Designing a smart technology application to promote joyful weight monitoring among patients after gastric bypass surgery

By Mourad Lagsir

Student number: s2155508

Supervisor: dr. F. Nijboer (Femke)

Critical Observer: J.H.W. van den Boer (Janet)

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Faculty of Electrical Engineering, Mathematics and Computer Science (EEMCS)

Abstract

Research: Patients that have recently received a gastric bypass surgery often perceive the annual follow up meetings that follow as annoying and time consuming and the same goes for monitoring their body weight weekly, which is recommended by the doctors. The latter has partly to do with the negative perception towards weighing. Weighing is perceived as confrontational and is often avoided because of that reason. Here we investigate: “How could a smart technology be designed to promote joyful weight monitoring among patients after gastric bypass surgery”. **Methodology**: There was an iterative design process including important stakeholders throughout the entire process, integrating elements of co-design. The final design allowed patients to play a touchscreen-controlled game while standing on a numberless scale. Nine participants (n=9, male=6, female=3) of an obesity clinic participated in a three-step usability test: 1) The thinking out loud method, 2) structured interview, 3) system usability scale questionnaire (SUS). **Results:** We have observed that the current design effectively promotes its theme of joyfulness by concluding that there is a high level usability and therefore satisfaction. There is an strong indication that the current concept could motivate the user to weekly step on a scale. Additionally, there is a positive conception towards the idea of gaming, the setup and the overall concept, however additional features could increase the level of joy even more. **Conclusion**: We conclude that this design fits within the current trend of weight management programs that attempt to personalize the healthcare not only for gastric bypass patients, but for overweight patients in general. Future research is suggested to include a longitudinal study to test if the concept stays evenly joyful after a few years as in the beginning.

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Introduction

1.1 Situation

Obesity has become a worldwide problem. The numbers have tripled since 1975 (WHO, 2020). According to the World Health Organisation (WHO), 1.9 billion adults aged 18 years and older were overweight in 2016 (WHO, 2020). Of these, 650 million people were obese. Overweight and obesity are defined as abnormal or excessive fat accumulation that presents a risk to health. A body mass index (BMI) over 25 is considered overweight, and over 30 is obese (WHO, 2020). In the Netherlands it was estimated that 14.9% of the population aged 18+ was obese in 2018 (Zantinge, van der Wilk, & Jager, 2020). Every year, 12000 Dutch citizens receive a gastric bypass to reduce their weight (Floor, 2020). The 'Ziekenhuisgroep Twente' (ZGT) hospital in Hengelo, treats 700 to 800 patients per year with this intervention. During the aftercare patients have to be monitored. They undergo a series of follow up meetings accompanied by a specialized clinic or in rare occasions the hospital itself. During the 5 years of aftercare, the amount of follow up meetings reduces each year. Patients often perceive these follow up meetings as annoying and time consuming and the same goes for monitoring their body weight daily. According to several interviews conducted by 'Monitor' in 2020 (a Dutch journalistic television show) many patients have gained weight after the five years of aftercare and have not successfully changed their lifestyle. Doctors indicate that patients lose interest after a few years or even months, though they are asked to monitor their weight for 5 years.

1.2 Relevance

It is important that patients keep monitoring themselves for several reasons. People only receive the option for a gastric bypass when efforts to lose weight were unsuccessful and their body mass index (BMI) is higher than 35. By definition, a BMI higher than 35 is labelled as severe obesity, which often means the patients has problems such as addiction, high blood pressure, heart disease and strokes, depression and an increased chance for certain types of cancer. From these, especially the mental health problems do not automatically disappear after the surgery. It is therefore essential that patients keep monitoring themselves to prevent themselves falling into their old patterns. Additionally, by sharing the data with the doctor, the doctor has a better overview of the situation of the patient and could give feedback if needed. Another reason is that self-monitoring stimulates the patients to self-reflect on their behaviour. Research shows that thinking about behaviour is a well-known approach for motivating and sustaining behaviour change (Orji et al., 2018). The trans-theoretical model of health change adds that health behaviour change involves progress through six stages of change: pre-

contemplation, contemplation, preparation, action, maintenance, and termination (Prochaska & Velicer, 1997). Thinking about behaviour (and reflecting on it) is in line with each of these six stages.

1.2 Research

Behavioral interventions are a central aspect in treatments that lead to weight loss, preventing weight gain or weight regain (Yeager et al., 2008). Self-monitoring and, more specifically, weight monitoring is one of the interventions that is perceived to be critical for success with lifestyle changes, however it is not very popular among neither patients nor weight management programs (Yeager et al., 2008). Some weight management programs even consider it a punishment. Thus, a technological intervention should be designed to promote joyful weight monitoring. Here we investigate:

"How could a smart technology be designed to promote joyful weight monitoring among patients after gastric bypass surgery."

Three sub-questions were formulated for an attempt to answer this question. First, what are existing methods of self-monitoring weight? Second, what are the challenges and opportunities regarding self-monitoring weight? Third, how could a smart technology be designed that makes weight monitoring fun? The first two questions will be answered in the state of the art chapter, whereas the third question is the focus of this research for which I will design, realize, test and evaluate an intervention. By understanding the challenges and opportunities of existing methods of self-monitoring and how to overcome the challenges, it is expected that a more joyful intervention can be designed for patients in the aftercare phase.

State of the Art

An important part of the design process is to obtain as much information on the subject as possible. Regarding my graduation project, this includes:

1. an elaboration of the existing methods to self-monitor weight
2. a critical analysis of the advantages and disadvantages of these methods
3. a description of the aftercare procedure
4. a description of the target group.

The first two elements answer respectively sub-question one and two as described in the introduction. The last two elements give valuable information that can be used in the design process (e.g. for user and system requirements purposes). This review will include all of these four elements. The first two in a literature review, and the final two separately. The review ends with some concluding notes with respect to this project's intervention.

2.1 Literature review on existing methods for self-monitoring

Introduction

The main objective of this literature review is to provide an overview of researched methods aimed at self-monitoring. The scope of this review is narrowed to the context of someone who lives at home. In the context of the hospital, the focus is mainly on accurate measuring devices and qualified nurses, whereas this review targets several ways to motivate people to monitor themselves to eliminate the need for hospital checks.

This review contains two parts. The first part regards existing ways to self-monitor body data. In this part, scientific and non-scientific methods to keep track of your body data are explored and descriptions of these methods are given. After these, the advantages and disadvantages of self-monitoring are succinctly discussed. Finally, conclusions are drawn in an attempt to summarize the methods of self-monitoring, and a recommendation is given on how to improve future interventions on this subject.

Review

Existing methods for self-monitoring weight

Scientific methods

Nowadays, there are several scientifically tested methods to self-monitor body data (e.g. weight, activity). By definition, the term 'self-monitoring' includes all forms of active ambulatory assessments. Since this graduation project is classified as scientific research, ideally a scientific way of testing is preferred. In science, two types of diary methods are known for self-assessment purposes. The first one, ecological momentary assessment (EMA), happens in the person's natural environment (Shiffman & Hufford, 2008). The person is asked a set of questions, often conducted by an smartphone app, to describe how they feel at multiple time points during the day (Shiffman & Hufford, 2008). This time points can be randomly chosen, regularly or triggered by event. In the past it has been shown that these app-controlled feedback devices can support sustainability of weight loss (Kurscheid, et al., 2019). Kurscheid and colleagues argue that this effect is presumably based on an increase in self-efficacy and the experience of control (Kurscheid, et al., 2019). Therefore these apps are interesting for use by dieticians or in any weight management program.

The second one, the experience sampling method (ESM), works the same as EMA but usually (not necessarily) in the context of a lab in which the person is asked to perform a task (Dimotakis & Illies, 2013). Generally, ESM refers to only capturing self-reported experiences (thoughts, states, events) using a sampling approach, while EMA tends to include physiological measurements next to these subjective measures. Both methods (EMA and ESM) make use of repeated momentary data collection and provide insight in how individuals think, feel and behave on a daily basis. Additionally, both methods are not influenced by cross-sectional data or recall bias, which makes these apps interesting for use by therapist and doctors. However, this graduation project will be based on usability testing instead of behaviour change. Therefore the EMA approach is less suitable because there is a need for qualitive data about the intervention which can only be obtained by asking the user questions about their experience with the design from person to person. This research can also not be called 100% ESM approached, since I will not repeatedly collect data, however, the capturing of self-reported experience is what I am going to focus on.

Although self-monitoring has been described as the cornerstone of behavioural treatment for weight loss (Burke, Wang, & Sevick, 2011), (Baker & Kirschenbaum, 1993), the Hawthorne effect cannot be overlooked (also known as observation bias). The experiments done by Franke and colleagues suggest that the consequent awareness of being studied possible impacts the outcome behaviour and therefore the results (Franke & Kaul, 1987). In ESM studies, the researcher can attempt to compensate

for this Hawthorne effect by asking the right critical questions about the experience, however in EMA studies this gets harder since EMA is really focussed on the natural habitat without influence from the researcher. Thus, the validity and reliability of EMA behaviour change study results can always be argued because of that reason.

What follows is one example of an EMA studies and one example of an ESM studies that are both aimed at motivating people to self-monitor. The EMA studies are relevant to my graduating project to get an idea of how my design could be implemented in future research, while the ESM studies give inspiration for how I could shape my own evaluation phase.

ESM study example 1: Facebook Groups

The first example. which is an ESM study, is the study done by Napolitano and colleagues. Napolitano and colleagues researched the effect of Facebook groups on weight loss of students. Through the Facebook group, the participants (20.47 ± 2.19 years old, 86.45 ± 17.11 kg, with a body mass index of 31.36 ± 5.3 kg/m(2)) had access to intervention content and could respond to polls and healthy activity or eating event invitations (e.g., on-campus farmers market, group fitness class, and cycling events) (Napolitano, Hayes, Bennet, & Ives, 2013). All of the information was accessible from home and the polls were published regularly during the day, however, The Facebook Plus group additionally received personalizes feedback of experts (e.g. tips and tricks) and a 'buddy' to serve as a support person. This influence of a third party that asks the participant about their experience, is what makes this study classifiable as an ESM study. Results show preliminary efficacy and acceptability of the two active intervention arms (97.0% found the program helpful, 81.3% found the videos/handouts helpful, and 100% would recommend the program to others) (Napolitano, Hayes, Bennet, & Ives, 2013). Although these results point at a difference in weight loss between the Facebook group (passive) and Facebook Plus group (active), there is no significant evidence that the use of normal Facebook groups is an acceptable and feasible method for weight management (Napolitano, Hayes, Bennet, & Ives, 2013). However, the study did show the potential of the Facebook Plus groups as a feasible method for monitoring the weight of overweight students.

EMA study example 2: Podcasts + Twitter

The second example, which is an EMA study is more critical on the use of social media for weight loss. Turner-McGrievy and colleagues examined whether a combination of podcasting, mobile support communication, and mobile diet monitoring can assist people in weight loss (Turner-McGrievy & Tate, 2011). The first participant group received only the podcast, and the second group received additionally a mobile app. All participants were overweight adults (n = 96, body mass index 32.6 kg/m^2). Podcasts delivered in the first 3 months contained a section on nutrition and physical activity

information, an audio blog of a man or a woman trying to lose weight, a soap opera, and a goal-setting activity. Podcasts delivered in months 3–6 contained only the nutrition and exercise portion of the podcast and focused on overcoming barriers and problem-solving issues. The Podcast+ Mobile group was additionally also instructed to download a diet and physical activity monitoring application and a social networking site (Twitter) app to their mobile device, through which they were encouraged to post their progress daily (Turner-McGrievy & Tate, 2011). This daily monitoring (that only the P+M group was doing) in the context of your own natural habitat is why this research can be classified as an EMA study. Although the above described Facebook group study group (from example 1) pointed at the potential of social media to stimulate weight loss, the results of this study are less positive about social media. The results were that weight loss did not differ by group at 6 months: Podcast+Mobile, n = 47; mean –2.7% (SD 5.1%); Podcast, n = 49; mean –2.7% (SD 5.6%). Additionally, days/week of reported diet monitoring did not differ between Podcast+Mobile (mean 2.3, SD 1.9 days/week) and Podcast groups (mean 1.9, SD 1.7 days/week; *P* = .28)) but method of monitoring did differ (Turner-McGrievy & Tate, 2011). Results confirm and extend previous findings showing a minimally intensive weight-loss intervention can be delivered via podcast, but prompting and mobile communication via Twitter and monitoring app without feedback did not enhance weight loss (Turner-McGrievy & Tate, 2011).

Non-scientifically tested methods for self-monitoring weight

The first example of an non-scientifically tested method is the use of smart scales. Smart scales are scales that automatically send the obtained data (usually body fat %, muscle mass % and water %) to an app. The app shows the progress of the user in various ways (charts, diagrams) and additionally give tailored feedback. Research shows that provision of a ‘smart’ scale with weekly tailored feedback substantially increases the frequency of self-weighing and the proportion of participants achieving an initial clinically significant ≥5% weight loss (52% vs. 28%) in an online commercial weight management program (Thomas, et al., 2017). The study provides support for the clinical utility of online commercial weight management programs and the potential for supporting technology such as ‘smart’ scales to improve adherence to body-weight self-monitoring and clinical outcomes (Thomas, et al., 2017).

There are many technologies (often apps in combination with an device) on the market that give an indication of the user’s body weight based on his/her physical activity and food diary. The goal of these technologies is usually to give personalized eating and training schedules without the user having to step on a scale. Self-monitoring is one of the popular behaviour change tactics that is often used in this apps, however it is good to mention that usually there other behaviour change tactics present as well, therefore the positive results that one experiences are most likely due to a lot of these tactics working

together. Besides self-monitoring, there might be elements in these technologies that I could use in my graduation project, which is why it is relevant to explore a few examples of these.

Pedometers, first of all, give objective data of physical activity throughout the day. They are known to sense your body motion and, more specifically, count your footsteps by either a turned pendulum technology, coiled spring mechanism or hairspring mechanism (Yeager, Heim, Seiler, & Lofton, 2008). Often there is an accompanying app that keeps track of the measured data. This app usually also allows for sharing the progress and planning the user's fitness schedule. Dombrowski and colleagues conclude that 'action planning' has a large effect on the results by stating that the combination of high weight loss goals and formulating detailed plans for changing dietary behaviours may be most effective in supporting weight loss (Dombrowski, Endevelt, Steinberg, & Benyamini, 2016). Besides, Verheijden and colleagues add that the 'social support' element should be encouraged in technological designs for healthcare by concluding a positive correlation between social support and health in their study (Verheijden, Bakx, van Weel, & Koelen, 2005). The action planning and social comparison elements are good to consider when coming up with new health monitoring technologies.

Accelerometers, on the other hand, are the expensive yet highly accurate alternative of pedometers. As opposed to pedometers, these devices are able to sense the intensity of the movement as well. This is because accelerometers have sophisticated sensors that convert physical movement into an electrical signal that is relative to the muscular force needed to produce the work (Yeager, Heim, Seiler, & Lofton, 2008). However, one could argue the usability of this technology due to the high costs and non-intuitiveness of these devices. Besides, although the accuracy is proven to be high, not much is known about the precision and resolution of these devices. Due to a lack of scientific prove on these accelerometers, for me as a design researcher, it is hard to solely rely on them.

Finally there is the use of metabolic devices. Next to the accelerometer technology, these devices also use heat flux sensors, galvanic skin response and skin temperature gauges. All of these technologies combined lead to a very accurate measurement of energy expended by the body throughout the day (Yeager, Heim, Seiler, & Lofton, 2008). Although Murakami and colleagues argue the validity of these devices, nonetheless these devices are often employed in hospital-based programs (Yeager, Heim, Seiler, & Lofton, 2008). Usage of these devices in scientific research requires official review and permission of the medical ethical committee. This is out of the scope of my graduation project and it is therefore unlikely that these devices will be used in my intervention.

Advantages and disadvantages of self-monitoring

There are several advantages of self-monitoring that are scientifically substantiated in multiple past studies. One important advantage of self-monitoring is that it raises consciousness which means that it makes people reflect on their behaviour. Orji and colleagues highlight that thinking about behaviour is a well-known approach for motivating and sustaining behaviour change (Orji, et al., 2018). The transtheoretical model of health change supports this statement by stating that health behaviour change involves progress through six stages of change: precontemplation, contemplation, preparation, action, maintenance, and termination. Thinking about behaviour and reflecting on it, is in line with each of these six stages (Prochaska & Velicer, 1997). Even more support comes from the field of psychology. The well-known behaviour change tactic 'self-monitoring of behaviour' is widely used in the field of nudge psychology to achieve long term behaviour change. Although the above described advantage helps to achieve sustainable long-term behaviour change, this is not always what is desired in research. In some research designs, short term behaviour change, might be the desired outcome. According to Majid (Majid, 2017), good research questions are often specific, measurable, achievable, relevant and time-specific (SMART). Regarding the latter, it does not matter if this time specification is long term or short term. It is yet to decide if self-monitoring also contributes to short-term behaviour change.

Another advantage of self-monitoring is that it creates self-awareness, which means that self-monitoring makes people assume responsibility for their behaviour by revealing the problem behaviour. Orji and colleagues indicate that self-monitoring confronts the person with their problematic behaviour, as opposed to attributing it to other factors beyond their control (such as genotype)(Orji, et al., 2018). The underpinning behaviour change tactic is called 're-attribution': unveiling the real cause of a problematic behaviour, and is often used to improve one's self esteem to perform the desired behaviour. Holmstrom and colleagues support the importance of reattribution to improve one's self-esteem (Holmstrom & Kim, 2015). They tested and acknowledged the recently proposed cognitive-emotional theory of esteem support messages (CETEMS) in which is hypothesized that sophisticated esteem support messages enhance state self-esteem by promoting cognitive reattribution and reappraisal of esteem-threatening situations and their effects on the self.

The last advantage of self-monitoring is that it promotes intrapersonal competition. Many people in the past that tried self-monitoring indicate that self-monitoring provides the opportunity for them to compare their performance with their goal and their past performances (Orji, et al., 2018). This

phenomenon is underlined by Ahola, who showed that competition-generated intrinsic motivation predisposition and social support are the two main properties of the athletic competition context (Iso-Ahola, 1995). However, I believe that whether or not this phenomenon is an advantage is strongly subjective. From my own experience I know that some people do not respond as positively to competition as others out of, for example, fear of judgement. Therefore, if a certain app provokes competition with other users through self-monitoring, it is suggest that designers also include some sort of reward for outperforming themselves.

Besides the numerous advantages of self-monitoring, there are also certain disadvantages that lead to challenges in further design research. First of all, self-monitoring could lead to health disorder and depression. Calorie counting apps, for example, might not be beneficial, if not harmful, to people with the tendency to be anorexic. Obsessive use of these apps could distract the user from the desired effect: a healthier eating habit. During the research of Orji and colleagues in 2018, one participant explained that although all started with daily calorie counting, it soon became an obsession which leaded to pushing herself to eat less each day. Additionally, calorie counting can cause a loss of food quality or even worse, justify for this eating poor-quality food. Even when tracking calories, the principles of an healthy diet remain the same. In my opinion, the user of the self-monitoring app should focus on more things than just the calorie intake, such as activity rate and food quality. Orji and colleagues support this statement by recommending that any future health intervention that discourages the negative behaviour, also should encourage the positive behaviour (Orji, et al., 2018).

Another disadvantage of self-monitoring is the labour-intensive nature of these apps. Although passive self-monitoring devices do allow for automatic monitoring, there are still limitations to this technology. For instance, food and drink consumption cannot be monitored by sensors, hence this needs to be inputted manually by the user. Burke and colleagues highlight that it is not natural for humans to track their own behaviours, thereby making it feel more like a punishment (Burke, Wang, & Sevick, 2011). Together with the fact that these apps often require a lot of work to calculate how many calories each consumption contains, makes people perceive self-monitoring as tedious.

The last disadvantage of self-monitoring is that, by definition, it stimulates self-criticism, which could be detrimental to one's self esteem. According to Panayotova, there are several potential mental harms caused by self-criticism. The first one being 'depression'. Panayatova states that unrelenting self-criticism paves the way for depression and anxiety and to some extent, may also predict depression (Panayotova, 2016). ''The tendency to blame oneself when things go wrong may lead to feelings of failure and low mood'' she explains. Another potential mental harm caused by self-criticism

is ‘projection’, Panayatova explains that a tendency to criticize oneself leads to projecting certain negative beliefs onto others, which then leads to the expectation of negative feedback or criticism from another (Panayotova, 2016). Both internal criticism, as well as expectation of external criticism, lead to the development of feelings of isolation and loneliness (Panayotova, 2016). All of the above described disadvantages, alongside the critical notes on the advantages, make self-monitoring hard to successfully implement by design researchers.

Conclusion

The main objective of this review was to provide an overview of researched methods aimed at self-monitoring. Self-monitoring can be done either in the person's natural environment (EMA) or in the laboratory (ESM). The EMA studies are usually pointed at behaviour change, while the ESM studies are sometimes just for usability testing purposes. Both are important studies that help evaluating the design. Studies on methods of self-monitoring mainly praise the low influence of cross-sectional data or recall bias, alongside an increase in self-efficacy, however, the influence of the Hawthorne effect is hardly taken into consideration in any study. Next to scientific methods, several non-scientific devices are already on the market that allow for some type of self-monitoring. Some of these monitor weight and some of these give an indication of the weight by monitoring physical activity. Although some of these promise a highly accurate way of self-monitoring, none of these have succeeded to be accessible for the average researchers while delivering accurate, precise and high-resolution measures for weight, except for the smart scales. A increased level of consciousness (knowing what the problem is), awareness (being aware of the consequences and taking responsibility for it) and intrapersonal competition are advantages that are mentioned in several papers. However, these papers all assume that sustainable long term behaviour change is the goal, though this does not necessarily have to be the case. Additionally, whether competition is in fact an advantage is highly subjective for it does not benefit all people equally. It could demotivate some of the users which is something that should not be overlooked by designers of future interventions that include competition through self-monitoring. This, alongside several mental harms like depression potentially caused by obsessive use and self-criticism, make self-monitoring a difficult method to implement successfully. Any future persuasive intervention should be strategically designed, for instance through the use of grounded theory such as the behaviour change tactics as described by Carey (Carey, et al., 2018), to eliminate the risks of mental harms. There is a need for more accurate, yet still low cost, pedometers alongside a need for more scientific research on the validity of these devices. More scientific research has to be done on the effect of self-monitoring on short term behaviour change and on whether more factors should be included to support self-monitoring (such as action planning or social support) to achieve the optimal result.

2.2 Description of the total bypass surgery treatment

In the Netherlands, the option for a gastric bypass surgery is only available for heavily obese patients (body mass index > 35). The doctor usually refers you to this operation if all the natural weight loss methods (e.g. a diet, increase of activity rate) failed. When the doctor decided that the gastric bypass surgery is the right option for the patient, the patient will receive all kinds of tests conducted by several specialist in the hospital. First, the doctor will research other past health issues of the patient. Second, a psychologist and a dietician will examine what already has been done to lose weight. Finally, the psychologist will examine whether you are mentally and physically healthy enough for the surgery. Based on these three tests, there are several situations in which a gastric bypass surgery is ruled out. When a patient has either an eating disorder, a serious mental illness, an alcohol addiction, a drug addiction, a treatable hormone abnormality, a pregnancy desire in the short term or a disease from which he/she can die short term, it is impossible to receive a gastric bypass in the Netherlands.

After the surgery, the aftercare starts. The aftercare consists of five years of accompaniment, usually under guidance of a specialized clinic, but sometimes under the guidance of the hospital as well. These five years consist of 1-2 years of intensive accompaniment (depending on the patient's performance) and during the remaining years there is often one mandatory meeting per year. In practice, the intensity of the first two years not only depends on the patient's performance, but also on the hospital. For example the Rijnstate hospital in Arnhem values a tailored and personal aftercare more than other hospitals. A spokesman of Rijnstate explains: "Weight maintenance will be harder for some patients than for others; our vision is that it is essential to provide more feedback to patients who need it". The Rijnstate hospital disagrees with how clinics as 'Vitalys' and 'Novarum' organize their aftercare trajectory nowadays. Therefore, since January this year, they support the patients with their own trajectory. The Rijnstate hospital is currently one of the most active hospitals in the Netherlands on the field of bariatric surgery.

2.3 Description of our target group: the patients

The target group of this research consist of patients (age > 18) that recently underwent a gastric bypass surgery. These patients are always ex-obese patients, though, except for their body, the patients have not changed mentally. They will often still cope with obesity related mental problems such as food addiction, alcohol abuse and sometimes even depression, suicidal thoughts or social exclusion (van Vuuren, et al., 2019). The lifestyle challenges of this group of patients are generally the same for

everyone. Per meal, the patients can only eat the amount that fits on a breakfast plate; the patient should not eat and drink at the same time (it is suggested to have half an hour between eating and drinking) and the patient cannot skip meals, since it is difficult to catch up at a later time.

2.4 Concluding notes

I assume that the challenges of self-monitoring for healthy people generally will also go for gastric bypass patients. However, the new lifestyle of gastric bypass patients challenges future interventions that include self-monitoring in the aftercare even more. The intervention should keep in mind the strict eating schedule of gastric bypass patients, alongside the other food restrictions as described in chapter 2.3. The intervention should fit in the current aftercare trajectory as described in chapter 2.2 and should be tested carefully. Ideally this means a combination of an ESM study (for example in the laboratory) followed by an EMA study in the patients natural habitat. Besides, considering that even for the average person self-monitoring could lead to mental harms, it is even more important to be cautious when working with ex-obese patients due to their higher vulnerability to these mental problems. Finally, the intervention should not provoke addiction in the negative way. It should motivate enough to keep the user interested, but it should not take over the life of the patient in the way that many calorie counting apps do. It is suggested (by eating disorder clinics) to not only look at the weight number or calorie intake, but also the lifestyle and emotions of the patient when working with (possibly emotionally unstable) patients (Monitor, 2020).

Methodology

This section describes the methods followed throughout the graduation project. An approach was applied based on The Design Methods of Creative Technology (Mader and Eggink, 2014). Moreover, a high involvement of doctors, supervisors and fellow students throughout the design process was necessary, integrating elements of co-design.

3.1 The Design Process

Throughout the bachelor Creative Technology, it was taught to follow a structured design process. In many projects, we, as students, followed the design process as described by Mader and colleagues. It consists of four phases: The Ideation, Specification, Realisation and Evaluation (Mader & Eggink, 2014). Ideally I wanted to go through this design cycle twice, however due to time constraints and the current COVID-19 measurements it was difficult to realize twice and test the design twice with the target group. Although I might not have tested my design twice, I did asses my initial design with a stakeholder (Dr. Verhagen), which eventually led to the final design. A visual representation of my design process can be seen in figure 1:

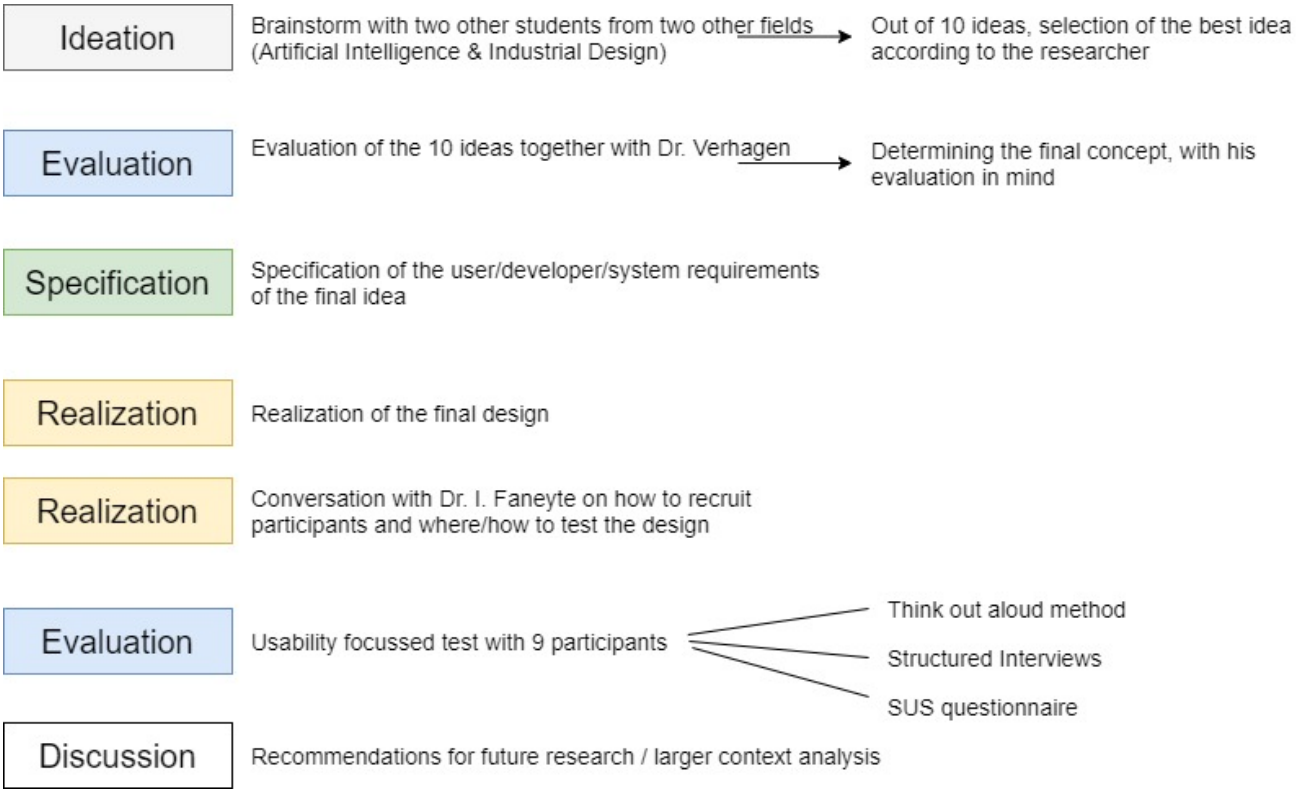

Figure 1: My design process in in chronological order from top to bottom

3.2 Chosen Design Techniques

Methods in the Ideation phase

In the ideal situation, there will be a multidisciplinary brainstorm in which as many ideas as possible are generated. This multidisciplinary aspect is something that has proven itself to result in many great ideas in past projects during my study. This is due to the fact that different disciplines approach the problem in a different way. Because of the COVID-19 restrictions, the brainstorm session took place on a medium called Greenlight (a video chat service of the company Big Blue Button), and the ideas will documented through Google Drive.

Additionally I received the opportunity to have an interview with an important stakeholder, Dr. T. Verhagen. The interview was used to early evaluate the 10 ideas that were generated in the brainstorm session. His input was also used to get a better understanding of the target group's context, which can be read in chapter 4.1. Eventually I came up with a final chosen idea based on his input and the state of the art analysis.

Methods in the Specification phase

Based on the results of the interview with Dr. Verhagen and conversations with my supervisor, I had a good idea of what the user and developer requirements were. Additionally, the disadvantages and advantages of self-monitoring (from the literature review) were taken into account to determine the right user requirements. Together, I concluded on what the system requirements were prior to actually building it. That way, I had a clear overview on what elements were to be included in the design based on all the previous research I had done.

Methods in the Realization phase

First of all, a list of tools to realize the design was created. This can be found in appendix 1. I realized the design by watching instructional videos on how to code a pressure plate system and how to create a touchscreen monitor. I ordered from Chinese suppliers with the hope that everything was of good quality. The final result was installed at the test location by using a high office desk as a stand for the monitor and the ground as surface for the pressure plate. A picture of this setup can be found in appendix 9.

Methods in the Evaluation phase

The methods that will be used to evaluate the design are 'user tests', 'structured interviews' and an 'online questionnaire'. These are methods that are often seen in ESM studies as described in the literature review. A conversation with a second doctor (Dr. I. Faneyte) from the ZGT was used to discuss how to recruit the patients. For this total evaluation (user test + interview + questionnaire) 15 participants were invited by Faneyte. They needed to consent with how the data was used before they could join (see appendix 3 for consent form). The user tests was done following the 'thinking out loud method' which is a method that encourages people to speak their thoughts aloud as they go through the user test (Van Somaren, Barnard, & Sandberg, 1994). The structured interviews consisted of 9 open questions (3 about the game, 3 about the setup and 3 about the concept in general). Do notice that only the first 6 questions can be classified as usability testing, however the answers on the last three questions provided interesting information for my discussion later on. The online questionnaire included 10 system usability scale (SUS) questions that were to be answered by means of a Likert scale. Appendix 4 includes a complete overview of the time schedule during the evaluation day as well as the 10 SUS questions (in dutch). Appendix 5 includes the interview questions (also in dutch).

The results of the user tests were first of all my notated keywords that the participants said during the think out loud tests. I noted down everything the users said while using the design with the hope to discover unforeseen flaws. Secondly, the results of the structured interviews were the answers on the open questions. To analyses these results I recorded and later interpreted the data. Interpreting the data was done an explorative way, which means that I searched for common themes. Finally, the results of my questionnaire were 15 calculated SUS scores that each gave a grade to my current design. The SUS questionnaire was initially designed for testing out website designs, however, the questions can also be applied to other designs. More about the potential errors in the discussion chapter under the section "limitations". The SUS scores range from 0 to 100 and are calculated based on the questionnaire in the following way:

- For each of the odd numbered questions, subtract 1 from the score.
- For each of the even numbered questions, subtract their value from 5.
- Take these new values which you have found, and add up the total score. Then multiply this by 2.5.

The result is not a percentage at all. Based on the score, the design gets an A, C or F. According to the theory behind the system usability scale, an A is given if the score is higher than 80.3, an C if the score

is between 51 and 80.3 and an F if the score is lower than 51 (Bangor et al. (2008)). Based on this score, together with the results of the think out loud tests and the interviews, I would discuss the intervention and propose a renewed design (see chapter 8.1).

Note: The results of an ethical assessment of the design had a huge impact on which participants are used in the evaluation phase. In the ideal scenario, the evaluation tests are done by patients that recently underwent a gastric bypass (my target group). However, by using patients, this research could possibly be classified as medical research which would automatically mean that an ethical assessment of the METC (Medical Ethical Assessment Committee) is mandatory. Due to time constraints (as described in chapter 5.2 “developer requirements”) this should be avoided. This means that the participants of the evaluation may possibly be just healthy people as opposed to patients.

Ideation Phase

In this section you will read how the brainstorm of ideas and results of the interview with dr. Verhagen resulted in a final design (divergence), as well as what features this final design has and where the inspiration came from (convergence).

4.1 Divergence

Brainstorm of Ideas

Before, and thus without the input of Dr. Verhagen, a brainstorm session was done on November 25th. A brainstorm technique called "brain netting" was used which means that there was one central person who wrote all the ideas down (in Google docs) after which a discussion followed. On purpose, I wanted the participants in the brainstorm (Rosa Eggink and Anne Sax) not to have any knowledge on the aftercare trajectory nor the patients view or the doctors view on the situation. The only goal was: coming up with ideas to motivate people to weigh themselves daily, considering that these people are ex-obese patients. Rosa Eggink is a third year bachelor Artifical Intelligence student. Her ideas came mainly from the fields of automated bot feedback and speech/face recognition. The second student, Anne Sax, is currently in her second year of the bachelor Industrial Design. Her ideas came mainly from the fields of business (e.g. rewarding the user with discounts on self-insurance) and joyful interaction (e.g. by using humor). All these different approach led to 10 different ideas. I recognized that the full potential would be achieved when combining the best elements of each idea, however I still needed the expertise of Dr. Verhagen to get a better understanding on what these 'best elements'' were (considering the context of patients). The 10 brainstormed ideas can be found in appendix 6.

Results of the interview with Dr. Verhagen

The context of my research is an aftercare trajectory which lasts for five years, starting the day after an obese patient received the gastric bypass surgery. Dr. T. Verhagen was interviewed to understand the context of the patients better. He indicated, first of all, that the **self-insurance** expires the moment patients step into a hospital. The fact that their self-insurance expires could hold patients back to seek professional help in time when their weight goes the wrong direction.

Secondly, during the first years of the aftercare, the hospital checks also include some psychological support, whereas the final years solely include a blood tests and vitamin level tests once every year. *"In the ideal situation",* he continues*, "the doctor receives weight data of the patient for the entire duration of the aftercare trajectory and could intensify this aftercare in time when it is needed, as opposed to when it is already too late*". The patients for which the aftercare is effective (e.g. they lost weight or stabilized it) naturally do not see the benefit of these hospital checks that only cost them their self-insurance. On the contrary, the patients that did regain weight (regardless of whether that is their own fault or not) often feel ashamed and guilty for it. Dr. Verhagen explains: "*ex-obese patients*

*find **nothing** worse than regaining weight". "When you ask them about that topic they almost always start crying"* he continues.

Thirdly, according to Verhagen, a big contextual misunderstanding exists among patients but sometimes also among professionals. Verhagen states: "*The concept of 'every pound goes through the mouth' is scientifically contradicted MANY times". "Sometimes genetics have such a large influence on the results of a patient, which is nothing to be ashamed of"* he concludes. Regaining weight is part of the natural process after one received a gastric bypass surgery. The goal of the aftercare is to stabilize the weight after it has regained to a healthy level.

Finally, as already mentioned in chapter 2.3, the patients often still cope with obesity related mental problems such as food addiction, alcohol abuse and sometimes even depression, suicidal thoughts or social exclusion (van Vuuren, et al., 2019). This is the main reason why certain behavior change tactics that include 'direct confrontation' or 'social comparison' are not recommended with this target group. According to Verhagen *"this could contribute to a negative spiral which is something we want to avoid at all times"*. He explains: "*Patients with a negative weight progress are certainly aware of that. Showing a red light as a means to confront or showing some positive progress of peers could only have a demotivating effect".*

In short: from the results of the we can conclude that a few things are definitely discouraged. These are:

1. A competitive element
2. Direct feedback (especially negative direct feedback)
3. Any form of social comparison
4. Daily actively weighing (this could only lead to obsessive behaviour, weekly is already a lot)

4.2 Convergence

Chosen Idea

There were 10 ideas (appendix 6) that varied from developing a social platform for these patients, to integrating the scale in an everyday used object, to incorporating some sort of reward, to playing a game and receiving direct feedback. All of the 10 were assessed on three elements. With the conversation with Dr. Verhagen in mind, I determined how motivating, feasible and desirable each idea is. Assessing the 'desirable' was done by analyzing the possible mental risks. The full analysis can be found as an ethical assessment report in appendix 10. Underneath you can find a table in which these three elements are assessed through either

1. - (totally not)
2. / (potentially)
3. + (definitely)

	Feasible	Desirable	Motivating
1. Level Up	+	/	+
2. Facing the timeline	/	-	/
3. WhatsApp Buddy	+	+	/
4. Funny Scale	/	-	/
5. Invisible Scale	/	+	-
6. Save the Day	-	/	+
7. Planning the Moment	/	/	/
8. Smart Toilet	-	/	-
9. InstaWeight	+	+	/
10. Save The Day 2.0	/	/	+

Table 1: Assessment of the 10 ideas

For the final idea, the potential harmful element of idea 1 (the competitive element) was left out, and the desirable element of idea 3 (the scale without weight number) was added. The final chosen idea is:

''A numberless scale that, when stepped on, activates a 1-3 minute minigame on a monitor right in front of them, controlled through touchscreen. The weekly measured body data is sent to an app that gives weekly feedback on their weight through text messages to the user. The data will also be available to the doctor to achieve a more individual tailored aftercare trajectory".

It is good to mention that, for motivating purposes, it is very desirable to implement the scale as ‘invisible’ as possible. This is to lower the threshold of deciding to step on it. However, this element is less important for usability testing purposes.

Features

The scale

The scale used in the final chosen design, was able to send body weight data to an app. This feature is seen in the so called “smart scales” that are already on the market. Besides measuring body weight, these scales are usually also able to measure fat percentage, muscle mass percentage, “body age” and able to calculate BMI, however, the doctors are only interested in the BMI and body weight data. The scale was placed on top of the pressure plate system. During the evaluation of the idea, the data was not measured. However it is good to know that this feature works and is available for future research on the design.

The pressure plate system

The pressure plate system was a self-made sensor that detected when someone was standing on the scale. This feature was needed to activate the game on the monitor on the right time. The pressure plates was in contact with the Arduino and the Arduino IDE with processing (read chapter realization)

The game

The interaction was programmed in the program “processing”, which is a software for prototyping code. Processing received information from the Arduino program and displayed a set of games when someone was standing on the pressure plate system. The games themselves were embedded links to the corresponding URL of the webpage that provides the minigame. By clicking on one of the game covers on the screen, processing opened the correct link.

The touchscreen monitor

The touchscreen monitor displayed the game. Through swiping and clicking on the screen the games could be played. Furthermore, controls such as zooming and zooming out, worked the same as with any regular iPad or smartphone.

Inspiration

The inspiration to choose Processing/Arduino/pressure plates came from earlier projects. I already had experience with these things due to past projects and I was confident it would work and I could rely on it. In module 2 I used pressure blades underneath the road to detect cars and to adjust the street lighting accordingly. The big advantage I found with using the pressure plate system, with respect to other sensors (e.g. motion sensor, camera), is that the sensor is purely hardware. Hardware is easier

fixable than software. Especially for my usability test it was crucial that everything worked and that I could fix it quick if it did not.

Specification

Before realizing the idea, I listed all the requirements that the design should fulfil. This list was based on all the previous information that we have obtained while researching the patients background and the context. This structured way of working allows for a structured conclusion later on in the project since I could evaluate point by point what requirements had been achieved and what not. Additionally some personal developer requirements are added.

5.1 User Requirements

The user requirements were as follows:

- The design should motivate the person to step on a scale
- The design should include joyful and entertaining games
- The design should have the right physical proportions
- The design should be stigma free and therefore not be confronting the user daily with their weight
- The design should not have a competitive element (with other users)

5.2 Developer Requirements

The developer requirements are as follows:

- The whole project should be concluded in 10 weeks
- The design should be realized in 2 weeks
- Due to COVID-19 constraints, I received one day for evaluation with patients
- The design as well as the consent form should not be collecting medical data
- All participants should voluntarily participate
- The evaluation of the design should be focused on usability instead of its effect on the motivation

5.3 System Requirements

The system requirements are as follows:

- The scale should be able to send the data to an app
- The whole system should be able to detect when someone is standing on the scale
- The monitor should be touchscreen to play the games easily.
- The monitor should be big enough to play games on
- The monitor should be positioned at appropriate height and distance from the scale to prevent muscle pain

Since I considered all requirements evenly important, I did not want to prioritize on over the other. If one requirement is met a little less in the end, then I consider that a flaw in my design which should be fixed in future research.

Realization

6.1 The pressure plate system

The goal of the pressure plate system is to let the Arduino know that someone is standing on a scale. I decided to create and program the circuit of a simple switch that is activated when two aluminum sheets touch each other. The circuit that I had in mind is shown in figures 2A and 2B

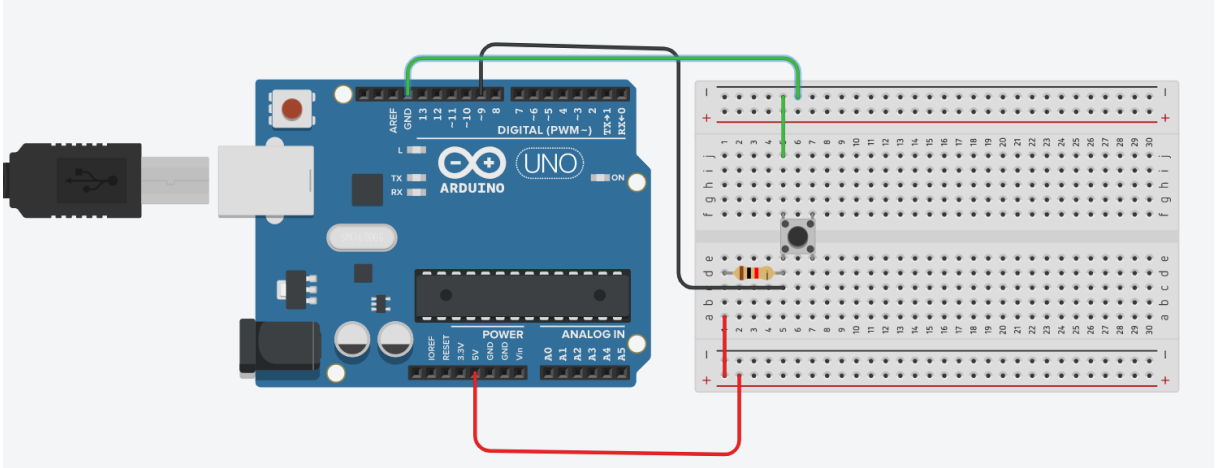

Figure 2A: visual representation of the circuitry

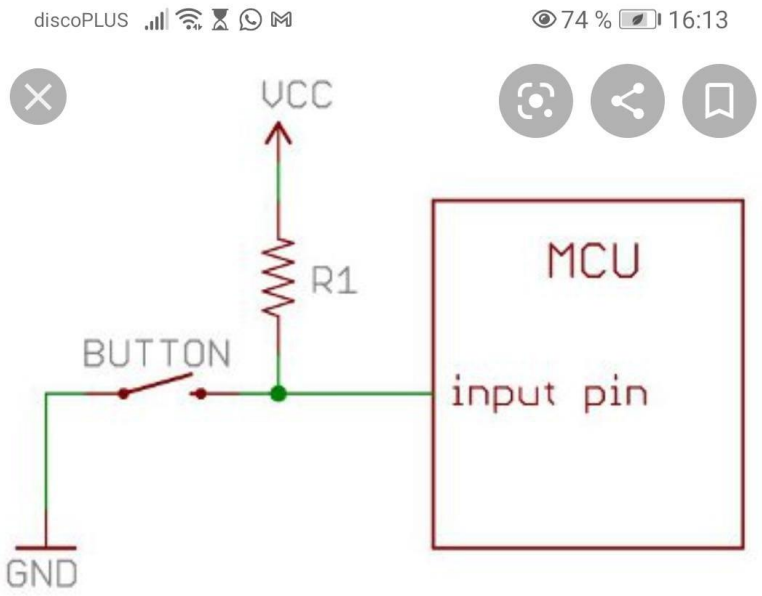

Figure 2B: The circuitry (Button = Pressure plates)

The function digitalRead in the Arduino IDE language reads how much the voltage level is on a chosen pin, thus, how much current is coming in. Whenever there is more than 2.5V on the pin, digitalRead will return 1, else it will return 0. In this circuit there are 2 options:

1. When nobody is standing on the switch the current goes from 5V, through the resistor into pin5, therefore pin5 will digitalRead the value 1.
2. Someone is standing on the switch, the current “choo ses” the easiest route (which is ground). Therefore pin5 will not get any current, and will read the value 0.

In my design, the button in the circuit is replaced by two plates of wood with aluminum on the inside. The two plates act as a switch (see figure 3)

Figure 3: Pressure plate sensor

By standing on the scale, the two aluminum plates on the inside touch which completes the circuit as show in the previous figures. Therefore the Arduino program knows when someone is standing on the scale and when not

6.2 The touchscreen monitor

The touchscreen monitor is realized by taking a regular 32 inch monitor and adding the infrared frame from the company Xintai. The frame will be placed on the sides of the tv screen as shown in figure 4

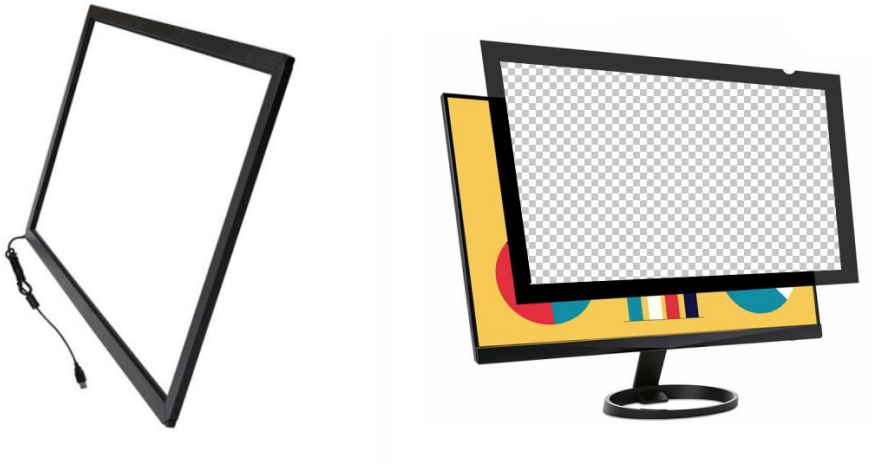

Figure 4: The Touchscreen monitor + Xintai infrared frame technology

The physics of the infrared frame are visualized in the following picture:

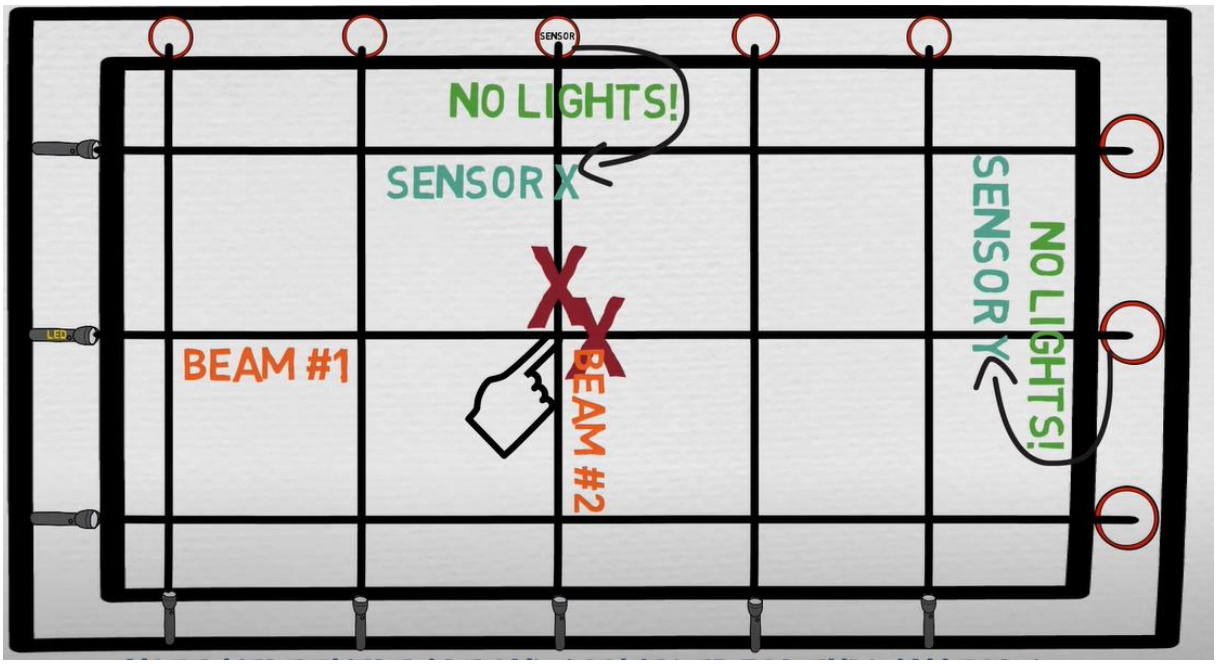

Figure 5: visual representation of the working of the infrared frame

Infrared frames are based on light beam interruption technology. There are LEDs placed on the inside of the vertical and horizontal side of the frame. For both these sides of the frame, light sensors are placed right in front of the LEDs at the exact opposite side of the frame (circled in red). When the frame is turned on (through USB connection), these LEDs start emitting beams of light and the opposite corresponding sensors start to detect them. However, when you touch somewhere on the screen, two light beams are interrupted and therefore the x and y location of your finger can be calculated and send to the computer through that same USB connection.

Therefore it does not matter what surface is underneath the frame. The easiest way is to display the computer screen through HDMI connection on a monitor, but a beamer would work just as fine. As long as the displayed screen matches the size of the frame (in this case 32 inch) any screen can become touchscreen.

6.3 Programming the interaction and choosing the games

The interaction was programmed through the Arduino IDE software. This software can interact with pins on the Arduino board and send the data to for example another programming platform (in our case Processing). Our input pin (see figure 2A and 2B) is pin 9. Remember that whenever someone stands on the pressure plates, the pin would read 0 (see code and), additionally, by serial printing it, the value is now send to the serial port. This will be used in processing later on.

```
int led = 9;
int value;
void setup() {
  Serial.begin(9600);
}
void loop() {
value = digitalRead(led);
Serial.println(value);
   }
```

Processing is able to strip of data from the serial port and use the data to control anything you want. In this game I wanted to display the words “step up” when nobody was standing on the scale, and display 4 game covers when someone was standing on the scale. The complete code can be found in appendix 7.

The 4 games that were chosen were Candy Crush Saga, Bubble Shoot, Subway Surfers and Sudoku. The main reason for choosing these games was that they were all easy to control through touchscreen. Moreover, all of them (except for sudoku) were initially designed for tablet screens.

Evaluation

7.1 Recruitment

Just like any standard usability test, the desired number of participants was aimed at 5 (Six & Macefield, 2016). During one of the mandatory poli days of the patients, participants were recruited by Dr. Faneyte. The procedure for recruitment was as follows

1. The patient voluntarily consented for participation during the meeting with the doctor, and was directed to a separate room after the meeting
2. In that room, the design was installed and I led the user test and took notes of what was said (think out aloud method)
3. The user was asked to answer a few questions about the design (about game, setup and design) (see appendix 5)
4. The user was asked to fill in a SUS questionnaire (appendix 4).

The user test was used to collect possibly usability errors that I had not thought of in the first place. The interview was used to collect structured answers about different elements of the design. The SUS questionnaire was used to label an overall score to the design. Together, these three sources were enough to conclude how joyful this current design was, and what could be improved in future research.

The test day was planned on 18 December, starting from 08:30 am in Hengelo. Thirteen people were planned to have a meeting with the doctor, therefore I hoped (and assumed) that at least 5 of these would volunteer in my experiment.

7.2 The Results

Nine patients participated in the test. Six women and 3 men with an average age of 43.6 (SD = 12.3).
In general 2 types of participants in my test can be distinguished. One group that liked gaming in general (P.1, P.6, P.7, P.8, P.9) and the other group that did not. In general the group that liked gaming gave more positive results, however, the group that did not like the games gave more ideas for other ideas that could be displayed on the monitor. Both groups gave valuable information for further research.

Results of the thinking out loud method

The three-phase test process started with the thinking out loud method. The thinking out loud method involves asking users to think out loud as they are playing a game with my design. Participants were asked to say whatever they are looking at, thinking, doing, and feeling at each moment. I wanted to determine users' expectations and identify what aspects of my design are confusing. These were some of the phrase I noted down while the patients were using the design (note that I did not say anything at all, only when they asked a question):

"Oh god this is not stable" (P.1 when stepping on the scale)

"Do I have to click somewhere" (P.1 while looking at the home screen)

"Oh I am totally not into games usually" (P.2 before stepping on the scale)

"How can I start with the game" (P.2 while looking at the play button)

"Oh I'll go for candy crush definitely. Don't you have Mario kart perhaps? (P.3)

"Do I have to swipe or click here?" (P.4 while playing subway surfers)

"Oh demn it reacts really really fast" (P.5 while playing bubble shoot)

"Oh I think I am dead" (P.5 although not being dead yet, just close to)

"This is really nice this, though it is a little sensitive but I am getting good now" (P.6 while playing candy crush)

"It is really sensitive, but, I have to admit I am just not good at this game, I am sorry haha" (P7, excusing herself while playing bubble shoot).

"I don't see depth very well so it is a little hard" (P.8 while playing subway surfer)

"Do you have angry birds perhaps?" (P.8 while looking at the home screen)

"You know blocks, or a puzzle would be nice as well to play on this screen" (P.9 while playing candy crush)

Besides the things that were mentioned, there were also things that were observed by me, the researcher. I noticed that most participants had difficulties with the stability of the pressure plate system, and I noticed that after a couple of minutes the participants suffered from weary/tired arms (which is called muscle fatigue) causing them to switch to the other arm.

Results of the interviews

After the thinking out loud testing phase, the interviews started. The idea of the interviews was to obtain qualitative data about different aspects of the design. An overview of the questions asked can be found in appendix 5. These are the results:

I started with questions about the games itself.

Q.1 Did you find the game difficult?

In general, most participants did not find the game they chose difficult to play. Examples of answers were:

"Oh well, it takes some time to get used to the game, but then it is definitely doable yea" (P.2)

"not at all" (P.3)

"you mean on a scale from 1 to ten? You have to figure out what you have to do but the game itself is not difficult no" (P.6).

Q.2 Which games would you also like to play?

In general the participants that found the games very easy, had the most suggestions for other games. Some knew a few games that they, or their friends and family, play. Examples of answers were:

Well, my husband plays a block game on his phones, some kind of puzzle but I don't know the name anymore. Such a brain games would be fun"(P.2)

"I always play patience but that is probably not possible or is it?"(P.2)

Well, me myself I play Mario games all the time, I find these very, very nice"(P.3)

"No candy crush is the only one I really like, I am at level 3600 somewhat, empties your mind really good"(P.1).

Maybe a normal card game like patience (P.4)

"Well, blocks is quite nice, and tile craft as well. Also puzzles with animals, no flowers, are nice" (P.8)

In the past I really liked Angry Birds (P.9)

Q.3 How did you find the interaction with the game?

In general, the participants indicated that the touchscreen reacts quite sensitive, however, after a while most participants got used to it and started enjoying the games more and more. Some of the interesting answers were:

Yea the interaction was fine, however I wonder how this scale is going to measure this right because my scale at home starts to measure all kinds of things of my body. Also, maybe it is nice to play the game while exercising on the treadmill (P.1)

"Nahh you have to get used to it, but then it is totally fine" (P.2)

''Now it went a little bit difficult, because the screen is very sensitive'' (P.3)

The screen was placed a little bit too close to me….(P.6)

"It was difficult with the swiping games, however that other game I played did not have this fast interaction, and then this is totally fine", so it depends a little on the game"(P.7)

"It was a little bit too fast in the response" (P.5).

"Yea it was for me….. it was a little hard to figure out. Instructions would be useful but in Dutch, NO English please"

After the questions about the game and the screen, I asked questions about the measurements of the setup considering this setup is used at home.

Q.4 What is your opinion on the dimensions of the setup?

I tried to let the patients think about their own situation and let them imagine the setup in one of their rooms. There was no general consensus here, almost ever participants had a different opinion on this. Some of the interesting answers were:

"No they measurements have to be bigger definitely, especially the scale considering people of my size, the monitor is nice and large, however a large Ipad would be nice as well because I have to stand really close to the monitor right now" (P.1).

"Well, the monitor can be a little smaller, but the scale is fine for me" (P.3).

"I think the scale can be a little bit bigger and the monitor is perfect" (P.4).

"I think you're standing really close to the monitor right now, the scale is fine for me. Maybe a little bit bigger" (P.6).

"I think that a tablet is large enough, however for elderly this might be easier to interact with. The scale is stable enough for me"(P.7).

"I think the measurements were perfect for me, the scale can be a little bit bigger"(P.8).

"For the scale, on every side 5cm extra would be perfect. The scale look a little bit breakable and with the patients', often insecure, minds that could lead to insecurity"(P.9).

Q.5 In which room would you like have this setup in the future

In general the participants indicated that they would not want the setup placed in a room that they often come. Some of the answers were:

"I think somewhere downstairs in the corridor" (P.1)
"In the bedroom, yes"(P.2)
"Where I have room left. Either the bedroom, or an extra room"(P.3)
"I have a sports room, so I would place it there" (P.5)
We have an office room, I think that would be a nice place (P.6)
Bedroom definitely (P.7)
I think in the scullery. At least not in plain sight (P.9).

Q.6 Would you like to see the number on the scale

Although the doctor indicated that monthly would be more than enough, the patients indicated in general that a weekly weighing moment would suit them better. Some of the answers were:

"*The weight? One time a week. Just like I do now" (P.6)*
"Yea, I don't walk away from it. It depends a little in which phase you are. Now that I have chosen for professional help I would like to see the number, but in the past I did not want to weigh at all. Weekly would be fine by me "(P.1)
"Ideally not at all, but yea then you do not get wiser from it either. Then weekly would be good"(P.4)
"Well, daily would cause a better awareness however twice a week would be better to keep the motivation I think"(P.5)
Definitely not at all. At max ones a month (P.8).

Finally, some questions about the concept/the idea were asked.

Q.7 Would a game motivate enough to step on the scale

There was a clear difference between people who liked gaming in general, as opposed to the people who did not. The ones who did not like gaming had interesting alternatives. Some of the interesting answers were:

"No, I'd rather see the news or the weather quickly"(P.6)

"I'm a little confused. I hear what you say but for me weighing is a one minute event. Why would I stand half an hour on that scale. If would do something that you don't have think long about. that he/she has gained weight. Because even without the number, he/she knows and feels that their weight goes up or down"(P.1)

"I do not play a lot of games, however, a game once a week would be doable yea" (P.3)

"Well if this was for daily use, then the news or weather would be better, but otherwise a game is better"(P.7)

No keep it a game, that is a nice distraction (P.8)

"Yes, definitely. Keep it a game (P.9)".

Q.8 Are there any other things you'd like to see on the scale

The patients pointed at a competitive element as well as social media implementation. Some of the answers:

"Maybe a choice to do a game or see the weather that would be the best"(P.6)

A competitive element would be very nice. Additionally, I am a good example of avoidance behavior. Therefore you would want to create something whereby the patient is not ashamed anymore to tell (P.1).

"Perhaps going on Facebook or Instagram would motivate more people to step on the scale (P.5).

"I think that adding a competitive element would keep me motivated a LOT. Because when a see someone else their weighing process is good with positive results, I want the same"(P.7).

Q.9 What do you think about the data being shared with the doctor to tailor the aftercare?

This is a very interesting question for later research. The fact that their data is shared with the doctor is assumed to be a sensitive element of this design. However, in general the patients had no problem with this at all. Some even encouraged this concept since it would save them time going to the hospital. Some of the answers

"*That is more of restriction to me than help. If that is essential for the aftercare then sure, but rather not. I find it an integrity problem"(P.6)*

"Yes, I think that would actually be a big advantage because the moment you stand on it, you do not see the results, but you know that someone on the other side is seeing it. But then the follow-up action is essential based on what they see. A doctor should adjust his feedback based on that and I

would like to hear that, as long as I do not see that number every day. But maybe that is a head-in-sand approach. (P.1)

"Yea that would be good, no problem with that"(P.4).

"That is really positive, I would immediately use the scale. Only a scale that sends the data would motivate me enough already and to be honest, I think such a scale should be placed in every patients house. But that would probably be too expensive… Also, it has got to be fast. A game is already too long."(P.5).

"I would not have a problem with that at all. If your progress is good then sure, otherwise I would also like appropriate help. That's is why I am here essentially"(P.7)

"Oh that is amazing, I have such a system to monitor sleep. And that works already really well" (P.9).

SUS score results

The SUS scores were used as quantitative data to assign a grade to my design. A screenshot of all the filled in questionnaires can be found in appendix 8. The SUS scores were calculated as described in the methodology chapter. The results are shown in table 2

Participant	SUS score
P.1	92.5
P.2	100
P.3	97.5
P.4	75
P.5	80
P.6	65
P.7	97.5
P.8	80
P.9	95

Table 2: The calculated SUS scores based on the filled in the questionnaire by all participants.

The average SUS score was 86,9 (SD=11.6) which indicates a high level of usability according to the patients.

Discussion

In this final chapter, the obtained knowledge during the project is discussed, together with the limitations and strengths of this research. Additionally, conclusive thoughts are shared, together with some recommendations for future work.

The goal of this project was to promote joyful weight monitoring among patients after gastric bypass surgery. According to the definition of joy (in Oxford Languages Dictionary), joy is a feeling of great pleasure and happiness. Satisfaction is a synonym of joy and is a metric of usability according to literature (Seffah, Donyaee, Kline, & Padda, 2006). Through multiple iterations and evaluations including important stakeholders and the patients, we have observed that the current design effectively promotes its theme of joyfulness by concluding that there is a high level usability, and therefore satisfaction. Additionally, based on the results of the thinking out loud tests, structured interviews and system usability scale questionnaires, there is an strong indication that the current concept could motivate the user to weekly step on a scale.

First, we investigated how the games were received by the patients. These games were short interaction touchscreen games. The general consensus, based on the interview results, was that although the touchscreen was difficult to interact with, the difficulty level of the games was not high. Furthermore, based on the keywords that were obtained during the thinking out loud testing phase, we can conclude that there is a need for additional text annotations to explain the desired interaction. This is supported by literature on game heuristics stating that: simple actions (e.g. selecting weapons, moving sprites around the map and selecting options from menus) that are essential for game play should be obvious and easy to perform (Brown, 2008). Complex actions that are necessary to game play should be taught, not discovered by trial and error (Brown, 2008). Moreover, several ideas for other games were given during the interviews, which indicates support from the patients towards the idea of playing games.

Second, we investigated how the setup was received by the patients. During the thinking out loud testing phase, problems with the stability of the pressure plate system were observed. Not all patients mentioned this problem, which can mean one of two things: either the stability was a subjective problem, or some patients did not want to indicate it for any reason. The latter scenario is supported by literature on the Hawthorne effect, which describes the phenomenon of individuals altering their behavior just because they know they are being observed (Susman, 2020). In the context of this thinking out loud test, this means that the participants might have altered what they said because I was in the same room, however there is no 100% prove for that. If this Hawthorne effect was really present, then that is a limitation of my evaluation method (more on that later). We have observed that there is a need for a more stable system which at least includes a larger scale. Furthermore, during the interviews, we have observed that, according to most participants, the monitor was placed too close to them and the monitor could have been smaller. We have also observed during the thinking out loud method that the patients suffered from weary/tired arms. It is expected that these two observations are linked to each other for the short distance between the monitor and the participants allegedly

caused the muscle fatigue. This expectation is supported by literature stating that muscle fatigue is a common symptom of obese patients (Caporuscio, 2019). We have observed that there is a need for setup that causes less muscle fatigue in such a short period of time. At last, among the participants there was consensus on the fact that the setup would be most suited in a room that was out of sight for it would otherwise be too confronting, however, the participants did mention that the room should be visited at least once a week in their weekly routine indicating the participants' awareness of their own avoidance behavior.

Third, we investigated how the total concept was received. The questions during the interview included the element of gaming on itself and the element of sharing data with the doctor without them seeing the weight number. Based on the target group analysis we expected a positive perception towards a concept that could save them these "annoying" follow up meetings. Compatible with our expectations the majority of participants indicated that regardless of whether there is a game or not included in the concept, the fact that their scale would be in contact with their doctor would already be enough motivation to use it. On the element of gaming there was no consensus. Some participants indicated that they would add extra elements such as a competitive element, social comparison or totally new features such as being able to check the weather or the news, however, in general the concept of gaming was well received. Additionally, the results of the system usability scale questionnaire support the total concept even further by indicating a high level of overall usability with respect to other similar studies using the same questionnaire (Perrin, Clark, De-Leon, & Edgar (2014); Condit Fagan, Mandernach, Nelson, Paulo, & Saunders (2012)). These studies show that it is hard to achieve a high SUS score when testing a first design, yet, this study succeeded in doing exactly that.

There were some limitations and strengths in this study. A first limitation is that there was no test in the patients natural habitat. As a consequence, we have no data on errors on issues that might have occurred when the researcher was not in the room. Additionally, we do not know if the concept would be received evenly joyful as it was now when the patients is supposed to actually use it in their weekly routine. By letting the user imagine this setup in their own natural habitat during the interviews, an attempt was made to compensate for this limitation.

A second limitation was that this research did not include enough participants to statistically indicate that there is indeed a positive sentiment towards the concept. It has previously been recommended that qualitive studies require a minimum sample size at least 12 to reach data saturation (Clarke & Braun, 2013; Fugard & Potts, 2014). This research only included 9 participants. Therefore, any positive observations of the concept are merely indications of a working concept.

A third limitation is more of limitation of the concept than of this research. There is no guarantee that the patient will not cheat by letting a family member stand on the scale when this setup is eventually implemented in the patients' home. This is something to consider for future research (more on that later in this chapter).

A final limitation of this research was that the system usability scale was used to assign an overall grade to the design. The system usability scale was originally designed by John Brooke in 1986 to evaluate websites (Dalangin, 2020), therefore it is uncertain how meaningful this number is in the context of this research. Although most questions in the SUS questionnaire can also be applied to other designs, we may theoretically only use this number as an indication.

The limitations lead to future research possibilities which will be discussed in the last paragraph. Besides these limitations there were also strengths in this research.

The first strength is that this research was conducted with the target group, as opposed to regular people. Therefore any qualitative data obtained is representative for the whole target group. This allowed for an accurate discussion and therefore an accurate and complete recommendation for future research (see last paragraph).

A second strength is that, besides the target group, more stakeholders were involved in the design process. An early evaluation with Dr. Verhagen and Dr. Faneyte allowed for a higher chance of a successful design.

A third strength of this research was that an ethical analysis was done during the ideation phase. This resulted in a deeper, more theoretical, understanding of the elements in my design.

A final strength of this research was that the research only demanded 30 minutes of the participants in which a lot of qualitive data was obtained due to structured evaluation techniques.

To conclude, this research adds upon the existing literature as described in the state of the art, by focusing on usability prior to focusing on behavior change. Additionally this research fits within the current trend of weight management programs that attempt to personalize the healthcare not only for gastric bypass patients, but for overweight patients in general. A remote technological intervention like this one contributes to these programs by increasing the amount of patients one specialist could help and by providing weekly accurate data to the specialist instead of recalled memories of the patient. The biggest limitation of this research is the lack of a test in the patients' natural environment, which leads to the recommendations for future research: it is suggested that a future design covers the needs as described in the discussion section above. Additionally, future research is suggested to

include a longitudinal evaluation to test if the concept stays evenly joyful after a few years as in the beginning. If the results of such a test are still positive, then implementation on a larger scale can be organized, for example in the form of a start-up company.

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Appendices

Appendix 1: Tools List

What	Price	Delivery
Xintai Touch Frame 40 Inch [1]	91,53 Euro 84,54 Euro	7-13 days Binnen op 3 Januari
Or Xintai Touch Frame 32 Inch [2]	88,85 Euro 90,79 Euro	10-19 days 7-13 days
Digital Smart Scale with App3	24,99 Euro	5 days
Laptop (windows 10)	/	Own laptop
HDMI cable to monitor	/	Own hdmi cable
Monitor (32 Inch or 40 Inch) Preferably 32 Inch	Perhaps an university monitor 40 euro's[4]	/ 7 days
Arduino UNO and wires	/	Own Arduino and wires
Wooden plates	/	Recycled Wood from projects
Aluminum foil	/	Own home aluminum foil

[1] https://nl.aliexpress.com/item/32924952452.html?spm=a2g0o.search0305.0.0.bd8c59d0JmtF58&algo_pvid=90fdf360-0a2f-4a38-8a50-de04dbd2592b&algo_expid=90fdf360-0a2f-4a38-8a50-de04dbd2592b-16&btsid=2100bdd016069465198328761e1f28&ws_ab_test=searchweb0_0,searchweb201602_,searchweb201603_#

[2] https://nl.aliexpress.com/item/32863431272.html?spm=a2g0o.productlist.0.0.5cfe6657rJjJg6&algo_pvid=2f6aa09e-7f00-4360-b3f4-b9b0cfa42ec4&algo_expid=2f6aa09e-7f00-4360-b3f4-b9b0cfa42ec4-9&btsid=0b0a01f816069490378278768e6988&ws_ab_test=searchweb0_0,searchweb201602_,searchweb201603_

[3] https://www.bol.com/nl/p/digitale-weegschaal-met-app-bluetooth-slimme-weegschaal-personen weegschaal-smart-scale/9300000012865134/?bltgh=spClkuvcoZ3VSv-9jShAFw.1_8.12.ProductTitle

[4] https://www.marktplaats.nl/a/audio-tv-en-foto/overige-audio-tv-en-foto/m1635335383-dual-32-inch-tv.html?previousPage=lr

Appendix 2: Time Planning GP Mourad Lagsir

Wanneer	Wat
Ma 16-11	Vragen zijn klaar voor interview met arts
Vr 20-11	10 Ideeën zijn opgesteld samen 4 andere studenten, op basis van interview met arts en de huidige situatie. **Goal: Mensen vaker op de weegschaal krijgen**
Za 21-11	Werk 11-19
Ma 23-11	Werk 10-18
Do 26-11	Op basis van hopelijk een gesprek met een patiënt zijn de 3 beste ideeën geselecteerd en de user requirements opgesteld (Hoodstuk 5.1). ***(Vragen of de patient mee wilt doen met latere user evaluation)***
Vr 27-11	De drie ideeën worden beoordeeld op User Solution Fit/Innovation/Feasibility/Long Term Behaviour Change • **Één idee wordt gekozen als winnaar** --- Teams vergadering met wethouders van Enschede/Almelo/Hengelo over Smart Street Lights innovatie uit module 2.
Di 03-12	Thesis Deadline **Hoofdstuk 3** (Methodology) en **Hoofdstuk 4.1** (Ideation Phase – Divergence)
Di 08-12	Thesis Deadline **Hoofdstuk 4** (Ideation Phase, Divergence and Convergence) en **Hoofdstuk 5** (Specification, User-/Developer-/System Requirements)
Wo 09-12 t/m Di 15-12	Idee realisatie tot testbaar iets (prototype maken)
Do 17/ Vr 18 December	User Evaluation (performance test) met X aantal patiënten **('t liefst live)** --- Making improvements on the design
Kerstvakantie 19-12 tot 03-01 Zo 02-01	User Evaluation days --- Refining User Requirements based on daily User Evaluation data ----------Deadline: Come up with user evaluation questions (quantitative and qualitative) and a method to analyse the quantitative results

Ma 04-01	Deadline Reflection Report
Do 07-01	Thesis Deadline **Hoofdstuk 6** (First Version/Refined User Req/Final Version)
Do 07-01	Interview with participants for final evaluation
Ma 11-01	Thesis Deadline **Hoofdstuk 7** (Evaluation)
Di 12-01	GP Evaluation, Go / No
Di 19-01	Thesis Deadline **Hoofdstuk 8** Conclusion
Di 26-01	GP presentation
Vr 29-01	GP thesis hand-in final
Ma 01-02	Start Minor Kunstmatige Intelligentie UvA.

Appendix 3: Consent Form

The following will provide you with information about the experiment that will help you in deciding whether or not you wish to participate. If you agree to participate, please be aware that you are free to withdraw at any point throughout the duration of the experiment without any further explanation.

In this study we will ask you to stand on a numberless scale and play a game of your choice. You hereby consent for testing out the design, participating in an interview about the design and filling in a questionnaire about the design. If you have any traumatic experiences with playing (touchscreen) games, such as for example problematic addiction, please inform the experimenter and the study will end now. All information you provide will remain confidential and will not be associated with your name. Your actual measured weight will not be used for any purpose in the research. Your age, gender and time after bypass surgery will be used for later analyses of the design. If for any reason during this study you do not feel comfortable, you may leave the laboratory and your information will be discarded. Your participation in this study will require approximately 30 minutes. When this study is complete you will be provided with the results of the experiment if you request them by your doctor. The doctor will then ask me to send the results of your experiment through email. If you have any further questions concerning this study please feel free to ask me, Mourad Lagsir, during the study. After the study, questions can be send to m.lagsir@student.utwente.nl.

Additionally, if you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee of the department of EEMCS, drs. Petri de Willigen, mail: ethics-comm-eemcs@utwente.nl or the supervisor of this research: Dr. Femke Nijboer, mail: femke.nijboer@utwente.nl

Please indicate with your signature on the space below that you understand your rights and agree to participate in the experiment.Your participation is solicited, yet strictly voluntary. All information will be kept confidential and your name will not be associated with any research findings.

_____ _____

Signature of Participant Mourad Lagsir, Investigator

Appendix 4: Plan van aanpak op de poli dagen

Betrokkenen en rollen:

- Experiment leider: Mourad Lagsir
- Contact persoon UT: Dr. Femke Nijboer
- Artsen: Dr. Verhagen, Dr. Faneyte

Opbouw apparatuur:

De apparatuur die ik nodig heb in het kamertje is vrij minimaal. Één tafel met 2 stoelen waarop de patiënt en ik kan zitten om de consent form te laten tekenen (en om de interview + vragenlijst op af te leggen) is gewenst. De monitor (tv) zal gemonteerd worden op een rollende tv standaard die ik zelf zal regelen dus verder is er niks nodig.

Rekrutering

Patiënten wordt tijdens gesprek met Dr. Verhagen of Dr. Faneyte gevraagd of ze aansluitend op hun afspraak mee willen doen aan een kort experiment van de Universiteit Twente. Zo ja, dan tekenen ze consent bij de doctor en worden ze daarna naar een kamer gebracht waar ik (Mourad Lagsir) mijn apparatuur al heb geïnstalleerd. Het enige wat ik te zien krijg is een 'participant number' en (na afloop van het experiment) de data van de persoon die dat nummer heeft (waarvoor ze eerder consent getekend hebben).

Experimentele procedure

Wat	**Methode**	**Analyse**	**Duur**
Informed consent bij de dokter	A5 met informatie -> Handtekening	/	2 minuten
Voorstellen	/	/	1 minuut
Experiment	Gebruik van het systeem door de patiënt	Think out loud methode (alles uitspreken wat je denkt)	15 minuten
Evaluatie 1:	Open interview over sub-topics van het design	Keywoorden opschrijven	10 minuten

Evaluatie 2:	10 vragen* over het systeem in general	System Usability Scale (1 t/m 5)	5 minuten
Bedankje			
Totaal			33 minuten

*vragenlijst:

1. Ik denk dat ik dit product frequent zou willen gebruiken.
2. Ik vond het onnodig ingewikkeld.
3. Ik vond het product makkelijk te gebruiken.
4. Ik denk dat ik technische support nodig heb om het product te gebruiken.
5. Ik vond de verschillende functies van het product goed met elkaar geïntegreerd.
6. Ik vond dat er te veel tegenstrijdigheden in het product zaten.
7. Ik kan me voorstellen dat de meeste mensen snel met het product overweg kunnen.
8. Ik vond het product omslachtig in gebruik.
9. Ik voelde me zelfverzekerd tijdens het gebruik van het product.
10. Ik moest veel over het product leren voordat ik het goed kon gebruiken.

Appendix 5: Interview vragen

Game

1. Hoe moeilijk vond u de game?
2. Welke games zou u liever/ook willen zien?
3. Hoe was de interactie met het scherm?

Setup

1. Wat vindt u van de afmetingen van de setup? -> En het formaat van de weegschaal?
2. In welke kamer zou u deze setup het liefst hebben staan voor wekelijks gebruik? En voor dagelijks gebruik?
3. Zou u het getal op de weegschaal willen zien? Zo ja, hoevaak?.

Concept

1. Zou een game uw motiveren om wekelijks op de weegschaal te staan?
2. Zo ja, zijn er nog andere dingen die u zou willen zien/doen op het touchscreen scherm?
2. Zo nee, wat zou u liever willen zien/doen op een touchscreen scherm?
3. Wat vindt u van het idee dat de dokter uw gewichtsdata wekelijks te zien krijgt en op basis daarvan uw behandeling intensiveert of versoepelt?

Appendix 6: The ideas

Idea 1: Level Up

- Each day has it's own short minigame (e.g. sudoku, 4 in a row)
- Max 100 points per minigame
- Points – Weight = Total Score for the day
- Compete with your friends on the map

BCT's:
- **Social Comparison**
- **Non-specific reward**
- **Habit formation**

Idea 2: Facing the Timeline

- Camera somewhere in the shower takes picture when you step on the scale
- The red/green LED light shows progress (compared to the previous day)
- At the end of each month your own sharable timeline will be created by an app
- Share the progress with your friends on the app

BCT's:
- **Social Comparison**
- **Exposure**
- **Prompts/cues**

Idea 3: Whatsapp Buddy

- Smart scale keeps track of body variables (weight/muscle mass %/fat%)
- User does not see the weight number while weighing
- User only receives updates from the scale through a whatsapp bot
- The bot gives compliments and feedback based on the data from the scale

BCT's:
- **Info about health consequences**
- **Biofeedback**
- **Social support (emotional)**

Idea 4: Funny Scale

- The smart, talking scale keeps track of body variables (weight/muscle mass %/fat%)
- Scale detects when the user entered the bathroom and reminds him/her to weight
- Scale tells a joke while weighing
- In case of a negative progress, the scale asks for a short explanation
- In case of a positive progress, the scale gives a funny compliment

BCT's:
- **Monitoring of emotional consequences**
- **Social support (emotional)**

Idea 5: The invisible scale

- The smart, talking scale keeps track of body variables (weight/muscle mass %/fat%)
- Scale is intergrated in the bathroom floor/bedroom floor
- User does not even notice he/she is stepping on the scale
- Scale gives and update once every week, through the chosen social media platform or mail

BCT's:
- **Feedback on behaviour**
- **Self-monitoring of behavior**

Idea 6: Save the day

- Save points every day that you weigh yourself
- Points can be used to get a discount on the fitness school or health insurance bill
- Business approach

BCT's:
- **Material Reward**
- **Self monitoring of behaviour**

Idea 7: Planning the moment

- On the smart mirror, the schedule of the week appears when stepping on the scale
- The next weighing moment can be planned through the smart mirror as well as through the calendar app on your phone
- The smart mirror is in contact with the calendar app and reminds the person at smart moments troughout the day.

BCT's:
- **Action planning**

Idea 8: Smart Toilet

- Toilet with weight element
- Facial recognition to determine who is sitting on the toilet
- Progress is shown through LED lights in the room (red or green)
- Summary of weight is given through email

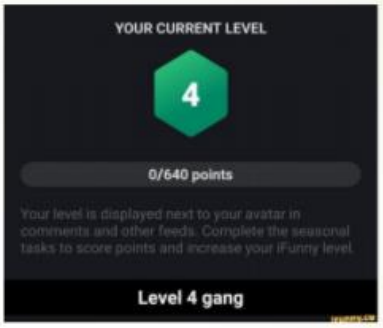
BCT's:
- **Social Comparison**
- **Exposure**
- **Prompts/cues**

Idea 9: InstaWeight

- Smart scale in the bathroom/bedroom
- Scale makes an visual summary of everything that is measured
- This visual image can be shared through the app
- Other patients can respond and compliment the progress

BCT's:
- **Social Comparison**
- **Self monitoring of behaviour**

Idea 10: Save the Day 2.0



- Save points every day you weigh yourself
- Enough points and positive progress means you can skip the next hospital/clinic check up
- Every day that is skipped, results in a substraction of points
- Current score can be seen on an app

BCT's:
- **Reward**
- **Self monitoring of behaviour**

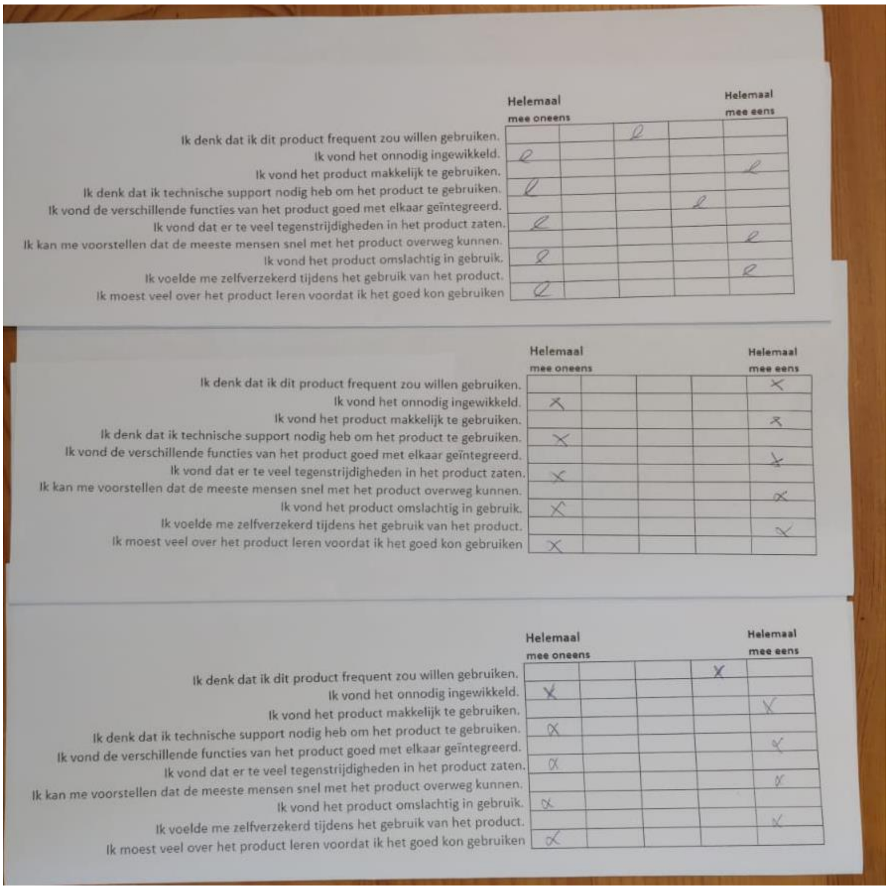
Appendix 7: Processing Code

```
import processing.serial.*;
Serial mySerial;
String myString = null;
int nl = 10;
float myVal;

boolean candyCrush = false;
boolean bubbleShoot = false;
boolean subwaySurf;
boolean sudoKu;
PImage candycrush;
PImage bubbleshoot;
PImage subwaysurf;
PImage sudoku;

void setup() {
  fullScreen();
  candycrush = loadImage("CandyCrush.jpg");
  bubbleshoot = loadImage("BubbleShoot.jpg");
  subwaysurf = loadImage("SubwaySurf.jpg");
  sudoku = loadImage("SudoKu.jpg");
  String myPort = Serial.list()[0];
  mySerial = new Serial(this, myPort, 9600);
}
void draw() {
  while (mySerial.available()>0) {
    myString = mySerial.readStringUntil(nl);
    if (myString != null) {
      myVal = float(myString);
    }
  }
  if (myVal == 0) {
    background(204);
    image(candycrush, 0, 0, width/4, height);
    image(bubbleshoot, width/4, 0, width/4, height);
    image(subwaysurf, width/2, 0, width/4, height);
```

```
    image(sudoku, width*0.75, 0, width/4, height);
  } else {
    background(0);
    textSize(100);
    text("Step Up", width/2-200, height/2);
  }
}
void mousePressed() {
  if (candyCrush) {
    link("https://www.king.com/nl/play/candycrush");
    candyCrush=false;
  }
  if (bubbleShoot) {
    link("https://www.shooter-bubble.com/");
    bubbleShoot = false;
  }
  if (subwaySurf) {
    link("https://lagged.com/play/2002/");
    subwaySurf = false;
  }
  if (sudoKu) {
    link("https://www.mindgames.com/game/Ultimate+Sudoku");
    sudoKu = false;
  }
}
void mouseMoved() {
  checkButtons();
}
void mouseDragged() {
  checkButtons();
}
void checkButtons() {
  if (mouseX < width/4) {
    candyCrush = true;
  } else {
    candyCrush=false;
  }
  if (mouseX > width/4 & mouseX<width/2) {
```

```
    bubbleShoot = true;
  } else {
    bubbleShoot=false;
  }
  if (mouseX> width/2 & mouseX< width*0.75) {
    subwaySurf = true;
  } else {
    subwaySurf=false;
  }
  if (mouseX> width*0.75) {
    sudoKu = true;
  } else {
    sudoKu=false;
  }
}
```

Appendix 8: Questionnaires filled in, in order, from 1 till 9



	Helemaal mee oneens				Helemaal mee eens
Ik denk dat ik dit product frequent zou willen gebruiken.			X		
Ik vond het onnodig ingewikkeld.	X				
Ik vond het product makkelijk te gebruiken.					X
Ik denk dat ik technische support nodig heb om het product te gebruiken.	X				
Ik vond de verschillende functies van het product goed met elkaar geïntegreerd.				X	
Ik vond dat er te veel tegenstrijdigheden in het product zaten.	X				
Ik kan me voorstellen dat de meeste mensen snel met het product overweg kunnen.					X
Ik vond het product omslachtig in gebruik.	X				
Ik voelde me zelfverzekerd tijdens het gebruik van het product.					X
Ik moest veel over het product leren voordat ik het goed kon gebruiken	X				

	Helemaal mee oneens				Helemaal mee eens
Ik denk dat ik dit product frequent zou willen gebruiken.					X
Ik vond het onnodig ingewikkeld.	X				
Ik vond het product makkelijk te gebruiken.					X
Ik denk dat ik technische support nodig heb om het product te gebruiken.	X				
Ik vond de verschillende functies van het product goed met elkaar geïntegreerd.					X
Ik vond dat er te veel tegenstrijdigheden in het product zaten.	X				
Ik kan me voorstellen dat de meeste mensen snel met het product overweg kunnen.					X
Ik vond het product omslachtig in gebruik.	X				
Ik voelde me zelfverzekerd tijdens het gebruik van het product.					X
Ik moest veel over het product leren voordat ik het goed kon gebruiken	X				

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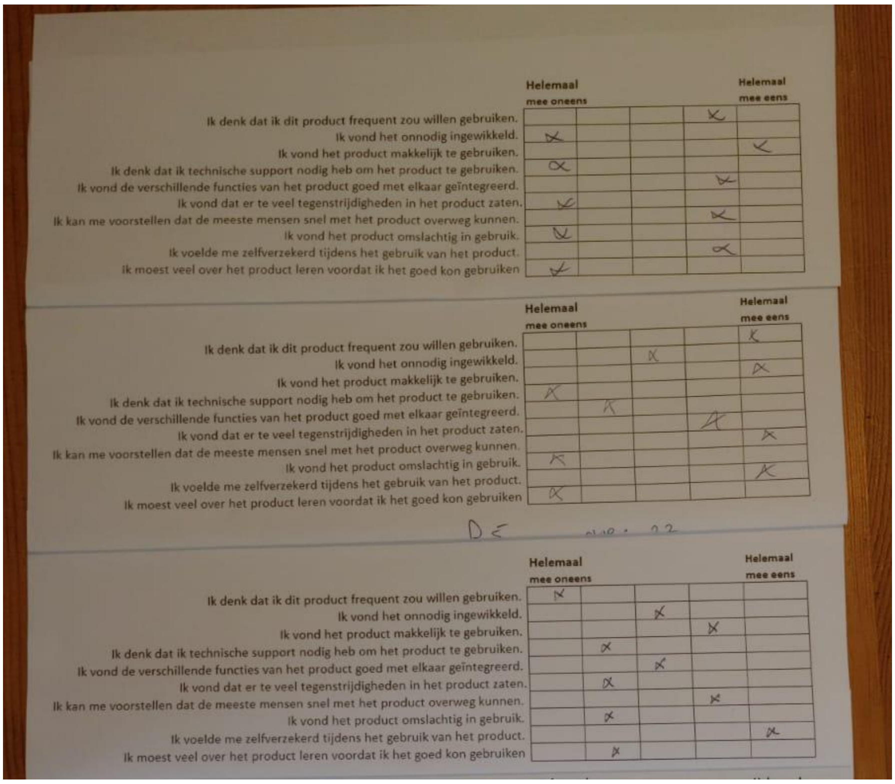
Ik vond het onnodig ingewikkeld.	X				
Ik vond het product makkelijk te gebruiken.					X
Ik denk dat ik technische support nodig heb om het product te gebruiken.	X				
Ik vond de verschillende functies van het product goed met elkaar geïntegreerd.					X
Ik vond dat er te veel tegenstrijdigheden in het product zaten.	X				
Ik kan me voorstellen dat de meeste mensen snel met het product overweg kunnen.					X
Ik vond het product omslachtig in gebruik.	X				
Ik voelde me zelfverzekerd tijdens het gebruik van het product.					X
Ik moest veel over het product leren voordat ik het goed kon gebruiken	X				



	Helemaal mee oneens				Helemaal mee eens
Ik denk dat ik dit product frequent zou willen gebruiken.				X	
Ik vond het onnodig ingewikkeld.	X				
Ik vond het product makkelijk te gebruiken.					X
Ik denk dat ik technische support nodig heb om het product te gebruiken.	X				
Ik vond de verschillende functies van het product goed met elkaar geïntegreerd.				X	
Ik vond dat er te veel tegenstrijdigheden in het product zaten.	X				
Ik kan me voorstellen dat de meeste mensen snel met het product overweg kunnen.				X	
Ik vond het product omslachtig in gebruik.	X				
Ik voelde me zelfverzekerd tijdens het gebruik van het product.				X	
Ik moest veel over het product leren voordat ik het goed kon gebruiken	X				

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Ik vond het onnodig ingewikkeld.			X		
Ik vond het product makkelijk te gebruiken.					X
Ik denk dat ik technische support nodig heb om het product te gebruiken.	X				
Ik vond de verschillende functies van het product goed met elkaar geïntegreerd.		X			
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Ik kan me voorstellen dat de meeste mensen snel met het product overweg kunnen.					X
Ik vond het product omslachtig in gebruik.	X				
Ik voelde me zelfverzekerd tijdens het gebruik van het product.					X
Ik moest veel over het product leren voordat ik het goed kon gebruiken	X				

	Helemaal mee oneens				Helemaal mee eens
Ik denk dat ik dit product frequent zou willen gebruiken.	X				
Ik vond het onnodig ingewikkeld.			X		
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Ik denk dat ik technische support nodig heb om het product te gebruiken.		X			
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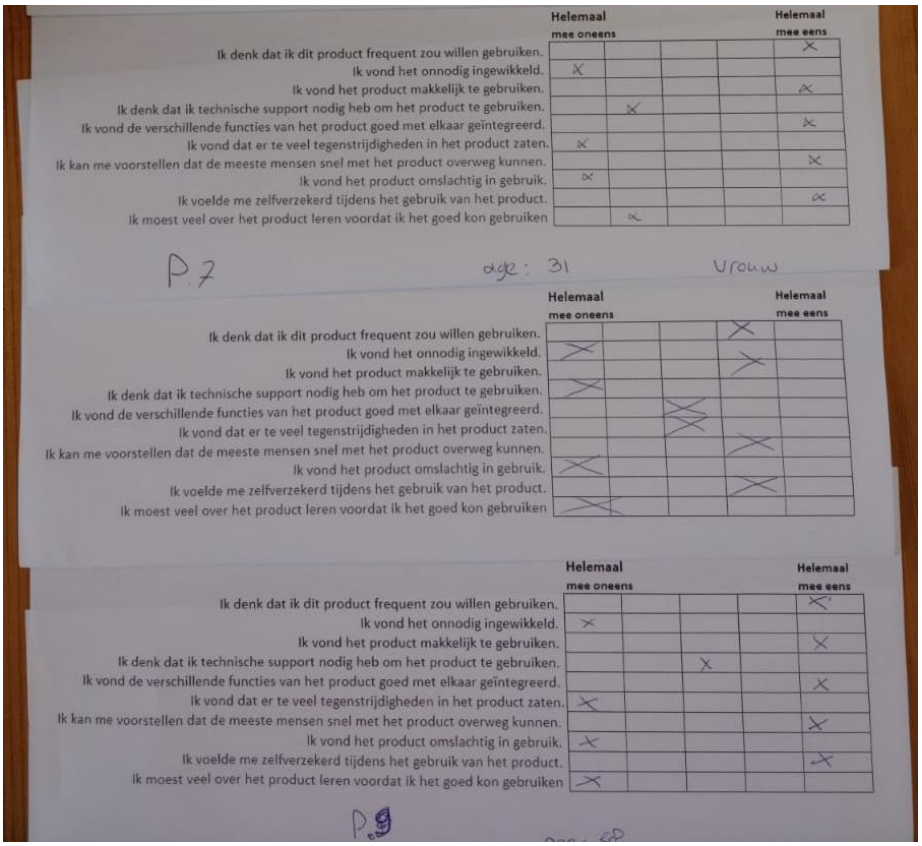
Ik kan me voorstellen dat de meeste mensen snel met het product overweg kunnen.				X	
Ik vond het product omslachtig in gebruik.		X			
Ik voelde me zelfverzekerd tijdens het gebruik van het product.					X
Ik moest veel over het product leren voordat ik het goed kon gebruiken		X			



	Helemaal mee oneens				Helemaal mee eens
Ik denk dat ik dit product frequent zou willen gebruiken.					X
Ik vond het onnodig ingewikkeld.	X				
Ik vond het product makkelijk te gebruiken.					X
Ik denk dat ik technische support nodig heb om het product te gebruiken.		X			
Ik vond de verschillende functies van het product goed met elkaar geïntegreerd.					X
Ik vond dat er te veel tegenstrijdigheden in het product zaten.	X				
Ik kan me voorstellen dat de meeste mensen snel met het product overweg kunnen.					X
Ik vond het product omslachtig in gebruik.	X				
Ik voelde me zelfverzekerd tijdens het gebruik van het product.					X
Ik moest veel over het product leren voordat ik het goed kon gebruiken		X			

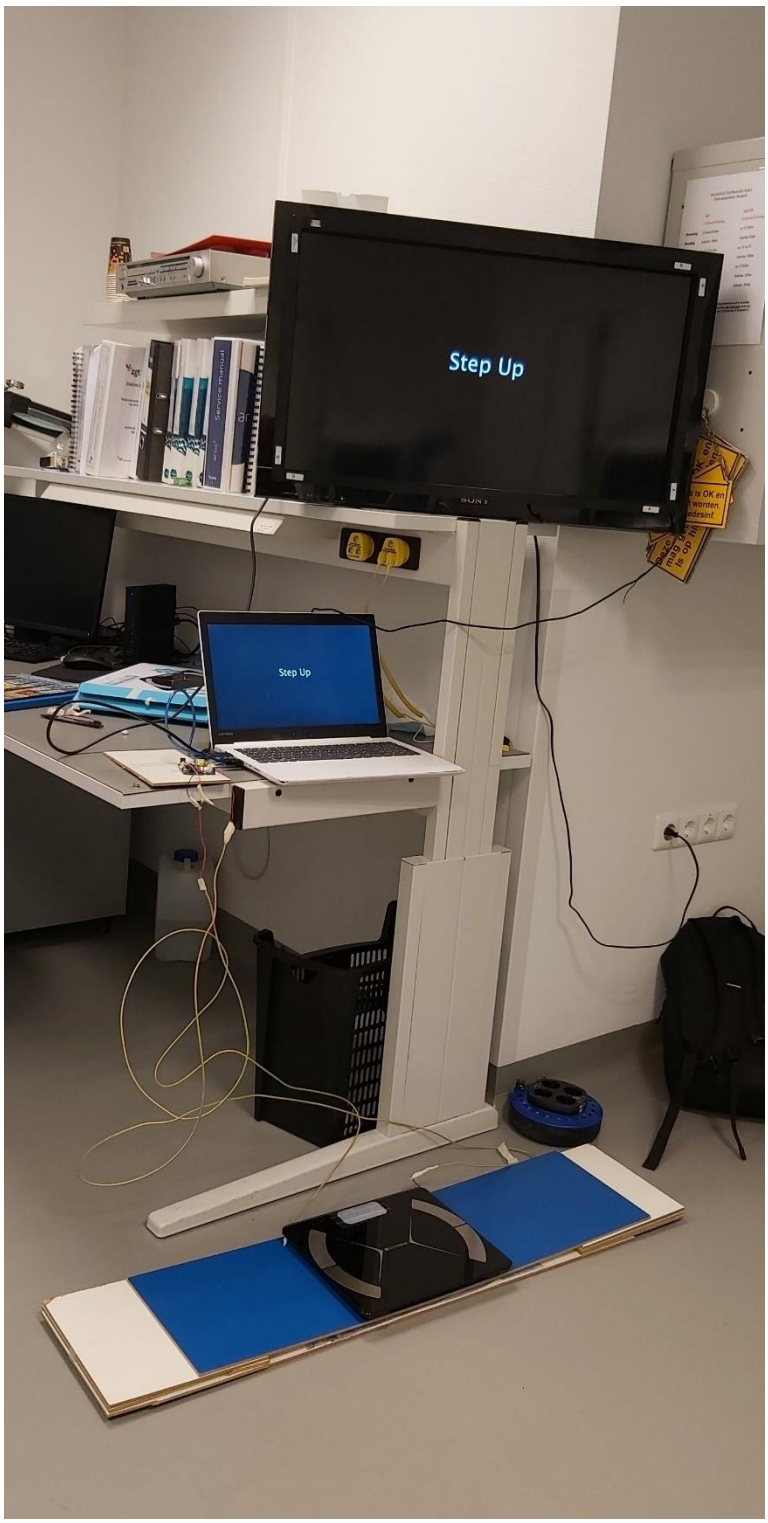
P.7 dqe: 31 Vrouw

	Helemaal mee oneens				Helemaal mee eens
Ik denk dat ik dit product frequent zou willen gebruiken.				X	
Ik vond het onnodig ingewikkeld.	X				
Ik vond het product makkelijk te gebruiken.				X	
Ik denk dat ik technische support nodig heb om het product te gebruiken.	X				
Ik vond de verschillende functies van het product goed met elkaar geïntegreerd.			X		
Ik vond dat er te veel tegenstrijdigheden in het product zaten.			X		
Ik kan me voorstellen dat de meeste mensen snel met het product overweg kunnen.				X	
Ik vond het product omslachtig in gebruik.	X				
Ik voelde me zelfverzekerd tijdens het gebruik van het product.				X	
Ik moest veel over het product leren voordat ik het goed kon gebruiken	X				

	Helemaal mee oneens				Helemaal mee eens
Ik denk dat ik dit product frequent zou willen gebruiken.					X
Ik vond het onnodig ingewikkeld.	X				
Ik vond het product makkelijk te gebruiken.					X
Ik denk dat ik technische support nodig heb om het product te gebruiken.			X		
Ik vond de verschillende functies van het product goed met elkaar geïntegreerd.					X
Ik vond dat er te veel tegenstrijdigheden in het product zaten.	X				
Ik kan me voorstellen dat de meeste mensen snel met het product overweg kunnen.					X
Ik vond het product omslachtig in gebruik.	X				
Ik voelde me zelfverzekerd tijdens het gebruik van het product.					X
Ik moest veel over het product leren voordat ik het goed kon gebruiken	X				

P.9

Appendix 9



Appendix 10 Ethical Reflection (Grade: 9.4)

Name: Mourad Lagsir

Program Name: Reflection II

Date of Submission: 05-01-2021

Name of Project:

Designing a smart technology application to promote joyful weight monitoring among patients after gastric bypass surgery.

Table of Contents

Description of the Project

According to the WHO, 1.9 billion adults aged 18 years and older were overweight in 2016. Of these, 650 million people were obese. In the Netherlands it was estimated that 50,1 & of the population aged 18+ was obese in 2019. Every year 12000 of these people receive a gastric bypass to reduce their weight. The ZGT, in Hengelo, treats 700 to 800 patients per year with this intervention. During the aftercare patients have to be monitored. They undergo a series of hospital checks usually in the timeframe of 5 years. These hospital checks are often perceived as annoying and time consuming and the same goes for monitoring their body weight daily. Doctors indicate that patients lose interest after a few years or even months, when they are asked to monitor their weight for 5 years. Common determinants of this behavior are shame, guilt and not seeing the overall benefit of these check-ups, because either they might have been relapsed or they have accomplished a healthy lifestyle.

The challenge is to make self-monitoring fun and to make sure that physicians can monitor patients remotely. Patients or ex-patients need to find a new motivation to step on that scale again, daily and for a longer period of time. Another challenge is to make the system perform as automatically as possible. The user is aware that he/she is sending data to the doctor but the system should not demand a very active position of him/her. The last challenge, which will be the topic of this ethical reflection paper, is that whatever I create, it should be stigma free. During the ideation phase as well as the evaluation phase there was a moment of ethical evaluation and by doing that I learned that there is a really thin line between physically helping people and mentally harming them (more on that in the next chapters).

I came up with a system that lets the patient play a game of their choice which can only be played when standing on a scale. All games only last 2 minutes at maximum and are supposed to be fun and entertaining. The games are played on a 32 inch touch screen that is positioned at the user's eye level. The idea is that the patient gets motivated to step on the "game scale" while it sends the collected data to the doctor (through a securely protected Wi-Fi connection). An image of the design can be found in appendix 1.

1.1 Vision Statement

It is important that patients keep monitoring themselves for several reasons. People only receive the option for a gastric bypass when efforts to lose weight were unsuccessful and their body mass index (BMI) is higher than 35. Such a high BMI often means that the patient has some type of severe obesity alongside obesity related problems such as addiction, high blood pressure, heart disease and strokes,

and depression. From these, especially the mental problems do not magically disappear after the surgery. It is therefore essential that patients keep monitoring themselves to prevent themselves falling into their old patterns. Additionally, by sharing the data with the doctor, the doctor has a better overview of the situation of the patient and could give individually tailored feedback. For both the doctor and the patient this data share is desirable because it saves the doctor time and it saves the patient “annoying” follow up meetings if positive progress is shown.

Engaging the design phase through moral values and ethical decision making

2.1 Choosing a methodology

During the ideation phase, together with 2 other students, we came up with 10 ideas that could possibly motivate someone to step on a scale (see appendix 2). These ideas were brainstormed from our own perspective, thus, we discussed what we would find motivating and joyful. I needed a method to assess the ideas based on feasibility, how motivating the idea is, and how ethically desirable the idea is. For the latter, I personally prefer a structured methodology to asses the ethical side of my project, which is why I chose to follow the ethical cycle as described by (Van de Poel, 2007). The ethical cycle is a model for moral problem solving, initially designed for teaching ethics, however it is strongly believed to be a helpful tool for structuring and improving moral decision in real life as well (Van de Poel, 2007). Following the ethical cycle should result in a good ethical judgement of my 10 ideas.

2.2 The Ethical Cycle in this project

2.2.1 Case

The case scenario is based on a conversation with Dr. T. Verhagen from the ZGT. I asked him about the background of an average patient that undergoes a gastric bypass surgery.

It is normal for obese patients to cope with several mental and health problems next to their weight. The average patient has to cope with things like social exclusion, bullying (intentionally but also unintentionally), which causes these mental problems. To comfort themselves they start eating which causes the health problem. Only in rare occasions the cause for obesity is that the patient just “loves” eating. Naturally, many diet programs mentally harm the patient because they take away their biggest source of consolation, which is (unhealthy) food. The patient is in need of a tool that benefits their weight, without it being too confronting, punishing or any other form of mental harm.

Many patients have tried several diet programs with mixed result. All these programs have in common that they all take away some sort of autonomy from the patients (it is always “do this, to achieve this”). However, what they do not have in common is how trustworthy they are. Some are based on large studies, while some are based on nothing more than believes. The patient is in need of a tool that lets him/her be as autonomous as possible while still receiving fair and accurate feedback about their weight.

2.2.2 Moral Problem Statement

The first set of two moral principles that cannot be fully realized at the same time are nonmaleficence and beneficence as described by Kitchener in 1984 (Kitchener, 1984). We want to benefit the patients physical health, however, we do not want to harm the patients mental health. What do we do when we have an action/design that does both. Which moral principle is more important?

The second set of two moral principles that cannot be fully realized at the same time are autonomy and fidelity. Complete freedom of choice and action is assumed to be too much of a risk for ex-obese patients. If they are in control of planning their weigh moments, the reality has shown that they will simply not do it (out of fear, shame etc.). A loyal and faithful technology should at least be transparent about what weight is measured, however, that truth is what discourages the patient to weigh in an (hypothetical) autonomous system.

The two sets can be combined into one final moral problem statement.

How to physically help patients (after gastric bypass surgery) without mentally harming them, in a faithful, yet autonomous, way.

2.2.3 Problem analysis

Whether it is the doctor, the patient or the hospital, all three have a common interest in the results of the aftercare trajectory after 5 years, therefore these three are the stakeholders in this project. We have distinguished 4 moral principles that are important to consider when it comes to designing a technology for healthcare. In this chapter I will discuss why and how each stakeholder would benefit from these 4 moral principles as described above, which explains why it is a problem that these 4 principles clash with each other.

Nonmaleficence

Naturally, any project would want to eliminate the risk of harming people. However, in the world of health care, this is not always as easy as it might seem. Every surgery and every trajectory comes with certain health risks that the patients agreed up on before the procedure. However, I feel like it is even more important to avoid mental harm when the technology is supposed to help an ex-obese patient than when it is designed for any other patient. This is because of the mental instability that most ex-obese patients cope with, even after the surgery. In their minds, they are still “the fat ones”, even though they lost a significant amount of weight. If any technology contributes to that negative image of themselves (perhaps by confronting too heavily), in my opinion, that technology is undesirable. Contrariwise, if a technology could benefit the patient’s weight, without having any risk of mental

harm, then that would save all the stakeholders a lot of time and money. The doctor could start focussing on giving feedback on the actual weight instead of spending their time as a therapist/psychologist; the hospital could help a lot more patients simultaneously because there is no need for mental support groups or any other meetings for mental support, and the patient benefits from a better health without having to worry about a negative self-image.

Beneficence

It is also very important to have the patients weighing themselves consistently for it benefits their weight in the following way: it alarms the patient in time if negative progress has been made. This is essential, especially when working with ex-obese patients, because these people have a natural predisposition for gaining weight, thus, gaining a lot of weight can happen really quick for these people. If you do not alarm the people in time, they will ask for help when it is already too late. The earlier a problem is diagnosed by the doctor, the better. By taking care of the problem in an early stage, expensive surgeries are avoided (which benefits the hospital as well as the patient), and the doctor can do his/her job better because he/she can help the patient way more effectively. However, the design problem is: how can we alarm the patient without confronting them too hard? Is it ethically right to let them see the number on the scale? Does the benefit of diagnosing a problematic weight in time outweigh the potential mental harms such as depression, negative self-image etc?

Autonomy

An important element to consider when realizing this principle through a design is how capable the user is to make rational decisions (the other one is helping the user understand how their decisions and their values may or may not be received within the context of the society (Kitchener, 1984)). Many people argue that ex-obese patients are not capable of making rational decisions when it comes to food intake. Based on that one could suggest a mother-child relation with the technology, where the technology tells the user what to do. I for one believe that these patients are perfectly capable of making rational decisions (presumed that they are well informed), as long as their emotions do not take over control. If the technology takes the emotion of the user into account, then a complete autonomous way of weighing is of course the ideal scenario for it saves the doctor and the patient time.

Fidelity

Whatever technology I design, it has to be trustworthy and faithful for it would increase the patient's respect (and therefore motivation) towards using the technology and it would save the doctor a lot of worries about the effect of the technology on the patient's progress. This means being transparent

about what is measured and who is viewing the data, and it also means giving sufficient feedback on the progress of the patient. Although showing the number on the scale to the user might be transparent, it might be preventing them to use the scale the next time out of shame and fear. Additionally, a (desired) autonomous system means a system without the feedback of a professional institute. One could argue how trustworthy this system is because we can only assume that the user is well-informed about the health risks (of not weighing consistently), but without control and feedback, it is hard to know this for sure. The design problem is: how can I ensure the trustworthiness of my design, without losing too much autonomy for the user.

2.2.4 Options for actions

If we choose to look at it from a non-consequentialism approach, then the moral principles have to be taken into account to determine the rightness and wrongness of an action or, in this case, a design. Regarding the first set of principles, I can choose to focus the design on beneficence with the potential risk of maleficence (especially mentally). Or we can really focus on realizing nonmaleficence and potentially miss out on some benefits the technology could have had. Regarding the second set of principles, I can choose to focus on realizing autonomy, while potentially losing some control and therefore trustworthiness. I can also really focus on an accurate trustworthy system, though possibly causing a mother-child relation between the user and the technology.

If we choose to look at it from a consequentialism approach, there is the option to totally neglect all moral principles and choose the design that produces the greatest good for the greatest number. Here we define consequentialism as being the same as the utilitarianism approach. There are more forms of consequentialism (such as egoism, situation ethics) but utilitarianism is the one I am most comfortable examining. I will use a conversation with dr. Verhagen to determine what elements would produce happiness to the greatest number of patients.

2.2.5 Ethical Judgement

Consequentialism (in the form of Utilitarianism)

The advantage of the consequentialism approach is that nuance is possible. Non-consequentialist tend to stick to moral values that they find very important, which determine the rightness and wrongness of an action, or in this case the rightness and wrongness of certain elements in a design (Sullivan & Pecorino , 2002). Consequentialists believe that the rightness or wrongness is entirely a function of the results. They ask the question: does the action contribute to the overall happiness of the greatest

number? The answer to this question could lie in the middle of two, three or even multiple moral principles and often works for a lot of people, but not all people (hence "for the greatest number"). To elaborate, the answer might be a design that realizes a little of both, beneficence and nonmaleficence, while being autonomous (till some extent) with enough feedback to realize a certain level of fidelity. I had a discussion with Dr. Verhagen on how the average patient thinks about weighing to help me determine how certain elements of the 10 ideas would influence the patients happiness. The elements examined were: direct feedback, an "invisible" scale, sharing the weight data with the doctor and a gaming element.

About the element of direct feedback (as seen in idea 2 & 8 in appendix 2) he said the following: "*many, many patients are terrified of the idea of regaining weight. When we, during the weighing moments in the hospital, confront them with a bad number, they nearly always start crying. It is important that whatever you come up with is stigma-free*". Afterwards he confirmed that this does not go for all patients. Some patients do have positive progress and then the confronting element does not cause any problems at all, however, most patient gain a lot of weight after the surgery, and most patients are terrified of that. Directly confronting the patient with their progress is expected to not contribute to most patients' happiness, therefore this element is not morally acceptable. An idea to replace this element, which solves this confrontation issue, is a numberless scale. By removing the number, you are removing the confrontation and you create the possibility for the doctor to give the feedback.

Secondly, Dr. Verhagen mentioned that he would like to have a better overview of the situation of each patient without having to call them daily. Many patient avoid the scale whereas their weight is the thing that the doctor is most interested in. One of the ideas suggested a scale that is disguised as a bathroom tile. This was Dr. Verhagen's reaction: "*although I do not believe in the capability of patients to make rational choices when it comes to weighing, that freedom of choice is exactly what most patients want. They do not want to be forced into weighing, and definitely not without their knowledge*". Of course an "invisible scale" could very easily obtain daily data which can be send to the doctor for feedback purposes, however, what happens if patients start avoiding that one "weighing tile" in the bathroom? This invisible scale element is expected to not contribute to the happiness, simply because people do not like to be deceived, and is therefore not morally acceptable.

Thirdly, the element of sending data to the doctor regardless of whether the patients wants it or not, is a hard one to judge. Dr. Verhagen said "*the patients have chosen the surgery and the aftercare trajectory themselves, so they have chosen to receive help from me. If they are not willing to share their weight data daily or weekly due to privacy issues then what are we even doing''*. I understand his reasoning, and on the long term I think he is right that sharing weight data can only contribute to the

patient's happiness because they receive more individually tailored support, however on the short term, when patients feel ashamed of the number on the scale, they won't be very happy to share that number with anyone. Again, I think it is essential that the patients do not see the number themselves to prevent that feeling of shame and guilt. Then, the element of sharing data with the doctor is morally acceptable.

Finally the gaming element is an easy one to judge. Gaming is perceived as fun among many people. As long as all the different age groups are taking into account, and as long as there is a choice of several games that can be played, it could perfectly contribute to the patient's happiness. Therefore this element is morally acceptable.

The consequentialism approach would result in an design without direct confrontation (e.g. a numberless scale), without the scale being disguised; a system that sends the weight data to the doctor, possibly by playing a game in the meantime. Now let's examine how non-consequentialism approaches these elements.

Non-consequentialism

A non-consequentialist theory of value judges the rightness or wrongness of an action based on properties intrinsic to the action, not on its consequences (Sullivan & Pecorino , 2002). Examples of non-consequentialism theories are: Kantian Categorial Imperative, Rawl's Theory of Justice, Divine Command Theory and Natural Law Theory. Most of these theories were designed to support problem solving in society rather than decision making, however for this ethical evaluation I will be using the Kantian Categorial Imperative because Kantian ethics is perceived as the direct opposite of Utilitarianism (Wikipedia, 2020). I hope to encounter differences in reasoning between these two ethical theories.

Kant presents the single categorical imperative of morality: Act only on that maxim by which you can at the same time will that it should become a universal law (Jankowiak, 2001). Kant formulated this categorical imperative through 4 principles. The principle of universalizability requires that, for an action to be permissible, it must be possible to apply it to **all people** without a contradiction occurring (Sullivan & Pecorino , 2002). Kant's formulation of humanity, the second section of the categorical imperative, states that one should act in such a way that you **always treat humanity**, whether in your own person or in the person of any other, never simply as a means, but always at the same time as an end (Jankowiak, 2001). The formulation of autonomy concludes that rational agents are bound to the moral law by **their own will**, while Kant's concept of the Kingdom of Ends requires that people act as if the principles of their actions establish **a law for a hypothetical kingdom** (Wikipedia, 2020).

What does this categorical imperative mean for our moral principle dilemma?

Earlier we defined 4 moral principles that contradict each other, however, following the categorical imperative we can clearly conclude which principles should have the focus. Regarding the first contradicting set of principles "beneficence and nonmaleficence" we must lay the focus on not harming people (nonmaleficence). This is because of the following scenario:

"Imagine that the principle of beneficence would become a law for a hypothetical kingdom. Then what happens when an act towards beneficence causes nonmaleficence? Then a contradiction with the second section of the CI arises which is: always treat humanity as an end".

Any act should avoid nonmaleficence at all times for that principle treats humanity, even if the consequence of that act is potentially beneficial.

Regarding the second set of principles, "autonomy and fidelity", the focus should be on fidelity. This is because of the following scenario:

"Let's say that the principle of autonomy becomes a law for a hypothetical kingdom. What happens if an autonomous rational agent decides to lie?"

Any act should avoid lying since it is a perfect duty to tell the truth, therefore, fidelity is the principle that should have the focus in design.

What does this categorical imperative mean for our 4 design elements

The element of "direct feedback" should be avoided because, if applied to all patients (which we should because of the principle of universalizability), it is expected to cause mental harm to some patients. Therefore it does not treat humanity. Note that the non-consequentialism approach **concluded the same**, though because of a different reason (which was "not contributing overall happiness").

The element of the invisible scale should be avoided as well, as it could deceive people into thinking they stand on a normal bathroom tile. Of course the patient will be aware of that tile, but nobody is *always* thinking about *every* step he/she takes in the bathroom. Deceiving people is against the perfect duty of telling the truth, therefore, any design should avoid it. Note again that the non-consequentialism approach concluded **the same**, though because of a different reason (which was "not contributing to overall happiness").

The element of sharing data should also be avoided. Although it does benefit most patients over the long term, it goes against some patients' will. I have personally talked to patients and some of them do not want to share their weight data at all due to personal reasons which should be respected. Besides, in the end, it is not a person, nor a group of persons who determine what the moral law requires from me, it is my own reasoning which is based on goodwill (third section of the CI). I can not act in such a way that is against someone's will, therefore, I cannot include the element of sharing weight data with the doctor. Note that the non-consequentialism approach concluded **something different** because of a difference in reasoning.

Finally, the element of gaming should not be avoided. Gaming is accessible to anyone of the target group (no handicaps or whatsoever) and treats humanity as it does not involve lying or harming in any way. Note again that the non-consequentialism approach concluded **the same**, though because of a different reason (which was "contributing to patients' happiness").

The consequentialism approach would result in a design in which the patients plays a game while weighing. However, the data will be send to an app (instead of a doctor) that analyses the data through an algorithm and gives feedback based on facts. The latter would for be a morally acceptable action .

2.2.6 STEEPLED Analysis

Often it is wrong to think that the future will be as the present. Therefore tools are created to prevent staying in your own micro-environment. A steepled analysis helps to determine how different factors influence the design and how these could lead to new elements in the design.

Social

Questions

1. The age distribution of people receiving a gastric bypass surgery varies from 18 till 65. Does a game appeal as much too each age group?
2. How health conscious and motivated are the people during their aftercare procedure. Is there a difference between the first year and the fifth year of aftercare

Discussion

1. No, It is expected that the younger age groups will be more motivated by a game than the older age groups, however, this can be solved quit easily. By either providing a broad choice

of games, or the option to check the weather/news/agenda instead, older people should be covered enough in the design.

2. The motivation is expected to decrease over time, however, new features can keep the user interested (think about game updates, system updates). When a new feature is planned to get implemented in the feature, it is suggested that the ethical cycle is revisited again to ethically evaluate it first.

Technological

Questions

1. Could improvements in chip implementation technology allow for a better renewed design?
2. Could improvements in Artificial Intelligence cause design changes?

Discussion

1. Definitely. The end goal is to provide information to the doctor. The scale will always have some negative image. If an bio-chip could totally replace the scale then I think that would be ideal for the concept to work. However, a variety of new ethical issues arise by doing that. Especially the principle of autonomy (as described by Kitchener) completely disappears. A renewed ethical assessment will be needed to determine if such chip is desired in healthcare
2. Yes, the better the algorithms become in giving feedback based on available health data, the lower the threshold is for a doctor to hand over the control to an mobile or desktop application. An ethical discussion may arise if the algorithms or the doctors are responsible for the progress of the patient.

Environment

Questions

1. How would the environment of the patient react on the design
2. How would the design function in a futuristic “smart environment”.

Discussion

1. That is situational. There will be situations in which the family is not supportive and then some ethical theories might discourage the use of the design because it then causes mental harm. However, I think in most cases, the environment will be supportive towards the patient.

2. In the future, smart homes might control every wall socket in the house through an app. Maybe a new health intervention could give personalized feedback based on the location of the patient (for example notify and plan the patient's meals when near a supermarket). Then this design could be a lot more supporting then just giving feedback on the number on the scale.

Economic

Questions

1. How could economic changes influence the design?
2. Could the patient economically benefit from the design?

Discussion

1. That depends on who is going to pay for the system. If the hospital includes it as part of their aftercare then the health insurance company might pay for it in the end. In my opinion this is the most ethical way to go (instead of letting the patient pay for it), because you would never want economic changes influence the quality of the aftercare.
2. The health insurance company could reward the patient for following the weigh moments strictly (by using the system). That reward could be a discount on their health insurance for example. Why would they do that? The health insurance companies benefit from healthy people because healthy people cost less, so, the health insurance company benefits from you weighing consistently.

Politics

Question

1. How do political beliefs influence design choices

Discussion

1. The more the leading political party values a high quality healthcare, the more they are willing to invest into technology that benefits the healthcare. That way, the government might even be the one paying for the system in the end, instead of the health insurance companies. Contrariwise, if the political party is very capitalistic, then they might argue it's the patient's own responsibility to be able to pay for quality healthcare. Then the patient is dependent on goodwill of the hospital and the fee's of the health insurance.

Legal issues

Question

1. How do legal limitations influence the design choices

Discussion

1. For now it is illegal for the health insurance company to obtain data about the patient's weight. However, it might be legal for the health insurance to see the amount of weight moments the patient had with the technology and reward him/her for that.

Ethics

Question

1. What are the ethical issues involved in the design process

Discussion

1. *See chapter ethical judgement chapter*

Demographics

Question

1. What do the demographics of the users mean to the usability of my design

Discussion

1. Many things can be hypothesized about this topic but there are always things that you expect that turn out to be the other way around. I expected that men would react more enthusiastic about the concept, however, during the evaluation I concluded the opposite. I expected that elder people would find the games difficult, however, everybody found the games difficult because they were poorly explained. The influence of demographics on the usability of a design cannot be overseen before you have actually tested it. Therefore, a usability test should be the first step in every design process.

2.2.7 Reflection

Reflection on the ethical judgement

The ethical reflection highlighted a few critical elements in my design which are: having direct feedback, having an unnoticeable scale and sharing weight data with the doctor. The utilitarianism approach would conclude that if it benefits a lot of patient's, then it is a morally right thing to do. However, Kant's approach (a form of deontology), would conclude to not do these things since the elements are against some of the patients' will and you should not treat patients differently than how you want to be treated. I believe that the answer is in the middle and it is an answer based on the principle of autonomy. I believe that we should let the patients choose themselves if they want their data shared with the doctor or not. We should let the patients choose themselves if they want to see the number on the scale and how they want their scale to be placed (visibly or invisibly). Of course, the hospital will inform them about all the benefits, however, it will then always be their own choice in the end.

Reflection on the STEEPLED analysis

During this analysis, several factors were examined that influence the design. By thinking about the design in a broader context, several new ideas and features came to mind. For future research, we can conclude that every new feature should undergo the ethical cycle since the STEEPLED factors change over time.

2.2.8 Morally acceptable action

The moral acceptable action depends on personal preference. We can choose to design for the greater good, or choose to design based on the rightness and wrongness of the design itself. Personally I usually tend to choose for the greater good, as I would find it almost "egoistic" to base my design on what I value the most. I believe that if you can help hundreds of patients each year with your technology, it outweighs the few patients that feel (or actually are) mentally harmed. However in this case, the mental harm that could be caused has such a large consequence on a patient's life that I might want to reconsider my believes. I do not feel that I am in the position of deciding one option based on an ethical theory. Therefore, I think, the morally acceptable action is to let the patients decide themselves on the critical elements of the design. Some patients would want a little bit more focus on beneficence and are ready to take the risk of confrontation and mental harms, and some people know that they should avoid this mental harm at any time. I think the patient's can very well decide that for themselves and if not, the doctor should support them in that decision. In the end, the technology

should serve the patient, instead of the other way around. If that means altering the design slightly for each individual case, then that is the most moral thing to do I believe.

Impact Statement, Limitations and Concluding Remarks

3.1 The larger context

I am trying to stabilize patients' weight by motivating them to weigh consistently and advising them to share that data with the doctor. In the larger context, the design I created, could become part of a health insurance program in which the user gets rewarded for following their weight moments. Another advantage of this design, with respect to the larger context, is that it could be applied to more situations. To explain, sporters/bodybuilders might forget how important it is to weigh consistently. The system could also act as a reminder for more family members of the patient to keep weighing. In the larger context, way more entities could benefit from using the system then I propose in my thesis.

3.2 Driver for change

In the context of the intervention serving as a mechanism for driving change, the intervention has two main goals. It attempts to mediate the relation between the doctor and the client, and it attempts to change the known negative perception of weight loss and weight maintenance. By automating the process of weight monitoring, the relation between the doctor and the client should change from 'a mother who is bossing her children around' to 'a respected individual with intrinsic motivation to keep on going, but who is passively and regularly checked by the doctor in case things go the wrong direction''

Furthermore, after the 5 years of aftercare, the patient might have gotten used to weighing consistently. Then the system might be passed on to someone else, therefore the systems can be recycled over time. To conclude, the ideal situation is that the system changes behaviour instead of that the patient's behaviour is depending on it.

3.3 Future research

The tests I did with the design had very positive results. However, these were results in a test setting, which can be biased. The single most important thing to research now is how patients would respond to such a technology when they have to use it in their own context, in their own homes and in their own daily routines. Would they still be motivated to play a short game? Would they still be willing to share the data every day with a doctor (even when they have an off-day)? Or in a broader context:

How does society react to technology that is placed in their house with the intention to help them physically or even mentally?

3.4 Future shifts in technology

Nowadays we see a lot of technologies arising that are meant to support healthcare. Biochips can soon be implemented in the body to monitor vitamin levels in the blood. Artificial intelligence will provide emotional support for those with mental problems or elderly that suffer from loneliness. The entire society is already influenced by mobile health applications such as MyFitnessPal. All of these technologies have their downsides and every time a new technology is designed the cost vs benefit analysis should be conducted carefully.

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