IN YOUR OWN TIME

A design influencing the perceived waiting time of families at the Prinses Maxima Centrum for child Oncology

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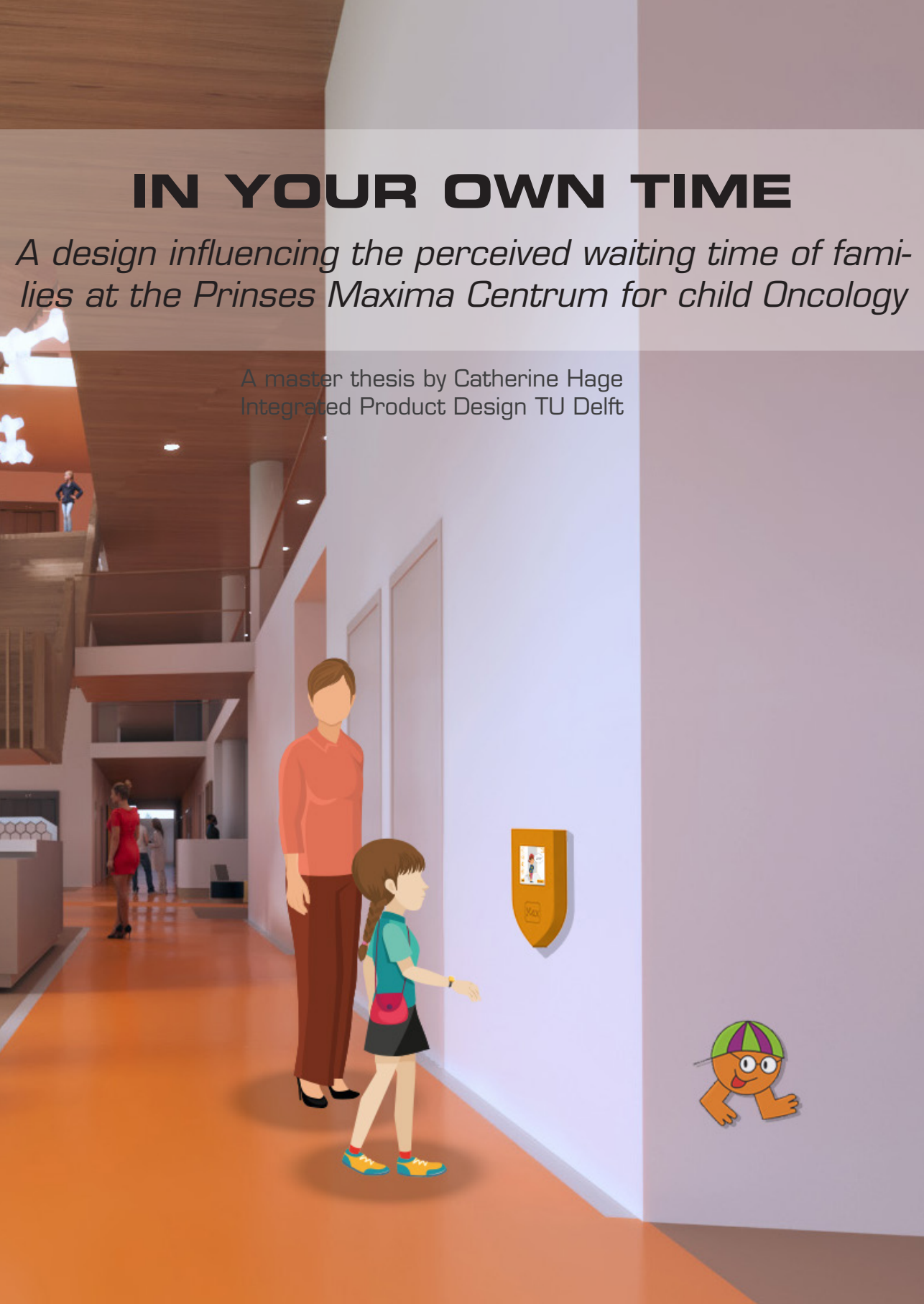

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PREFACE

In your hands you hold the final chapter of my life as a student. I have been a student since I was four years old and although it hasn't always been an easy ride I've loved learning new things and exploring the world of science. So I am sure that although I will no longer be enrolled as a student I will always be studying.

For the past ten months I've been working on my graduation project, the grand finale.. From the beginning I knew that this project would not only be difficult because of the amount of work that needed to be done but it would also be a psychological challenge; Could I keep my head in the game? Could I keep a positive attitude? And most of all could I keep believing in myself? The answer is: Yes. It hasn't always been easy but I managed. And to be honest, I am quite proud of myself that I did it.

However, I didn't do it all alone, there were some very special people that guided me through this process.

First of all, my coaches, who gave me the opportunity to explore this vision of mine.
I would like to thank Huib for being the first one who agreed to coach me which gave me the confidence I needed to proceed with this vision. You always knew exactly which questions to ask in order for me to improve and continue.

Thank you Renate, for always being there for me when I struggled. You kept believing in me and your positive attitude brought out the best in me.
And I would like to thank Erik, who opened his office to me and let me be part of an amazing design team. Thank you for your patience which enabled me to discover and develop myself as a designer.
I would also like to thank the team of MMEK' who let me work amongst them and who were always available when I needed someone to discuss my ideas with.

Furthermore I could not have done this without my mother who was always just a phone call away. Thank you mom for your support and your love.

And of course my boyfriend Ben, you truly are the best! No matter how deep I fall you will always be there to pick me up and dust me off. Thank you so much for all the times you had to get angry with me in order for me to go back to work. For all the times I just needed someone to talk to in order to get my thoughts straight. And thank you for putting up with me even though it has not been easy for you either.

And finally I would like to thank my friends, family and all others who lend me an ear when I needed to talk about this project. Whether it was for me to gain more information on a subject or just to comfort me. I am grateful for your time and advice.

EXECUTIVE SUMMARY

This project started with a vision. Going to the hospital is an unpleasant experience mainly due to the long and undefined waiting times. This is even more of a problem for patients who go to the Princess Máxima Center for paediatric oncology. A solution should be found to make the waiting experience more bearable for these patients.

Research has been done on the different types of cancer, how these they are treated and how the future Princess Máxima Centre will accommodate this. From this it became clear that especially the patients in the treatment phase experience the most and the longest waiting times. During a consultation with an oncologist and a nurse it became obvious that the patients who go to the day-care and the policlinic have the most difficulty coping with their waiting times. An observational research was done on in the current policlinic oranje to establish what the day of a patient looks like. From this observational research a swimlane diagram was created to describe the day of the patient.

From the swimlane diagram it became clear that patients deal with different kinds of waiting throughout the day. These different kinds of waiting include:

- Waiting for an appointment
- Waiting for results
- Waiting for medication
- Unplanned waiting

A literature research was done to define what waiting is exactly and which factors have an influence on the waiting experience. Waiting is directly linked to time. Because humans do not possess a sense to measure time, they base the passing of time on the senses they do possess, their experiences and internal and external stimuli. This results in a subjective passing of time, which in general is quite accurate and in line with the objective passing of time. But specific factors such as emotions and stress can result in a different subjective passing of time. The same goes for waiting, the perceived waiting time can deviate from the actual waiting time. A waiting experience can be made more pleasant by reducing the perceived waiting time. This can be achieved by promoting a positive approach behaviour by providing the waiting person with a sense of control, through stimulating exploration and by giving a form of entertainment, thus stimulating dominance, arousal and pleasure.

For this project the users are not just children who have to go to the hospital for treatment, but their parents as well because the waiting equally affects them and the mood of the one can greatly influence the mood of the other. However, both experience waiting differently and their perceived waiting time is influenced by different factors. For the parents the biggest problems are the loss of control they experience when going to the hospital and not knowing what is going to happen with their child. This results in them experiencing an “extended now” phase. The children however, are aware that something unpleasant is going to happen and the anticipation of this unpleasant experience in combination with boredom due to a lack of activities lead to an extended perceived waiting time.

Therefore, both parent and child require different a solution when it comes to reducing the perceived waiting time. The

parents need to be provided with a sense of control and given information. While the children should have activities that allow them to "forget the time".

The target group has been defined as families who visit the policlinic and have several appointments per day. However, families that are admitted to the OKEs are also considered. Resulting in a target group of 165 families per day. Within this group the focus will be on patients from six to eleven years old.

With this information several ideas where created. After a selection three idea directions where distinguished; a game for the children, an app for the parents and a tracking device which allowed both parent and child to stay in touch.

While assessing these idea directions it became clear that they form three different aspects of the problem. So a combination of all three ideas was made. Resulting in a concept system which includes an app for the parents and a device for the children with which they can play games and that doubles as a tracking device.

The device used by the children is a basic wearable on a bracelet with an RGB LED grid and a vibrating alarm to receive notifications. The wearable will also contain an NFC chip. To play games and to read notifications there will be portals all over the hospital. These portals consist of a tablet and an NFC reader. Furthermore there will be patches placed on the walls, floors and furniture of the hospital. These patches are stickers containing an NFC tag and can be part of the games on the portals. When the patches are not part of a game they can still activate the wearable: by tapping the patch with the wearable a pattern will appear on the LED grid. Both the wearable and the app will get notified when it is time to go to the appointment. Parent and child can track each other down making use of the Wi-Fi grid which the hospital uses for their track and trace system. This entire system is called "MAX".

For this project only the wearable has been worked out into detail. The wearable will be 3D printed and contains a 5x5 LED grid, a vibrating engine, an NFC chip, a Wi-Fi module and an accelerometer and gyroscope chip. The battery in the wearable should be able to last up to 10 hours without charging.

The games that can be played should stimulate social interaction, physical activities and mental challenges. Examples are:

- *Hide and seek*: Several children log onto a portal after which one of them is designated the searcher and the other go and hide. The searcher uses the wearable to find the hidden players.
- *Treasure hunt*: The goal is to find and tap as many patches as possible within a given timeframe.
- *Simon says*: The portal is surrounded by 4 patches of different colours. A series of colours is displayed, the child needs to memorise the sequence and tap the colours in the right order.

To test the system interviews are held with several families. These families did not represent the actual target group (children with cancer and their parents)

because of privacy regulations. However, the families could definitely relate to the target group so their opinions were very valuable. In general all families were positive about the system, they liked that it gave the children something to do and that the parents would receive more information. However, the parents noted that they could not see a purpose for the system in their present lives, but they could imagine it to be a great solution for the families who deal with child cancer. They really liked that it provides a physically active game while it also gives the kids some freedom. The children liked the idea that they could play games and that they would get a notification when it is time to go to an appointment.

To further develop the system the other parts also need to be worked out and a more elaborate user study needs to be done. The most important however is to work out the software in more detail, especially since this has the most influence on the function and cost of the entire system.

With this project as a base, a sound foundation has been created for a system that can help to make waiting a more enjoyable experience for all involved parties.

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INTRODUCTION

This chapter contains a brief introduction of the assignment, the company (MMEK') and the hospital (Prinses Máxima Centrum).

ASSIGNMENT

This assignment was inspired by an ACD project of the master Integrated Product Design for the Princess Máxima Center (C. Hage, 2016). Which resulted in a concept for a wearable which gives the patients more insight in their waiting time (see figure 1).

With this project as inspiration, an assignment was created to find a solution for the long and frequent waiting times the patients encounters during the treatment of child cancer.
Families that have to deal with child cancer often experience a lot of stress and anxiety and sense a of loss of control. The long and tedious waiting times, which are not uncommon when going to the hospital, will only increase this discomfort.

This project will not only focus on the children but also on the family members who accompany them since cancer greatly impacts the life of all who are involved.

The goal of this assignment is to design a product-service system which reduces stress and allows the families to have a more pleasant waiting experience. The focus will not necessarily be on reducing the actual waiting time, but on reducing the perceived waiting time. This will result in less stress and a sense of control.

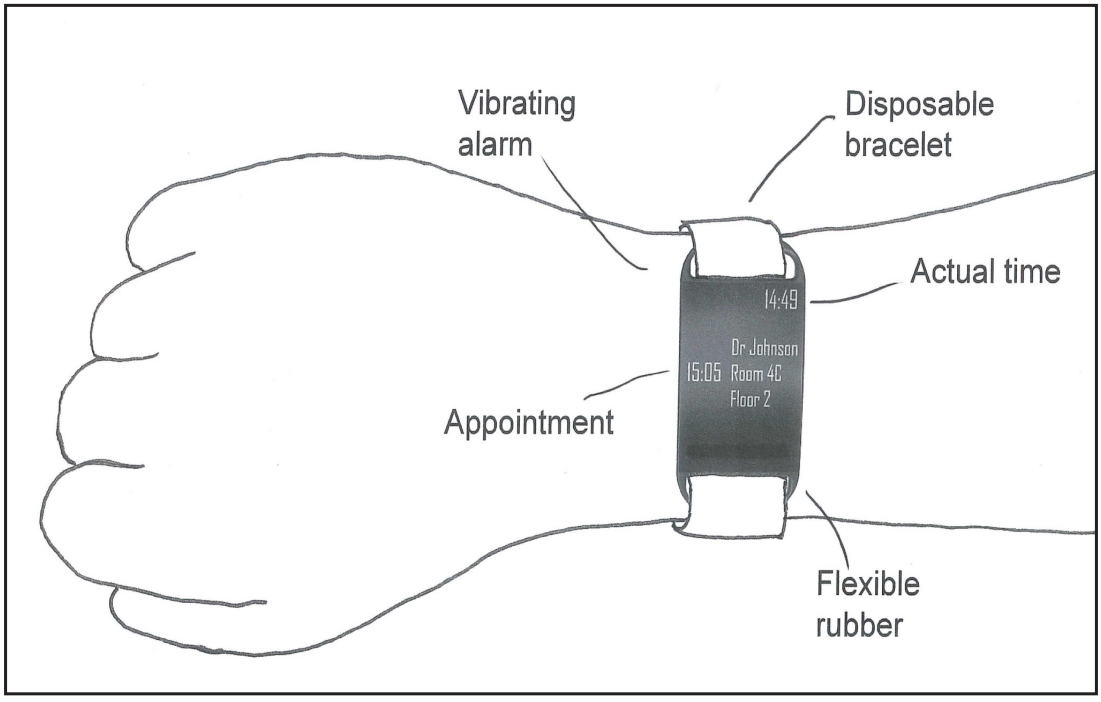


Figure 1: Wearable concept for the ACD project

MMEK' is a company founded by Martijn Meeske and Erik van Kuijk "specialising in creating transformative experiences that engage, fuel and drive audiences in all walks of life." (MMEK.nl). The company specialises in experience architecture and designs interactive environments and exhibits for museums and hospitals. Their focus is on how the environment is perceived by the user and their goal is to make it a fun experience for all who visit. With their team of experienced architects and industrial and graphic designers they provide a unique service which covers everything from custom built furniture to colour schemes and way finding. Figure 2 displays a vision of MMEK'.

The Princess Máxima Center has invited MMEK' to design the interior of their new building. They designed the patient rooms and several ABOs (afleidings en bewegings oppervlakken). These play- and educational areas are meant to distract the patients and their families while visiting the hospital as well as to encourage the children to come out of their rooms.

Figure 2: A vision from MMEK' (MMEK.nl)

PRINSES MÁXIMA CENTRUM

In the Netherlands every year 550 children are diagnosed with a cancer. To ensure the best possible care for these children a new healthcare initiative was required. The VOKK (Vereniging ouders, kinderen en kanker), SKION (Stichting Kinderoncologie Nederland) and Odas teamed up and the idea for a National Children Oncology Centre (NCOC) was born. This vision was further developed and resulted in the Princess Máxima Center. In this centre all paediatric oncology healthcare and research will be centralized in order to increase the chances of survival and reduce health related issues during and after treatment. By centralizing the healthcare, the medical staff gets more experience and knowledge resulting in better healthcare. The aim is to raise the survival rates from the current 75% up to 90% in 2025. (prinsesmaximacentrum.nl)

The Princess Máxima Center works with shared care centres, the main treatment will be centralized in the Princess Máxima Center but smaller check-ups and simple chemotherapy can be outsourced to one of these affiliated hospitals.

The goal of this hospital is to focus on both the cure and the care of the patients. With the increasing survival rates the realisation came that it is not only important to focus on saving the patients but also on making sure that their lives will continue as normal as possible. Especially with children, whose bodies and minds are evolving very fast, it is important to keep these developments stimulated even though their bodies are not as fit as their peers and their minds are occupied with other thoughts. The Princess Máxima Center aids in this by focusing on Development Oriented Care (DOC). Which means that the hospital stimulates the children to develop as normally as possible while also providing psychological support to the patient, its parents and their siblings.

For children.
Against cancer.

Princess
MÁXIMA
center for pediatric oncology

DEVELOPMENT ORIENTED CARE

The NCOC wants to achieve cure for all children with cancer while maintaining optimal development chances for these future adults. The main characteristic of the care within the NCOC is that it is not only clinical focussed but also patient centered, with a focus on the psychosocial care as well as the medical care.

Development oriented care (DOC) is defined as an integrative type of care that focuses on children with cancer and their families as a whole. It strives to support the normal development of a child, despite their life-threatening disease and the harsh treatment they have to undergo. (F. Aarsen et al, 2012). Development oriented care tries to actively involve parents and children as full members of the health care team and assigns them responsibility of the disease and treatment to a significant extent. This includes involving the parents in decision making and sometimes even allowing them to join staff meetings. The parents and children are also allowed to join advisory boards to give them a say in how to improve the hospital.

Development oriented care is not only about educating the child it also assures the child can develop as normal as possible. Thus the disease and treatment interferes with the daily life of the child (and the family) as little as possible.

The development can be categorised as physical, intellectual, emotional-psychological, social, and spiritual. All these categories are addressed within the Princess Máxima Center both through the healthcare as well as the environment. The so called “parent-child units” (ouder-kind eenheid, OKE) designed by MMEK’ are a good example of DOC as they allow the parents and children to be together while also giving them the freedom to have some privacy when desired.

RESEARCH

A brief analysis on paediatric oncology has been done. This was followed by several interviews with medical staff and an observational research at the policlinic of the current Prinses Máxima Centrum. Furthermore, a literature study has been done on what waiting is and how this can be influenced.

Every year approximately 550 children in the Netherlands are diagnosed with a cancer (VOKK.nl). The treatments these children have to undergo are completely different for each type of cancer and every child. However, 5 main categories can be defined. When a family doctor suspects cancer the child will be sent to the hospital. At the hospital a diagnosis will be made, followed by a treatment phase in which the goal is to get rid of all cancerous cells in the body. Once the child is cancer free regular check-ups are required during the aftercare phase. This will last 5 years, after which the LATER phase begins. This phase will last the rest of the patients' life and is meant to monitor possible side effects from the treatment. Currently over 75% of all children survive child cancer, however, this also means that 25% will not survive. They will be cared for every step of the way during the palliative phase. Figure 3 shows how the different phases relate.

DIAGNOSIS

The first step is the diagnosis to determine the kind of cancer involved. This means that the child needs to undergo a series of tests and scans to determine the specific type of cancer. These tests and scans include blood tests, urine tests, CT-scans, X-ray's and sometimes even biopsies. The diagnosis takes place either at a shared care centre or at the Princess Máxima Center. There are 15 main cancer categories (See figure 4) which can be divided into numerous subcategories.
In the Princess Máxima Center these cancers will be treated on 2 separate floors, the second floor is intended for solid tumours and neuro-oncology (the left half of the pie chart) and the third floor for haematological oncology (the right half of the pie chart). Solid tumours and neuro-oncology refer to tangible tumours while haematological oncology refers to blood and lymphoma cancers.

TREATMENT

After the cancer is diagnosed a treatment plan is established. This varies for each type of cancer and every child, but the main pillars of cancer treatment are:

- Chemotherapy (chemo)
- Radiation therapy
- Surgery

Almost every patient will receive chemotherapy. There are over 50 different chemos (skion.nl, n.d.) which all address different kinds of cancer. The way the chemo is distributed varies from oral medication to IV's. Some chemotherapy can be taken at home (sometimes with the aid of home care) but for most chemos one has to go to

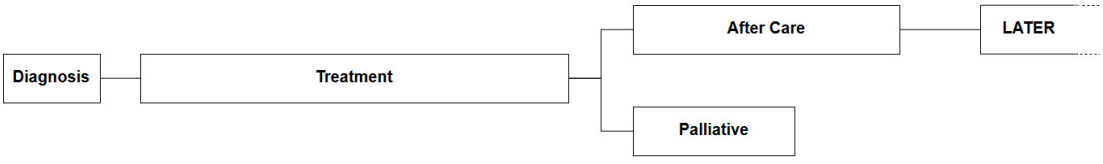


Figure 3: visualisation of the different phases

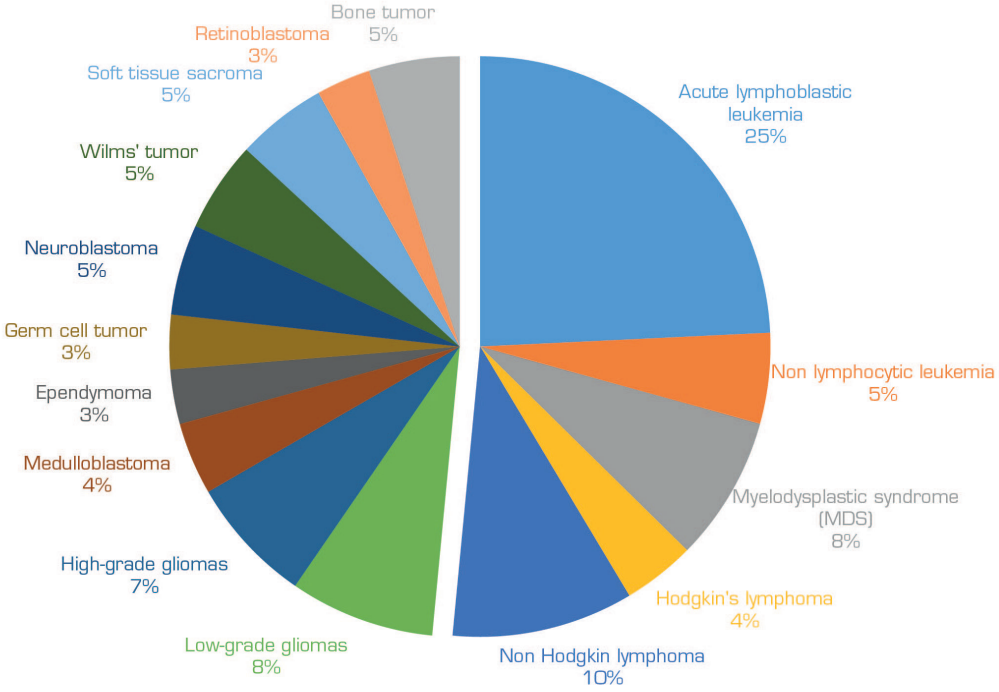


Figure 4: main categories of child cancer

one of the shared care centres or the Princess Máxima Center itself. In general these chemos can be given during the day so the child does not have to stay overnight. However, there are chemos which require a 24 hour IV. Each kind of treatment has different side effects which require additional care. There are for example chemos which cause hearing loss so regular visits to the audiologist are required. Others can result in weight gain so a dietician will be checking in regularly.

Some kinds of cancer will require surgery. A solid tumour can (partially) be removed by surgery, however this is not possible for haematological cancers. Both groups can receive radiation therapy. The patients with haematological cancers will receive radiation therapy mainly to prepare for stem cell transplantations while for solid tumours radiation therapy is used to decrease the size of the tumour. Both surgery and radiation therapy are not performed at the Princess Máxima Center. For surgery the Princess Máxima Center uses the operating theatres of the WKZ (Wilhelmina Kinder Ziekenhuis). For radiation therapy bunkers are required to contain the radiation. The Princess Máxima Center uses the bunkers of the UMCU (Universitair Medisch Centrum Utrecht) to treat their patients.

Aside from these main treatment methods there are regular physical check-ups and scans, as well as psychosocial check-ups by for example the child life specialist and the psychologist.

AFTER CARE

With the current treatment methods up to 75% of the cancer patients are cured. However, these patients still need to be monitored closely so they need to come back to the policlinic every few weeks or months for check-ups.

LATER

When a patient is cancer free for 5 years he or she still needs to be monitored, especially to check for any long term side effects of the medication. This means that child cancer survivors will be monitored for the rest of their life.

PALLIATIVE

The Princess Máxima Center aims for a 90% survival rate in 2025. This means that there still will be children who do not recover from their illness. These children will no longer receive curative care, instead they will receive palliative care which focuses mainly on pain relief and providing coping assistance.

CONCLUSION

Each of these phases comes with its own challenges and difficulties regarding appointments and thus the inevitable waiting. However, the two phases every patient will encounter are the diagnosis phase and the treatment phase. The diagnosis phase is very short; sometimes it only takes a day to make a diagnosis, while it is not uncommon for the treatment phase to last up to 2 years. This project will focus on the treatment phase.

STAKEHOLDERS

Many people are involved in the care of the patients. The main treatment will take place at the Princess Máxima Center. However, smaller treatment issues will be dealt with at one of the shared care centres. These are also necessary when, for example, a patient develops a fever. In that case the patient has to be able to get to a hospital within 30 minutes. In most cases the Princess Máxima Center is too far away. Furthermore, not all treatments at the Princess Máxima Center will be performed in the centre itself. For surgery the rooms of the WKZ will be used. While for radiation therapy the bunkers of the UMCU will be available. In figure 5 all stakeholders are displayed.

Some stakeholders (like the laboratory) do not have a direct connection with the child, while others (like the school) will not likely be contacted by the Princess Máxima Center directly.

However, with most stakeholders both the family and the hospital are involved in the communication. This also fits the vision of DOC since the parents and children are regarded as full members of the team.

CONCLUSION

This project will only focus on the treatment which is provided at the Princess Máxima Center itself.
Which is visualised within the dotted line in figure 5.

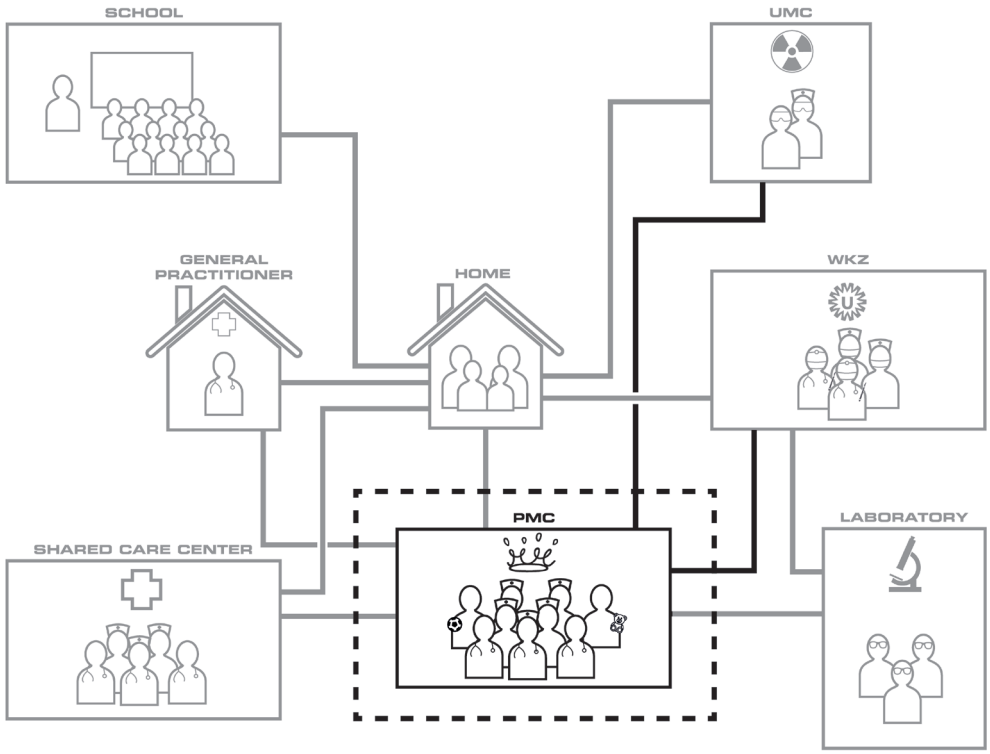


Figure 5: Overview of the stakeholders including design scope

FUTURE PRINSES MÁXIMA CENTRUM

The Princess Máxima Center will be housed in a new building which is currently under construction. This building will face the WKZ and will be connected to it via an air bridge. Figure 6 shows the location of the Princess Máxima Center, the WKZ and the UMCU.

The location in Utrecht was specifically chosen because of its central location in the Netherlands and also because it is close to an academic hospital with an excellent child department. To the proximity of the WKZ allowed for a bridge to connect both hospitals. This is a fast and safe route between both hospitals for patients who require surgery or check-ups with the specialists at the WKZ.

Figure 6: Map of the Prinses Máxima Centrum, WKZ and UMCU

FLOORPLANS

The Princess Máxima Center aims to centralise all different types of care not only in one building but also on one floor. The second floor for example is designated for solid tumours and neuro oncology. This means a lot of ultrasound imaging will be performed. So there is an ultrasound department located on the second floor. The third floor on the other hand, which is intended for the haematological oncology, has a department specially designed to perform bone marrow- and lumbar punctures.

The new building consists of 4 floors as shown in figure 7. Every floor has a specific function.

- Ground floor: entrance, radiology department, LATER polyclinic
- 1st floor: offices, psychosocial care, science centre
- 2nd floor: Solid tumours and neuro oncology
- 3rd floor: Haematological oncology

For more detailed information about the floor plans see appendix A.

All the areas which are outlined in red are related to the treatment, so these are generally the areas the patient will go to for appointments. The yellow areas are public spaces and the yellow outlined areas are the ABOs (these include the building area, the science centre and the park). So these are the places you can go to when you want distraction.

Treatment areas

General public areas

Designated public areas

OKE's

OKE's in isolation

Non accessible

Outdoor areas

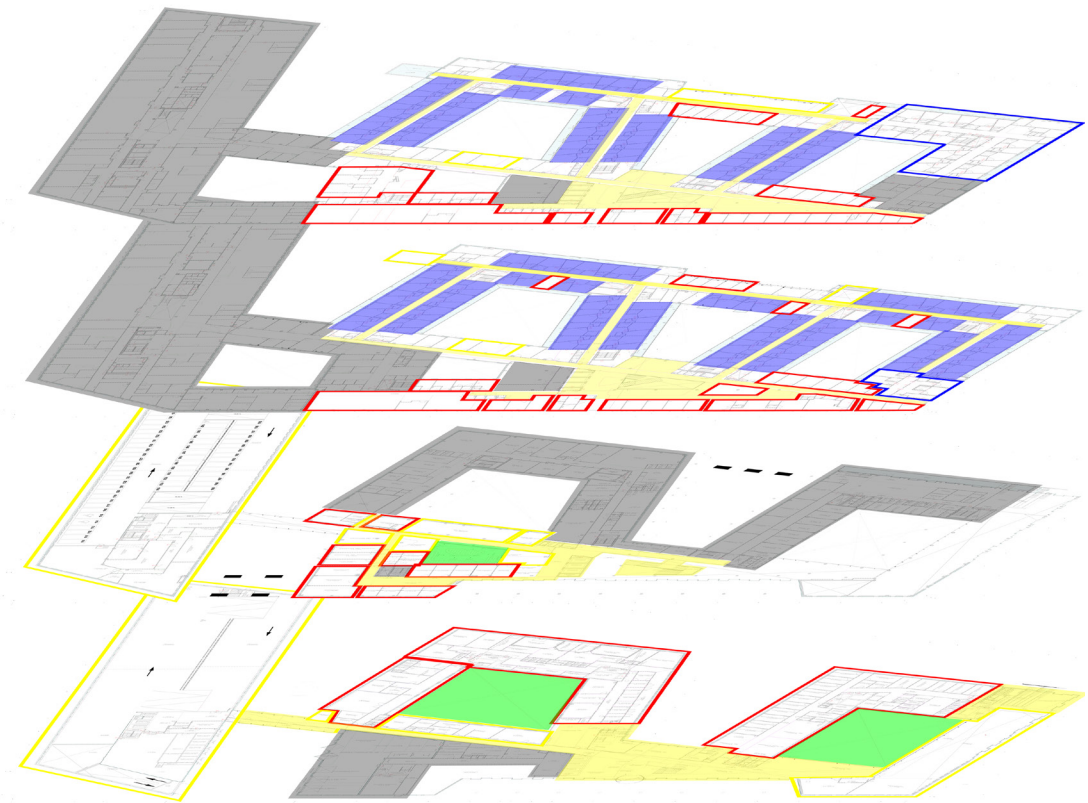


Figure 7: Floor plans of Prinses Máxima Centrum

When going to the hospital patients either visit the policlinic as out-patient or stay at the clinic in one of the OKEs as in-patient. During a consultation with an oncologist (A. Marvincurve, 2017) and a nurse (A. Dorsthors-Holtrop, 2017) it became evident that especially the patients at the policlinic are most inconvenienced by the waiting times. To get more insight an observational research was conducted at the current policlinic (poli oranje). The goal of this research was to determine what patients will encounter at the policlinic; which treatments do they receive and what is done by whom. From this a patient journey for the current policlinic was created as well as a patient journey for the future situation. During the research there was no focus on how the patients spend their waiting time but it was endearing to see a mother and her daughter dancing through the halls to pass the time.

Most of the children that come to the policlinic will be admitted at the day care either for chemotherapy or for small surgeries such as lumbar and bone marrow punctures. The group that receives chemotherapy is the largest, so the focus for this patient journey is on patients that receive chemo (although patients that are there for a different reason are likely to follow a similar route).

As a part of the DOC, the Princess Máxima Center aims to reduce hospital visits to a minimum. One way to achieve this is by scheduling multiple appointments on the same day. The benefit of this is that the child will only miss one day of school and the parents only need to take one day off at work. However, it also means that child and parent have to stay at the hospital the entire day and have to go from appointment to appointment. This results in long days at the hospital.

This means that when a child comes in for chemo it is very likely that he or she will also be visiting other departments such as the radiology department or a different specialist.

Aside from these non-chemo related appointments the day of every patient is very similar. The medical staff of the Princess Máxima Center (Dorsthors-Holtrop, 2017) has created a flowchart to show the route the patient currently follows at the Princess Máxima Center situated inside of the WKZ (figure 8). Every patient needs to undergo tests in order to get chemo, this means that his or her blood will be checked to see if the blood levels suffice. If the blood levels are too low the patient will not get chemo and has to come back a week later to follow the same route.

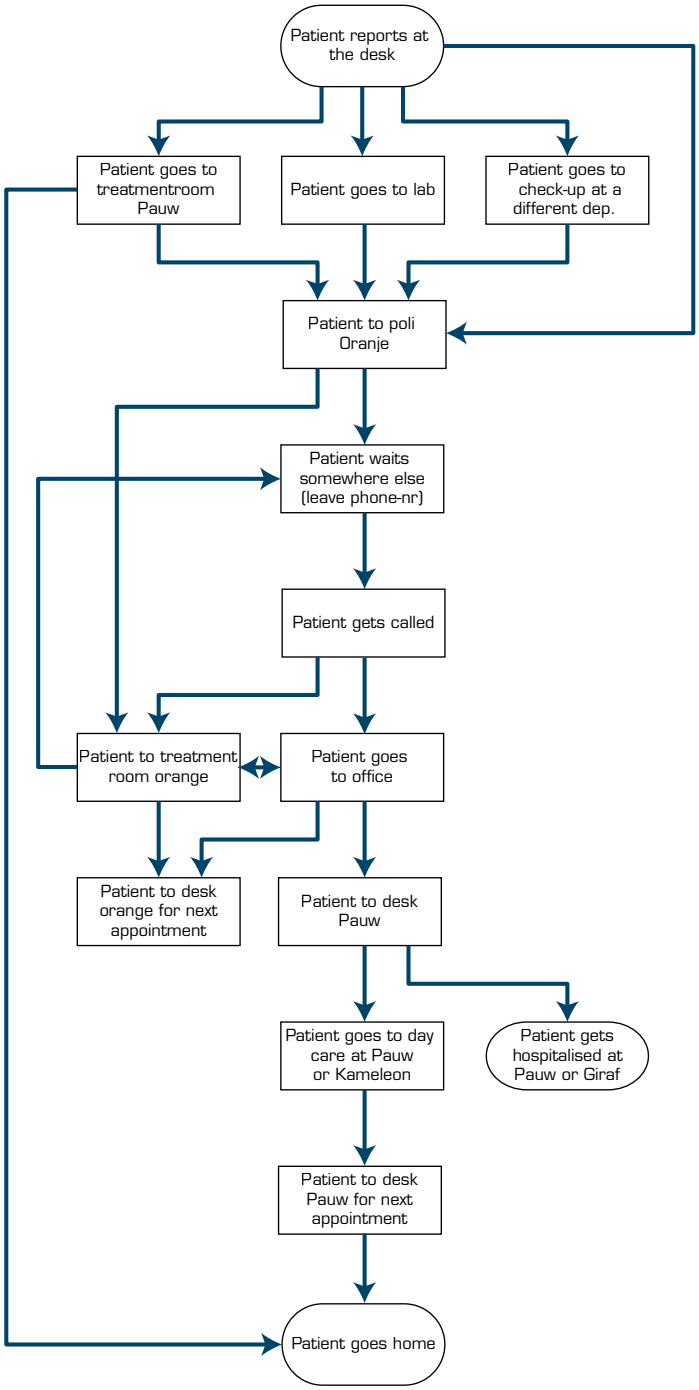


Figure 8: Flowchart of patient, defined by the medical staff (Dorsthors-Holtrop, 2017)

Based on the flowchart provided by the hospital and the observational research conducted at the current hospital. A swimlane diagram (figure 9) was created for the future situation in the new facilities. In appendix B both the current and the future situation are explained in more detail.

SWIMLANE DIAGRAM

The swimlane diagram shows the route of the family, coloured blue, and the different medical specialist involved in the treatment.

The patient journey starts when the patient checks in at the service desk of the Princess Máxima Center. He or she is then sent off to all non-chemo related appointments such as scans or check-ups at other departments.

Once this is done, the patient will return to the policlinic and will next be headed to the lab to have blood samples taken. The blood results need to be in before an appointment with the doctor. Once the results are available the medical assistant will notify both the doctor and the family. The doctor explains the results and decides whether or not the chemo can be administered. If the chemo can be administered, the patient will go to the day care for treatment. If the blood values do not suffice, the patient returns to the desk to make a new appointment.

Although the steps in this time line are generally the same for each patient, the length of the time line is definitely not. On average an appointment with the doctor takes about ten minutes. But administering the chemo can vary from thirty minutes up to four hours. The time frame for the non-chemo related appointments depends highly on the number and the nature of these appointments. A check-up at the audiologist will take only fifteen minutes but an MRI scan can take up to an hour.

The minimum time spend in the hospital is about one hour and thirty minutes. In this case the patient only comes in for a short chemo injection. On the other hand it is also possible for a patient to spend up to ten hours in the hospital. For example when an MRI scan needs to be made while the child is anaesthetised and a check-up at another department is scheduled. Followed by a chemo injection of four hours. On average, the patients will be in the hospital for about four to six hours.

CONCLUSION

Patients who come to the policlinic have to deal with the most uncomfortable waiting times. Most of these patients are admitted to the day care for a chemo treatment. They spend on average four to six hours at the hospital.

During this time they need to visit many different departments, not only in the Princess Máxima Center but also at the WKZ and the UMCU.

Not only the length of their day in the hospital is uncomfortable, they also face many different appointments and waiting times.

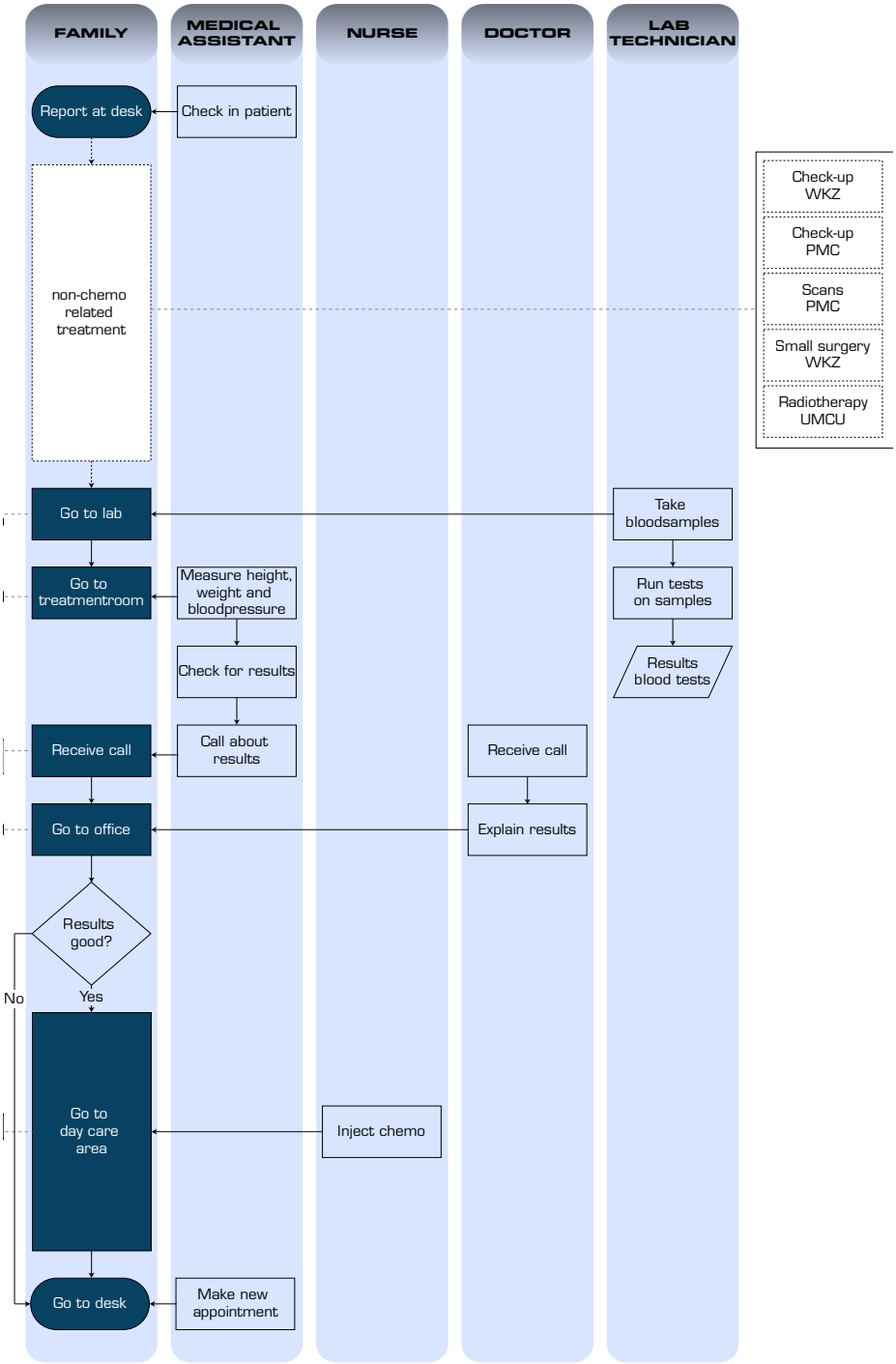


figure 9: Swimlane diagram of the future situation

WAITING TYPES

Based on the patient journey several kinds of waiting can be distinguished. When thinking about waiting the first thing that comes to mind is waiting for an appointment. However, that is not the only reason why people have to wait at a hospital. Other kinds of waiting are:

Waiting for results

Blood needs to be analysed and scans need to be checked, this takes time. Sometimes these results are essential in order to be able to proceed with the treatment. For example when testing blood levels before chemotherapy.

Waiting on the IV

When you are hooked up to the IV it can take quite some time for the IV bag with medication or blood to empty. This type of waiting is connected to a limited freedom of movement.

Waiting for medication

It is not uncommon for the children to get some kind of pre-medication before a treatment. For example when a child is afraid for needles. The spot where the needle will enter the body is rubbed in with an anaesthetic cream to numb the area. It takes up to thirty minutes for this cream to work properly. The same goes for contrast fluids used to enhance images of CT-scans. After the fluid has been taken in, some time is needed before it spreads throughout the body.

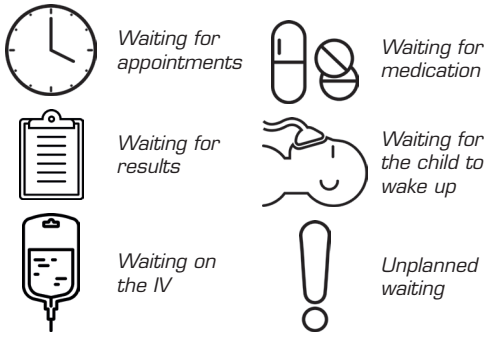
Waiting for the child to wake up

When a child is in surgery it will not be aware of how long it is anaesthetised. However, the parents who are waiting are all the more aware of how long it takes. This is the same for all treatments which require the patient to be anaesthetised.

Unplanned waiting

In addition to these five kinds of waiting there are unanticipated waiting times, for example when there is an emergency and you have to see a specialist without an appointment. Or when something goes wrong such as equipment failure.

The different kinds of waiting are added to the patient journey (shown in figure 10) to show where each kind of waiting occurs. The 'unplanned' category could occur during every step in the diagram so in order to keep the image clear this one is left out.



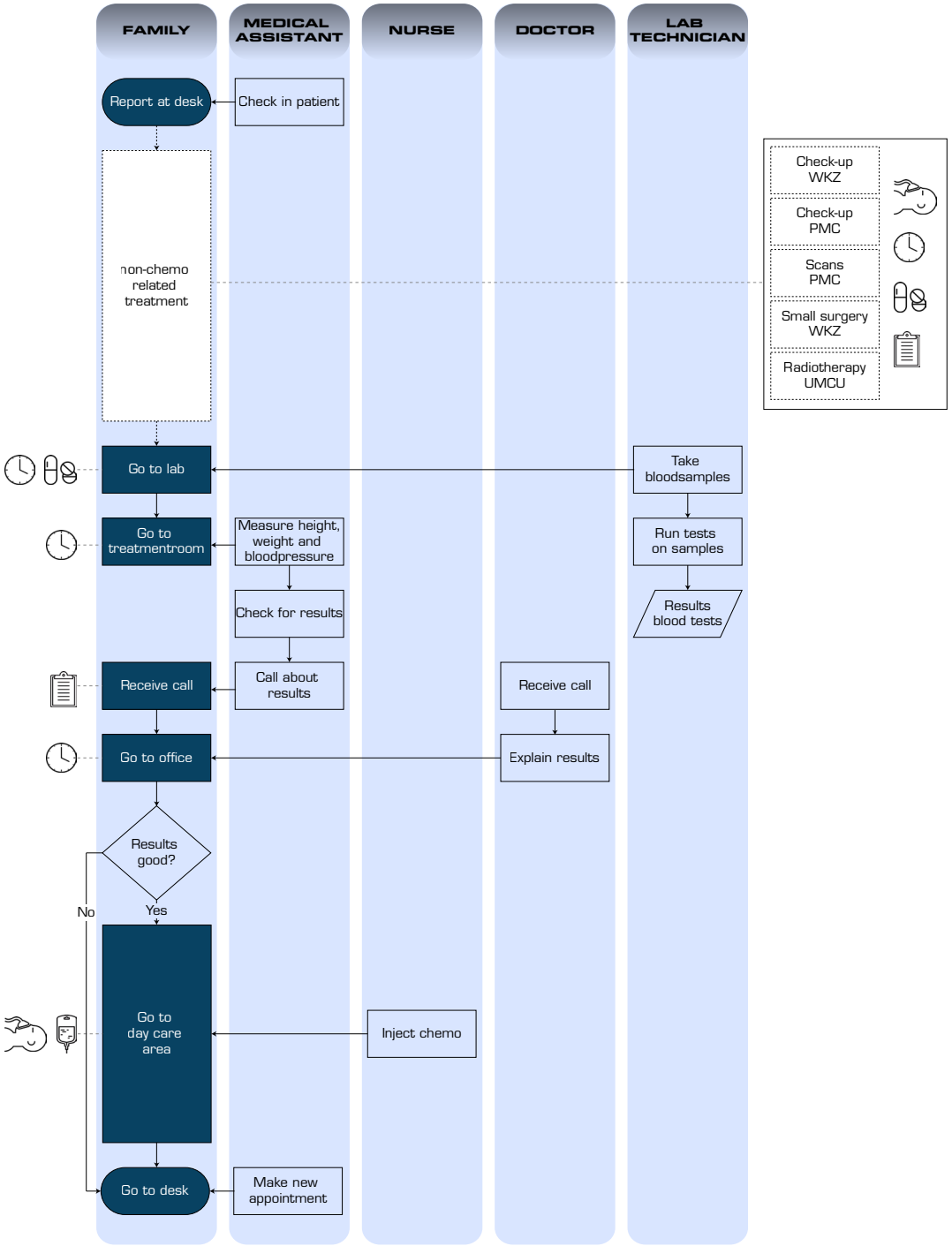


Figure 10: Patient journey including differend kinds of waiting

'Waiting is a form of imprisonment. One is doing time, but why? One is being punished not for an offence of one's own, but for the inefficiencies of those who impose the wait. Hence, the particular rage that waits engenders the sense of injustice. Aside from the boredom and psychological discomfort, the subtle misery of waiting is the knowledge that one's most precious resource, time, a fraction of one's life is being stolen away, irrecoverably lost.'

- Morrow, 1984 -

People see waiting as something that is inevitable when going to the hospital. Healthcare appointments are made using time block systems, this means that the time of the doctor is divided into several blocks and each kind of appointment takes one or several time blocks. For example, a regular check-up takes one time block while an intake meeting takes two time blocks. However, not all appointments fit within the allotted time block, resulting in a delay for all following appointments.

TIME PERCEPTION

Waiting is defined by the dictionary as "staying where one is or delaying action until a particular time or event." (oxforddictionaries.com, 2017) Waiting is thus inextricably linked to time. So in order to get a better understanding of waiting it is important to understand time.

Time is something that everyone thinks they understand, however, when asked to give a compact definition of time it becomes clear that this is not as easy as it sounds.

Time is something we cannot grasp, as Block and Zakay (1997) explain, people do not possess a sense to perceive time, so in order to make an estimation on how much time has passed one has to rely on other senses and experiences. The passing of time as experienced by one is called subjective time opposed to objective time which is the actual time. In general the subjective time as perceived by a person resembles the objective time quite accurately. However, the subjective time can be influenced by several internal and external factors resulting in a discrepancy between the objective and subjective time.

"Put your hand on a hot stove for a minute, and it seems like an hour. Sit with a pretty girl for an hour, and it seems like a minute. THAT'S relativity."

- Albert Einstein -

According to Vohs and Schmeichel (2003) people who have to suppress emotions tend to overestimate the time. As dealing with child cancer can evoke a lot of emotions, suppressing these emotions while waiting at the hospital is not uncommon. This suppression of emotions leads to a sense of extended time, the so called extended now, resulting in a longer subjective time. So time goes slowly for people who have too much time at a moment which is inconvenient for them (van Hagen, 2015).

The passing of time while waiting can be divided in actual waiting time, perceived waiting time and acceptable waiting time (A. Pruyn, A. Smidts, 1998). The actual waiting time relates to the objective passing of time while the perceived waiting time relates to the subjective passing of time. Acceptable waiting time

is the time a person is willing to wait for a particular service. The acceptable waiting time can greatly influence the perceived waiting time. If the actual waiting time is shorter than the acceptable waiting time, the perceived waiting time feels shorter than the actual waiting time. However, if the actual waiting time exceeds the acceptable time, the perceived waiting time feels longer than the actual waiting time (A. Pruyn, A. Smidts, 1998).
So in order to improve the waiting experience it is not necessarily required to reduce the actual waiting time. It is also possible to alter the acceptable waiting time and the subjective passing of time, thus shortening the perceived waiting time.

According to Bailey and Areni (2006) attention can be processed both temporal and non-temporal. With temporal processing people are consciously monitoring the passing of time while non-temporal processing refers to activities that are not related to time. Decreasing temporal activities results in less information regarding the passing of time, thus resulting in a shorter subjective time.

EXTERNAL STIMULI

A stimulus organism response model (SOR model) was created by Mehrabian and Russel (1974) and displays how environmental stimuli influence behaviour via emotions (figure 11)
The environment is able to influence emotions of a person, resulting in approach or avoidance behaviour. Approach behaviour is a positive response to the environment, feeling connected with the place, wanting to explore it and wanting to return there (van Hagen, 2015). Avoidance behaviour results from a negative response to the environment. Wanting to leave, feeling uncomfortable and feeling no connection with the environment (van Hagen, 2015).

The positive approach behaviour can be stimulated by adding the correct environmental stimuli which can be linked to the emotional states; pleasure, arousal and dominance (PAD) as identified in the model created by Mehrabian and Russel (1974)

Pleasure stands for the degree to which a person feels comfortable or content in an environment;
Arousal stands for the degree to which a person is stimulated by the environment;
Dominance is the degree to which a person has a sense of control over the situation.
So in order to stimulate an approach response the environment should feel comfortable to one and should stimulate him or her as well as provide one with a sense of control over the situation.

However, in order to create these emotional states the stimuli should neither be too little nor too much. (van Hagen, 2015) Only when one finds himself in the comfortable zone one can focus on non-temporal activities which can lead to a shorter subjective time.

THE BENEFITS OF WAITING

Even though long waiting times can be unpleasant there are several benefits to waiting, especially in this

case where the families have to deal with multiple appointments in one day. The time between appointments can be used to process the previous appointment and prepare for the next. Without these intermezzos the families have no time to recuperate which will also lead to stress.

CONCLUSION

In order to create a more pleasant experience, the actual waiting time does not necessarily need to be reduced. Instead it is more important to reduce the perceived waiting time. This can be done by reducing the subjective time, for example by providing the one that is waiting with non-temporal stimuli and by creating an approach behaviour by stimulating pleasure, arousal and dominance.

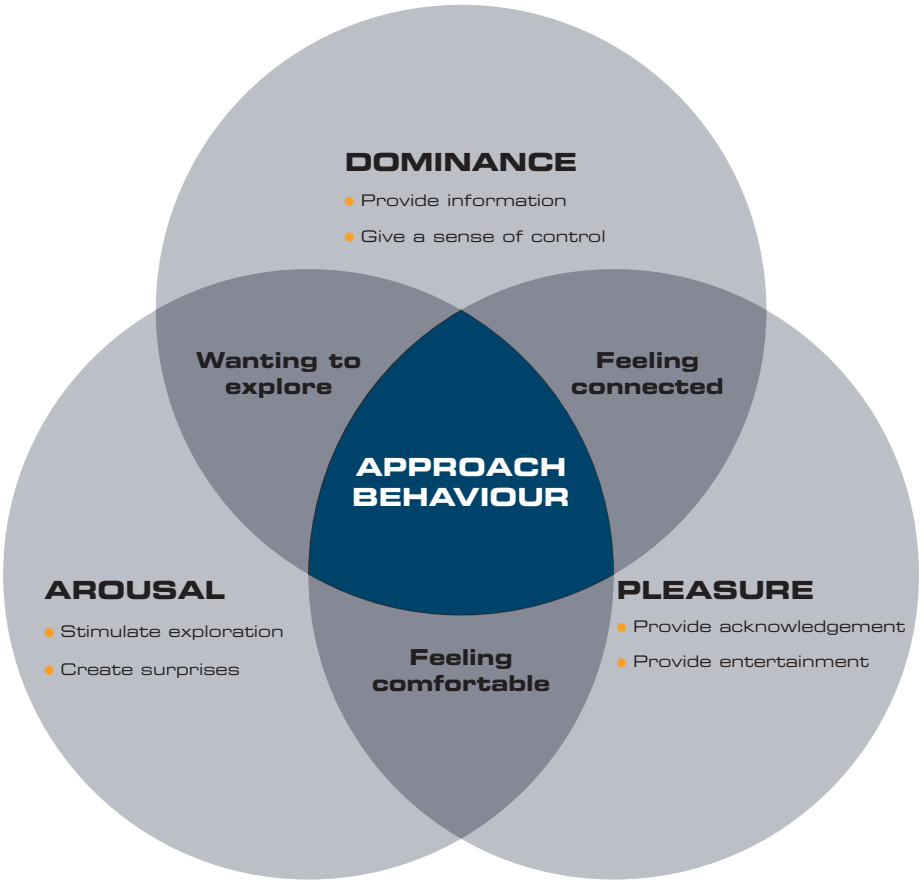


Figure 11: The factors that can influence an approach behaviour

Not only the children have to go to the hospital, but their parents as well. The mood of the one can greatly influence the mood of the other. So when searching for a solution to reduce the perceived waiting times both children and parents need to be considered.

To get a better understanding of the users it was possible to join several creative sessions organised by Jannie Dijkstra Pinto Leite (2017) who was defining personas of the families who visit the Princess Máxima Center. During these sessions various members of the medical team, from different disciplines, gave examples of families they encountered. Based on this information a framework was created which resulted in 6 different personas. Figure 12 shows one of these personas. See appendix C for a complete overview of the personas.

These personas, together with the literature study, observational research and interviews have led to a better understanding of the issues both parents and children experience which result in a lengthened sense of waiting;

For parents the main problem is the lack of control and high stress levels due to not knowing what is going to happen next (for example in the case of waiting for blood results). In combination with suppressing emotions this results in a mental state of “extended now”.

Children on the other hand are more affected by the anticipation of an unpleasant experience and the boredom due to a lack of activities, which leads to a longer subjective waiting time.

To solve these problems different solutions are required.

It is important for the parents to be given a sense of control and a form of non-temporal activity to get their mind out of the “extended now”. This can be done by providing them with information which increases the sense of control and gives the wait meaning, thus decreasing the stress levels of the unknown.

For the children the non-temporal activity is also important because it provides distraction and gives the children something to do. They should ‘forget the time’ and thus forget the anxiety that comes with the anticipation of an unpleasant experience.

CONCLUSION.

From this research it can be concluded that the parents have a need for information and a sense of control, while the children mainly need a source of distraction.

FAMILY NAME: VAN BENNEKOM

FAMILY MEMBERS

Max 3yr
Patient. A cheerfull little guy.

Joost 39yr CEO of IT company
Father. Works a lot but always tries to make time to go the hospital with his son.

Marieke 37yr Manager
Mother. Always comes prepared. She likes to keep a list of questions and wants to be kept up-to-date

Sarah 6yr
Sister. Comes to visit her little brother frequently.

FAMILY DESCRIPTION

The family has a steady home situation, Marieke has taken sick-leave while Joost keeps on working. However, they both like to spend time in the hospital with Max and want to be there when descisions are made. The recovery of Max comes before everything although they do try to make time for Sarah as well.

They can count on friends and family especially both grandmothers like to assist and spend a lot of time babysitting Sarah and cooking diner.

DISEASE

Max was diagnosed with a neuroblastoma last year. A "wait and see" strategy was applied. Unfortunately the tumor did not decrease so now Max just had surgery and he will start with chemo really soon.

INTERACTION

The family is very loving and are eager to help where possible. Max doesn't let the treatment bother him although he is not very fond of the needles. Marieke is the one that does all the talking although it is obvious that both parents are very well aware of the situation. They have done their research and want the medical team to be fair and honest with them. Their focus is on current situation but they want to be prepared for the future as well.

PARTICIPATION

Both Parents try to be at the hospital as often as possible. When Max is admitted they alternate who stays the night.

They are very involved and even though they do believe that the medical team knows best they are eager to know everything and closely monitor their child. Marieke keeps a diary in which she writes down everything that has happened to Max and how he responded both physical and mental.

Figure 12: One of the created personas

FINDINGS

In this chapter the target group is defined and the findings from the research are combined into a list of requirements.

This project focuses mainly on the families who come to the policlinic and have multiple appointments a day.

Every year approximately 550 patients are diagnosed with a cancer. Some of these cancers can be treated in a short amount of time; for these patients the treatment phase only lasts several weeks. For other cancers it takes several years. For example the most common form of child cancer, leukaemia, has a treatment phase of two years. At any time there are approximately 700-800 patients in the treatment phase. The day care areas on the second and third floor of the hospital have room for respectively fifteen and twenty patients at any given time. Approximately fifty patients will visit the day care area every day (F. de Munck Mortier, 2015). Before these patients come to the day care area they first visit the polyclinic. In addition to the day care patients another sixty consultations are performed at the polyclinic. Most of these patients only come for a check-up, so in general they have no additional appointments. There is room for 85 patients at the clinic, they also have multiple appointments during the day. Although they are probably less mobile than the out-patients many of these patients like to get out of their rooms once in a while.

These patients range from zero to eighteen years old. For this assignment the focus will be on the six to eleven year olds and their families. As shown in figure 13 this is about 26% of the total patient group. So every day there will be about forty patients within this age group at the hospital. However, although the focus is on the six to eleven year olds, it is desirable to find a solution which also works for the three to six and twelve to eighteen year olds. The 0-2 year olds are excluded from this target group since they have a different perception of time due to their limited experience. This requires a different design approach. In total there will be approximately 165 children every day that fit within this target group (see figure 14).

Conclusion

The target group consist of out-patients who have multiple appointments per day and are between six and eleven year old. In-patients and patients in the age groups three to six and twelve to eighteen should also be considered. Resulting in approximately 165 families a day.

	0-2 jaar	3-6 jaar	6-11 jaar	12-18 jaar	TOTAAL
totaal zorgunit hemato-oncologie	37	82	56	82	257
subtotaal Neuro-oncologie	*11*	*39*	*44*	*24*	*118*
subtotaal Solide tumoren	*36*	*30*	*43*	*61*	*170*
totaal zorgunit Neuro-oncologie/ solide tumoren	47	69	87	85	288
TOTAAL	84	151	143	167	545

Figure 13: An overview of the total number of patients each day (F. de Munck Mortier)

AGE	OUT-PATIENTS Policlinic	Day care	IN-PATIENTS OKÉ	TOTAL
0-2	9	8	13	30
3-6	17	14	24	54
6-11	16	13	22	51
12-18	18	15	26	60
TOTAL	60	50	85	195

Figure 14: an oververview of the total number of patients based on location

FINDINGS

The user consist of the child that has the cancer and the entire who joins them to the treatment sessions. The project will focus on the treatment phase at the Princess Máxima Center itself with an emphasis on the policlinic. This results in a target group of 700 to 800 families of which every day 165 are at the hospital for treatment. When these families come to the policlinic they have to deal with different kinds of waiting at different moments.

- Waiting for appointments
- Waiting for results
- Waiting for the IV
- Waiting for medication
- Waiting for the child to wake up
- Unplanned waiting

From the research it can be concluded that in order to make these kinds of waiting a more pleasant experience, the perceived waiting time should be reduced. This can be done by stimulating an approach behaviour by providing the user with a sense of control, creating a comfortable environment and by stimulating exploration.

Both parent and child have different issues with waiting which result in an extended perceived waiting time. For the parents this is mainly due to not knowing what is going to happen and a loss of control. While for the children it has more to do with the anticipation of an unpleasant experience in combination with boredom due to a lack of activities.
So the parents have a need for information and should feel like they have some sort of control while the children should be provided with an activity that could make them “forget time”.

This can be combined with the vision of MMEK’ to make sense of information and to provide meaningful interactive environments and also fits the vision of the Princess Máxima Center to provide medical healthcare in combination with development oriented care.

While aiming to achieve a better waiting experience, it is essential to keep in mind the reason why the family visits the hospital. The family comes to the hospital for treatment and in order to achieve this they have to visit several specialists. These visits are organised in a big agenda leading to specific times for each patient to visit the specialist (appointments). When a patient comes to the hospital he or she will have to follow a schedule of appointments at different times and different locations.

The treatment phase of a patient can vary from eight weeks up to two years. During that entire timeframe the families often are faced with waiting, so it is important that the product can reduce the perceived waiting time throughout the entire treatment phase. The goal is furthermore to stimulate exploration and to get the families out of the waiting room. So they should be able to use the product throughout the hospital.

CONCLUSION

In order to achieve the reduction of the perceived waiting time an approach behaviour should be stimulated by providing the user with a sense of control, stimulating exploration and by creating a comfortable environment.

Furthermore the parents and children should be addressed separately since the parents have more need for information and a sense of control while the children have more need for an activity to distract them.

LIST OF REQUIREMENTS

Based on the findings an initial list of requirements was created. The most important requirements are:

- The product should contribute to a comfortable environment
- The product should provide the user with a form of distraction
- The product should give the user a sense of control
- The product should be relevant throughout the entire treatment
- The product should stimulate exploration
- The product should be accessible throughout the hospital.

Figure 15 gives an overview of the general requirements.

Other requirements to keep in mind have to do with hygiene. Since the product will be used by children with a very low resistance, it is important that it is easy to clean and sterilize. This means that the exterior should be constructed of a material which is resistant to water and detergents. Furthermore the product should have few and preferably no holes and cavities as these provide places where dirt and germs can accumulate.

It is also important to bear in mind that the product will be used by children, so durability and portability should be considered as well.

During the design process more advanced requirements were added to the list. See appendix D for the full list of requirements.

1 GENERAL

1 PERFORMANCE

1.1.1	The product should provide the user with information about appointments (time, location, participants)
1.1.2	The user should have access to the product throughout the hospital. This includes the public spaces and the day care area but does not have to include the treatment rooms and radiology department
1.1.3	It should be possible to notify the patient through the product. These notifications can refer to waiting times, but also to treatment related information as well as personal messaging
1.1.4	The product should encourage exploration through the hospital
1.1.5	The product should provide the user with a sense of control (evoke dominance), this does not have to relate to waiting
1.1.6	The product should make the user feel comfortable in the environment
1.1.7	The product should provide the user with some kind of distraction
1.1.8	The product should be relevant throughout the entire treatment phase
	It should be possible to trace the location of the product to:
1.1.9	Locate the user (e.g. when a child runs away)
1.1.10	Recover the product when lost
1.1.11	Discourage theft
1.1.12	Receive directions

Figure 15: overview of the general requirements of the list of requirements

IDEATION

In this chapter the initial ideas are presented as well as the descision making process that is used to make a choice between these ideas.

The findings from the analysis phase gave inspiration for many different ideas. They varied from games for the children to monitoring devices for the parents. The most interesting ideas are shown in the following images (figure 16). For an overview of all the ideas see appendix E.

DECISION MAKING

These ideas were tested using a sticker system. The most important demands from the Program of requirements are all linked to a different colour sticker.
The different categories are:

- The product should contribute to a comfortable environment
- The product should provide the user with a form of distraction
- The product should give the user a sense of control
- The product should be relevant throughout the entire treatment
- The product should stimulate exploration
- The product should be accessible throughout the hospital.

Each idea was rated with a full, a half or no sticker for each category.

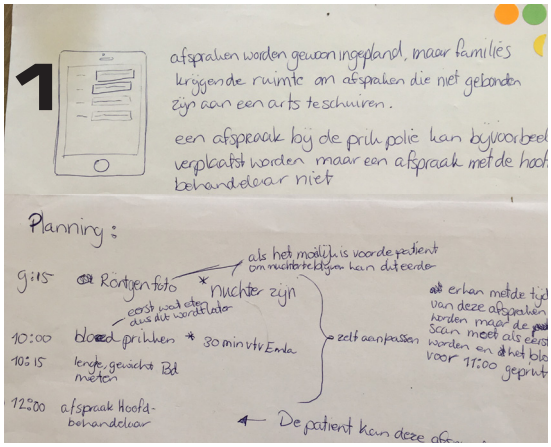
From this the four ideas with the most stickers were selected.

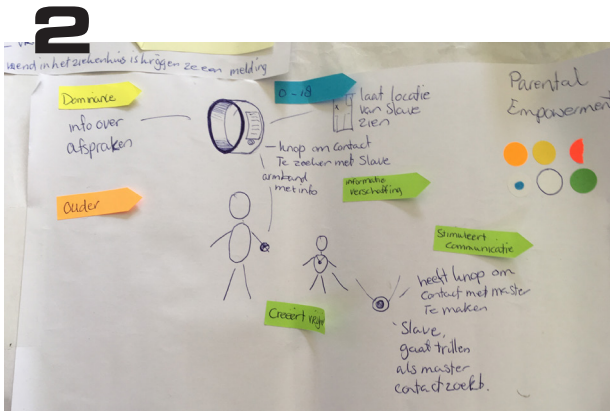
An app for the parents to monitor the appointment schedule, which would give them more information as well as a sense of control.
A tracking device consisting of a bracelet for the parents and a necklace for the children. Through these devices they are able to communicate with each other like a walkie talkie. Furthermore the parents' bracelet has a display that shows the location of the child's necklace. This provides them with a sense of control and a means to feel more comfortable by knowing where their child is.
A game that encourages the children to explore the hospital. They will receive a disk with a display and throughout the hospital markers are placed on walls, floors, furniture etc. They can collect animals (or other collectibles) by placing the disk over a marker. This will encourage them to explore and will provide a means of distraction
Another game makes use of screens on the wall. A patient can log onto one of the screens and gets to see its avatar. Completing different treatments will earn them points which they can spend on the appearance of their avatar. This gives a sense of control and provides them with a form of distraction. It also encourages them to go through with the treatment since that is how they can earn points.

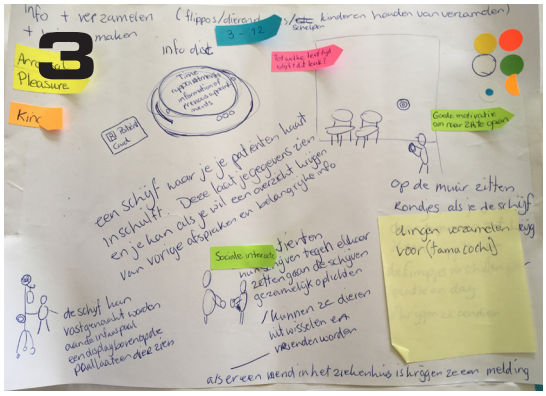
These four ideas resulted in three design directions:

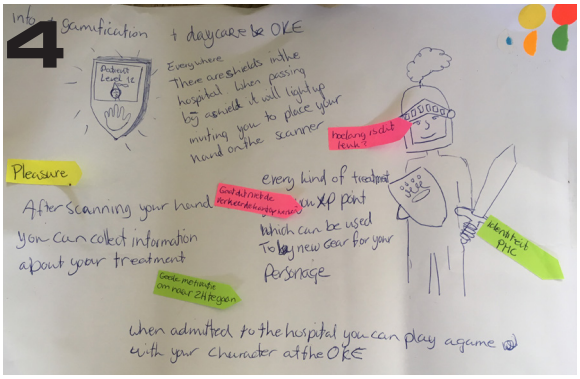
- App
- Tracking
- Game

These three directions were further developed, see appendix F for the further developed design directions.


1
afspraken worden gewoon ingepland, maar families
Planning:
Röntgenfoto
nuchter zijn
bloed prikken
30 min uitv. Enda
zelf aanpassen
De patient kan deze


2
Dominante
info over afspraken
0 - 19
Parental Empowerment
Ouder
Stimuleert communicatie
heeft hulp om contact met master te maken
Slave, gaat trillen als master contact zoekt.


3
Pleasure
Kink
info dist
een schijf naar je je patienten kant
op de muur zitten
Sociale interactie


4
gamification
+ daycare bij OKE
Pleasure
After scanning your hand
you can collect information
about your treatment
every kind of treatment
you XP point
which can be used
To buy new gear for your
Persnage
When admitted to the hospital you can play agame
with your character at the OKE

COMBINING IDEAS

While discussing the three options it became apparent that these are three different aspects of the solution. The app focuses on giving the parents information, the game focuses on providing the children with a form of distraction and the tracking device gives both of them a sense of control. In order to design a concept that satisfies all of the main criteria a combination of the three design directions was made, resulting in the following concept system.

This system consists of a device that can both be used to track the children and to play games and an app for the parent, to give information about their waiting times and that serves to connect with their child. It could also display other meaningful information about the treatment. Both the parent and the child will receive a notification when it is time for an appointment. This provides them with a sense of control. Both the app and the device will be connected to the Wi-Fi and be linked to a personal account on which the patients' data is collected. This account is connected to HiX, the program the Princess Máxima Center uses for their patient administration. As HiX contains confidential information direct communication cannot be established. Only the medical staff has direct access to HiX. See figure 17.

The main features of the system are the app for the parents and the device for the children. These will be reviewed more in detail in the following chapters. In this project the focus will be on the device for the children, the app will be addressed in a nutshell only.

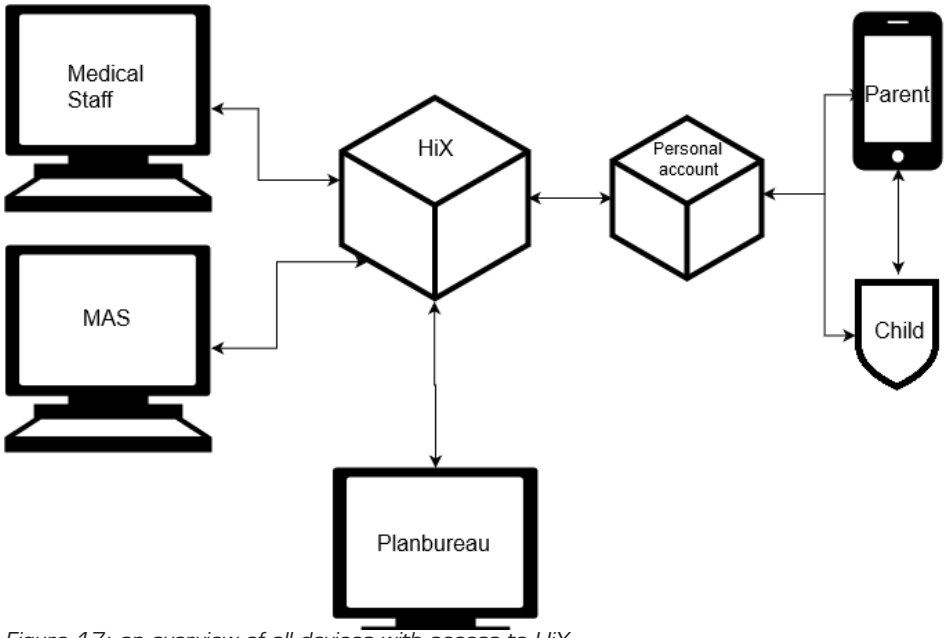


Figure 17: an overview of all devices with access to HiX.

As stated earlier, the main issue for parents is the lack of control and high stress levels which in combination with suppressing emotions results in a mental state of “extended now”. To provide them with a sense of control and to get their minds out of the “extended now”, information should be provided.

In this case “providing information” will be done via an app. This app will give them insight into their schedule and can also be used to inform them of changes to this schedule. This gives them more control over the situation which should lead to less stress. Via the app the parents can communicate with their child; they can send messages and locate their position. Furthermore, the app can be used for other means related to the treatment of the patient. For example to monitor the medicine intake of the patient and to make notes during or in advance of appointments, which can be linked to the schedule, to ensure that they will not forget to ask vital questions. Figure 18 shows what the interface of the app could look like.

Figure 18: Diffrerent interfaces of the app.

The main problems for the children are the anticipation of an unpleasant experience and boredom due to a lack of activities which lead to a long perceived waiting time.
Therefore activities should be provided, in order to give them a means to “forget the time”.

To provide an activity, a game will be developed which can be played via a device that also doubles as a tracking device. The goal of the game is to distract the patient and to stimulate physical activities and social interactions.

The game should provide distraction during the entire treatment phase so it should be interesting over a longer period of time. Because the waiting times for different appointments vary, it should be possible to play for several minutes up to half an hour.

Although this game should distract patients from the waiting time it should not interfere with the treatment, so when it is time to go to an appointment it should be possible to interrupt the game. It would be even better if the game could be used as a motivation to go to the appointment.

To incorporate the DOC the game should promote physical activities and social interactions. There are several interesting play and educational areas (ABOs) in the hospital. Visits to these locations could also be incorporated.

To determine what kind of device should be used for playing the games a study has been done to compare a handheld device, to a basic wearable bracelet in combination with portals. See figure 19.

In this study the pros and cons of both devices where evaluated and from this comparison it became evident that the wearable was the preferred choice. Especially because the wearable itself is less expensive and more durable than the handheld device. Furthermore the wearable is more portable and stimulates physical activity as the children are required to go to a portal in order to use it. See appendix G for the full comparison.

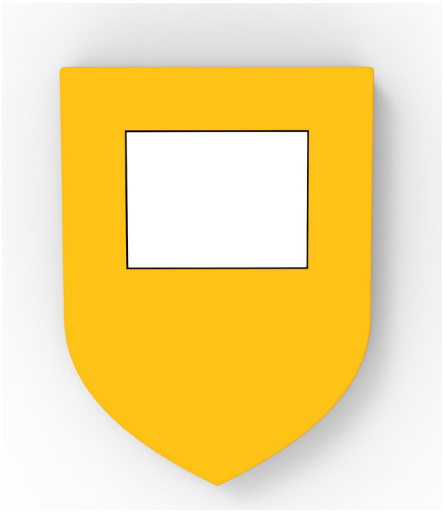


Figure 19: A basic wearable in combination with a portal was compared to a handheld device

CONCEPTUALISATION

The ideas have been futher developed into a sound concept of the total system.

The app, wearable and portals together form a system which can serve as a solution to decrease the perceived waiting time of the families. To tie the entire system together and make optimal use of the environment one additional feature will be added to the system. Throughout the hospital there will not only be portals which can be activated by the wearable, there will also be patches, stickers embedded with an NFC tag. These patches can be used as game elements but will also activate the lights on the wearable when not part of a game. These patches add a surprising element to the environment while also tying the different locations together.
Figure 20 shows an overview of how the different elements in the system are connected.

The system is called MAX, referring to the Princess Máxima Center, to making MAXimal use of the hospital and to giving the families a feeling of MAXimum control.

The goal of the system is to keep the children occupied and entertained during their waiting time while contributing to the development oriented care. Additionally it gives the parents a sense of control and provides a means of distraction for them as well.

Each element will be briefly explained followed by a scenario that explains the intended use. In the Embodiment chapter the elements will be described more in detail.

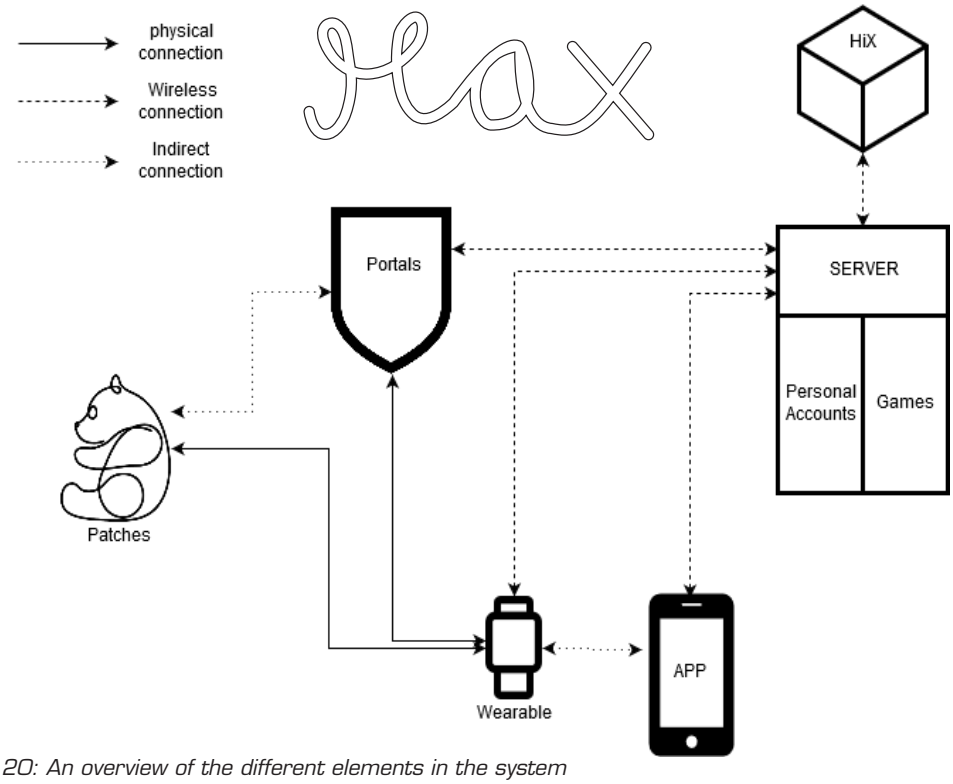


Figure 20: An overview of the different elements in the system

WEARABLE

The system consists of a wearable which is worn by the patient. This wearable contains only a few features: a grid with GRB LEDs and a vibrating engine is used to convey messages and a single button can be used to locate the nearest portal. It contains an NFC chip which can be used to log in to the portals. Furthermore it has a microprocessor and a power supply and is connected to the Wi-Fi network. In order to determine its position it also contains an accelerometer and gyroscope chip. Figure 21 displays the exterior of the wearable.

The wearable can be used for:

- Receiving notifications
- Finding directions
- Playing games
- Creating an interactive environment

Figure 21: The exterior of the wearable

BRACELET

The wearable is connected to a bracelet which the patient receives during the first visit. The bracelet belongs to the patient while the wearable stays at the hospital. The bracelet consists of a silicone band with a plastic connector plate attached to it. While not in use the bracelet looks very nice and is suitable to wear every day. Engraved in the connector plate is the Princess Máxima Center logo, see figure 22.

Figure 22: The bracelet including the connector

PORTALS

Throughout the hospital there are multiple portals where the patient can check in using the wearable. These portals contain a tablet and an NFC reader. Figure 23 shows the exterior of a portal. There are several features that all portals contain.

On each portal:

- Notifications can be read
- The schedule of the patient can be looked up
- A destination can be selected such as:
    - Other portals
    - Parents
    - Treatment rooms
    - Other patients

Figure 23: A portal with a tablet and NFC reader

PATCHES

Throughout the hospital there are patches placed on walls, floors and furniture. These patches are stickers of about 10 to 20 cm diameter which contain NFC chips. They could be part of a game, but when not used for a game tapping them will display a nice pattern on the wearable. These patches could be used in waiting areas of the WKZ polyclinics as well, making the Princess Máxima Center children who have appointments at these policlinics feel noticed. See figure 24 for examples of patches.

Figure 24: Examples of patches

GAMES

At each portal different games can be played. These games can make use of patches but could also be stand alone. Furthermore games could encourage social interaction, when for example you need multiple players to play a game. The type of games vary for each location. Games at ABOs can be longer and more physically active. While games close to the treatment rooms are meant to keep the children busy for the final minutes of their waiting time, so these games need to be shorter.

The goal of the games is to provide distraction, to stimulate interaction and to create physical and mental challenges.

To give an impression of how the MAX could be used in the Princess Máxima Center a story was written. It is about nine year old Sarah who has to go to the hospital to get chemotherapy.

Sarah and her mom left home early, Sarah is very nervous because she will not only be receiving chemo today, but she also needs an echo. The doctor wants to know what the tumour looks like now that she has had several chemo sessions.

She was not allowed to eat this morning because the food could prevent a clear view of the tumour in her belly, this makes her a bit grumpy. Fortunately traffic was light and they arrived at the hospital in time. After parking the car, Sarah and her mom head to the 2nd floor of the hospital to check in at the "solid tumours" department. Here nurse Saskia logs them into the system. But that is not all, Sarah may also pick a MAX. She chooses a pink one, her favourite colour. Saskia places the pink MAX over a scanner and registers Sarah's patient file to the device. She hands the MAX over to Sarah who slides it onto her bracelet. By pressing the button on the MAX arrows appear. Sarah follows the arrows which lead to a portal. She holds the bracelet to the portal and her avatar, Maxim, appears. "Welcome Sarah! Good to see you, are you ready for your echo?" Maxim asks. "Let's look at your schedule for today". Together with her mom Sarah looks at her schedule. Mom also has the schedule on her phone, but they like to discuss the different appointments and any activities they can do between appointments. "Look mom, there is plenty of time for breakfast after the echo is done." Sarah notices. Then her MAX starts to vibrate and the lights turn blue. This means there is a message for her. On the screen of the portal an envelope appears. Sarah presses the envelope. It is a message telling her to go to the radiology apartment, her appointment will be in fifteen minutes. Maxim asks whether they can find it on their own or if they need directions. Sarah knows where it is, so she doesn't need the directions. Together they walk towards the radiology department. Mom points out a flower on the wall, Sarah taps it with her bracelet, and a colourful pattern appears on her MAX.

When they arrive at the radiology apartment, Sarah spots another portal. She logs in and Maxim appears, telling her that she has to wait several more minutes, but if she wants to they can play a little game. This sounds good, so Maxim explains the game. There are four flowers on the wall surrounding the portal. Each flower has a different colour (green, blue, yellow and red) Sarah taps each flower with her MAX. Now the game begins, Maxim shows the colours in different order and it is up to Sarah to tap the flowers in the right order. Each time she does it right a new colour will be added to the list. Maxim starts with three colours red –blue-green. This was easy so a new one is added red-blue-green-blue. Still no problem. In the end Sarah manages to memorise a sequence of 15 colours! A new record according to Maxim.

Mom calls Sarah, the treatment can start any minute so there is no more time for another game. As she says it, the door opens and the lab technician appears, it is time for the echo. The gel is really cold, but she takes this really well and the lab technician manages to get a good

image of the tumour. So now it is finally time for that breakfast! They head to the restaurant where Sarah picks a slice of apple pie and a hot chocolate with whipped cream, while her mom sticks to a coffee and a croissant. This is the only reason Sarah doesn't mind fasting before a scan, she knows she gets a treat afterwards.

They enjoy their meal and have a talk about the upcoming dance routine Sarah has been practising for. While all of a sudden her MAX starts to vibrate and the familiar blue lights appear. There is a message. Mom looks at her phone and notices that she got a notification as well, Sarah needs to give blood. They walk to the nearest portal and indeed Maxim tells them it is time to go and give blood. This time Sarah does ask for directions. On her MAX arrows appear directing her towards the elevators, however she decides she wants to take the stairs.

After arriving on the correct floor, the MAX guides them towards a treatment room where the nurse is already waiting for them. This time she only needs to fill a little tube so a pinch in Sarah's finger is enough. While they wait for the results Sarah asks her mom if they can go to one of the play areas. This is fine with her, so Sarah presses the button on her MAX and is directed to the nearest portal. Maxim asks if she wants to go to the science centre or if she wants to visit the park. Sarah has never been to the park so she is curious to see what she can do there. Her MAX directs her to the park where several children are using their MAXs to play hide and seek, this looks like fun so she asks her mom if she can join. Mom is fine with that, she grabs her book and looks for a comfortable place to sit. Sarah joins the other kids, they all check in at a portal and at random one of the bracelets changes colour, this time a little boy is picked, he will be the searcher. Sarah hides behind a big pillar and a plant. She can see a little bit through the leaves of the plant. Several children are found, but then she notices that the boy is heading in her direction. As he comes closer she sees his MAX pulse and with each step in her direction the pulsing increases. He finds her and taps his MAX against hers. The lights on her MAX turn red.

While she waits for the other kids to be found she receives a notification, it is her mom telling her that she went to the bathroom but will be back soon. So Sarah decides she wants to explore the park a little. There is a cave and an area where she can listen to music. After a while however she wants to go back to her mom, so she approaches a portal and asks for directions towards her mom. The arrows on her MAX direct her back to mom who is reading her book on a bench on the other side of the park. Together they head back to the 2nd floor because it is almost time for the results to come in. As they arrive mom does indeed receive the message that the results are in. While they walk towards a portal the doctor appears and tells them they can join him for a consultation. The blood levels where sufficient so Sarah can have her chemo for today and the echo shows that the tumour is decreasing so the treatment is working. This is the best news they have heard in a long time! But now it is time for the chemo, Sarah is happy that it works but she hates the stuff, it gives a funny taste in her mouth and she feels very sick afterwards.

They go to the day care and she sees her favourite nurse is working today. This immediately lightens her mood. Danielle notices them and comes to greet them. “Are you ready Sarah? You had to make an echo today didn’t you? How did that go?” So Sarah tells her that the tumour is getting smaller. Danielle is so happy about this news that she gives Sarah a big hug. “That is fantastic news!” Sarah smiles but then her mood drops again. “Yes but I still need that nasty chemo…” Danielle smiles “that is true, shall we hook you on then? Better get it over with so you can go home and celebrate.”

So Sarah is connected to an IV-bag and has to wait for the strange fluorescent pink liquid to empty. Suddenly her MAX starts to vibrate again. She takes her IV pole and walks up to one of the portals in the day care area. Maxim appears and asks her if she wants to play a little game with her, she suggests a game to give her a make-over or hangman. Sarah chooses hangman. Maxim starts with a word and Sarah has to guess the letters, when she is correct, it is Sarah’s turn to come up with a word. They play for a little while and mom comes and joins in as well. Then Danielle stops by and notices that the IV is nearly empty. So Sarah finishes the game and waits for the final droplets to disappear. Danielle unhooks her and they are finally ready to leave the hospital.

As they walk into the parking lot the MAX start to blink and vibrate like crazy! “A, that’s right” Sarah exclaims. She nearly forgot to hand in the MAX. She walks over to a deposit box, slides the MAX from her bracelet and drops it into the box. Now they are ready to go home.

EMBODIMENT

To get a better understanding of the software an expert in electronics engineering, computer system management and software development (A. Kooijman 2017) was consulted.

The software of the total system can appear quite complex, however when dividing it in smaller categories it becomes clear that all different components are not that complicated after all.
Figure 25 shows an overview of how the different elements of the system interact.

SERVER

Most of the information will be stored on the server. For example, patient accounts, games, a database with the portals and a database containing the patches.

The server will function as a gateway to provide communication between the wearable, portals and the app. It is connected to HiX to get up-to-date patient info related to medication and appointments.

WEARABLE

The wearable itself is actually a very basic system. It is connected to the server via the Wi-Fi network. This is mainly used to send patterns for the LEDs and to send and receive information about the location of the wearable. Depending on the number of patterns they can either be saved internally on the wearable or on the server. The benefit of saving the different patterns on the wearable is that there is less dataflow on the Wi-Fi network and the patterns will be displayed faster. However the disadvantage is that the wearable should have more memory and

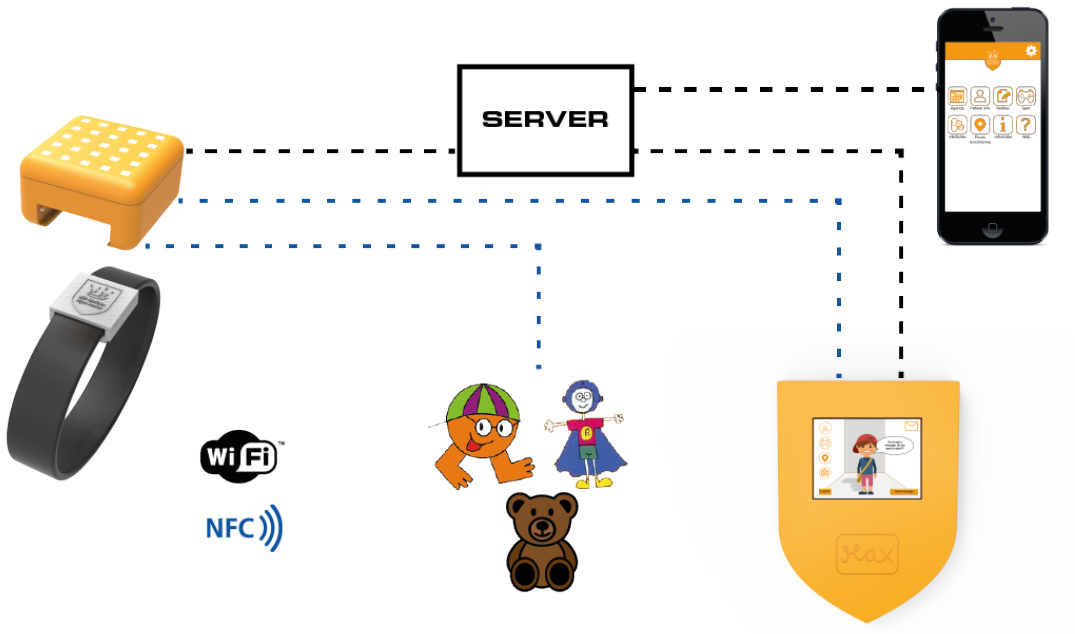


Figure 25: an overview of the different wireless connections used in the system.

that it is more difficult to add or change patterns.

In this case changing the patterns is one of the ways to keep the environment interesting so saving the patterns on the server is more desirable.

Furthermore, the wearable needs to register the NFC tags in the patches. This information then needs to be sent to the server which initiates the correct action (display a pattern or register as part of a game). And finally the gyroscope and accelerometer chip is used to determine the exact position of the wearable, making it possible to show directions.

The data retrieved from the accelerometer and gyroscope could be collected to give an indication of the movements of the child which can be used to monitor its physical activity.

PORTALS

The portals will be used to display the personal accounts of the patients and to play games. However, with this the question is, will all the games be saved on the tablet or will they be retrieved from the database on the server. Both situations have advantages and disadvantages. If the games are stored on the tablet it would decrease the dataflow required to play games and would increase the speed of the games. However, storing the games on the server would make it easier to add new games and to update the old ones.

The best storage location for the games depends on the number of games and the size of each game. This has not yet been studied so in order to determine this more research needs to be done.

PATCHES

The patches are passive, so when tapped they only send out one signal to the wearable. This signal will be verified via the server, after which the patch will either be recognised as part of a game or a pattern is send to the wearable.

APP

The app is stand alone in the system since it can function autonomously. It has a Wi-Fi connection to communicate with the server. The data from HiX will be transferred via the server to the app. When the parent sends a message to their child, this will also go via the Wi-Fi network. Via the app the child can locate its parent. This is done by making use of the Wi-Fi grid of the hospital.

PORTALS

The portals consist of a tablet and an NFC reader inside of a casing. The shape of the casing has been inspired by the Logo of the Princess Máxima Center and looks like their shield (see figure 26). The tabled needs to be connected to a power source, so there should be a wall socket close by. The casing consists of a wooden frame with a laminated plastic coating.
Based on the total number of patients per day and where these patients will be during the day the portals are placed throughout the hospital. There will be 165 patients at the hospital each day, a ratio of one portal for every three patients has been established. Resulting in 55 portals. In figure 27 the location of each portal is marked by an orange dot.

On the ground floor there will only be a few portals, since the children are not likely to spend much time there. There are two portals in the waiting area of the radiology department, two in the main area and one in the restaurant. On the first floor the focus is on the DOC, so there are already a lot of things to do here, such as the library, the Muzikids and the science centre. Placing more portals will not contribute to the environment here.

The second and third floor are the areas where the children will spend the most time. Most portals should be placed here. In the day care areas there is room for respectively twenty and fifteen patients so there will be respectively six and four portals there. The polyclinic is the main area of each floor and has twelve treatment rooms, so there will be six portals in each polyclinic. Furthermore in the clinic there will be so called “nisvullers” spaces in the hallways which are decorated with a little game or artwork. These could also house a portal. On the second floor there are ten nisvullers and the third floor has eight of them. There are also portals in each ABO.

There will be one portal outside of the Princess Máxima Center, this portal can be found at the radiology department of the UMCU and serves to entertain the children that need to undergo radiation therapy

Depending on the location different games can be played. At the ABOs the games will be longer and bigger because these are the locations the children are likely to spend the most of their time, while the games in the waiting areas are shorter since these are just meant to cover the final minutes of the waiting time. The games inside the day care areas can be longer but should not be too physically demanding since the patients are likely to be walking around with an IV stand.

Figure 26: A visualisation of a portal

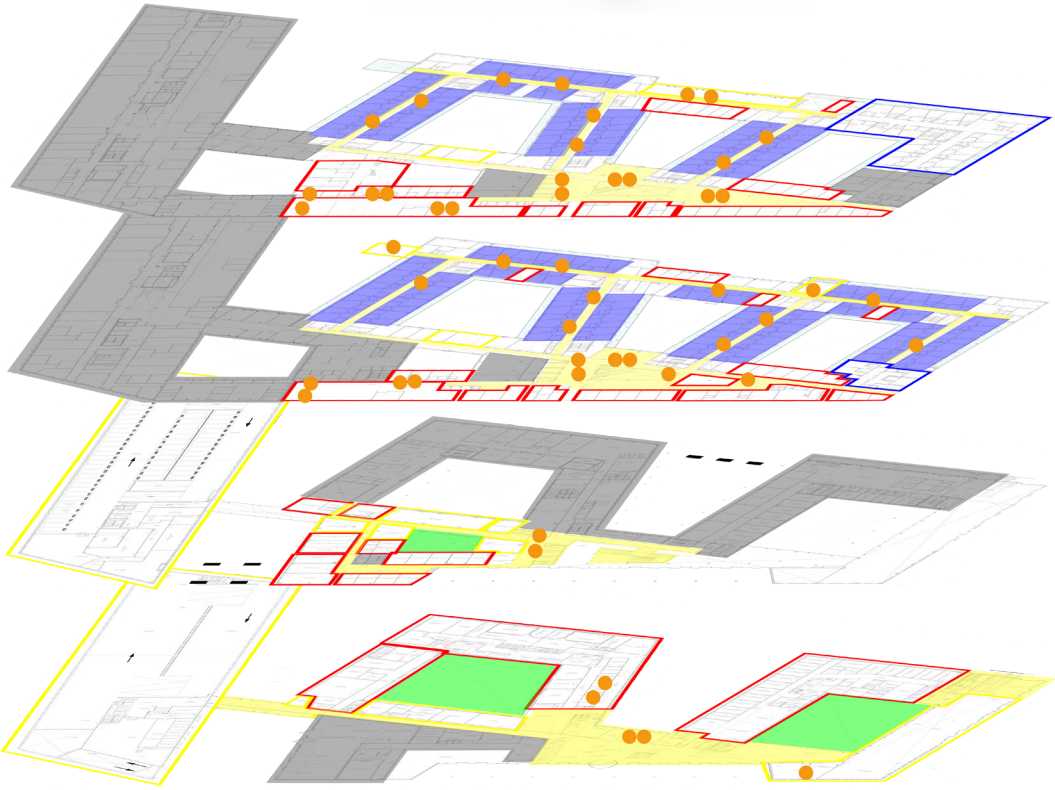


Figure 27: Floorplans of the Princess Máxima Center, the orange dots represent the locations of the portals

PATCHES

The patches are stickers that include an NFC tag. These stickers can be images from the science centre or the wayfinding icons and can be used to connect the different areas. The patches are used to make the environment interactive since tapping the patches with the wearable will display a pattern, see figure 28 for examples of the patterns. The patches could be used for a game, figure 29 gives an example of how the patches could be part of a game.

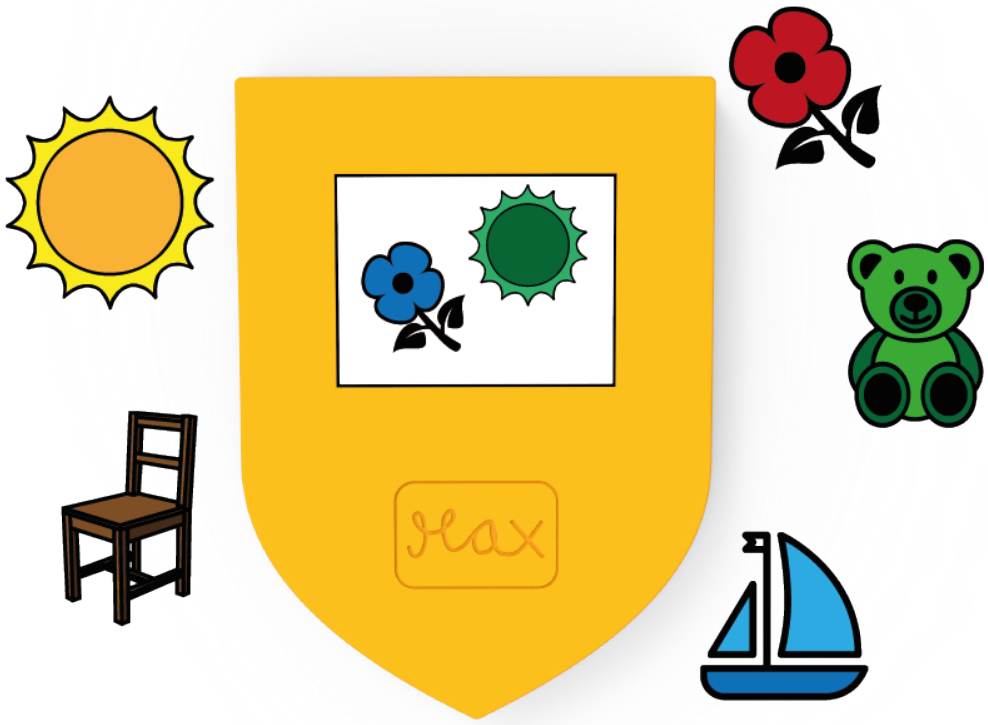


Figure 29: An example of how the patches could interact with a portal

GAMES

The games are meant to distract the children while providing them with DOC oriented stimuli such as physical or mental challenges. The type of game depends on the location of the portal. For example in the park the game could be a form of hide and seek with several children. Each child logs on to the portal and one child is selected to be the seeker (the lights on the bracelet will change colour) then, while getting hints from the bracelet the seeker searches for the other children. The other kids can be found by tapping their bracelets. At the science and discovery centre the game could very well be more like a quiz or an educational game.

Because the goal is to get the patients out of the waiting rooms and into the ABOs the games in the ABOs need to be entertaining for a longer period of time. The games near the treatment rooms are intended to fill the final minutes before an appointment so these games need to be shorter and easy to quit when the doctor arrives.

The games at the day care should be longer because the patients will spend a lot of time there. However they are likely less mobile with their IV stand. So these games could focus more on the mental development of the children and less on the physical development.

Examples of possible games:

Treasure hunt: Using the directions on the bracelet to locate mystery patches
Collectable: Collecting as many points as possible within a given time by tapping patches

Musical patches: there could be an area where the patches contain a little speaker and tapping the patch will produce a sound, so by tapping multiple patches music can be created.

Simon says: the portal is surrounded by 4 patches of different colours. The portal shows the colours in a specific order and the child has to tap the patches in the same order, each time the child is correct a new colour is added to the list until the child fails to get the order right or when it is time for the appointment. (Suitable near the treatment rooms)

Brain training: The portal is surrounded by several different shaped patches which each have a different colour, see figure 29. The portal shows 2 objects at once but the colours are messed up. Every time there is either one object displayed with the correct colour or one object and corresponding colour completely missing. The goal is to find the correct patch and tap it within a given timeframe. This game could also be played with several players. In that case there will be no timer but the portal keeps track of how many correct answers each player has. (Suitable for in the day care area)

An individual and detachable bracelet has been chosen opposed to a design that has an integrated wearable and bracelet. This has been done because of ergonomics. According to a statistical survey at a Canadian school (sensusatschool.ca 2006) The average circumference of the wrist of an eight year old girl is 138 mm, while an eleven year old boy measures on average 150 mm. See figure 30. The target group of this project consists of children between six and eleven year sold. A six year old girl will have an even smaller wrist. To ensure a good fit it is necessary to make custom bracelets. An additional benefit of personal bracelets is hygiene. The children are already faced with diminished immune systems. A personal bracelet is less likely to transfer diseases. To ensure good hygiene, the bracelet will be made of an easy to clean material and will have few cavities and holes. Furthermore the bracelet should be as cheap as possible to keep the total costs low. A silicone bracelet has been chosen. The bracelet comes in several different sizes and colours so the children can choose the one most to their liking (see figure 31).

To make it possible to attach the wearable to the bracelet a connector piece will be added. This needs to keep the wearable in place but also needs to look nice when the wearable is not attached. Here a smooth surface is required as well due to the hygiene. A design was created with two separate plates that lock together around the bracelet and is held in place through a hole in the bracelet. Figure 32 shows an exploded view of how the three parts fit of the bracelet together.

DIMENSIONS

The circumference of the bracelet is variable, but the width is constant at 12mm. Based on this width the connector pieces are designed. See figure 33 for the dimensions of the connector pieces.

Age (years)	Girls	Boys
	mm	
8	137.83	141.48
9	140.33	145.01
10	144.27	148.56
11	147.82	150.34
12	149.30	156.04
13	151.70	161.01
14	152.48	163.82
15	153.19	165.44
16	153.27	169.43
17	154.85	173.87
18	151.79	169.20
19	146.59	176.16

Notes: The wrist circumference was measured in millimetres and not in centimetres like the other body measurements. There are too few students below 8 years of age or older than 19 to calculate a meaningful average for these groups.

Source: Statistics Canada, Census at School, 2006/2007.

Figure 30: Average wrist circumference, by age (Sensusatschool.ca 2006)

Figure 31: Bracelets in different sizes and colours

Figure 32: Exploded view of the bracelet

The wearable is the most complex of all the different elements, so this part has the most elaborate embodiment phase.

SHAPE

As shown in figure 34 several different shapes have been created to determine which shape would be the most suitable. The outside of the wearable should have an LED grid and a button.

Since the device will be used by both boys and girls with ages ranging between six and eleven the shape should be appealing but not too outspoken. Therefore a symmetrical design is preferred. Furthermore it should have minimal cavities and hard to reach places to ensure easy cleaning. Finally it will be used by children while playing so there should be no sharp edges. It should be robust and able to withstand rough play.

Therefore the third shape as shown in figure 34, is the most suitable. Due to its rounded edges and symmetrical design the shape is very appealing while still quite neutral. The button on the side makes it usable while not disturbing the symmetrical feel of the wearable. The wearable can be used by both right and left handed children. Like the bracelet, the wearable comes in several different colours so children can choose the one they like most (see figure 35).

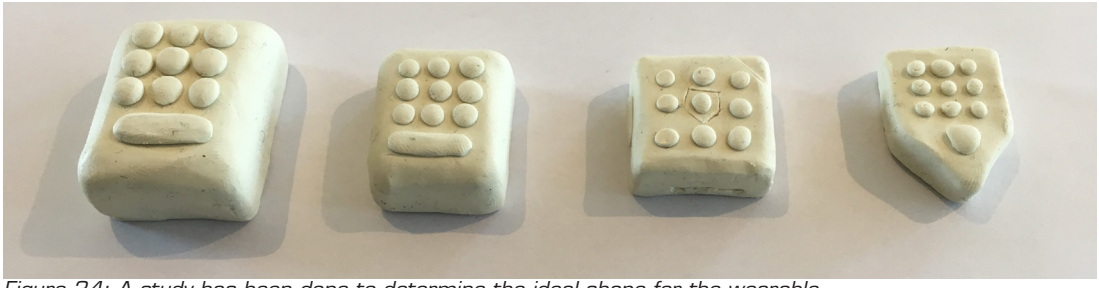


Figure 34: A study has been done to determine the ideal shape for the wearable

Figure 35: The wearable is available in different colours

LED GRID

The wearable will contain several RGB LEDs which will be used to notify the patient, show directions and display nice patterns. LEDs are chosen opposed to a screen to keep the production costs low. They can give hints while still keeping the message clear. The goal is to keep the number of LEDs to a minimum while still being able to convey messages. First a grid of 3x3 was tested. However, it was not easy to convey directions such as changing floors with this design and there was a very limited display of patterns. So a bigger grid of 5x5 LEDs was tested. The 5x5 grid makes it possible to show numbers thus making it easier to communicate to which floor you should head. Also with this grid the possibilities for different patterns increases significantly. See figure 36 for a comparison between the 3x3 and 5x5 grid. For more patterns see appendix H.

Figure 36: A heart notification on a 5x5 grid

COMPONENTS

In order for the wearable to function it requires several components. Firstly it needs a circuit board with 5x5 RGB LED grid, a control button and a vibrator motor. However it also needs an accelerometer and gyroscope to determine the position of the wearable and a Wi-Fi module with antenna to receive and send signals and to determine the location. Furthermore there needs to be an NFC controller which can both function as a reader and a tag. Lastly it needs general electronics to make it work, microprocessors, a power supply (battery), a charging system and other components such as transistors and resistors.

In general the components are based on a Fitbit charge HR™. This is an activity tracker that has close similarities to the MAX system. Both systems are wearables that require small components to fit the wrist of the user. Figure 37 shows the components of a Fitbit charge HR™. The coloured words correspond with the outlined components.

Both systems use an accelerometer & gyroscope chip and have a vibrating engine. The battery of the Fitbit has the following dimensions 19*13*2mm and is designed to last up to four days while constantly measuring the heartrate. The battery of the MAX only needs to last ten hours without the measuring heartrate, so a smaller battery could be considered.

There several differences. The Fitbit makes use of a Bluetooth connection in contrast to a Wi-Fi connection and has a display instead of LED's. Furthermore the Fitbit has a heartrate sensor and an altimeter which will not be found in the MAX. The MAX on the other hand requires an NFC controller which is not present in the Fitbit.

A list of dimensions and prices of the additional components has been drawn up. For more information about these components see appendix I.

With this information a suggestion for the placement of the components within the desired shape has been done. As shown in figure 38, there will be three separate circuit boards, one for the LEDs, one consisting of the Wi-Fi module and one containing all other components such as the NFC controller and the microprocessors. Furthermore it will house the battery in one of the sides, the vibrating engine will be placed next to the Wi-Fi module.

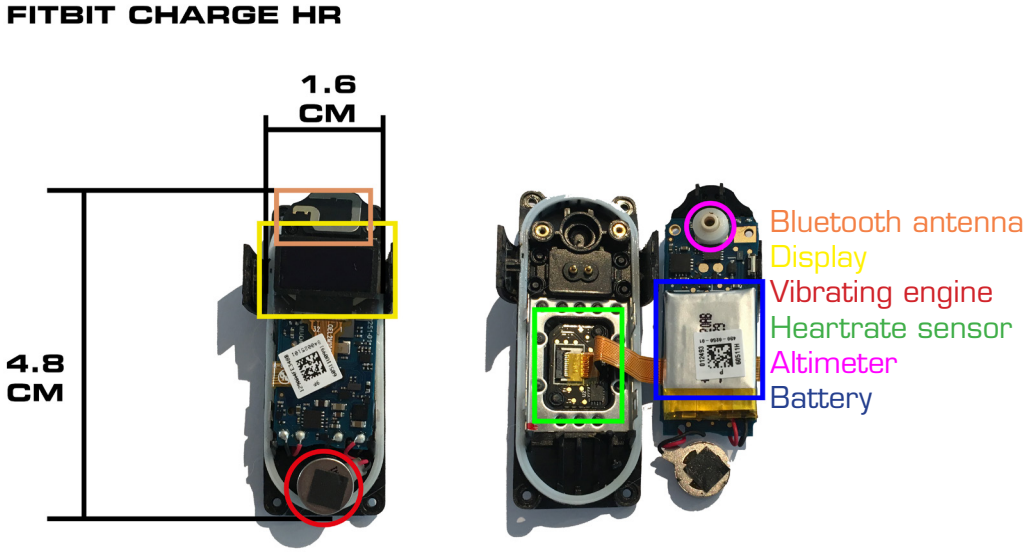


Figure 37: The components of a FitBit charge HR

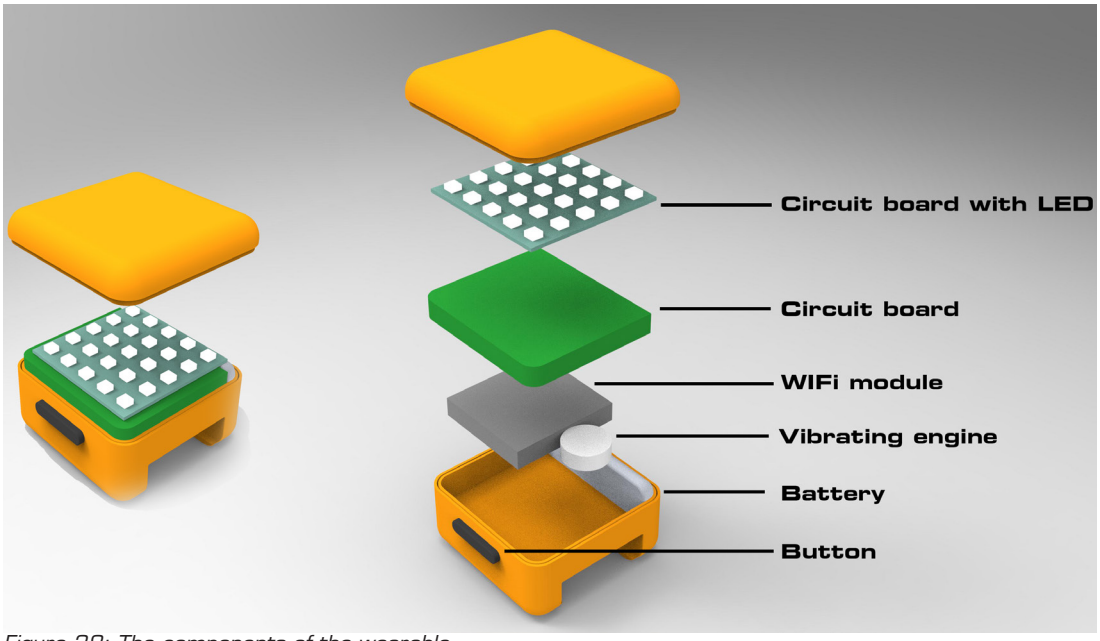


Figure 38: The components of the wearable

DIMENSIONS

Based on the information of the components the dimensions could be determined, see figure 39 (dimension in mm).

PRODUCTION

The target group consist of 165 patients a day, so a batch size of 200 units is required. This is quite small, so there are only a few production techniques suitable for making the wearable. This could either be done by CNC milling, or by 3D printing. The size and shape of the design make it very difficult for CNC milling resulting in high production costs. So for this product 3D printing is the most suitable solution. This can be done with ABS filament. After assembly the units will be dipped into a silicone coating to make the wearable waterproof and resistant against detergents, UV radiation and acids. For the use of this method of silicone dipping an expert (B. de Smit, 2017) has been consulted. This method has not been used before on 3D printed products, however, it is very likely that it will work as intended.

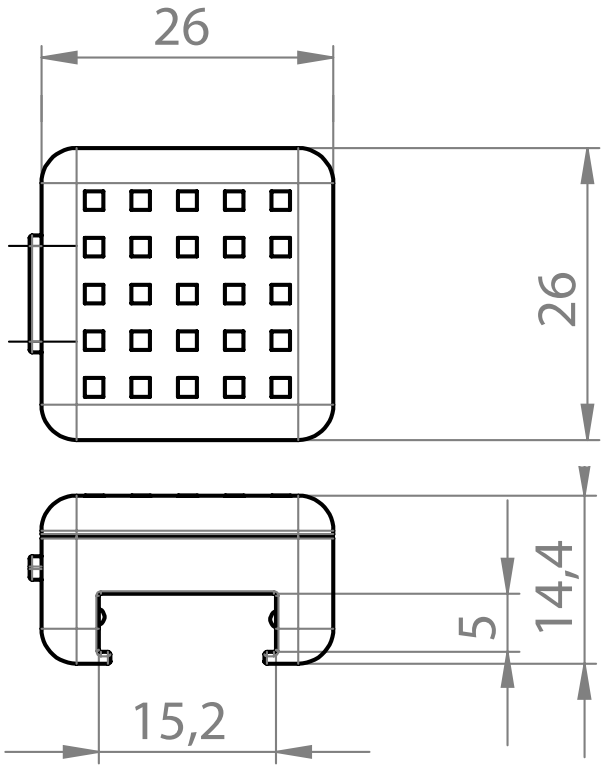


Figure 39: The dimensions of the wearable in mm

MAINTENANCE

Charging the device will be done by sliding the wearable onto a docking station. On both sides of the sliding part of the wearable there are brass charger pins. The docking station holds a brass strip to each side of the slider bar. These make connection with the pins which results in a closed circuit and allows for charging (see figure 40). Each docking station can hold up to 30 wearables and charges them overnight.

The silicone coating guarantees easy cleaning. However it is not possible to sterilize the wearables in an autoclave. Both the silicone and the components are not resistant against these high temperatures and pressures. To ensure proper cleaning the wearables can be cleaned using an UV light to sterilise the wearable, such as the phonesoap, this UV box can hold up to 6 wearables and it takes about 5 minutes to sterilize them (phonesoap.com n.d.).

If the wearable is damaged, the silicone coating could be removed exposing the casing. If the casing is broken a new casing can be printed and the components can be placed in the new casing. If there is a problem with the electronics, the affected part could be disassembled and replaced. After this a new silicone coating must be applied.

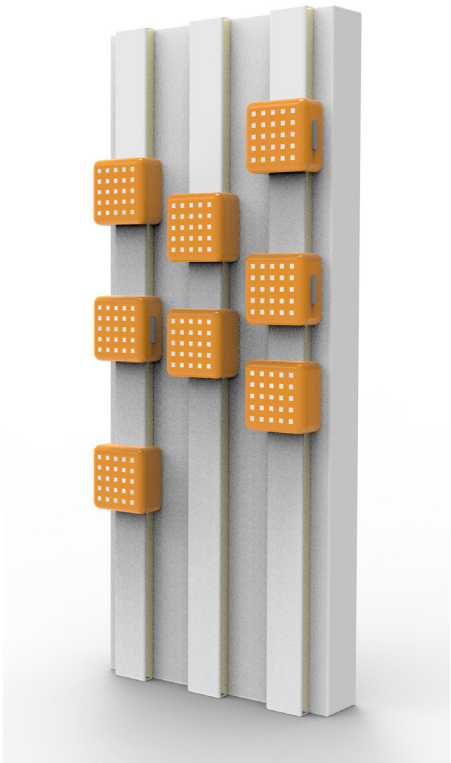


Figure 40: the docking station

PRODUCTION COSTS

To determine the costs for the entire system an estimation for each different element has been made. The products should last up to three years.

GENERAL

Since there is be a lot of 3D printing required. A 3D printer should be purchased, This will cost approximately €4000,- excluding software and filament which could add up to €16.000,- Furthermore a server needs to be purchased which could costs up to €4000,-.

BRACELET.

Each patient receives its own bracelet. Thus resulting in 550 bracelets per year, so in total over 3 years 1650 bracelets will be produced. The bracelet itself costs less than €5,-. The connector pieces can be 3D printed this costs about €1,00. Including assembly and post processing the total price for one bracelet does not exceed €7,50.

WEARABLE

Every day 165 children will be making use of the wearables, including a small margin, 200 wearables will be produced.

The casing of the wearable will be 3D printed, this costs about €2,00. The components inside of the wearable are more expensive. The electronics inside the wearable will cost approximately €15,- (A. Kooijman, 2017). The design and production of the circuit board is estimated to cost €120,- per unit. Including assembly, casing and silicone, the entire wearable will cost €147,00.

PORTALS

The portals are the most expensive since they include tablets. There will be 50 portals throughout the hospital so this means 50 tablets (IPads) of €400,- and NFC readers of €20,-. The total price for the portals, including the frames and assembly costs are €555,-. In addition to this extra construction facilities will be created such as wall sockets. This will cost an additional €50,-.

PATCHES

The patches are fairly cheap, the NFC tag costs less than €1,- and the stickers itself will cost about €2,-. Programming and placing each tag takes time, so each patch will cost approximately €6,-. There will be approximately 500 patches throughout the hospital.

OTHER

Additional costs will be made for the production of the chargers. These will costs €205,- per piece and there will be two chargers at each check-in desk, so 4 chargers total. The UV lights for sanitizing will be purchased and costs about €50,- per piece, of these there also will be 2 for each desk. Other costs will be made for man hours related to purchasing, designing and production guidance, this adds up to €58.500,-.

SOFTWARE

The most important part of the system is the software, for this a rough estimate has been made. The programming of the software consists of:

- The wearable
- Data exchanges via the Wi-Fi network
- Data exchanges via the NFC chip
- The interface of the portal
- Games
- The app
- The connection with HiX.

It is estimated that this will cost approximately €170.000,-. However this is a very rough estimate and depends highly on how detailed the graphics need to be for example. Will the game be in HD or will it be like a cartoon? That makes a lot of difference in the price.

TOTAL

Figure 41 shows the total sum of the system. The entire system costs in total €324.545,-. Divided by the number of users (1650 over three years) the system costs €197,- per patient. See appendix J for an overview of the cost estimate.

COMPONENT	UNITS	PRICE PER UNIT (€)	TOTAL PRICE (€)
General	-	-	20.000
Bracelet	1650	7,5	12.375
Wearable	200	147	29.400
Portals	50	605	30.250
Patches	500	6	3.000
Charger	4	205	820
UV light	4	50	200
Man hours	-	-	58.500
Software	-	-	170.000
TOTAL			**324.545**

Figure 41: the total sum of the cost estimation

EVALUATION

To test the product a prototype was created. The goal of this prototype was to see how the children would interact to it and how it would fit them. Visual models of the wearable and bracelet were made. A regular silicone bracelet for children was bought and the connector pieces and the wearable where 3D printed. Early in the design process several prototypes where created to get a better understanding of the dimensions of the product. See figure 42 for the initial prototypes.

These early prototypes where used during the interviews. This gave an impression of what the wearable would look like when worn by a child. After the interviews new prototypes where printed of the final design. This also included a print of the top and bottom part of the wearable to show how much space there is for the components. Figure 43 shows the final prototypes.

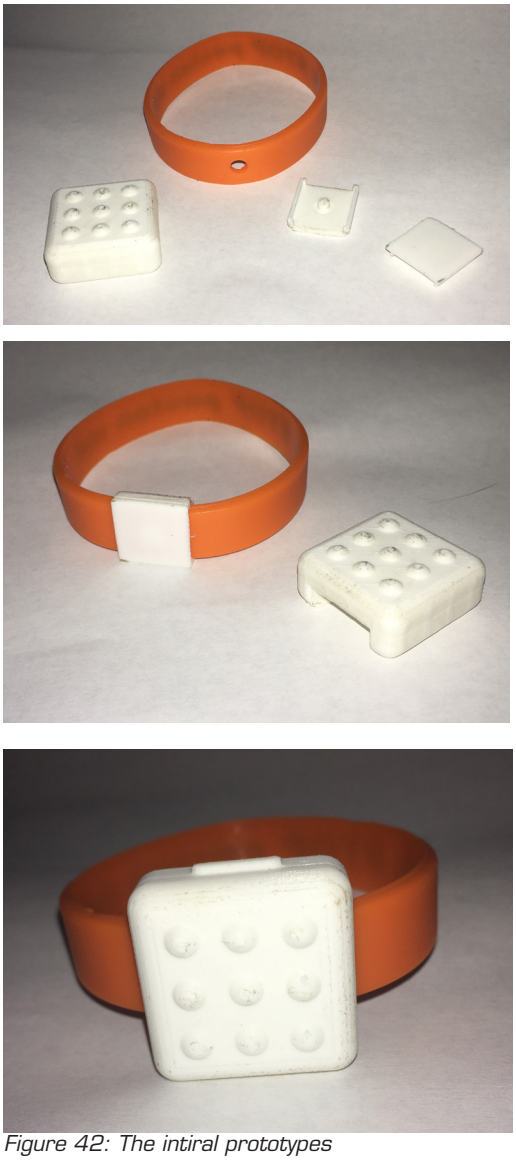


Figure 42: The intiral prototypes

A small test was conducted to test how children and parents respond to the MAX. In total 3 families where interviewed, each interview lasted about 20 minutes. The families that were interviewed had no experience with child cancer.

The families consisted of:

- A mother and her ten year old son
- A father, a mother and their eight year old daughter
- A father, a mother and their nine year old daughter

All parents and children loved the concept and came with good comments. Although only three families were questioned, there was a clear variety between these families. One family was really into smartphones, the daughter had her own phone and the parents had an app to monitor the GPS location of that phone. Another child hardly ever touched a phone instead he spent his time reading books or playing with whatever was available. One of the families has a lot of experience with going to the hospital with their child. Their daughter needs to go to a children's hospital every six months to undergo several tests during a single appointment. These are short procedures so they never spend more than one hour at the hospital.

All parents noted that they currently have no use for a system like this since they do not have to deal with these long days at the hospital or another location for that matter, but they definitely could see the benefits of the system when dealing with long and frequent waiting times. One mother explained that she values the life lesson of being bored. But she also noted that, when dealing with child cancer and having to go to the hospital every week, this could really be a blessing.

The parents loved that the games involve physical activities opposed to playing a game on a phone or tablet. They also noted that it would give the children more freedom and independence. They also stated that it would depend on their child whether or not they would let it roam free around the hospital. All of the interviewed parents would let the son or daughter who participated in this interview roam free with a device like this.

The children were asked if they would rather play a game on a phone or use the MAX. They all chose the MAX, especially because they could use it to play with other kids as well. One of them even suggested a nice location for a patch. "Wouldn't it be funny that while you are tapping patches the doctor comes in and you tap him, since he has a patch on his arm!"

The families were also shown different light combinations and where asked to identify their meaning. The arrows and numbers were clear to them. However notifications from other persons (such as hospital staff and the parents) required some additional suggestions.

The children were asked to put the bracelet on and were then asked to place the wearable onto the bracelet without further instructions. Each of them immediately understood how to slide the wearable over the connector piece, however 2 of them needed help from their parents to get it on. The bracelet used for the prototype is meant to be for children and has a diameter of 16cm however it was clearly too big for these children. Especially the girls had really tiny

wrists so the wearable would not stay on top of their arm (see figure 44).

CONCLUSION

Both the parents and children loved the concept. However the parents could not think of other situations where this could be convenient. The children could really see themselves playing with it and were disappointed when they had to hand it back, however the size of the bracelet was way too big so smaller bracelets are required.

Figure 44: The fit of the bracelet on the interviewed children

RECOMMENDATIONS

During this project several assumptions were made which require further research. The system consists of several different elements, all needing further development. More user research must to be done, especially with the designated target group which was not addressed during this project. Several consults with experts are also required, especially in connection with the software and the server. This also includes making a connection with HiX, which contains private information that must be protected at all times. Each component of the system requires further research.

APP

Research needs to be done to determine the demands and wishes of the parents when it comes to designing the app. This includes the interaction between parent and child and how the app could make the information the parent receives more suited to her/his needs.

PORTALS

The outline for the portals has been suggested, however the dimensions and materials need further development. Also it should be investigated if it is possible to purchase a tablet containing an NFC reader instead of a tablet and a separate NFC reader.

PATCHES

The shape, material and size of the patches need to be established. For the material it is important that a durable and easy to clean material is used since the patches should last up to 3 years and will be touched by children with a low resistance.

BRACELET

Currently a silicone bracelet is used. However, during the interviews it became evident that this bracelet was too big for the children. Also the skin of the children can get really sensitive due to the treatment; this can result in allergic reactions to these bracelets. Additional research is needed to determine the best way for the children to carry the wearable.

WEARABLE

The hardware of the wearable is currently only generally defined and lacks detail. An expert needs to be consulted to design the circuit board. This could influence the dimensions of the wearable, which in turn would require a new exterior design. A silicone coating is suggested to make the wearable waterproof and resistant against detergents and UV radiation. There is no evidence that this method of silicone coating will work on a 3D printed product, so further research is needed.

It could be interesting to add sound to the wearable, this will stimulate an additional sense resulting in an even more interactive environment.

GAMES

Currently several suggestions for games have been made. However, these are not worked out in detail, so in collaboration with a game designer this part of the system needs to be addressed. It also must be established weather to use one large game which includes several smaller games or if only the smaller games suffice. It is important that the games remain interesting to the children during

the entire treatment. For this several methods can be used such as “open ended play” (think of Lego) or “easy to learn, hard to master” (for example candy crush). To make games interesting a reward system could be used.

Furthermore the games should be tailored to the physical abilities of the children, meaning that if a child is less mobile the game should be adjusted to this.

OTHER

In addition to these recommendations it is also important to study the policies of the hospital, especially when it comes to hygiene, scheduling and privacy to make sure that the product complies with the standards of the hospital.

It would also be interesting to research the possibilities of making the system more suitable for other markets which have to deal with lots of waiting like airports and theme parks.

DISCUSSION

PROJECT EVALUATION

SETTING BOUNDARIES

When I started this project I had a vision but not a clear perspective on how to realize it. It took me a very long time to establish the boundaries of the project. The result was a lot of less relevant research, such as a complete analysis of the different types of chemo. Even though this research did help me to better understand the world of paediatric oncology, it did not have a direct influence on the design choices that were made in the final stages.

It was rather difficult to set the boundaries for this project, especially since it covered so much ground. Even defining the user was difficult because waiting was not only an issue for the patients and their parents. The medical team could also be included in the problem, not to mention the WKZ patients and doctors. Thus setting boundaries became one of the main tasks of this project. The final outcome was a very big project, with a lot of side tracks which were not elaborated and a lot of assumptions which had to be made.

TIME MANAGEMENT

The analysis phase took about 4 months. In the initial planning I estimated that the analysis would take me about 4 weeks. Because time management has never been my strong suit, it was one of the things I wanted to work on during this project. Exceeding the estimated time of the first phase so drastically made me even more aware of my shortcomings in this field. However, the length of time spent on this phase can also be partially explained by the difficulties I had with defining the boundaries of the project. Another reason the planning did not fit the reality was because I compared this project to a JMP project, but I overlooked the fact that JMP generally involves 5 or 6 people. If they all work on a project full time, that comes down to 240 hours per week. Only one person works on a graduation project, be it more than full-time. This comes not even close to 240 hours a week (after all, a week only has 168 hours). So after the analysis phase, I rescheduled the planning and asked myself what was and was not relevant for this project. The result was considerably better time management.

USER RESEARCH

I would have liked to talk to the intended users (families that deal with child cancer). These families already have very much to deal with so they are very protected by their environment, making it difficult to approach them. However, talking to the medical staff gave me a good insight into the users. Also children and parents who do not have to deal with cancer can still relate when it comes to waiting. Every parent can relate to being worried about the well-being of their child. So the opinion of the interviewed families was considered to be very valuable.

PERSONAL DEVELOPMENT

I have always perceived graduating as a big scary mountain to be conquered. This became even more evident when during the final GPS week a lecture was given about graduating. All I could think of was how I had to do that all by myself and that there was no way I was able to do that. So when the time came and I had to find a graduating assignment and look for coaches, it took me quite some time

to build up the courage to go and talk to people.

Now that I have actually conquered that mountain, I have come to realise that it is not so bad after all. Yes it requires a lot of strength to pull yourself up and it is very easy to lose your balance, but there are so many nice people around to help you and to guide you. If there is one lesson in life I learned during this project it is that you are not alone, there are so many people willing to help; all you need to do is ask. Which brings me to a second lesson: You can always ask for help and people are more than willing to share their knowledge and experience with you. These lessons may be of limited value when it comes to the project itself, but to me, as a person, these lessons are the ones I value most.

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