medicine, it gets worse. Then that would be for me a stronger reason to change my behavior" – P4*

> *"And especially this, I find useful that you can see how much effect it has. That you can see "oh, I don't*

take my medication," and then you immediately see the effect that you feel more stuffy. So that you clearly see it in a graph, is real proof. I think that is quite smart." – P6

Also, the weekly overview in which users can see their adherence proved to be motivating. The patients want to obtain the highest possible score.

"And ambitious, that is really something that I think, oh then I really want to make sure that they are all at the top. Or that I think, then I really want to perform good as possible" -P2

At last users state that the "see progress" function provides them with insight and that insight is helpful. The "see progress" goal provides users with insight.

"I wrote down "informed." Its really like you have information and way more overview over the long term. It is more tangible. And "knowledgeable" because you better understand that is happening, what is going on. What are the good and the bad times in the year? I'm going to add calm. I think that the insight can also provide some calmness"-P4

"But I was like ahh this is what I wanna see you know. A way to track what's happening. I really like the two bars with the medicine intake and how you control your asthma. I think that's super helpful." –P5

"Super cool. I love it. I really like that it knows when you use your reliever and that you can keep track of that." – P5

Asthma control questionnaire

In the design, the ACQ is used to rate the level of asthma control. Twice the suggestion was made to also implement a function that allows the user to give their own perception of their level of asthma control. The patients want to rate themselves how satisfied they are with the treatment themselves. As I agree with the patient's opinions, and I believe that it would increase the feeling of control, I added this function to the ACQ.

"Because sometimes it may be that you did wake up at night, but that you are still satisfied. And then it may not come out as completely controlled, but still, it could be that you believe it was a good week nonetheless. So maybe you could add that, that you can give it a number yourself too, about how you believe t is going" -p2

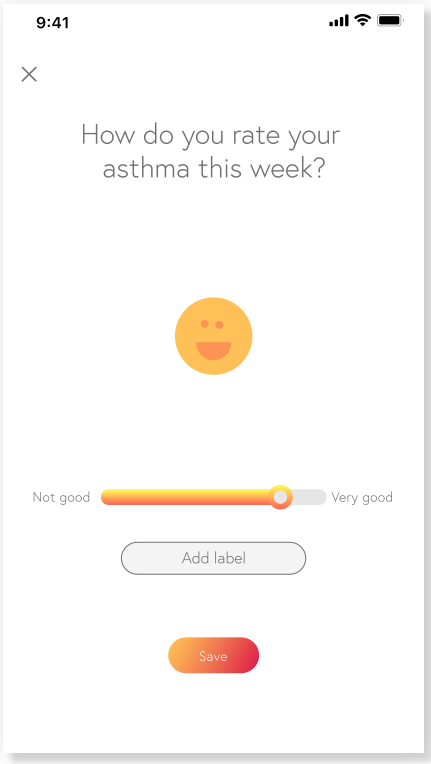


Figure 74. *A screen was added to the ACQ that enables the patient to rate their own perception f the week as well*

Discover triggers

The participants recognized that discovering triggers can be a hassle. Also, it is quite challenging to figure out what it was. They are therefore excited about the app being able to help them to keep track.

> *"Oh, I would really like that. Because at a certain point you know yourself, when the weather is nice, then I have more complaints. But then you have the feeling that there is something more to it, and that is quite difficult to find out for yourself. Then it is helpful if such an app can help you a bit with that." -P2*

> *"I have that very often that I think "oh, maybe it is because of THAT, I should remember that," and then you just forget it again. And then you think, that is a shame... So this is useful that it just remembers it, and at a certain point will also draw a conclusion." -P6*

The participants stated that being able to identify triggers and to keep track of them makes them optimistic and gives them a feeling of control. It gives them the idea that they can do something about their complaints and that it would thus increase their capabilities.

> *"No, it is an ongoing thing, which you do not understand exactly, which is very elusive, and it is difficult to control it in that sense. I think that the moment you get a better understanding of what a trigger can be that you get a sense of control and a feeling that you can do something about it. it would give a feeling that you can influence it, and that seems very nice to me, that feeling" -P4*

For the trigger questionnaire, two suggestions were made. First, it was suggested also to enable the user to fill out the trigger questionnaire when they had increased asthma complaints but did not use the reliever. Second, to enable the user to skip the questionnaire and to fill out the trigger directly, in case they are sure of the cause of their increased complaints.

Sharing information with the GP

Most users are reluctant to share their information with their general practitioner. Especially medication use is something that they are not comfortable sharing. They know that this could be very helpful, but are afraid of being judged.

Additionally, users feel like it is an app for themselves. They see it as their personal tool that they can use to get insight and to draw conclusions. They see a role for the GP when they notice something is off; in that case, they would like to take their data to the GP.

> *"I think I would really enjoy the app for myself. Like I was saying that I can check it, and sort of self-diagnose what is going on, I think that is like the huge advantage, is you feel like you have control over your situation" –P5*

Air quality score and the physical device

The participants were interested in having the physical device as an addition to the app. The participants state to often worry about the air quality both inside their house and outside. Interestingly most users started coming up with uses for the insight themselves; for example, they mentioned it could help them to decide to open a window or not, or to do exercise outside or inside. Some users did state that they would like to get a little more insight into the air quality than just red=bad white=good. Therefore, the interface was enhanced with RGB LEDs that can indicate the air quality using red/orange/green light.

> *"You might have had your windows open for a week, and then at the end of it, you really don't feel well. And that's when you think oh I need to do something. But this could tell you like immediately when something is like bad air quality." -P5*

Figure 75. *Old interface (left) and new interface (right).*

Personalization

Tailoring content

The participants appreciate the different personalization aspects of the app. Features that were especially appreciated were the feedback and matching the content. They appreciate that the app creates an overview of their asthma and that the information, therefore, is adjusted to this.

> *"You also read on the internet a lot of things about: "a lot of people have it from childhood" ... I don't have that.. "people have it when they make an effort" ... I don't have that either... So those are already many things that discourage you from reading on." – P2*

The tone of voice:

Researching the effect of the tone of voice was challenging. Only one of the participants was identified as "passive," and one was identified as "curious" based on the previous research. Interestingly both preferred the screen that was designed for them. This result indicates that there could be an advantage in personalizing the tone of voice. However, additional tests should be executed to confirm this.

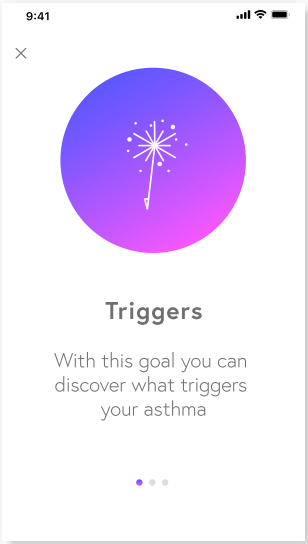


Figure 76. *Screen for the curious*

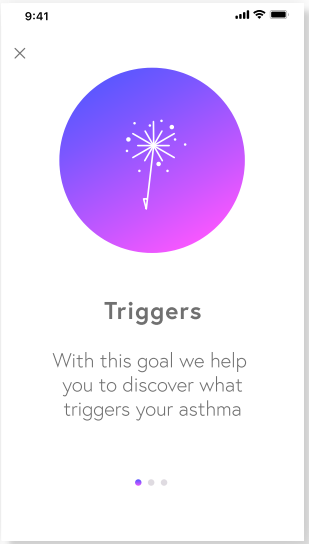


Figure 77. *Screen for the passive*

Curious persona:

"It is about YOUR asthma, and therefore, I like the formulation that YOU can discover. It appeals more to me because I am the person that wants to know this, and I and the person that has an interest in knowing this. So I need to discover what MY triggers are."

Passive persona:

"I think this one is more pleasant; I think that because of the word help, it is more friendly"

Home page

Level of information:
It was assumed that the passive persona requires less information on, for example, the weather quality than the curious persona. When interviewing the participants, it was noted that the participants appreciated a quick overview. However, they also want to have a sense of control; they want to know why the weather quality is a "9" or a "6".

Layout & design
Most users made positive comments on the design. They appreciated the use of color and the clear structure of the app. They did, however, comment that the homepage was not in line with the rest of the app and that they would like some more color here. This feedback was translated in the final home page as presented in Figure 80

Conclusion
The app was perceived very positively by the participants of the research. Some interactions were not immediately clear and needed some explanation. Insights on these interactions and improvements can be found in the section recommendations.

Users were highly positive about being able to get insight into their asthma and being able to collect data on their triggers, asthma control, and adherence. They appreciated having all the information they need in one place. Besides that, they noted that they appreciate the personalization of knowledge. They were also positive about the fact that the app takes the patient on a journey, and that information is personalized.

At last, they stated that it could help them to become more adherent and to take action when needed.

It can, therefore, be concluded that vea satisfies the desired user experience and function analysis. The main points for improvement are further developing the micro-interactions with the digital design and making the use-flow upon first opening more intuitive.

> *"Yes I think so, I think that would really help me deal with my asthma. Because you break it into little pieces, so you can easily go through the process without it being a huge mountain. So to say." -P4*

> *"I would use the app myself too" -P6*

> *"It would be nice if it gets developed further, I think a lot of people would benefit from that" -P3*

> *"I think that it can give you a lot of insight. And that insight eventually can help you" -P2*

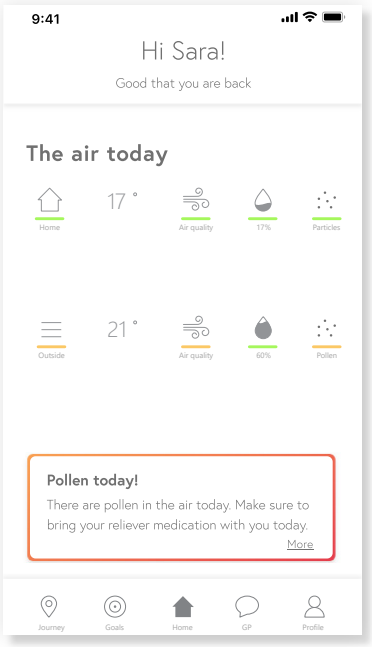


Figure 78. *Home screen for the curious*

Figure 79. *Home screen for the curious*

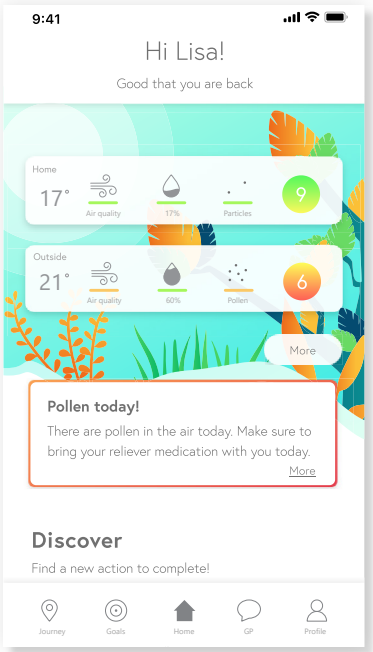


Figure 80. *New home screen. The screen uses a number and intuitive color coding to communicate the air quality at a glance, but also displays some in depth information. More information can be obtained by clicking on "more"*

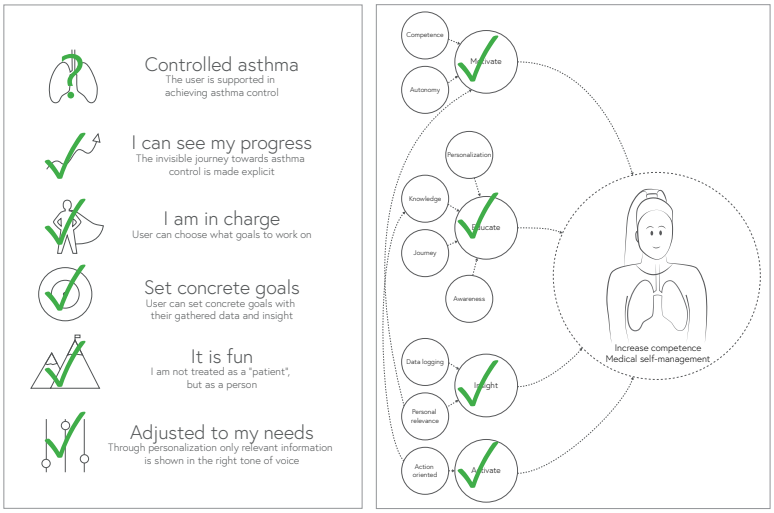


Figure 81. *Evaluation of the desuerd user experience and function analasys with users*

5.2 Healthcare provider evaluation

The design was also evaluated with two GPs. The main goal of this evaluation was to use the expertise of the GPs to value the design from a healthcare provider perspective. The evaluation was intended to evaluate both the design for the patient and the design for the GP.

Research set-up

Two semi-structured interviews were held with the GPs. Both a visual overview of the concept for the patient and the GP interface were presented. Below some of the main findings are presented. In Appendix 16.2, the full list of insights can be found.

Key insights

Influence on asthma control

Both GPs received the design positively. They believe the app could provide the asthma patient with insight on their level of asthma control and triggers.

> *"I really like it, and it looks incredibly beautiful. I also think it can ensure that people get better control of their asthma and that it can ensure a better quality of life." -GP1*

> *"...So their asthma is less unpredictable for them. And I certainly think that it has a positive effect on the quality of life because it just works well. And in the end, you really hope to prevent asthma attacks with that." -GP2*

Influence on asthma treatment

Both GPs agreed that it would be useful for the treatment, to get insight into the data of the asthma patient. They believe that this could be helpful to discuss the results with the patient.

> *"And that if you can see how things are going then maybe you can adjust the medication downwards. It can really ensure optimal treatment." -GP1*

Smart inhaler

During the interviews, some limitations to the concept were mentioned. First of all, both GPs noted that the use of smart inhalers could be a useful addition to the concept. However, they were skeptic about the time it will take before smart inhalers are seen more on the market. One of the GPs proposed to make earlier versions of the app work without smart inhalers.

Newness

Another comment was that most apps work very well in the beginning. Rather soon, however, the newness is gone, and most apps end up not being used as much. This is indeed a significant risk when making an app. Through keeping the input required by the user as little as possible, the user hopefully keeps their interest. Besides that, the concept will be most useful in the first year after diagnosis and is intended to support the user to become fully independent in managing their asthma eventually. The required minimum interaction with the app will be on a weekly basis, the first two to three months, depending on how well their asthma gets in control. After that, the interaction could go down to once a month.

GP interface

At last, it was commented that medical IT brings quite a hassle with it and that integrating the information gathered by the app into the computer system of the GP may take years. I, therefore, suggest enabling the user to export their data into a PDf format. This way, they can take the information to their GP whenever they want to.

Conclusion

In general, both participants were positive about the design. They believe it can have a positive influence on both the self-management of the asthma patient and the level of asthma control. Some shortcomings that were noted is the development time of both the GP interface and the connectedness to a smart inhaler. This was foreseen in the implementation plan. The implementation plan suggests first to develop an MVP (Minimum Viable Product) that excludes these features.

At last, the GPs had concerns about some of the wording and graphical visualizations that were chosen. They were concerned that people with a lower IQ might not be able to grasp everything fully. As the target group is well-educated people, this was not an issue within the design process. It is, however, desirable to maximize the target group. To do so, an expert would have to look at making these aspects easy to grasp for everyone.

Figure 82. *Evaluation of the desuerd user experience with GPs*

5.3 Conclusion

Evaluating the list of requirements

Throughout the project, wishes and requirements were set for the final design. These can be found in Appendix 8. An evaluation based on each of the requirements was performed and can be found in Appendix 17. Most of the requirements were met, however, some that are not met or difficult to evaluate are elaborated on in the Appendix and translated into recommendations.

Evaluating the assignment

To conclude this thesis, the final design proposal was evaluated against the initial assignment.

> *"Design an asthma self-management system that both empowers and supports recently diagnosed asthma patients and increases their competence of medical self-management."*
>
> **-Assignment**

The initial research question was "How can design for increased competence improve medical self-management."
The concept of self-management was researched and several barriers that patients face in self-management were uncovered. Also, several behavioral theories were researched.

The main problems that asthma patients face are inadequate knowledge sources and a lack of insight. The answer to the question "How design can improve the competence of medical self-management?" was found in the synthesis.
Through personalizing knowledge, increasing insight into one's own condition and providing action-oriented advice, asthma patients have the tools to be able to better self-manage their disease. These findings were translated into the design direction:

> *"Develop a personalized knowledge source that creates a journey of education, increased insight, and translates this into concrete actions for the patient. This will be done through design for increased competence and autonomy."*
>
> **-Design direction**

In answer to this design direction, vea is proposed. Vea enables the user to set goals that are designed to improve medical self-management.

The goals split the process of obtaining self-management in little doable steps: first, the user gets the primary education. Then the user can work on the goal step by step. Working on the goal personalizes the design, enabling the design to provide relevant education and action-oriented tips. Enabling the user to choose their own approach and supporting action increases their feeling of autonomy and competence.

The user evaluation demonstrated that the proposed design is undoubtedly promising. Both asthma patients and general practitioners indicated that the design could lead to increased insight, motivation, and enhanced competence of medical self-management.

The benefits of vea will reach further than enhancing the asthma patient's competence to self-manage their disease. Enhancing the asthma patient's self-management could lead to better-controlled asthma and eventually to an increased quality of life. At last, introducing vea has the potential to optimize the treatment of asthma by general practitioners.

The main limitation of this master thesis is, however, determining the long-term effect of the design. Although the design has shown to be promising, unfortunately, no statement can be made of the long-term effect of vea on the actual improvement of medical self-management. To be able to do so, the design should be further developed and tested in the long term.

5.4 Recommendations

There are a few limitations to this thesis and the proposed design that should be taken into account upon further development of vea. This section discusses these limitations, which are organized under the lenses: desirability, feasibility, and viability. Besides some limitations, the project was also scoped, as it was susceptible to time constraints and executed individually. This means that some exciting opportunities can be considered for further research and development. These can be found under considerations.

Limitations

Desirability
First of all, most of the user research was qualitative research. This has two shortcomings. First, the findings are based on a rather small group of asthma patients. It can, therefore, not be guaranteed that this is a good representation of the average target group. Besides that, qualitative research is susceptible to bias from the researcher. Although it was attempted to be as neutral as possible, bias will most likely still have had its influence. Besides that, the design was also executed by one person with a limited set of design competences. To overcome these limitations, the following recommendations are made:

Research - It is recommended to evaluate the proposed design and problems it tries to solve with a larger group of participants. This way it can be ensured that the design solves the right and most urgent problems in medical asthma self-management.

Intuitiveness
Data presentation - During the evaluation, it was noted that some of the data presentations in the feature "see progress" might be difficult to grasp for some patients. It is recommended to make these graphs and visuals more intuitive and easier to understand.

-Navigation: Some micro-interactions with the app are not intuitive yet. The relation between the goals and the journey should be improved. Besides that, the goal tiles could be supported with icons, so their intention is understood with one glance.

Medically correct
Content – The content for the app should be created in co-creation with medical specialists.
Validated trigger list – The trigger questionnaire is currently based on the available information on longfonds.nl. There are, however, numerous triggers that are not explicitly mentioned on longfonds.nl. To make the app perform optimally, a validated and more complete trigger list should be created.

Data logging
Connected inhaler – In the first releases of the design, there will most likely not be a connection to a smart inhaler. The logging of medicine intake should be reconsidered. An optional seamless way of logging the adherence should be integrated.

Trigger questionnaire – The user should be able to fill out the trigger questionnaire when they did not use the reliever. Besides that, it is advised to enable the user to skip the questionnaire and identify the trigger right away if they know what their trigger was.

Feasibility

To demonstrate the feasibility of the design, an implementation plan was developed. This plan contains several recommendations to achieve the launch of vea, see section Implementation plan. Below these recommendations are listed once more.

- Release vea in three steps: version 1, version 2 and version 3
  - Version 1: MPV of the app
  - Version 2: Physical device & GP interface
  - Version 3: Connection to smart inhaler

- Digital development: To launch the digital design, a step by step plan can be found in Appendix 14.1; in summary, the steps that need to be taken are:
  - Additional research: First additional research needs to be done to determine the behavior of the app
  - Design: Second the app should be designed & content should be generated
  - Development: Last, the app can be developed and programmed

- Physical design: to optimize the physical design it is recommended to reconsider the use of AAA batteries, as using Li-ion batteries saves space and the battery might last longer. Also it is recommended to insert ribs into the casing for extra rigidity.

Viability

This thesis is a pursuit to develop a viable concept that enhances asthma patients' self-management. The evaluation was an attempt to determine whether this goal was obtained. Although the design seems promising, there are a few shortcomings. First, the design can only facilitate better self-management; it cannot guarantee it. Eventually, it is up to the patient to actually take charge. Besides that, the design could not be tested in actual use. To be sure that the concept becomes viable, some recommendations are made.

Tone of voice – One of the key aspects of the concept is personalization. An aspect that was difficult to evaluate was whether adjusting the tone of voice to the persona results in improved user experience. It is recommended to test this personalization on a larger scale with asthma patients.

Pilot – Before launching the app, it is advised to do a pilot. This pilot can be done with an (almost) fully functional version of the app. During this pilot, it can be determined if the app is desirable over a longer period. Also, several additions to the design could be made to improve its viability.

SLA – to keep the app functioning optimally it is advised to arrange an SLA agreement with the developing party (see Appendix 14.1).

Considerations

To keep this thesis reliable and doable within the set time, it was scoped to a specific target group and medical self-management. This means that several aspects were left out of the project. Some of these aspects that could be considered for implementation are mentioned below.

Setting your own goal – Another possibility could be to enable the asthma patient to set their own goal. For example, they could set a goal for that week and then evaluate themselves whether they made the goal or not. This would allow for some extra personal relevance in the design and gives the user some more flexibility in setting the goals.

Low health literacy – The copy and visuals of the digital design could be redesigned to also match the needs of asthma patients with low health literacy.

Behavioral self-management – it is advised for CAHAG to consider implementing behavioral self-management goals into the design. In the current concept, these are left out, but some examples of goals that would be beneficial to the self-management of asthma patients are:

- Quit smoking
- Get fit
- Healthy weight
- Mental health (relieve stress)
- More energy (sleep better)

5.6 Personal reflection

At the beginning of the project, I set myself the goal to develop a fully finished product service system. I was well aware of the fact that developing both an app and a physical product was rather ambitious. Nevertheless, I was not going to give up on this goal.

Spreading my attention over both an app and a physical product has proven to be rather challenging. As I had never really designed an app before, doing so was a steep learning curve. During the project, I developed my graphic design and digital interaction skills at a high pace. Being able to work together with VanBerlo facilitated this learning curve even more. Discussing with several employees gave me great insights into the world of digital interaction design.

I consider myself to be very lucky that I was able to work together with so many stakeholders on this project. Working together with CAHAG has given me a lot of insight. Not only did I learn about asthma as a disease; also, I learned a whole lot about designing for a medical context. Having many stakeholders involved, with each their interests, in combination with restrictions in the form of rules, legislation, and IT provided me with a great challenge and insight into the real world of design.

Besides working with CAHAG, I was also able to work together with VanBerlo. Being able to work on this project in a professional design environment enabled me to transcend my own expectations for the project. I am very grateful to the enthusiasm of all the employees of VanBerlo. Whenever asking a question, I was sure to be involved in a discussion of at least 30 (if not 60) minutes.

Considering that my master is in IPD, I think I might have applied a rather straight forward approach towards developing the final design. In my master IPD, I learned to pay a lot of attention to the constraints that you are designing within. This resulted in an ideation phase that fit pretty well within these boundaries, and perhaps it was not so much "out of the box" as I would have done in the past.

At last, I believe that designing for self-management is a rather complex challenge. It entailed medical aspects, behavioral aspects, and several stakeholders. Looking back, I think that I could have scoped my design process a bit more. This would have allowed me to put greater detail in some aspects of the design. Also, it would have been a good addition to do more test sessions in between with asthma patients. I noticed that evaluating my concept with patients lead to very fruitful feedback, and I would have loved to be able to implement more of it into the final design.

Nevertheless, I believe that I did a very complete project, and I am proud of the final design proposal that I am handing over to CAHAG.

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Mock-up credits:

Page 100, 103, 117: https://goodmockups.com/free-apple-gold-gray-space-gray-iphone-8-app-screen-mockup-psd/

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