Improving toilet posture: Design of an adjustable toilet footrest

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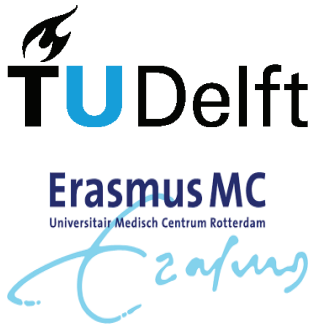


Gratitude

While I am aware that completing a thesis is never supposed to be easy, completing one during a pandemic is nearly impossible without unconditional support from your inner environment. The digital and physical presence of my girlfriend, parents and friends were of great support and I would like to thank them dearly.

Having bi-weekly meetings with my supervisory team were, too, of great help. The structure, enthusiasm and constructive feedback that was gained from these meetings helped me proceed and keep up the working pace during the whole project duration.

Special thanks go to the company mentor, ErasmusMC staff and nursing home staff for providing professional knowledge and insights. Not to forget, the IDE workplace staff, research participants, and other IDE experts also deserve a big thank you.

After finishing the thesis of the Master Integrated Product Design, I am ready to explore more unknowns in the design industry.

Summary

It is time to break the taboo on something that every person does every day: excretion. Using the toilet for micturition and defecation is familiar to everyone. However, discussing personal troubles with going to the toilet is frowned upon. Constipation complaints and urine retention are common, especially among the elderly. There are multiple ways of countering these complaints, with this report focusing on taking the right body posture while sitting on the toilet. This posture consists of raising the knees above hip height, aiming for more pelvic floor muscle relaxation.

This report explores a new product design that helps people to fight constipation and urine retention complaints, by assisting them to get an ergonomically beneficial toilet posture.

First, the current scenario of this problem and its environment was explored thoroughly, in order to create the full relevant picture. Information was gathered from the target group, medical professionals from ErasmusMC Rotterdam (i.a. urologists and pelvic floor therapists), nursing home staff and other IDE experts. Existing solutions are not fulfilling, or even dangerous, especially for elderly users. Therefore, the target group in this project is focussed on the elderly.

Through solving subproblems, researching technical possibilities and pinpointing wishes and demands, possible design directions were explored. Eventually, the EasyRaise was chosen as the proposed concept that aimed to solve the problems best.

The EasyRaise consists of a platform that effortlessly lifts the legs of the user upwards to the user's personal perfect height. The user operates the platform by him-/herself with a wireless remote and is informed by a medical expert on the desired optimal height of the platform. Hand support can be included to help the user get on and off the platform and provide help with standing up and balancing. The remote can be stored on the hand support extension.

The proposed concept of the EasyRaise went through three types of evaluation. A physical prototype was created to test the working of the lift mechanism. Target group participants were asked to assess the functionalities and desirability of the concept. Finally, ErasmusMC staff were invited to share their medical insights on the EasyRaise, and whether they would recommend it.

The EasyRaise leads to increased quality of life and decreased health costs, as autonomy is enhanced and medicines like laxatives are diminished.

The report is concluded with a set of recommendations and conclusions that elaborate on the steps needed to take this concept to the next development stage.

Table of contents

Introduction

To conclude the MSc. Integrated Product Design with Medisign Specialization and to achieve the title of engineer, a graduation project is executed for 20 weeks. This graduation project was set up in cooperation with the urology department of Erasmus University Medical Centre in Rotterdam. Their urology department stands under the supervision of prof. dr. Bangma, who founded the start of this project and acted as a company mentor throughout. In essence, the goal of this assignment is to help the elderly defecate and micturate by helping them to relax their pelvic muscles by getting in the right body position.

Problem statement

The main problem that will be tackled in this graduation project is that the current western toilet does not allow a healthy body position for all users to defecate comfortably, possibly resulting in constipation. Additionally, the bladder is also emptied more effectively with the right body posture.

According to Schuster (2015), constipation occurs more frequently with age, so especially elderly people struggle with this problem. After 65 years old 26% of women and 16% of men suffer from constipation. A rough 10% is added for both genders at 84 years and older. These numbers show the prevalence of the condition and prove the rising need to help people battle it.

Sitting down to help relax pelvic muscles during micturition improves emptying the bladder (Rane & Iyer, 2014). In addition, especially women can suffer from urinary tract symptoms due to, among others, voiding style and voiding position (Wang & Palmer, 2010).

Project content

The aspired end result of this project is a proof of concept that showcases the intended use of the product. Three stages are walked through in order to make this project a success.

- Stage I: ***Analysis***. The problem area is explored and defined.

- Stage II: ***Development***. Solutions to solve the problem are explored and developed.

- Stage III: ***Evaluation***. The proposed concept is tested and evaluated.

The full project explanation declared in the project brief can be seen in Appendix A. The full planning can be seen in Appendix B.

Stage I – Analysis

The main goal during the analysis phase was to paint to right picture for this project and to find the right questions to answer. What exactly is the problem that needs to be solved? Who has this problem and what are their specific wishes and needs? Figuring out the answers to these questions helps in finding the right environment for a valuable solution.

1. Problem definition

In the introduction, the problem is stated in the following single sentence: “the current western toilet does not allow a healthy body position for all users”, but of course, there is much more to it. The first question that probably comes to mind is: “What is a healthy body position on the toilet?”. This whole project revolves around toilet business, which may be a topic that is often not talked about. It is time to get rid of this taboo and open up the conversation. This chapter elaborates on what current problems occur in the toilet space, which acts as a foundation for this report. There is much more commotion about toilet body posture with respect to defecation problems in comparison to micturition problems, hence the attention goes mainly towards the first mentioned.

Image 1.1. Squatty Potty commercial (Squatty Potty, 2015).

Bad toilet habits

Maybe one knows that there is quite some science behind going to the toilet in a healthy and ‘correct’ way, but maybe it has never crossed the mind. You might have come across the commercial of a unicorn that poops rainbow ice cream that went viral in 2015, as seen in image 1.1 (SquattyPotty, 2015). It is explained that with the use of a footrest you can defecate a lot easier. This section elaborates on why this commercial teaches quite a valuable lesson.

General

Having difficulties with going to the toilet can happen to anyone. According to colorectal surgeon Baeten (2021), roughly eight to ten per cent of the Dutch population struggles with incontinence or constipation to a certain extent. The main influencer in one’s toileting skills are the pelvic floor muscles (See image 1.2 for the anatomy of pelvic floor muscles). The pelvic floor muscles support the internal organs like the bowel and the bladder, and their main function is controlling whether you hold in or release urine and faeces (Continence Foundation of Australia[1], 2020). Relaxation of the pelvic floor muscles is required for satisfactorily emptying the bladder and bowel. There are many possible implications of having difficulties controlling one’s pelvic floor muscles, for example, incontinence of both defecation and urine and sexual issues.

Additionally, almost one in four women suffer from pelvic floor dysfunction post pregnancy (Nygaard et al., 2008). The consequences of pelvic floor dysfunction vary from urinary and faecal incontinence to constipation and sexual issues (Catharinaziekenhuis, n.d.).

Definition constipation

According to Bharucha et al. (2013), constipation is commonly defined by a reduced amount of stools. However, they identify a number of factors indicating constipation:

- Hardness of stool
- Straining needed to defecate
- Frequency of stool
- Relief of discomfort after stool

Additionally, the Bristol Stool Form Scale, visible in appendix C, can be used as an indicator of the quality of one's stool. When the stool looks like 1 or 2, a person has constipation related complaints (Continence Foundation of Australia², 2020).

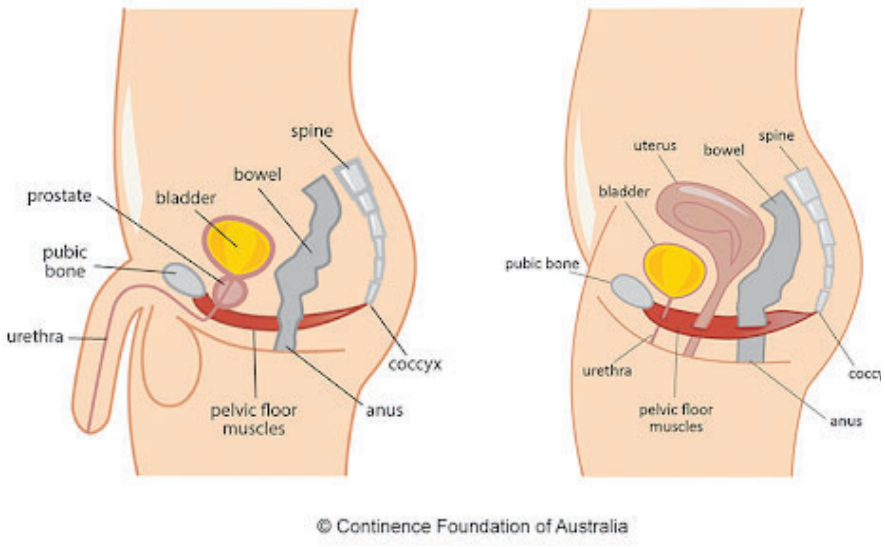


Image 1.2. Human anatomy showing pelvic floor muscles supporting nearby organs (Continence Foundation of Australia¹, 2020).

Causes

Constipation can be caused by a number of factors, for example, a low-fibre diet, lacking hydration, stress, lacking physical exercise or physiological reasons (Catharinaziekenhuis, n.d.; Darmgezondheid, n.d.). In older adults increased medicine usage, decreasing mobility and other underlying diseases can also affect the risk for constipation (De Giorgio et al., 2015; Hsieh, 2005).

Prevention

To prevent constipation complaints, the causes mentioned above need to be considered in one's daily life. Essentially, this generally comes down to a certain change in lifestyle. Drinking more water, gradually increasing fibre intake and more physical exercise are all adjustments in one's everyday rhythm (Miller, 2016).

Moreover, a flawed body position can play a crucial role in preventing constipation (Dimmer et al., 1996; Miller, 2016). The specifics of the preferred body position are covered later in the chapter.

A common tool to battle constipation is prescription laxatives (Petticrew et al., 1999). 50% to 74% of constipated home residents use laxatives daily (Gallagher & O'Mahony, 2009). These high percentages also came forward in personal interviews with nursing home employees. However, the exact effectiveness of laxatives is questioned (Werth et al., 2015; Fleming & Wade, 2010). A study by Fosnes et al. (2011) even states that a laxative treatment on its own is insufficient to get rid of constipation complaints. Additionally, a study by Faigel (2002) states that in America alone approximately $800 million is spent on laxatives per year, showing the economic impact of this measure.

Consequences

Not being able to defecate when necessary is a nuisance in itself. However there are a number of additional complaints that can come with it. Additional complaints are abdominal bloating (Mounsey et al., 2015; Stichting Kanker, 2016), abdominal pains (Catharinaziekenhuis, n.d.; Stichting Kanker, 2016), haemorrhoids and anal fissures (Talley, 2004; NHS, 2020; Darmgezondheid, n.d.; Dimmer et al., 1996). Haemorrhoids are swollen veins around the anus, and anal fissure is torn tissue; both symptoms can be itchy and annoying and contribute to more constipation (WebMD, 2021). Both are caused by too much straining and pushing too hard as well as passing of hard stools.
It is important to mention that constipation decreases the quality of life (De Giorgio et al., 2015;), which confirms the reason for existence of this project.

In terms of more extreme consequences, according to Roberts et al. (2003) and Jacobs & White (1996), constipation and laxative use correlate positively with an increased risk for colorectal cancer, with especially constipated black women at the highest risk. However, such correlations have also been doubted (Dukas et al., 2000).

Taboo

Having difficulties with toileting can be a sensitive topic to talk about. It can be considered taboo to discuss your toileting habits and flaws. This can be even more damaging to your health, as being unable to discuss personal constipation problems could cause anxiety and stress - and stress can be an additional constipation factor (Sanofi, 2018). It is time to break the taboo around toileting habits, with innovative solutions being a start to the conversation.

Body position

Getting into the wrong body position while going to the toilet is disadvantageous for one's bowel movement and is therefore a risk factor for constipation. Getting into the right body position helps to avoid constipation complaints and related health struggles (Hari Krishnan, 2019). This section elaborates on how one's body position on the toilet influences how smoothly excretion can occur.

Squatting

From literature, it becomes clear that defecation in a squatting position is healthier than a 'normal' sitting position. This is also confirmed by doctor Marian Loth, a toilet design expert at the TU Delft. The squatting position and sitting position are both schematically shown in image 1.3. In squatting position one positions their knees above the height of their hips, but more specifics on this topic will be elaborated in the following subsections.

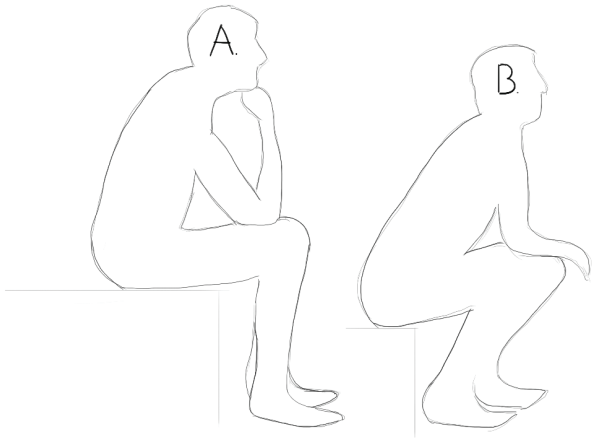


Image 1.3. A showing sitting position, B showing squatting position.

In a study conducted by Sikirov (2003) a standard height toilet, a lower toilet, and squat position were compared. The results show that sensation of satisfactory bowel emptying in sitting defecation posture necessitates excessive expulsive effort compared to the squatting posture.

In a Japanese study by Sakakibara (2010) three body positions were compared: sitting, sitting with 60° hip flexing, and full squat (sitting with 22.5° hip flexing). They found that the greater the hip flexion achieved by squatting, the straighter the rectoanal canal will be, and accordingly, less strain will be required for defecation. A study in 2013 by Ahmed et al, concludes that squatting also helps to cure and prevent anal fissures.

Next to squatting and regular sitting, Takano and Sands (2016) suggest that leaning forward into 'the thinker' position can also influence defecation, referencing "The Thinker" statue from Auguste Rodin (1881). They said: ""The Thinker" position seems to be a more efficient method for defecation than the sitting position. This technique may be helpful when retraining patients with constipation". Such an adaptation to one's toilet position might be easier, in comparison to squatlike adaptations. Image 1.4 shows the sculpture of 'The Thinker'.

Even though the quality of hard conclusions or limitedness of test population size of some of the aforementioned studies leaves some room for improvement, they are clearly pointing away from the standardized sitting body position. So what happens inside our body that explains these preferences?

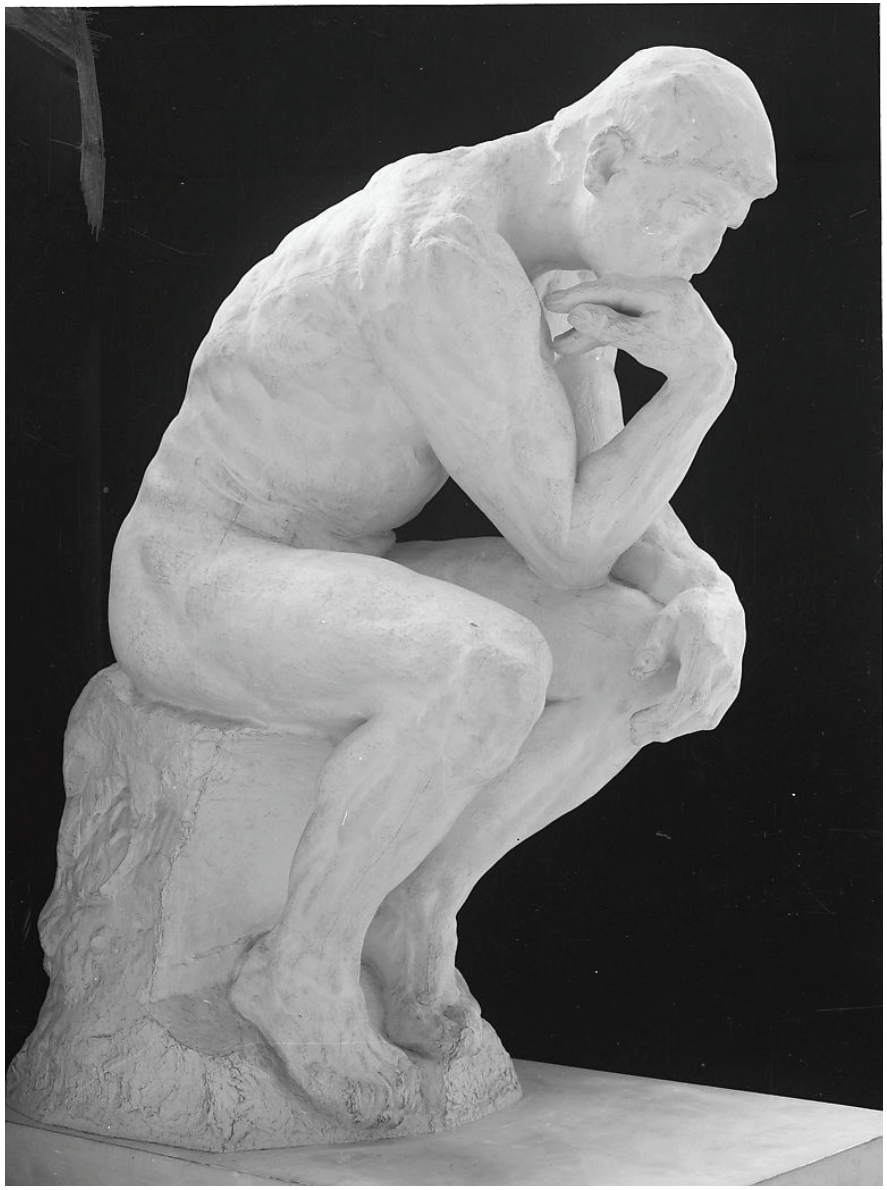


Image 1.4. "The Thinker" sculpture (Rodin, 1881).

Anatomy

This subsection explains why raising the knees above the hips makes defecation easier anatomically. The main influencing factor here is the pelvic floor. The pelvic floor muscles support organs like the bladder and bowel and are essential during a toilet visit. The pelvic floor consists of a number of muscle groups, of which one is called the levator ani. Within this muscle group, the puborectalis muscle (PB) (Modi et al., 2019) is the most important one.

The reason why the PB is so important is because it has a grip on the rectum. The PB is indicated with number 2 in image 1.5, and the rectum with number 3. When the PB is contracted, at rest, no stool can pass. Naturally, this is the state the muscle stays in most of the time. Relaxation of this muscle is only desirable during a toilet visit. The main aspect, important for excretion, that is influenced by contraction and relaxation of the puborectalis muscle is the anorectal angle. The anorectal angle is defined by the angle the rectum canal makes with respect to the anus (number 5), as shown with the dotted line (number 1) in image 1.5. Number 4 represents the anal sphincter muscles.

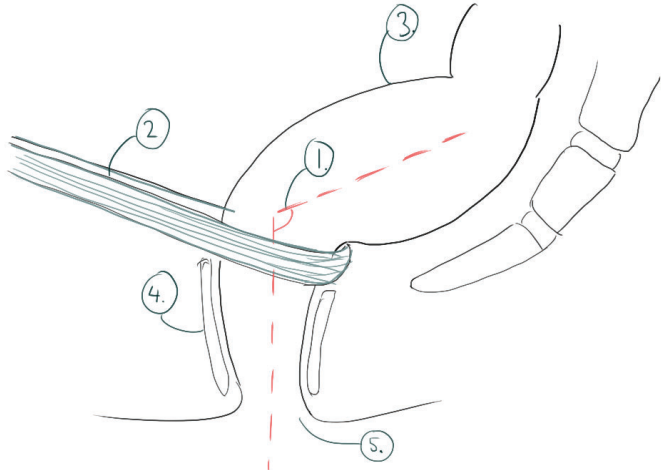


Image 1.5. Schematic drawing of the anorectal angle and its surrounding factors. The number labels are explained in the text.

This anorectal angle is the most important factor in the debate between squatting and sitting/toilet body positions. Ideally, the anorectal angle moves towards a straight angle during defecation, thus removing the kink in the rectal passage. When the PM is contracted, the kink in the passage is tightly secured, causing an acute anorectal angle. However, when the PM is able to relax completely, the rectal passage is able to remove the kink, and the anorectal angle moves towards a straight angle.

In essence, the puborectalis muscle has a hold on the pathway towards the anus.

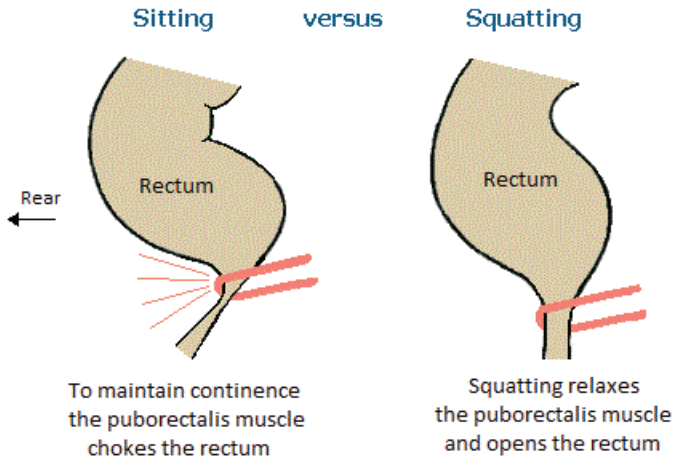


Image 1.6. How the puborectalis muscle acts when sitting and squatting (Tagart, 1966).

Image 1.6 shows a schematic representation of how in a 'normal' 90° position the puborectalis muscle blocks off the pathway for easy defecation, in comparison to a squat-like position (Tagart, 1966). Image 1.7 shows the respective body positions, also with indications of the PM (MaagLeverDarmStichting, n.d.).

Image 1.8 shows two additional possible body positions when sitting on the toilet (C and D). Position C shows the situation of a person using a toilet seat raiser, which makes relaxing the puborectalis muscle even harder, as the pelvic floor muscles are difficult to relax when the upper legs make a large angle with respect to the spine. This is regularly the case for elderly. Situation D shows the situation of a child (or short adult) not able to reach the floor with their legs. Dangling of legs/feet also complicates relaxation of the pelvic floor muscles. Being able to place your feet on supportive ground is important for adequate relaxation of the body, and thus for defecation. According to ErasmusMC urologists, your feet are preferably positioned at a 90-degree angle towards the lower legs.

Target angle

The western toilet allows 90-degree angles, while the squatting position suggests a more narrow angle between the spine and upper legs. Online research does not point towards a specific angle that is the best. Multiple angles are mentioned: 60° (Healthline, n.d.), 45° (Tushy, 2020), 35° (Toiletops, n.d.; Ahmed, 2013), or the smallest angle possible (Sakakibara, 2010). The goal remains the same: straighten out the anorectal angle. Image 1.9 on the next page shows the body positions per angle. Reaching such joint angles can be quite challenging, especially if a person is older, not as flexible, or suffering from muscle diseases.

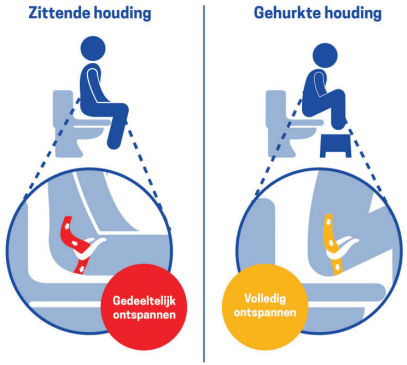


Image 1.7. How the puborectalis muscle acts when sitting and squatting respectively (MaagLeverDarmStichting, n.d.).

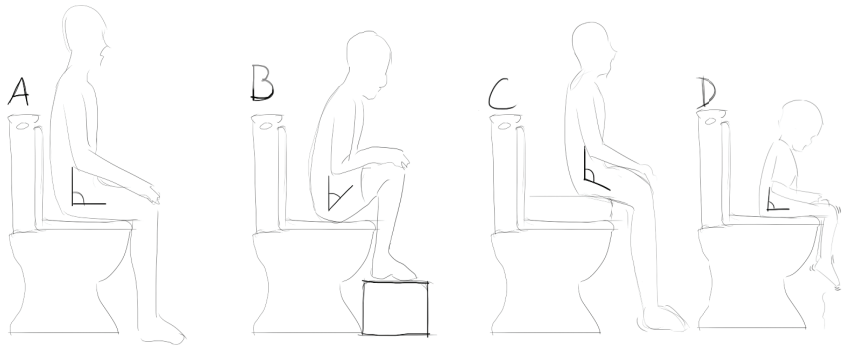


Image 1.8. Multiple different toilet positions.

Cultural influence

A huge influential factor in deciding which posture one takes on the toilet is depending on where they live. In many Asian and African countries, the squatting position is more popular than the sitting position used in the western civilizations (Ahmed et al., 2013; Sikirov, 2003). Two squatting toilets from these continents are shown in images 1.10 and 1.11. Squatting toilets are regularly considered more hygienic because the skin is never in contact with the actual toilet, in contrast to the sitting toilet (von Münch & Milosevic, 2015). On a similar note, according to Rooprai et al. (2017), constipation complaints are a lot less common in Asian squatting populations in comparison to Western civilizations; 9% to 27% respectively. Once again indicating a correlation between a healthy defecation body position and complaints like constipation and haemorrhoids.

Micturition

The main issue addressed in this project revolves around defecation, however it must not be forgotten that defecation goes hand in hand with another activity: micturition. How does micturition influence the defecation process? And how is micturition influenced by a squatting position? From literature research, it appears there is not a clear best position for micturition, as discussed below.

A slightly different body position is recommended for micturition, in comparison to defecation by Koninklijk Nederlands Genootschap voor Fysiotherapie (2017). Image 1.12 shows this ideal position on the right, with a straightened back and 90 degrees body angles, taken from their brochure on micturition.

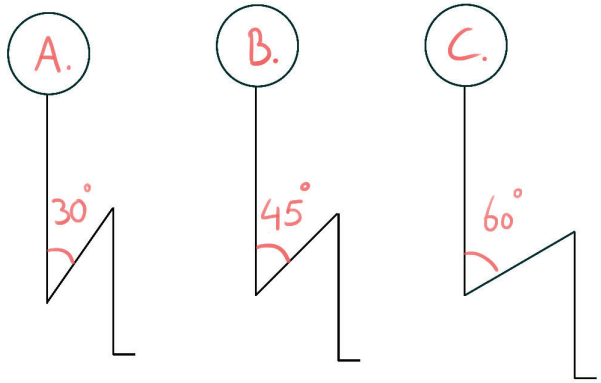


Image 1.9. Schematic representation of possible spine-upper leg angles during squat-like position.

Image 1.10 & 1.11 Squatting toilet (Perrault, 2020; Sunrise, n.d.).

ErasmusMC urologists confirm this straight back position and recommend it to all their patients with urination problems. From interviews with M. Volker and C. van Bruchem (2021), child urologist and senior urologist nurse respectively at ErasmusMC, squatting is not recommended to patients. This is confirmed by Rane and Corstiaans (2009), who present no significant differences in micturition when comparing squat position to non-squat position.

Contrarily, Bush et al. (2015) explain that micturition does improve when leaning forward and in a squat position. Rane (2011) states that leaning forward with foot support is the best position on a western toilet. In 2014 again Rane & Iyer discussed a positive trend in excretion and consequent pelvic floor relaxation due to leaning forward or squatting, thus indicating a preference over a standard sitting position in terms of micturition.

Similar to defecation, it is also important during micturition to have full relaxation of your legs and pelvic floor muscles (Bekkentherapeut, 2016). For men in general, but elderly men in particular, micturition while sitting helps empty the bladder in comparison to standing and therefore reduces the risk for urinary infections (Goel et al, 2017; El-Bahnasawy & Fadl, 2008). Additionally, while relaxing the pelvic muscles in squat position, one makes better use of gravity during excretion; which also helps in emptying the bladder.

In conclusion, a single best body position during micturition was not discovered. Individuals can decide their own most comfortable position if they have no complaints. However, raised knees would be a solid option to consider when experiencing urine remaining in the bladder.

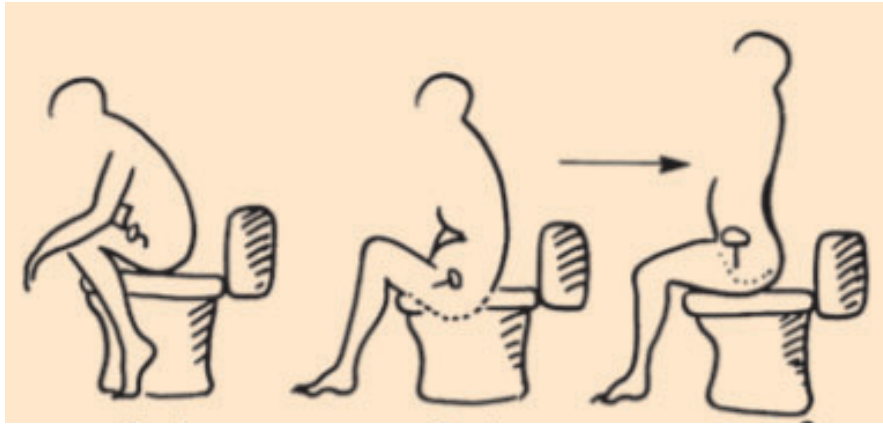


Image 1.12. The far right position is indicated to be desirable for micturition (KNGF, 2017).

2. Target group

Having difficulties urinating or defecating occurs at all ages. However, for this project, two target groups were considered as most relevant; children and the elderly, for the Dutch population.

Children

The main issue that children have when using the toilet is the fact that their legs are not long enough for their feet to reach the floor. This causes dangling legs, and therefore muscle tension, which is disadvantageous during excretion, according to ErasmusMC children urologist Volker. Wennergren et al. also showed this in a study in 1991, measuring the pelvic muscle relaxation in children with and without foot support; where dangling feet meant significantly less muscle relaxation. The same problem occurs with short adults.

When children learn toileting, they generally use a potty, on which they do reach the floor. However when transitioning from potty to 'adult toilet', the floor becomes out of reach. In that case, having dangling legs is quite far from the ideal and healthier squat position, as portrayed in image 2.1. and 2.2.

According to Mediq CombiCare (n.d.), twenty percent of children between four and six have trouble going to the toilet. With statistics from the Dutch Central Bureau of Statistics of 2020, a rough static estimation can be made of the current possible Dutch children target group.
The amount of children aged four to six is 530.583 (CBS, 2020), times 20% gives 106.116 children. Assuming there are probably also some older children that face the same problem, the group size is set to 150.000.

Image 2.1 & 2.2 Children's posture on an adult toilet in comparison to a potty.

Image 2.3 shows two examples of currently existing solutions for children to have solid ground beneath their feet. For children the main need is a product that adapts to their growth; as their legs get longer, the footrest height needs to change. In the ErasmusMC child urology department, this small-stepped change in height per child is taken seriously when using the hospital toilet. Image 2.4 shows their solution to this problem: a number of wooden planks with different thicknesses.

Image 2.3. For children there are also specific toileting tools. (FineWay, 2019; Squatty Potty, n.d.).

Image 2.4. EramusMC's solution to different leg lengths among kids using the same toilet.

Elderly

Constipation issues occur more frequently with increasing age and shoot up after age 65 (Johanson, 1989; Higgins, 2004; Schuster, 2015). From people aged 65 or over, 40% have constipation issues, which increases to 80% for the elderly in nursing homes (Seniorenwijzer, 2020).

Looking at the Dutch statistics again, this results in a much larger target group compared to children.
The amount of elderly 65 to 100+ years old is 3.419.268 (CBS, 2020), where 40% gives 1.367.707 people.

As elderly people are generally less mobile, this not only makes them more prone to constipation complaints (due to lack of movement), it also makes it harder for them to use specific aids. Additionally, they want to stay independent in their own homes and keep their abilities for as long as possible (Jonsson, 2004). Wanting to stay independent could be a reason why 52% of injuries of people 85 years or older occur when using the toilet (Stevens et al., 2008).

Additionally, according to the United Nations (2017), the world's population is aging to such extents that globally people aged 60 years or over will be doubled in 2050. This means that this target group will only continue growing.

Focus group

Even though constipation is a problem that occurs at all ages, the aforementioned two groups have the most benefits to a new toilet solution. The final result preferably serves a purpose for as many people as possible, however, the focus will be on supporting the elderly, due to a several reasons.

- The served group is significantly larger.
- The need is higher.
- There are more additional requirements, which makes it more challenging.

Providing enough support is important because constipation is associated with poor mobility (Donald, 1985). And giving a sense of security is important because a quarter of the respondents indicated they are always afraid of falling in the toilet, coming from extensive research by Dayé (FRR, 2011).

3. Context exploration

To gain a better understanding of the context in which this assignment takes place, this chapter elaborates on several influential aspects in designing a solution.

Market analysis

A benchmark was carried out to get a grasp of what products already exist in the market. Regarding existing products, mainly products for elderly and kids were considered.

Toilet space

Naturally, micturition and defecation take place in the toilet space. While every home has its own unique toilet space, there are several elements that most people have in common. The toilet could have a dedicated room for it, but is also commonly located in the bathroom.

Common items

Through observations of toilet spaces, a number of common items were identified. Image 3.1 shows an example of a toilet space, with indications of common items. Appendix D shows more personally taken pictures of toilets.

Items that are (nearly) always present:

- toilet bowl
- ready-to-use toilet paper (1)
- toilet paper holder (2)
- sink (3)
- toilet brush (4)

Items that are common:

- garbage bin
- small carpet in front of the bowl

As all of these items are generally found around the toilet bowl, they need to be taken into account. Luckily, most of the items are moveable, which makes them easier to work around.

Image 3.1. Toilet of grandparent of the author, with common items highlighted.

Toilet bowl

The toilet bowl is one of the most influential factors for the new design because the new product needs to function in harmony with it. There is quite some variance in available toilet bowls. For example, the shape of the bowl (as indicated in image 3.2) can be rectangular or circular or a shape in between. Currently, bathroom retailers allow the customer to personalise their toilet bowl completely in terms of width, length, height and shape (Villeroy & Boch, n.d.).

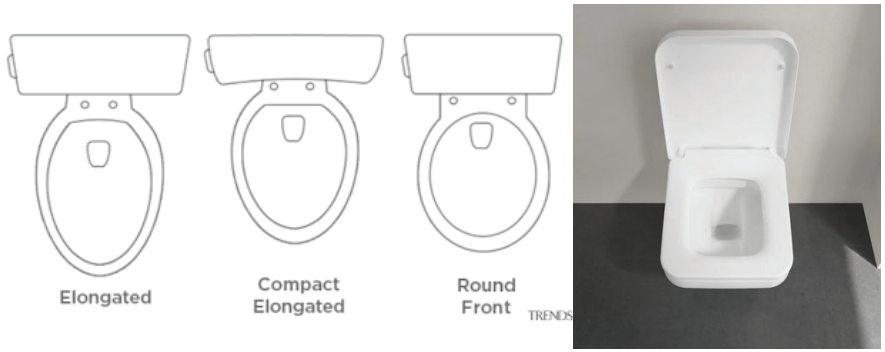


Image 3.2. Different shapes circular toilet bowls (TRENDS, 2019; Villeroy & Boch, n.d.)

Image 3.3. Wall- and floormounted toilets.

The mounting of the toilet can also differ between floor- and wall-mounted, as shown in image 3.3. Having a wall-mounted toilet allows the user to keep the floor around it cleaner, because there are fewer seams and contact points. With respect to this project, having a wall-mounted toilet gives more space for possible solutions around or under it.

Additionally, there may be some variance in height of the toilet. The average toilet height is 40 cm (Badkamerwinkel, n.d.). Wall-mounted toilets can be hung at any comfortable height for the user. However floor-mounted toilets have less flexibility, other than the size they come in. Higher toilet versions exist of around 46 to 52 cm, which are also called senior-toilets (Banobenelux[1], n.d.). During a visit to a nursing home, the toilets were measured and they all turned out to be 52 cm. Image 3.4 visualises the variations.

Demand: The product needs to accommodate for all toilet shapes, and up to a toilet height of 52 cm.

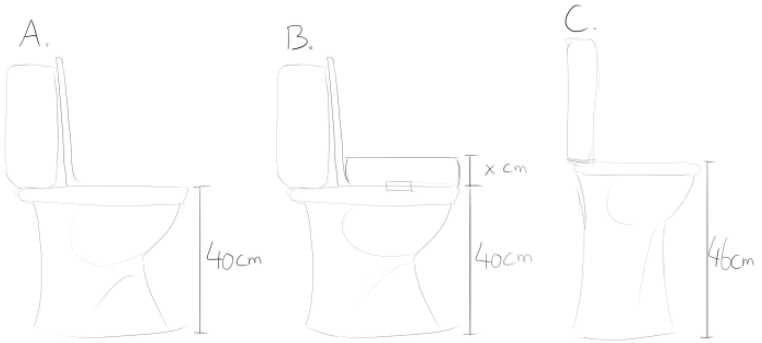


Image 3.4. Toilet A is a standard height toilet. Toilet C is the senior toilet. Toilet B shows a standard toilet with toilet seat raiser.

Available space

So how much space is left for the solution in a standard toilet room? It is hard to keep all existing lavatories into account, therefore some assumptions were made. Image 3.5 shows the space available around the toilet.

Dimensions A and D are dependent on the size and shape of the toilet, whereas dimensions B and C are dependent on the size of the toilet space. Even though hanging toilets are increasingly popular, there are still plenty of standing toilets, therefore the space below the edge of the toilet cannot be considered available.

Dimension B is expected to be more critical for the design in comparison to dimension C, because the legs of the user are positioned in front of the toilet. B is set to 65 cm, and C on 20 cm, to be the minimal available space. These values are based on observations of familiar toilets.

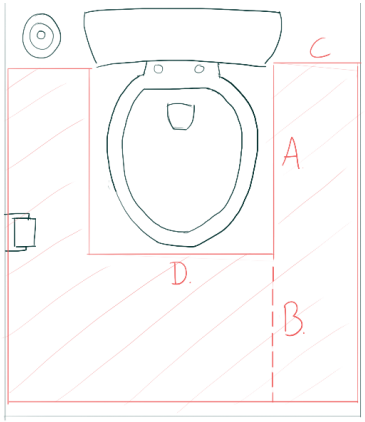


Image 3.5. The estimated dimensions of the space around the toilet that is available for the solution.

Support

Especially for elderly, some support can be needed in the toilet space to enable autonomous handling. This subsection shows some examples of existing products for this category. The main function of all these products is to provide help with sitting down on, standing up from, or balancing while sitting on the toilet. A study by Stevens et al. (2008) states that 19% to 37% of the injuries by 65+ years old occur while sitting down on or standing up from the toilet seat.

Collage 3.1 shows a collection of different supports for elderly, for both back and arms. The most interesting one is a mechanically supported toilet bowl that is able to move up and down, to help the user get on and off (Banobenelux², n.d.). This means that the whole toilet is able to move on the vertical axis, which is a pretty elaborate solution. In appendix E more support products can be found.

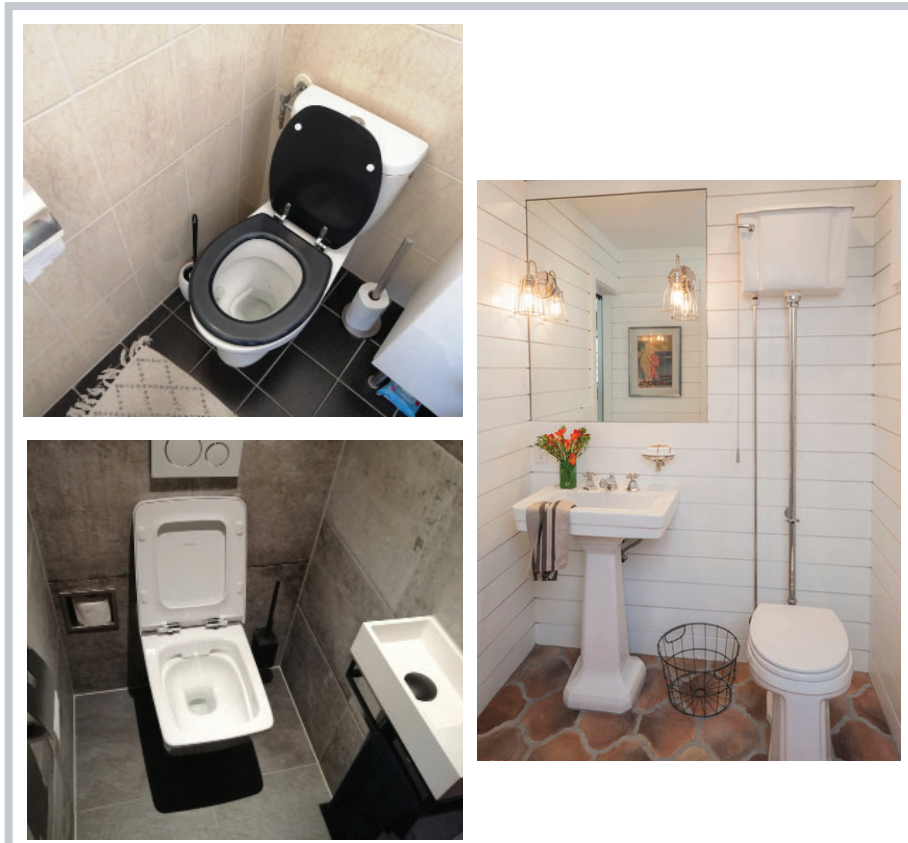
Backrest

In the attempt to elaborate on relevant aspects regarding the toilet space, the backrest should not be forgotten, because how one uses the backrest influences the body position. One common element is the toilet cover, which is what one would be leaning on when leaning backwards.

It has become clear that the position of the back differs per person. In conversation with nursing home staff, it was found that some elderly who struggle to keep upright due to muscle fatigue actually lean against the back. Contrarily, leaning forward, thus not touching the back at all, came forward several times in user research.

Collage 3.1. Different support products for elderly.

Different types of toilet water reservoirs also influence the back support, as shown in collage 3.2. The water reservoir can function as the back support, it can be implemented in the wall, or it can hang higher up.



Collage 3.2. Different water reservoirs influence the backrest.

Footrest

The toilet footrest is a common tool to adjust one's body position while sitting on the toilet. The knees are raised, resulting in a more squat-like position. Collage 3.3 shows a collection of different footrests.

The main purpose of such footrests is to bring the user into a better position during defecation. A study by Modi et al. (2019) confirms this advantage, quoting their result: "...utilizing the DPMD (footstool) resulted in increased bowel emptiness, reduced straining and lowered bowel movement duration.".

Looking at what heights are currently used for toilet stools, the most common height for base models is around 18 cm. This also counts for the squatty-potty, which is probably the most famous toilet footrest (Toiletops, n.d.). For a higher toilet of 46 cm, a higher toilet stool of around 22 cm is usually recommended (SquattyPotty, n.d.).

Flawed for elderly

In essence, the footrest tries to achieve the main goal of this project; allowing the user to take a healthy body position to defecate. It is quite a successful product that seems to help many people. When Squatty Potty first aired on television, they made one million in revenue within the first 24 hours, showing that people were waiting for such a product (CNBC, 2018).

So why does this product not suffice? As explained, the focus of this project lies on elderly users. As elderly users are usually less mobile, they struggle to use this product on a daily basis. The footrest needs to be relocated before and after every use, which can be a daunting task for example when you have trouble balancing. The same goes for people using walking aids, it is hard to move in a small space like the lavatory. Additionally, such a footrest requires the user to lift up their legs themself and place them on the product, while sitting on the toilet. This movement can be a problem for immobile elderly.

Collage 3.3. Collection of different footstools.

Toilet process

Image 3.6 displays a simplified ten-step representation of the current use scenario when going to the toilet. Going to the toilet is a routine process of actions that are carried out every single day.

During the current use process there are some areas that could cause more trouble than others.

- 2. ***Positioning*** yourself in front of the toilet can be a challenge for elderly with a walker or with balancing problems.
- 6. When the user is finished they need to ***clean*** themself. This action requires the user to get into somewhat awkward body positions where the mass moment is distributed differently; which can cause problems with balance.
- 7. The user ***standing up*** can be an issue for elderly with lower muscle capacities.

It is important to avoid making the toilet process more difficult overall, with special attention for the three mentioned.

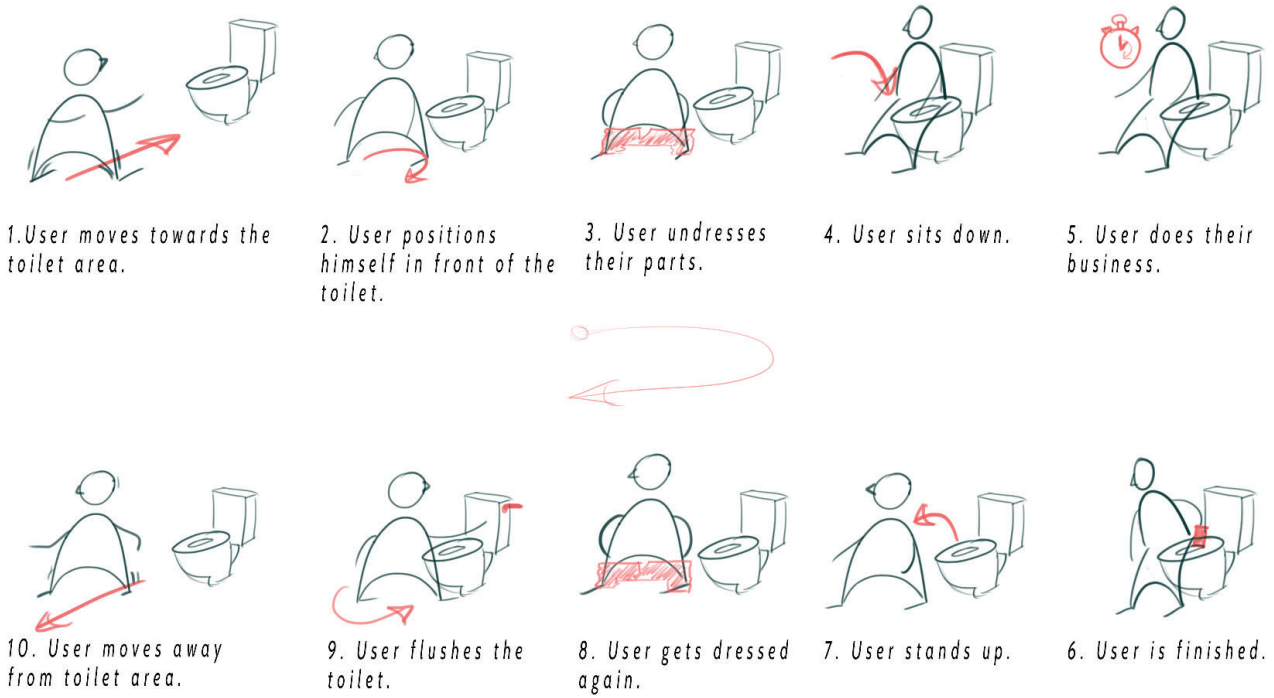


Image 3.6. Current toilet process.

User research

Involving the users into the design process essential in getting a valuable design. Their insights can help to determine the right problem areas, as well as increasing understandability and physical ergonomic satisfaction.

Initial questionnaire

To get a better initial view on the customs of the target group, a small online questionnaire of three questions was set out to an elderly panel from the TU Delft. The full mail can be found in appendix F (in Dutch). Eventually, seven responses were received, of which the relevant results were briefly discussed. Full responses can be found in appendix G.

The three questions were the following:

- In the first question, the participants were asked about their current toilet position. This was relevant to ask because it would give an indication of the current state of the problem scenario. Image 3.7 was shown as guidance and served for multiple choice.

Answer: At the first question all body positions were mentioned except B. Leaning forward was mentioned more than once, in addition to every participant being able to place their feet flat on the ground.

- The second question was about the things that can go wrong during a toilet visit. For this several options were given too as inspiration (e.g. standing up from the toilet).

Answer: At the second question, few problems were mentioned except for increasing effort for standing up.

- The third question revolved around current helping tools the participant might be using, for example hand support.

Answer: No helping tools were mentioned in the third question.

A bonus question was added, which asked the open question of what must not be forgotten during this project.

Answer: In the bonus question several interesting ideas were given. One of those ideas was to have a footrest that is not there when you approach the toilet and want to sit down, but then comes upwards when the right position needs to be taken.

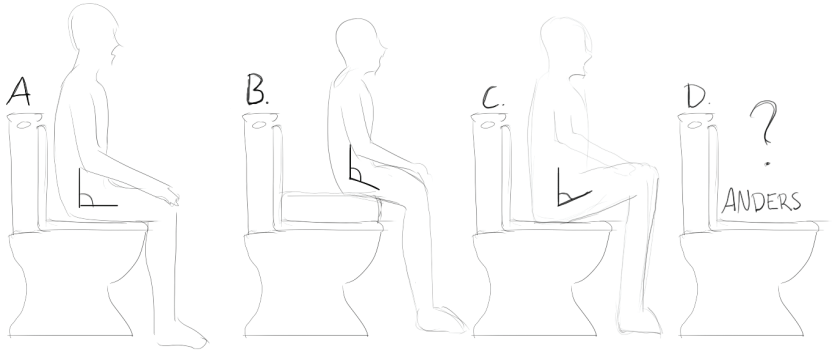


Image 3.7. Possible toilet positions.

Nursing home

As briefly mentioned earlier, the nursing homes Marente Huis aan ‘t Waard and Topaz Zuydtwijck in Leiden were visited to speak to employees that have plenty of first-hand experience of elderly using the toilet. A nursing home was a possible location of where the new product might be used, therefore it was relevant to get a closer look at such a facility.

Plenty of interesting insights were gathered from the visits. Below is a list of the most relevant findings:

- Home improvements can only be carried out individually to a limited extent. Collective home improvement within such organisations is a slow process.

- As the residents of the nursing homes generally have a worse health condition than average, it will be harder for them to use new products. Conditions like Parkinson and Huntington obstruct them from making the right body movements, and conditions like dementia and korsakoff obstruct them from learning to use new products.

- A lot of laxatives are given to residents. The percentage of the residents taking a daily dose of laxative with their breakfast goes up to 80%.

Due to the above findings, the decision was made to leave the nursing home outside of the scope, with respect to the target group, in the design process. Even though many of the residents could benefit from such a product, their present conditions would make this project too difficult for the given time constraints.

Experts

Next to nursing home employees, medical professionals from ErasmusMC (child urologist, senior urologist, urotherapist and senior caretaker) were also interviewed. The perspectives and input from these medical experts have been mentioned throughout already. Additionally, TU Delft sanitary design expert M. Loth was able to provide some insights on toilet usage too, appendix K includes observations of five participants in toilet environment. Below is a list of the most important insights and confirmations from the experts:

- Constipation is a frequently occurring problem in hospital patients.

- Defecation problems are often connected to micturition problems like urine remaining in the bladder.

- Relaxation of the pelvic muscles is the most important factor.

- Going to the toilet is a process that is carried out routinely.

Persona

As a final result of the context exploration, two personas were created to make the target group more concrete. Personifying the target group into personas helps to describe the target situation more concretely as well as to create a clear image to focus on during the design process

'Elderly' as a target group is fairly open for interpretation; there was a need to make it more concrete. Through the user questionnaires and visits to nursing homes a greater understanding was created about the specifics of the target group. Below the personas of Madeline and Frederick can be found.

Persona I: Madeline
Age: 79
Status: widow
Living: alone in a flat

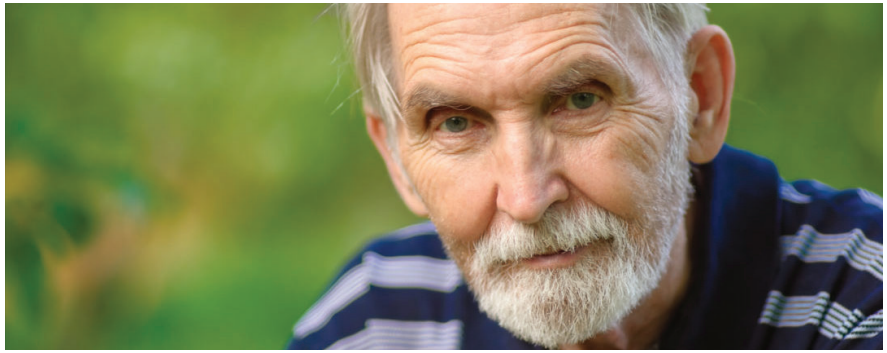
Madeline lives in a flat where homecare comes three times a day to help with tasks like dressing and showering. She has a walker that she uses at all times, because she has trouble walking independently. She does not go outside that often anymore, because she is gradually losing eyesight and sometimes has balancing issues. She uses a toilet seat heightener additional to her heightened toilet, which causes constipation issues.

Madeline has some supporting elements in her bathroom helping her turn navigate, so with a new product she definitely needs some form of balancing help.

Persona II: Frederick
Age: 84
Status: married
Living: apartment with his wife

Frederick lives in a single-floor apartment with his wife. He is still quite active and goes out for walks and visits the elderly exercise group regularly. He absolutely hates being called old, and denies that he too sometimes needs help. Due to his age he has regular constipation problems, which goes the same for his wife.

For Frederick it is important to have a modular product that is able to serve both him and his wife, because they use the same toilet.



Focus

These two personas are used to demonstrate the diversity within the elderly target group. However, it is important to note that the focus should be on making a solution that fits Madeline, rather than Frederick. The reasoning is that if Frederick can use it, it does not mean that Madeline can, but that does work the other way around. For people in need of less help fitting solutions already exist. Therefore the challenge is to create a solution that works for the more difficult group within the elderly.

4. Specified design brief

The analysis section can be concluded with a new, specified design brief that clarifies and elaborates on the discoveries made during the analysis phase.

Target group

The main target group consists of elderly people (65+) who still live in their own house. Elderly people were chosen over children, who could also benefit from a similar product because the target group's size is larger and brings some additional challenges to the table. Nursing homes and hospitals are being left outside the scope for now, in order to keep the design space within limits.

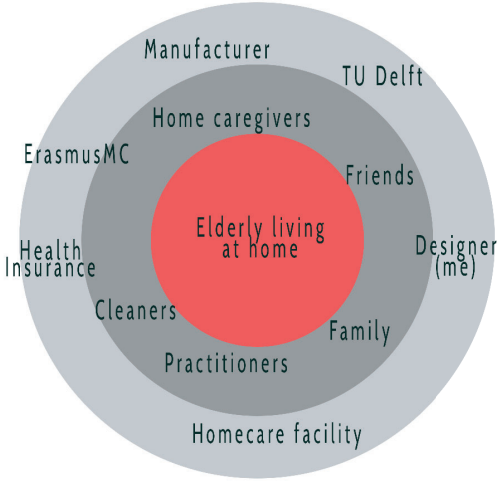


Image 4.1. Stakeholders map including the relevant stakeholders.

Involved stakeholders

Naturally, not only the end users are important to make a product a success. There are numerous relevant groups of people that are involved in this project. The stakeholders that are influenced by or are exerting influence on the project are displayed on the map in image 4.1. The inner circle contains the end user, the middle circle contains stakeholders close to the end users, and the outer circle contains stakeholders that are the furthest away from the end user but still influence the product development. The Quadruple Aim framework is used to ensure quality in healthcare systems (Bodemheimer, 2014), and was used to name all relevant components in the stakeholder map. The Quadruple Aim framework ensures quality care for the individual user and the general population while keeping costs low and the caregivers in high regard; as shown in image 4.2.

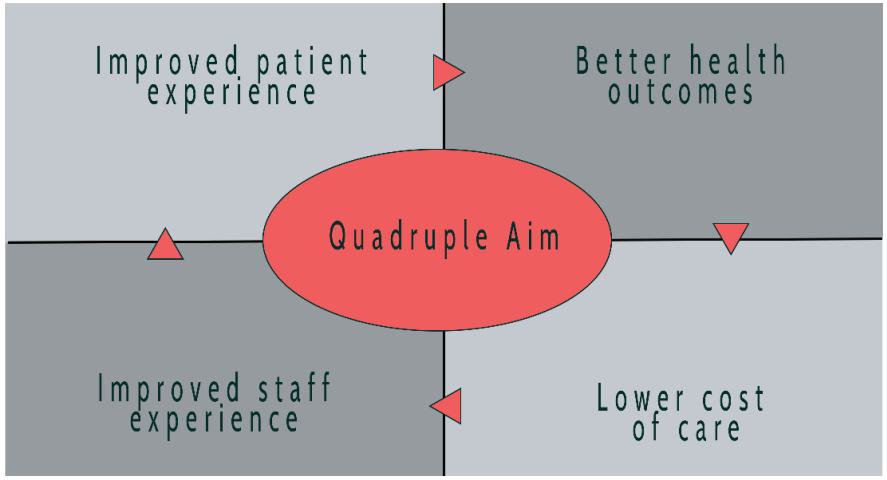


Image 4.2. Quadruple Aim framework.

Vision

In essence, the following quote describes what the goal is of the new design:

"Enabling all users to choose and reach their most preferred healthy toilet body position"

Additionally, another goal is reaching a user journey that is as seamless as possible. Going to the toilet is an activity that every person on earth has to do every day. The new product needs to fit in this ritual without learning a whole new procedure, to make the threshold of using the product as low as possible.

Benefits to be offered

One of the most important questions is what is wrong with current solutions that allow people to take on a healthy body position during defecation? When looking at the current solutions for this problem the following flaws were discovered for elderly users:

- The target group is too immobile to use a regular toilet footrest. Moving it in and out of use around the toilet and lifting their legs on their own muscle power is impossible.

- Rather big and expensive installations exist that help reach a better position and also allow the user to stand up, but they require a lot of space and renovations. This gives these products a high threshold before purchasing.

- Other existing solutions that help stand up from the toilet do not provide the right defecation position.

Requirements

From the information gathered in the analysis phase, a set of requirements was set up to function as both a summary and a foundation for the development phase. This subsection lists the most relevant requirements. In Appendix L a full list of requirements and wishes can be found, which was set up in accordance with Pugh's list (Roozenburg & Eekels, 1998).

Key requirements

- The product must improve the user's body position during defecation and micturition.

- The product must provide support to help with sitting down and standing up.

- The product must not add more than two minutes to the user's regular toilet ritual.

- The product's aesthetics should not be stigmatizing towards elderly products.

- The product should be cleanable with household cleaning products.

- The product should pose no additional risk to falling or other damage.

Stage II - Development

During the development phase, the focus shifts away from trying to find the right questions to answering them. What do we include or exclude from our scope? How can we solve it? Through iterative and creative processes the subproblems of this project are tackled and a final concept is proposed.

5. Design direction

This whole project consisted of many different activities that together form the design process. This chapter elaborates on the initial creative part of the design process, to get to know all the possible directions to solve the problem.

Ideation

Ideation is a creative process that runs parallel with many analysis activities and is all about creating solutions to the problem. A number of brainstorming techniques have been applied, derived from the Delft Design Guide (Boeijen, et al., 2014). Among others, group brainstorming, "how can you's" and SCAMPER-method have been used to generate ideas.
In appendix M notebook scans of the ideation can be found.

Examples of topics that were brainstormed on:

- How to raise and lower a platform
- How to make sure the product does not interfere when out of use
- How to empower the user over the controls

Below, a few idea categories are listed that came forward during ideation.

Footstool

The regular footstool was taken as a starting point to see what solutions this could provide. A simple cardboard prototype was made to experience such a product first-hand, shown in image 5.1.A.

From this regular footstool a number of adaptations were created. Another prototype was made where the footstool would have different heights, as shown in image 5.1.B.

Findings:

- Replacement is unhandy
- Need to take it away before cleaning the buttocks.
- Position of footstool with respect to the bowl differs between usage and storage, which is challenging to do while sitting.
- The lowest setting can be stumbled open

Image 5.1.A & 5.1.B Cardboard prototypes of footstool.

Plenty of adaptations were made based on such a footstool. For example, implementing it into the floor, and all types of mechanisms to raise and lower the foot platform. Image 5.2 (top) shows a grasp of such footstool ideas.

Toilet seat

Other ideas revolved around changing the height of the toilet seat instead of the feet. In this way the user would move their body up and down vertically, with an automated helping system. Image 5.2 (middle) shows a few adaptations of toilet seat design.

Others

An important part of ideation is thinking outside of the box, to get inspiration. Image 5.2 (bottom) shows some other ideas that came up during brainstorm sessions.

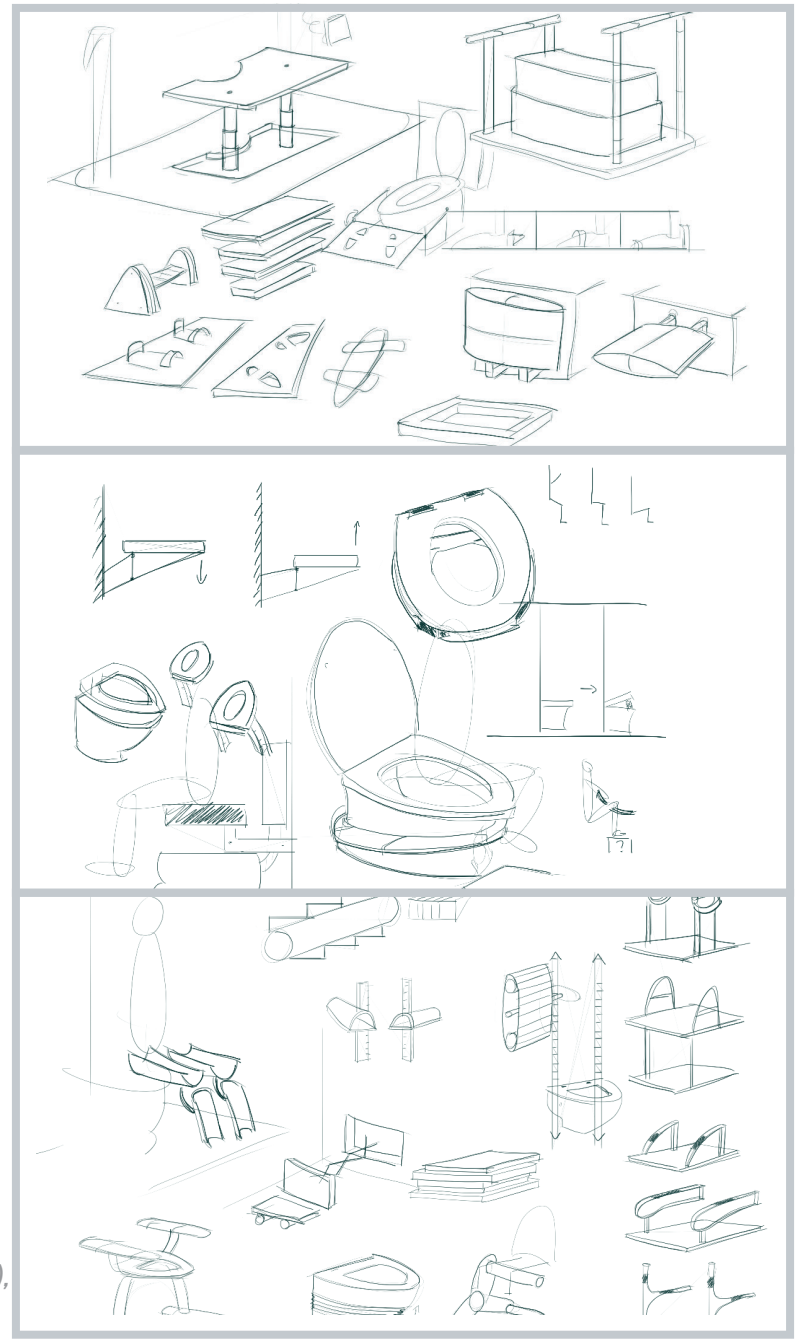


Image 5.2. Brainstorm sessions on footstool (top), toilet seat (middle), and others (bottom).

Project opportunities

The initial ideation phase resulted in plenty of ideas, as previously described. However, not all ideas were completely feasible or desirable. The ideas were subdivided into a number of clusters to create an overview of which opportunities were explored. The following list of clusters followed:

- Adjustments to the toilet bowl itself / a whole new toilet bowl.
- Renovation to toilet surroundings is needed (e.g. floors or walls).
- Something gets added/attached to the current toilet bowl.
- A completely standalone product that functions and stands apart from the toilet bowl.

Additionally to the clusters, the ideas could be divided into two categories: ideas solely focused on achieving the right body position, and ideas that also include help with standing up. The next paragraph elaborates on which decisions were made to narrow down the project directions.

Design direction choice

Narrowing down the available design directions was important in order to make the project more specific. Making the project more specific helped in keeping pace in the design process, and in making design-specific choices.

Therefore, considering the clusters, the decision was made to exclude ideas that require renovations in the toilet space or new toilet bowls. The most important reason is ensuring the new solution is more accessible than having to renovate the toilet space and install big systems like the height-adjustable toilet or drilling into the floor. Not having to do renovations also makes the purchase/instalment cheaper as the need for involving other disciplines like renovators is dismissed.

In short, there are the following reasons to avoid toilet renovation ideas:

- Higher threshold for purchase, because more effort and time is needed for installation.
- Installation costs a lot more.
- More professions involved.
- It may not be allowed in rental housing.

One of the learnings of the analysis phase is that standing up from the toilet can be a prominent issue for elderly during a toilet visit. Therefore, the decision was made to exclude ideas that solely focus on enabling a healthy body position rather than also assisting with standing up.

In short, there are the following reasons to exclude ideas that do not assist in standing up:

- Safety is essential.
- More complete solution.
- Inseparable from the main problem.

Direction: footstool

From the idea generation and possible design directions, it became clear that many directions were possible within the third and fourth cluster. However, as mentioned previously, it is not only important to get in the right angles, it is also important for someone to have their feet on a flat surface for healthy defecation. Therefore, the footstool is taken as the starting point of the next detailing phase. The traditional footstool will be adapted in such a way that the platform below the feet moves up, on control of the user, bringing them towards the squatting position, and lowers when the user is finished.
The following chapter explains the first iteration of such a concept.

6. Foundation of concept development

As soon as the design direction was verified, the conceptualisation phase was initiated. This chapter elaborates on the creation of initial concept 1.0, which is the first iteration of the solution. A number of substantial subtopics of designing a footstool were tackled to come to the most promising solution. For an easier understanding of the nature of the subtopics, this chapter starts with a sketch of the end result of the primary concept phase. Then, the subtopics are addressed.

Concept 1.0

Image 6.1 shows a sketch of one of the first concept iterations. Concept 1.0 was the result of a morphological map of seven subtopics, shown in image 6.2. These seven subtopics will be discussed after this section, and consist of the following:

- plateau mechanism
- plateau reach
- plateau shape
- force counter
- hand support shape
- user input

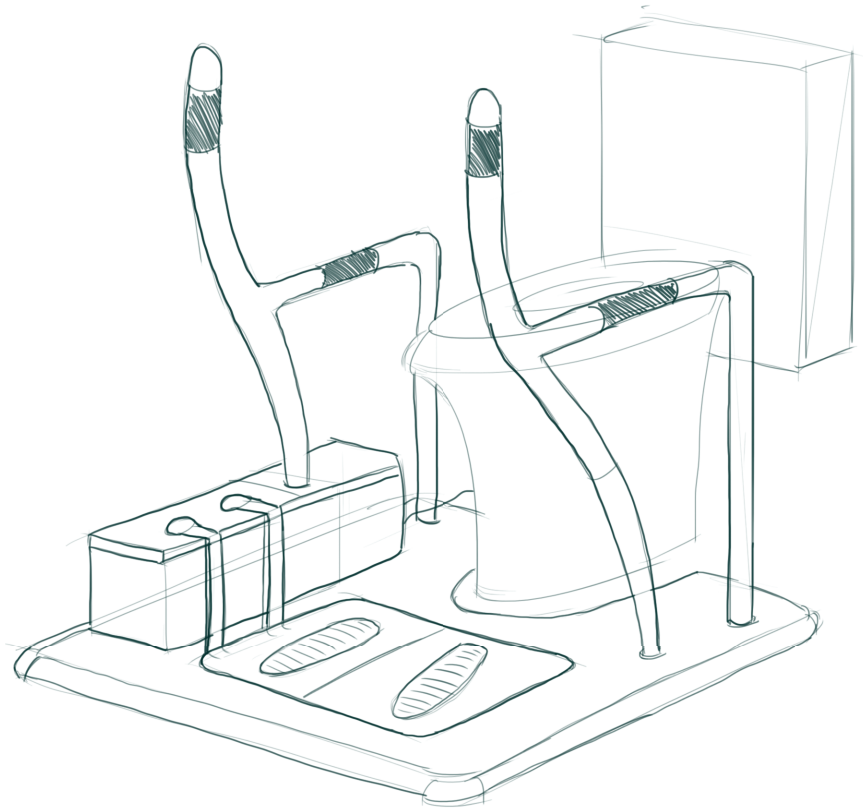


Image 6.1. Visualisation of concept 1.0

In short, the general idea of concept 1.0 is to have the user step onto the larger platform, with support from the handles. Once on the platform, the user sits down and positions their feet on the plateau that is embedded into the larger platform. Then, the user can make use of buttons on the support handles to raise and lower the platform.

Usage

Image 6.3 illustrates the general working principle of concept 1.0, which evolved from the standard toileting use scenario as shown in chapter 3. The five actions which changed with respect to the standard usage are circled red.

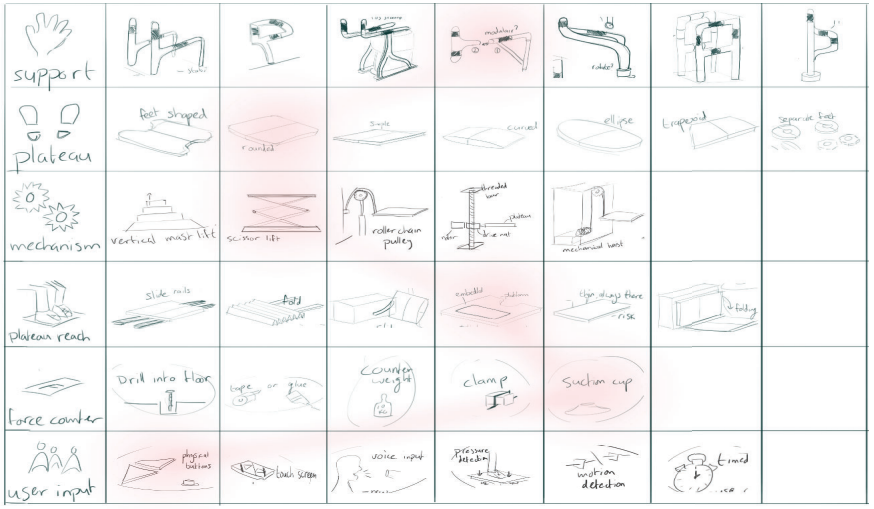


Image 6.2. Morphological map.

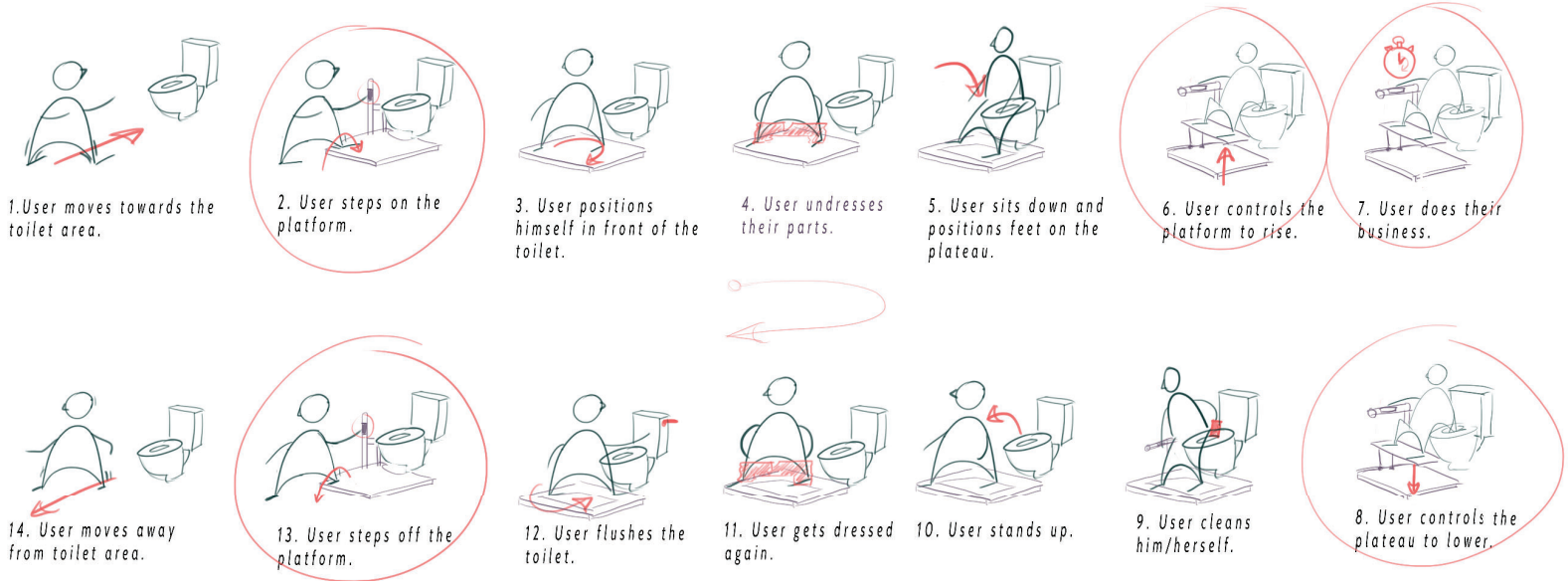


Image 6.3. New use scenario.

Plateau

The main and most influential component of the concept is the way the feet of the user are raised and lowered, in a pleasant and smooth way. This lift is essential for the existence of this project: helping the user in a healthy body position.

Foot lifting mechanism

There are numerous mechanical systems that allow a one-axis motion as needed in this solution. Appendix N shows a number of such systems that were found when looking into existing solutions.

The mechanical lifting system that was chosen was a spindle powered scissor lift. The spindle is powered by a rotation motor and is able to push the scissor lift upwards. Chapter 7 dives into the details and safety of this system, and chapter 8 elaborates on a prototype made to test out this mechanism.
A number of characteristics were considered when deciding for the scissor lift, listed below.

- Strong and stable
- Manageable size
- Height reached
- Readily available
- Speed and sound

No hard limits were set during the selection process, for example maximum amount of decibel produced, due to time constraints. Instead, the decision was made based on comparison.

At this phase of the project, the mechanism was positioned in a box on the side of the platform, assuming it is too high to place straight underneath.

Plateau reach

Another sub solution revolved around getting access to the plateau that is lifted and lowered. Appendix O shows the brainstorm session on this sub solution. Eventually the decision was made to have the lifting plateau embedded in a larger platform because this allows the user to safely perform all pre-toileting actions on a large platform rather than on the small lifting plateau. The most interesting alternative idea was to have the plateau slide or fold under the feet of the user, however, these ideas were dropped due to safety and construction issues.

Height displacement

Due to the human-centred orientation of this project, it was important to take into account some necessary ergonomic factors. With the help of the TU Delft DINED tool (Molenbroek, 1980), an extensive anthropometric database, the most important body measures and their percentiles were considered. The height displacement of the plateau is relevant to ensure the user gets in the right ergonomic position.

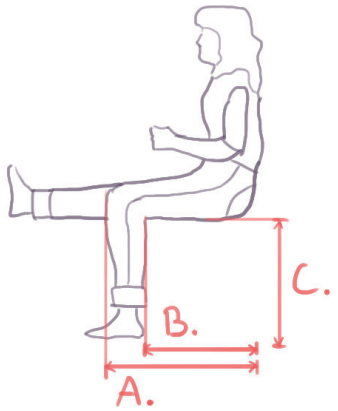


Image 6.4. BKD, PBD and PH indicated

The length of the lower leg and upper leg are immensely important for determining the relevant product dimensions. The upper leg corresponds to the average of the buttock-knee depth (BKD)(6.4A) and the buttock-popliteal depth (BPD)(6.4B), because the pivot point of the knee is in the middle of both measurements. The lower leg corresponds to the popliteal height (PH)(6.4C) in DINED, and is defined as the vertical distance from the foot to the knee. It was important to have the pivot points as the length's end, because with these points the height displacement could be calculated, as shown in the following paragraphs.

Within the target group of elderly people, the goal was set to help as many as possible; this was translated in DINED to include P1 to P99. All dimension tables mentioned in this chapter are derived from the Dutch Adults, aged 60+, male and female and measured in 2004 in DINED. Table 6.1 shows the values of the relevant leg measurements.

populations	Dutch adults 60+, mixed		
measures	P1	P50	P99
Buttock-popliteal depth (mm)	433	496	559
Buttock-knee depth, sitting (mm)	547	617	687
Popliteal height, sitting (mm)	369	450	531

Table 6.1. The relevant leg dimensions, for P1, P50 and P99.

The leg measurements can be translated into the desired height for the footstool, making use of the Pythagoras theorem. In appendix P the calculations of the maximum footstool height can be found. The target maximum height of the footstool was set to 350 mm. As an example, image 6.5 shows the situation for p50, with exact relative lengths (measured in pixels).

For comparison of the maximum height, the Squatty Potty encourages a height of 220 mm for a toilet 460 mm high. The maximum height of this product is higher because the toilet is assumed to be 520 mm, and the P1 (shortest people) are taken into account.

Demand: The product needs to reach 350 mm height.

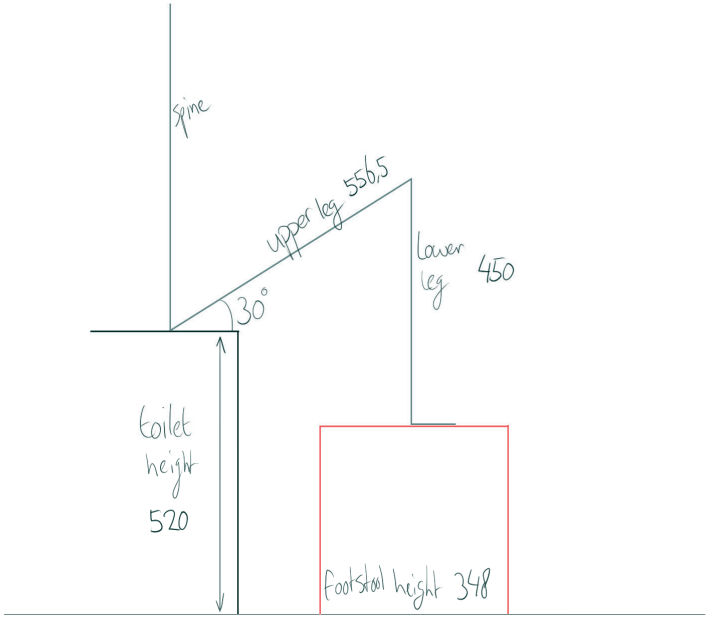


Image 6.5. P50 footrest height with exact relative heights.

Weight carried

The footstool needs to be able to carry the weight of the legs of the user. The weight of legs can be calculated as a portion of the total body mass.

Table 6.2 shows the body mass of the target group, taken from DINED. The mean segment weight of the total leg is 18.43% of the total body weight for females, according to van Plagenhoef (1983). The mean weights of all body segments can be found in appendix Q.

A simple calculation of 0.1843 * 99 gives 18.2 kg, gives the amount of leg weight the footstool needs to lift for a P99 elderly. The placement of this force is assumed to be centred on the plateau. However, the amount of force exerted increases when you lean forward, moving your body centre of mass forward. A simple test confirmed this reasoning, as presented in images 6.6 and 6.7. When sitting up straight, the scale indicated 15 kg. When leaning forward onto the legs the scale indicated 30 kg. Therefore, to compensate for possible user behaviour of leaning forward while leaning on their own legs instead of the hand support, the footstool needs to lift at least 40 kg. Image 6.8 shows schematically what happens to your centre of gravity during these positions, for clarity.

Demand: The product needs to be able to lift 40 kg.

populations	Dutch adults 60+, mixed		
measures	P1	P50	P99
Body mass (kg)	47	73	99

Table 6.2. Body mass of target group from DINED.

Image 6.6. Less kg is shown on the scale when sitting up straight.

Image 6.7. More kg is shown on the scale when leaning forward.

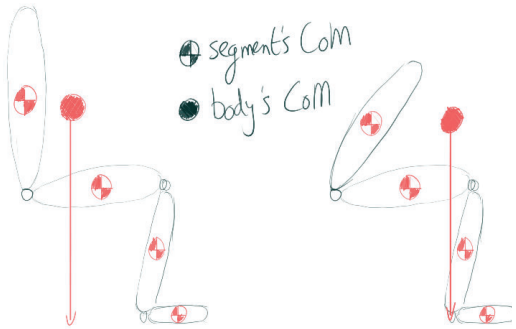


Image 6.8. Centre of gravity moves forward when leaning forward.

Plateau size and shape

In essence, the plateau needs to comfortably fit two feet on it. The foot length of the target group was taken from DINED to determine the length of the plateau. The upper limit was taken of 300 mm to accommodate all feet smaller than that.

For the width of the plateau the hip breadth was taken as the foundation. Assuming that the users place their feet a little inwards in relation to their hip breadth, and to keep the plateau somewhat compact, 450 mm was taken. This assumption was confirmed by observations of toilet use by TU Delft expert dr. M Loth.

Table 6.3 shows the relevant dimensions from DINED, and image 6.9 shows the size of the plateau in relation to a toilet.

The shape of the plateau is set to a rounded rectangle. This shape is a clean design and fits well in the product. Appendix R shows the brainstorm session regarding different plateau shapes.

populations	Dutch adults 60+, mixed		
measures	P1	P50	P99
Hip breadth, sitting (mm)	334	404	474
Foot length (mm)	214	254	294

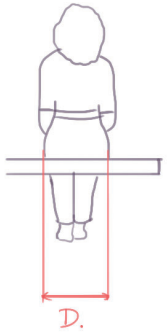


Table 6.3. DINED measurements of hip breadth for foot length.

Hand support

As mentioned earlier, assisting with the sit to stand (STS) movement is considered part of the project. The STS is defined by Roebroeck et al. (1994) as moving the body's centre of mass upward from a sitting position to a standing position without losing balance.

From the Friendly Restroom Project research by Dekker et al. (2011), hand support was found to be effective in helping elderly

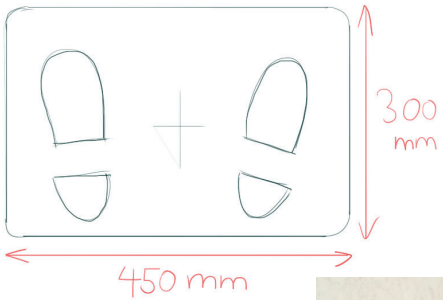


Image 6.9. Plateau dimensions and shown in relation to toilet.

during the STS movement. The findings from their research were directly translated into this project, due to their exact relevance and applicability to this project.

Measurements

For sitting down and standing up, vertical supports were most preferred by elderly subjects (Dekker et al., 2011). For balancing and also standing up horizontal supports were preferred. Image 6.10 shows the results image from Dekker et al. (2011) where the orange bars represent the preferred choices of the participants. The vertical supports were preferred at elbow height, and the horizontal support is preferred at buttock height.

The elbow height (while standing) was taken from DINED (table 6.4), and the average (a height of 1025 mm) was used in order to serve both short and tall people. The horizontal grip is set at 620 mm, 100 mm above the toilet height of 520 mm, relating to the buttock height and average thigh clearance from DINED.

Demands: Vertical grip point needs to be at a height of 1025 mm. Horizontal grip needs to be at a height of 620 mm.

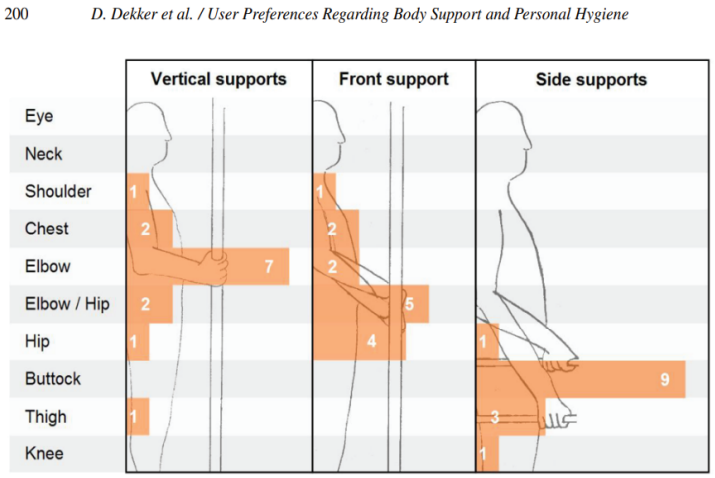


Image 6.10. Research from Dekker et al. showing preferred heights.

populations	Dutch adults 60+, mixed		
measures	P1	P50	P99
Elbow height, standing (mm)	876	1025	1174
Hip height (mm)	816	937	1058
Fist height, standing (mm)	628	742	856

Table 6.4. Relevant DINED measurements.

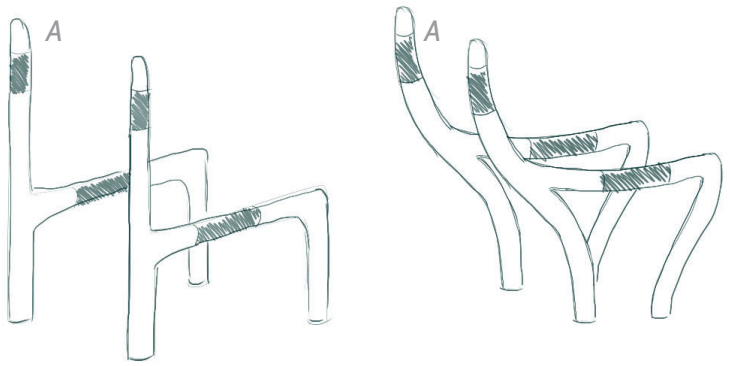


Image 6.11. Initial hand support design.

Shape

The initial design of the hand support is shown in image 6.11A on the previous page. Alternative designs from the brainstorm can be found in appendix S. The design was kept as simple as possible to keep its function clear. However to make its appearance more natural and aesthetically pleasing some curvatures were added, as shown in image 6.11B.

Image 6.12. Different hand grip circumferences. Powergrip on the left.

measures switch axis	Grip circumference (mm)		
populations	P 1	P 50	P 99
Dutch elderly 50–54, mixed	127	127	127
Dutch elderly 55–59, mixed	128	128	128
Dutch elderly 60–64, mixed	126	126	126
Dutch elderly 65–69, mixed	125	125	125
Dutch elderly 70–74, mixed	125	125	125
Dutch elderly 75–79, mixed	122	122	122
Dutch elderly 80+, mixed	119	119	119

Table 6.5. Relevant DINED grip measurements.

Noteworthy, the thickness of the hand support needs to enable a power grip. A power grip allows the user to firmly grip the support (Erhsson, 2000) when standing up and sitting down. For a power grip, a smaller diameter is needed than the closing circumference of one's fingers, as presented in image 6.12. The hand support circumference is therefore set at 119 mm, going for the lower limit of the DINED grip circumference measurements for elderly (Table 6.5).

User input

The way the user interacts with the product is also important for a smooth use scenario. In order to make the threshold of learning to operate a new device as low as possible, familiarity could be beneficial.

Physical buttons suit elderly users well, because they give sensory feedback when pressed. This gives a major advantage over the alternative of a touch screen. Other ways of input like voice recognition were also dismissed because this is relatively

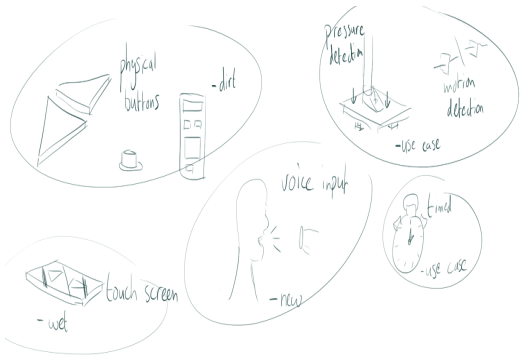


Image 6.13. User input brainstorm.

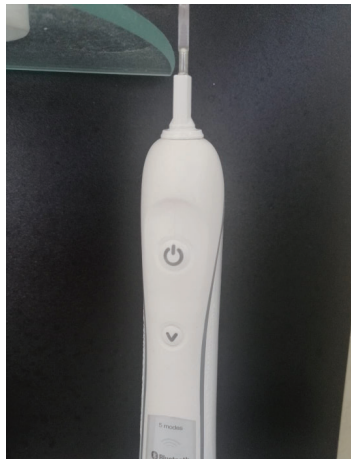


Image 6.14. Toothbrush inspiration.

new technology and would require the users to learn. Image 6.13 on the previous page shows a grasp of the user input brainstorm.

For reference, buttons on an electric toothbrush were taken as inspiration, as shown in image 6.14. These buttons are commonly recognizable, and well resisting against water and other liquids. Besides sensory feedback of button presses, visual and audio use cues were also considered useful. These cues could be given when the lift is ready to go up or has reached the right height. The button configuration needs to be easily related to their functionalities for clear understanding. Chapter 7 elaborates on the way these physical buttons and other use cues are implemented in the design, and which button configurations were chosen.

Reflection

In comparison to previous design projects during IDE bachelor and master courses, the conceptualisation phase of this specific project went quite differently. Usually from the ideation phase a number of ideas, between three and five, are chosen as 'most promising' and continue to be further developed into more concrete concepts. However, during the solving and ideation of subproblems in this project, decisions were already made about what directions to go for. For each subproblem in the morphological map, a sub solution was chosen to be better than its alternatives, resulting in a singular concept version 1.0. Even though this was a new way of working, it worked out well, as it took away the hassle of choosing between different concepts. However, deciding on which sub solution had the most potential also had its difficulties, mainly in determining the amount of justification for a decision.

7. Proposed concept: EasyRaise

Image 7.1. Concept render of the EasyRaise, with the plateau in maximum height.

This chapter elaborates on the final proposed concept (2.0) called the EasyRaise. The EasyRaise allows elderly users to safely take a comfortable and healthy body position on the toilet, in order to prevent constipation complaints and urine retention. This chapter elaborates on the usage, functionalities and specifications of the final concept. Image 7.1 shows a digital render of the EasyRaise.

Overview

The EasyRaise's primary aim is to enable elderly users in reaching a healthy body position for defecation and micturition. It does so by providing both a firm plateau for the feet to stand on while sitting, as well as raising the knees upwards towards a squat-like position. The advantages of both these characteristics of a good body position have been explained in chapter 1.

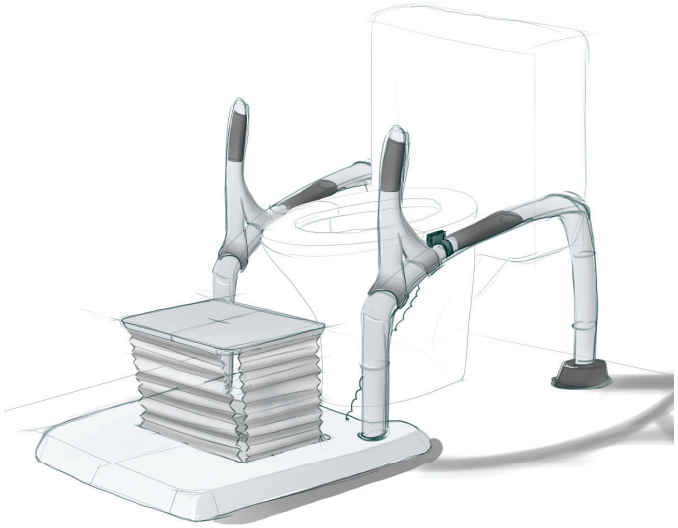


Image 7.2. Concept drawing of the EasyRaise

The secondary aim of the EasyRaise is to support the user with sitting down on the toilet, standing up from the toilet, and balancing while sitting on the toilet. The support frame that can be placed on the platform can consist of both a vertical and horizontal segment to cater to all individual preferences.

Image 7.2 shows one of the earlier concept drawings of the EasyRaise. Image 7.3 shows a render of the EasyRaise in a toilet space, on its lowest setting Image 7.4 on the next page visualises the overview of the EasyRaise.

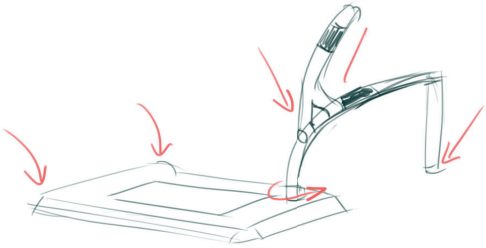
Image 7.3. Render on minimum height in real toilet space.

Prepare

The user is advised to try the EasyRaise in battling constipation and urine tract.

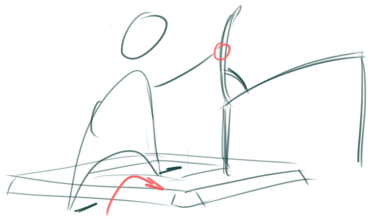
A medical professional or the user can preset a certain footstool height.

The user can choose if and how many hand support they want, to fit personal needs.

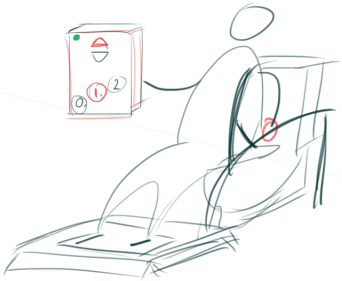


The bigger components of the EasyRaise are assembled inside the home of the user.

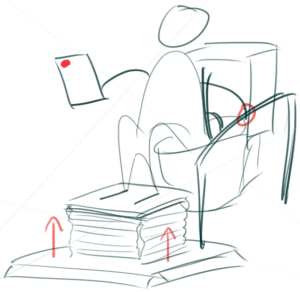
USE



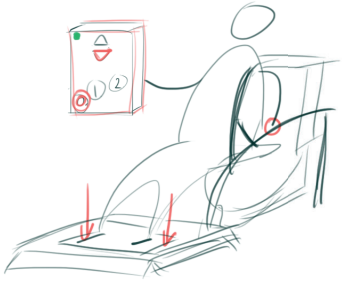
The user can hold on to the support while stepping onto the platform.



Once settled, the user pressing 'up' or one of the presets, to start lifting the legs.

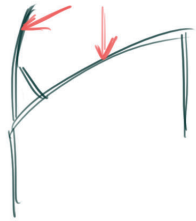


While the lift is stationed at the desired height, the user does their business.

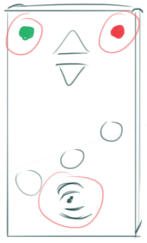


Once finished, the user presses 'O' to lower the lift. A clear signal is given when the lift is at its lowest, for safety.

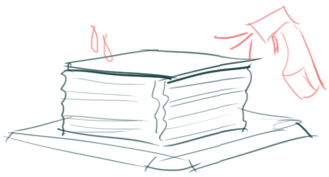
Features



The rails can be used for:
- stepping onto platform
- rising up from toilet
- balancing while sitting



The remote has both visual and auditory use cues regarding the state of the lift, for safety



The EasyRaise is protected against splattering and is easily cleanable.

Image 7.4. EasyRaise overview visualisation.

Use case

Once the user realises they need help with overcoming their toilet problems, or when a medical professional attends them to it, the EasyRaise is recommended.

In a case where the product is advised to a specific user by a medical professional, the medical professional can advise the user on which height is recommendable, and set this height onto one of the presets. However, when this product is brought in by an independent user, they can operate the presets themselves. Image 7.5 visualises how the user would be seated with the plateau on maximum height.

Main benefits

So what functionalities make this final concept worth someone's investment (time, effort, money)? The three most important unique selling points are listed below.

- The EasyRaise's main reason for purchase is helping the user raise their knees while sitting on the toilet more easily than any other current alternative on the market. Existing static footstools require the user to reach below the toilet to move the footstool to the right position in front of the toilet. Additionally, these footstools require the user to lift their feet independently to heights well above their capabilities. Both of these actions are impossible for elderly users with less mobility.

- More specifically, the EasyRaise stays in the same place in and out of use meaning there is no action required from the user to move it into place when used. In addition, the lifting plateau is embedded in the larger platform, so the user is not forced to lift their legs to the desired height themselves, instead they are comfortably lifted by the EasyRaise.

- Another benefit of the EasyRaise is that it functions as a standalone product, and does not require a bathroom renovation in order to function. It is placed on the floor around the toilet, so no drilling or bathroom renovation is needed.

Design

The general working principle of the EasyRaise has now been explained, but what about its appearance? During the project, the design principle of 'form follows function' was adhered to, but some design elements have been implemented. Common elderly aid products can be rather stigmatizing in their appearance, as was described previously. The EasyRaise is aspired to be integrated into the general toilet space appearance and should be nothing to be ashamed of, rather than being labelled a mechanical helping tool. The decorative aspects of the EasyRaise come forward in its materialisation and rounded shapes. The blue theme as presented in image 7.1 is customizable.

Image 7.5. Plateau on maximum height use case (for shorter people).

Specifications

There are plenty of subcomponents that make the proposed concept a whole. The specifications of these subcomponents and the choices that were made in the process are discussed.

Footlift mechanism

The mechanism that was chosen to make the vertical lift is the scissor mechanism. In chapter 6, the mechanism was placed beside the lifting plateau, assuming it would be too high to fit in the platform. However, placing it inside the platform with a maximum height of 10 cm (explained in the following subsection) looks better and provides more balanced support.

The driver of the scissor mechanism works like the following. A stepper motor is rotating a screw thread. The stepper motor is powered by a battery or adapter, is controllable through a stepper motor driver, and is controlled with buttons. The stepper motor is connected to the screw thread. With each rotation of the screw thread, the scissor arms are lifted, because the nut is the only moving component. On top of the scissor arms is a plateau on which the user rests their feet. Image 7.6 shows a schematic representation of the components. Image 7.7 shows these components in practice, as they were used for a prototype, which will be discussed in chapter 8.

The calculations about which forces are involved and which stepper motor is needed to give that force can be found in appendix T. The design is influenced by, among others, the screw gear's properties, the available space and the downward force. The chosen components are based on the theoretical calculations, therefore the prototype needs to show if the system works in practice too. The goal is set to raise the platform from

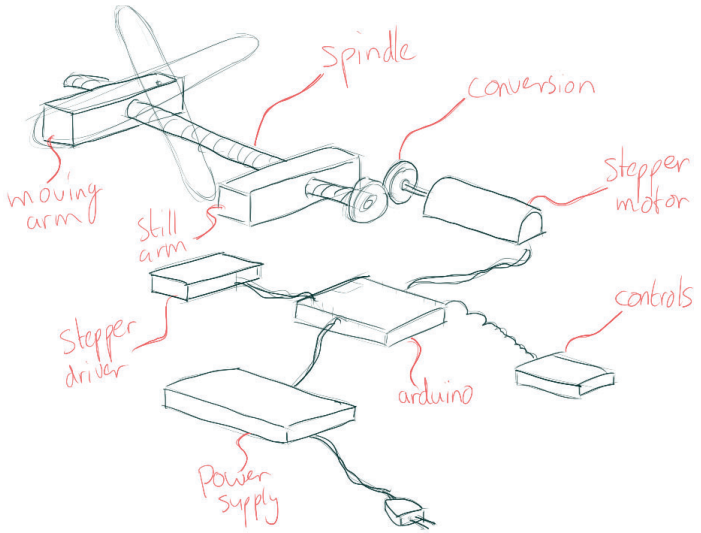


Image 7.6. Mechanism component overview

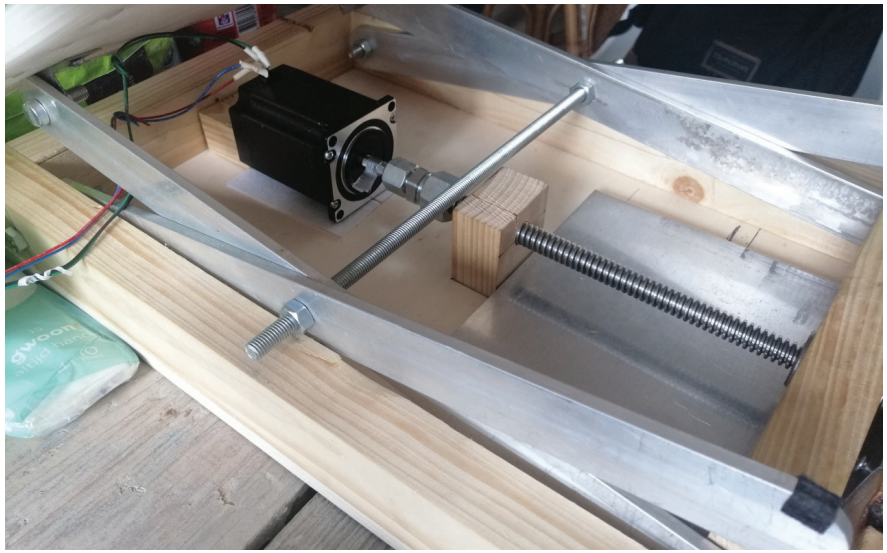


Image 7.7. Mechanism overview in practice.

lowest to highest point within 30 seconds, which is something that needs to be tested too. This goal time is an assumption based on the maximum amount of time before it gets annoyingly slow, and too fast could be considered dangerous.

Power

Naturally, the stepper motor needs to be powered in order to work. It is assumed there are no readily available wall sockets on 220 volts in the toilet space, therefore, a battery is needed. The exact current draw of the stepper motor needs to be determined with the prototype, but it is assumed to draw 4 Amps. The battery life is calculated by dividing the battery capacity over the load current. The following demands were set:

- The battery needs to be rechargeable.
- A full charge needs to provide for two months, which is assumed to be 300 minutes. Assuming the stepper motor is used for 5 minutes per day (five times up and down). Once lifted, the stepper motor does not need to deliver power, because the scissor system can hold the weight solely.
- The battery needs to fit within the dimensions of the platform.

Image 7.8. Readily available 20.000 mAh powerbank (Conrad, n.d.).

Providing 4 Amps for five hours demands a battery life of 20.000 mAh. Such power banks are currently also available for laptops, for a price upwards from €30, and an acceptable recharge time of around three hours. Image 7.8 shows an example of such a power bank.

The power bank needs to be extractable from the EasyRaise, or an extension cord needs to be provided by the user for in-device charging. The battery packet can be stored in similar fashion as electric bicycle extractable batteries. As the battery needs to be near the stepper motor, there is space right on the side of it when placed on its side. It is placed on the edge of the platform with the opening sideways, as depicted in image 7.9. No splashing can come from upwards and since it only needs to be recharged once every two months, the location being arguable annoying to reach is accepted. In image 7.9, '1' is the battery, '2' is the controlling chip, '3' is the stepper driver, and '4' is the stepper motor.

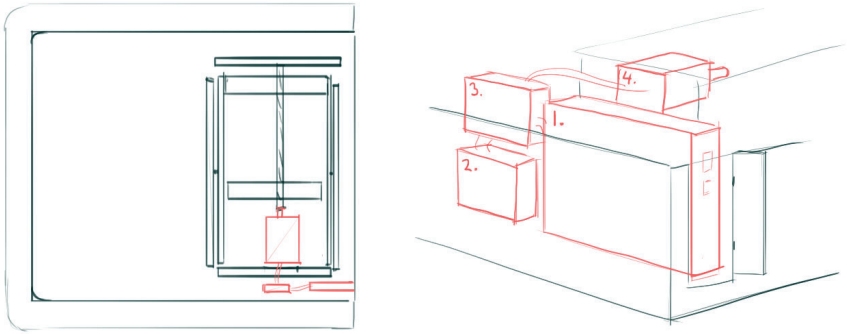


Image 7.9. Electronic component placement.

Platform

As mentioned, the footlift mechanism sets out a number of constraints regarding the design of the platform. One of the important properties of the platform is its height, because elderly users could have problems with raising their feet high. Additionally, the platform can be a possible stumbling obstacle. Therefore the goal was to keep the platform as low as possible; but what limit need to be kept?

No DINED measurements were available on comfortable step height for the elderly target group, however, it has been researched by Steenbekkers and van Beijsterveldt (1998), and Brooks et al. (1974). The results of their research are presented in image 7.10. The percentages indicate which portion of the participant group was able to step up the relative height. Brooks' research also tested whether a handrail influenced the comfortable step height.

Taking both researches into account and assuming there is a handrail available, the step height upper limit goes to 18 cm, to serve 99% of the target group. 18 cm high is a demand, getting the step height as low as possible is desired (a wish). The hand support is there to support the users too. Users with a walker can park their walker close to the hand support and switch hands in order to step up on the platform. Image 7.11 illustrates stepping up the platform.

this study 60 - 80+		Brooks et al. (1974) 60 - 80+		
step height [cm]		step height [cm]	with handrail	without handrail
10	100%	9	100%	98%
19	99%	18	100%	95%
28	94%	27	98%	84%
37	72%	36	93%	58%
46	45%	43	74%	42%

Image 7.10. Research results from Steenbekkers & van Beijsterveldt (1998), and Brooks et al. (1974).

Having a ten centimetre high platform in the toilet space is susceptible to being stumbled upon. The edge of the platform is not totally right-angled, but instead there is a slope on the side to prevent users from stumbling on the upper millimetres. Image 7.12 shows the slope. Additionally, having a raised platform that is visibly higher than the ground can be easier for the user to see where it starts and ends, when there is enough contrast with the floor.

Image 7.11. The support handle can be used to step onto the platform.

A LED strip is added around the edges of the sides, to draw even more attention and to remind the user there is a platform. The LEDs could be controlled by a motion sensor, so that they enlighten when a person enters the toilet area. Image 7.13 shows an example of such a led strip.

The size of the base platform is also a relevant point of discussion. Theoretically, one could argue to make the platform cover the whole lavatory floor in order to prevent stumbling and mimicking a floor-integrated construction. Doing this would be hard to realise. However, the base platform does need to have such a size that the user can comfortably stand and orientate on it; but cannot be excessively large as not all lavatory are spacious. Therefore, the platform size is set to 650 x 650 mm for standing space, as shown in image 7.14. Taking up the maximum available space that was discussed in chapter 3

The platform needs to have anti-slip measures to avoid dangerous situations with slipping. Synthetic rubber anti-slip stickers are placed on the standing area, similar to image 7.15.

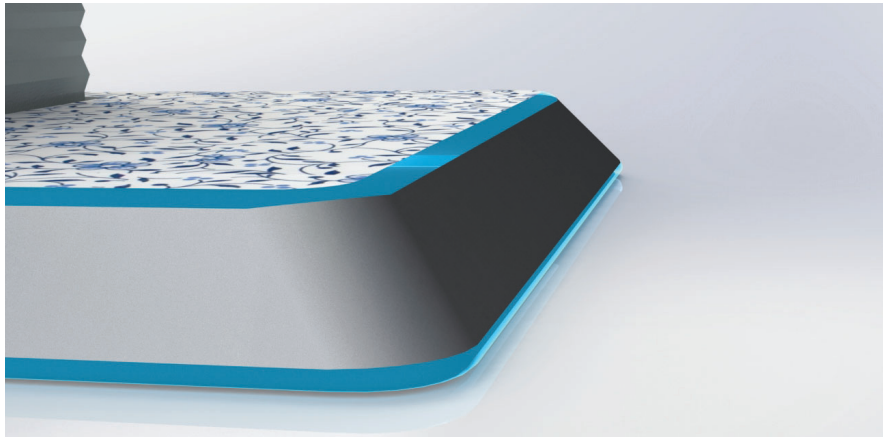


Image 7.12. Sloping side of the platform.

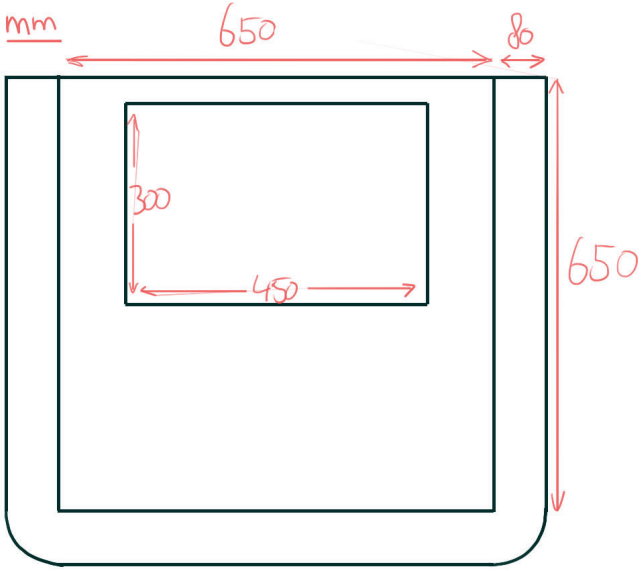


Image 7.14. Platform sizing.

Image 7.13. RGB LED strip available for less than €10 (Ledstripkoning, n.d.)

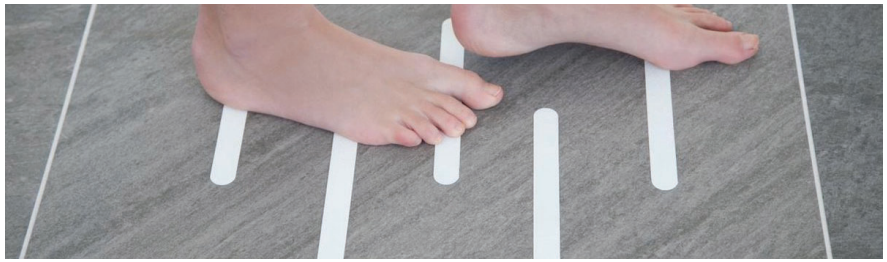


Image 7.15. Anti-slip strips (Totale Zorgwinkel, n.d.)

Hand support

The hand supports are a modular system, consisting of vertical and horizontal grips for both sides. The modular system was created to accommodate users that already have some type of hand support near their toilet, where adding two additional hand supports from the EasyRaise would be troublesome.

In the first instance, both the vertical grip and horizontal grip would be recommended to fully assist the users while using the EasyRaise. However, the user is able to personalize their desired support. The horizontal grip helps the user with balancing while their feet are raised, which is therefore the basis of the setup. The vertical grip would be an add-on for users that prefer or need this STS assistance.

Image 7.16 shows the separate pieces of which the support consists. The back-leg stands separate from the main platform so that the platform could be made more concise. This makes the EasyRaise much less robust-looking. The front leg is connected to the platform. To provide support with stepping onto the platform the supports needs to be placed sufficiently to the front.

The hand supports are subjected to a number of possible forces, therefore their stance and connection to the ground need to be firm. Appendix V shows an estimation of the forces that could play a role. The hand support is an extra in relation to the main function of lifting the user's legs. A lot of extra research is needed in making the hand support stiff enough for this use case.

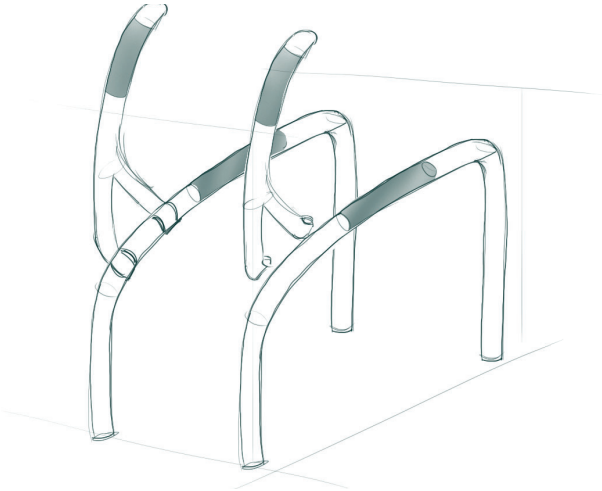


Image 7.16. Horizontal arm support as a foundation, with the vertical hand support as add on.

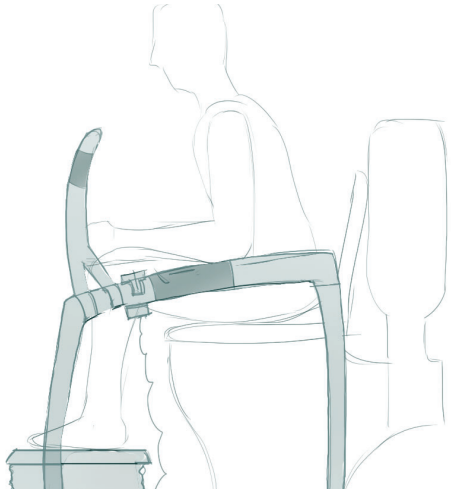


Image 7.17. Sketch of support in relation to user

Control

Early in the report, the goal was mentioned to have a seamless experience while using the product. This section elaborates on how exactly the user interacts with the product to operate it.

The user's primary operation on the EasyRaise is controlling the lifting plateau. Initially, the physical buttons were supposed to be implemented into the hand support, however, when a user would opt for no additional hand support (all support already present in their home), there would be a conflict. Therefore, it was decided to have a separate remote with buttons. This remote is inspired by the remote of an automatic chair. Image 7.18 shows an example of such a chair remote. Its recognizability will be helpful for elderly to understand the purpose and interface.

The interface of the remote is schematically presented in image 7.19. It was important to make the buttons a decent size, to make it easier to press for elderly. Physical feedback and a click-sound are given when the buttons are being pressed. The two arrow buttons are used for manually setting the height of the lift. The bottom three buttons are used to set the lift to predetermined heights, with 0 returning to base. Two heights can be set in case two people in the same household need a preset, similar to car driver seat presets.

Two LEDs are placed on the remote for visual communication. The green light will only shine whenever the plateau is fully embedded into the platform and secured. The red light indicates "danger" and shines whenever the plateau is not securely embedded; which shows the user to not step off.

Image 7.18. Example of a chair remote (Amazon, 2020).

Image 7.19. Button configuration.

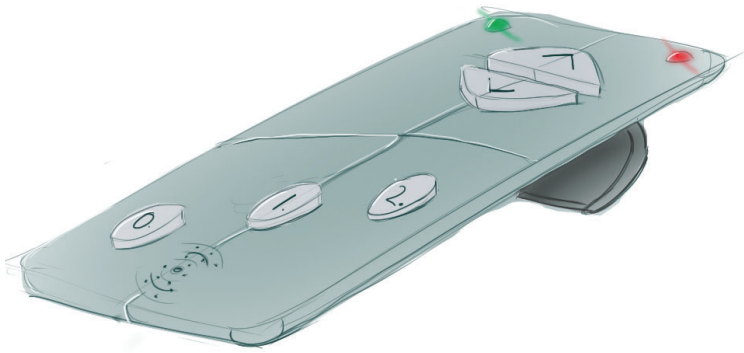


Image 7.20. Concept drawing remote.

The remote will also include a small speaker, to give the user additional use cues in case of bad eyesight. A distinct 'caution' tone lets the user know the platform has started ascending, whenever the user presses the buttons. The caution tone will also be heard when the plateau notices too much weight is put on it. This might happen when the user has forgotten not to step off without the plateau being in its base, and starts to lean forward to get off. Sensors in the scissor mechanism will detect such shifts in downward force. A distinct 'clear' tone lets the user know when the plateau has safely returned to its base, and the user can start cleaning.

Image 7.20. shows a concept drawing of the remote. On the back, a hanging system is attached to hang the remote on the hand support. The remote will be wireless, to avoid tripping over the wire.

Cleaning

As the EasyRaise is placed in a toilet area, it needs to be kept clean. The outside casing needs to be easily cleanable by the direct user or possibly a household cleaner. The materials for the outside casing and hand support are resistant to regular household cleaning items.

When the platform is cleaned, preferably no liquids are able to penetrate into the mechanism room. With a small, simple rubber sealing around the plateau, no soap or water can leak through while being cleaned. Image 7.21 shows a possible d-shaped rubber seal extrusion, that could be used.

Once the plateau is lifted to a certain height, the mechanism below it is exposed. To make sure nothing gets in between the motion range, for example a belt or splattering from the toilet, a cover is added to protect the open mechanism. The cover is pulled up in a regular folding pattern as the plateau rises, as depicted in image 7.22. The cover is both functional in keeping parts clean, but also in terms of safety.

Demand: Cleanable met household items.

Image 7.21 Rubber sealing to prevent cleaning liquids to leak through (Rubbermagazijn, n.d).

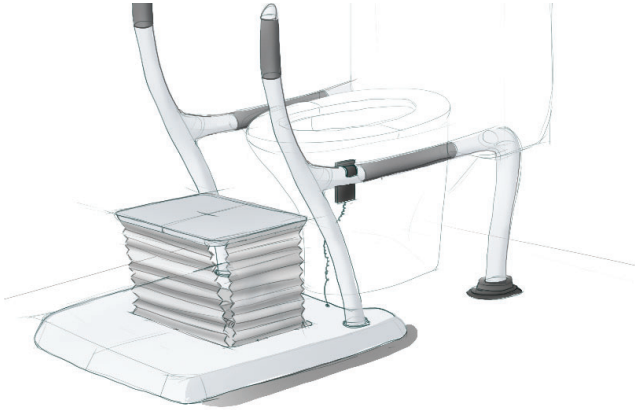


Image 7.22. Protective cover.

Installation / maintenance

One of the criteria that came forward while specifying the brief of the project was to make the installation a low threshold. This criterion is met in the sense that no adjustments like attachments or excavations have to be made in the toilet floor or walls. It does not need to be screwed onto the floor either, so installation makes no permanent changes in its environment.

However, the size of the product is quite significant, because the user is not expected to put together the parts themselves, outside of the hand support. This means that the platform and hand supports are fully assembled beforehand.

Demand: Installation does not require permanent changes in the toilet room.

Materialization

The EasyRaise consists of a number of sub assemblies, as shown in image 7.23. The sub assemblies will be discussed briefly individually, with a bill of materials to conclude.

- Base platform
- Lift mechanism
- Lift plateau
- Hand support
- Remote

Base platform

The base platform is used to place the hand support legs on, it holds the lift mechanism components, and is used by the user to stand on before and after using the toilet.

The base platform topside will be made of a sheet of 6 mm Trespa. Trespa is durable, easily cleanable and can handle moisture. The base frame supporting the Trespa plate will made of steel. Steel has the desired strength characteristics, as it needs to support the full body weight of the user. Exact form and shape of this base frame needs to be considered. The angled sides are made of HDPE, for wear resistance and moist handling.

Lift mechanism

As mentioned earlier in this chapter the lift mechanism consists of a number of components. The stepper motor, stepper motor driver, and power supply do not have specific materials to mention. The arms of the mechanism will be made of 5 mm aluminium flat bar, because they need to be sturdy. The spindle axis is a trapezium screw thread from hardened steel of 12 mm

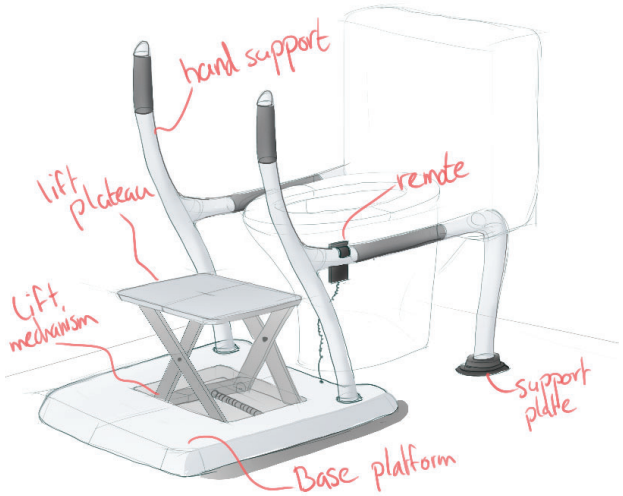


Image 7.23. Subassemblies of the EasyRaise

diameter and 3 mm pitch, with accompanying nut. The nut is pressed into the moving lateral axis. The arms need to move in a single direction, so they need to be guided.

Lift plateau
The plateau will be made of a TRESPA plastic plate. Trespa is durable, easily cleanable, and can be well-attached to the arms. The softcover that is attached to the bottom of the plate is made from sheet plastic that folds into a pattern when collapsing.

Hand support
The hand support's main frame is made from aluminium. Aluminium is lightweight and provides strength to handle the forces. There will be a gripping piece made of silicone rubber on both the vertical and horizontal support, providing extra grip.

The support plate for the back leg is made of HDPE plastic. This material is well resisting against liquids and wear down, is durable, and has good strength characteristics. Since no realistic force exertion scenarios are explored for the support handles, the materials can still change to ensure the right strength qualities.

Remote
The remote's casing is made of ABS plastic, which is a common material for such casings. It is able to resist regular usage and water splashing.

Bill of materials
Image 7.24 shows the initial list of materials that together form the EasyRaise.

Business
Besides all the specifics of the embodiment of the EasyRaise, the business side is also worth being shortly addressed.

Cost price
With respect to the commercial side of the EasyRaise, the cost price is relevant to narrow down. The very rough estimation of the cost price is based on the material costs, operational costs, and assembly, and comes down to an estimated €570. The

Component	Part	Material
Base_plate	_frame	Steel
	_top	Trespa
	_side_long	HDPE
	_side_corner	HDPE
	_led	Misc.
	_led_cover	PMMA
	_anti_slip	Rubber
Lift_mechanism	_arms	Aluminium
	_electronics	Misc.
	_spindle_axis	Steel
	_spindle_nut	Steel
	_rollers	Steel
	_frame	Aluminium
	_shaft_coupler	Misc.
Lift_plateau	_top	Trespa
	_soft_cover	PVC fabric
	_rubber_seal	Rubber
Hand_support	_frame	Aluminium
	_grip	Silicone rubber
	_plate	HDPE
Remote	_electronics	Misc.
	_casing	ABS
Assembling materials	Screws, nuts, bots	Steel

Image 7.24. Bill of materials.

material costs take up the largest portion with a rough €330. Appendix W shows the breakdown of this estimation.

The size of the primary batch size depends on the market demand. The batch size is relevant to determine production investment costs and preparation of distribution. In chapter 2 the number of elderly people with toileting complaints that fit the target group was said to be 1.367.707 people. If only 5% of this group is interested in buying the product, the number goes down to 68.385 people. Therefore a primary batch is set to 50.000, to be on the safe side.

Sales

For the sales plan of the EasyRaise, there were also a number of options. It can be sold independently, as a service, or on rental. Some elderly products, like walkers, can be covered by health insurance, whereas other more specific tools are to be paid for. A rental system for the EasyRaise is a viable option, because when the EasyRaise is recommended by a medical professional, it immediately functions as a proof of need for insurance. When the user is in need of the EasyRaise they start the rental period. Once the product is no longer needed, possibly due to new physical or psychological limitations or even passing, the product is handed back to the distributor. There are no direct competitors for such an automatic footstool and it is used on recommendation of a health professional. A rental system has its advantages over a single sale system because of several reasons:

- It is a smaller investment for the user compared to buying the product as a whole.
- The distributor knows how many products are in current use.
- The distributor can provide a repair and maintenance service, which is beneficial for both parties.
- It is environmentally attractive through waste reduction.

Additionally, the EasyRaise could gain some extra income by selling accessories for the toilet space. Examples of such accessories are:

- A toilet paper holder that can be added to the hand support (7.25A).
- A toilet paper storage that can be added to the hand support (7.25B)
- Aesthetic additives for customizing the EasyRaise's appearance (7.25C). Such aesthetic additives can consist of a sticker sheet to fit on top of the base platform and different colour hand grips.

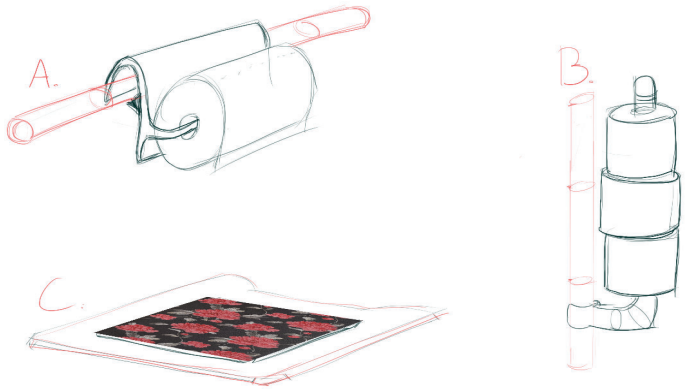


Image 7.25. Different possible accessoires

Stage III - Evaluation

Throughout the project, you can ask yourself if what you are working on is right. During the final phase of evaluation, we try to touch upon that subject via a number of evaluation methods. Once evaluated, the concept undergoes its final iteration for this project by stating recommendations on what could be interesting to change about the concept, for a successful end result.

8. Concept evaluation

The concept is evaluated in three different ways, with different purposes. A physical prototype is made to check if the scissor mechanism works as intended. A group of medical professionals from ErasmusMC will verify the direction this project has gone. The aspired end user is addressed to gain insight in the desirability and understandability. This chapter elaborates on all three evaluation methods and describes their goal, method, results and conclusions. The chapter is concluded with adaptations on the prototype based on the findings from the evaluations.

Physical model evaluation

The goal of the physical prototype is to verify whether the scissor mechanism that was chosen for the vertical lift is in the right direction. Additionally, the exact force exertion of the stepper motor is determined via trial and error, and more knowledge is needed on the force conversion to the spindle.

Component overview

The prototype can be divided into two subgroups. The first group is the scissor frame, made of construction materials, and the second consists of the electronics.

Scissor frame

The scissor frame was made of a wooden base plate and top plateau, aluminium scissor arms, and a metal screw thread. Image 8.1 shows the final result of the scissor frame (without the top plate). The following materials were used:

- Two wooden plates of thickness 450 x 300 x 12 mm for bottom and top.
- Wooden beam of 28 x 44 mm for bottom sides.
- Four aluminium beams of 30 x 5 mm for the scissor arms.
- Trapezoid screw thread M12 with 3 mm pitch, with fitting nut for the spindle axis.
- Gas pipe connection 8 mm to 12 mm.
- M8 screw thread through the scissor arms' centres.
- Assembly material consisting of screws for wood attachment and M8 bolts for rotating points of the scissor arms.
- Plastic top cover.

Appendix X shows images of the materials that were used.

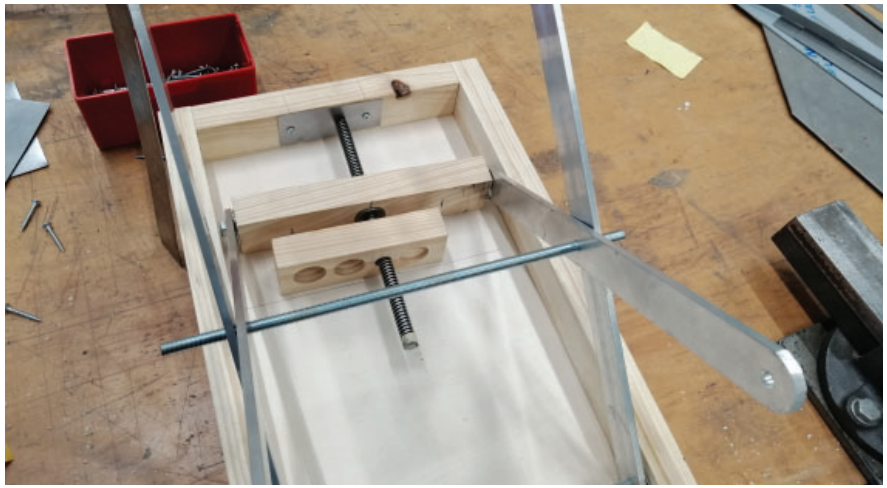


Image 8.1. Scissor frame without electronics and top cover.

Electronics

The electronics consisted of a number of components that together make the stepper motor work as intended. Push buttons were implemented for controlling the motor more easily, in comparison to implementing code each time. Image 8.2 shows the final result of the electronic circuit. The electronics consist of the following components:

- A NEMA23 stepper motor with a maximum current of 4A. The stepper drives the screw thread axis.
- TB6600 stepper motor driver, which is needed to control the stepper motor.
- A 12V 5A power supply, which is usually used as an adapter for computers, was used to power the stepper motor. The 5V that the Arduino can provide is not enough power.
- An Arduino + grove shield that are used to attach buttons to and communicate code with the computer.
- Some grove shield compatible buttons that were used to easily start and stop the stepper motor.

Appendix Y shows separate images of the electronic components. Appendix Z shows the Arduino circuit.

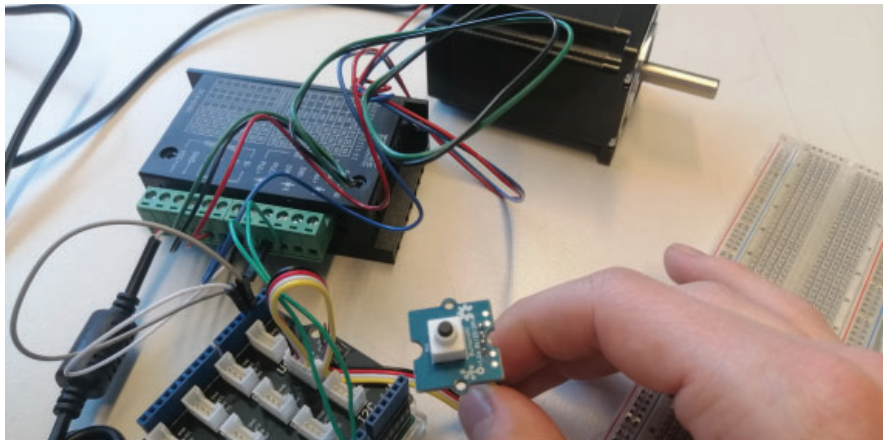


Image 8.2 Electronic components.

Assembly

Assembly of the scissor frame was fully carried out in the IDE workshop, where workshop employees could help out when deciding on which screws or bolts to use for example.

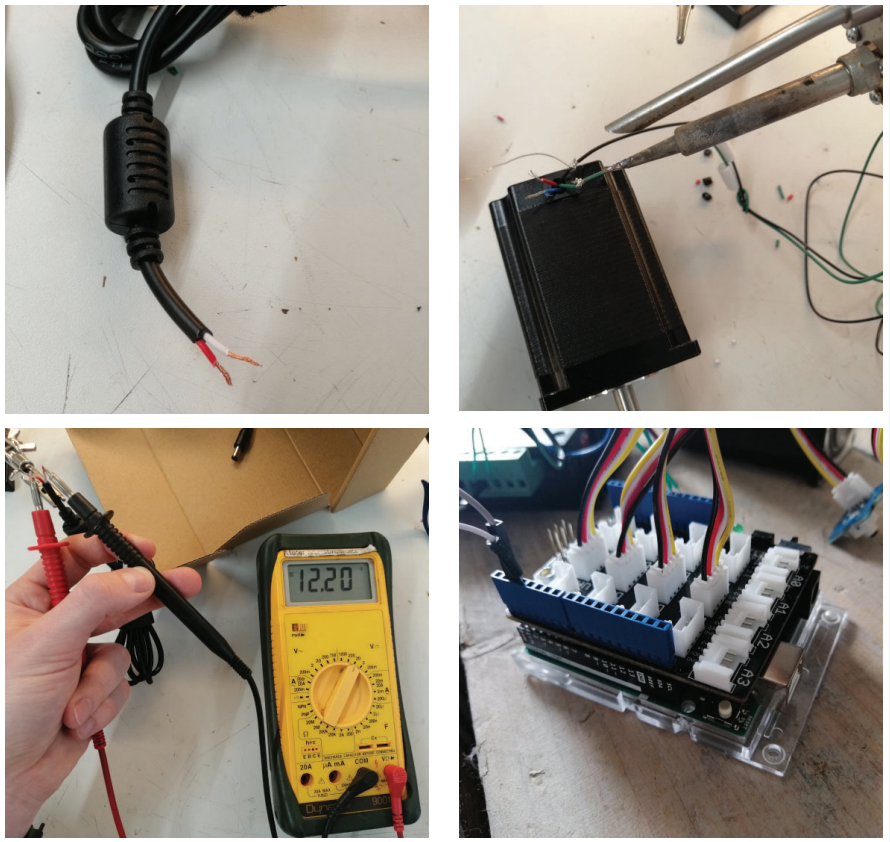
Collage 8.1 gives an indication of how the assembly process of the scissor frame went. All tight connections were done with screws (top left). All scissor connections to the wood needed to be able to rotate, so they were done with bolts (top right). The aluminium staffs needed to be rounded around the edges to allow their rotation (middle left). The screw thread bolt needed to be firmly attached to the wood, so the bolt was sandblasted to roughen it (middle right), and then pressed into a slightly smaller hole in the wood. The corner pieces on the bottom of the top plate were created out of a small aluminium plate (bottom left). To prevent the screw thread from drilling into the wood, a small aluminium plate was attached to the back wooden beam (bottom right).

Collage 8.2 shows the assembly of the electronics. The power supply needed to be cut and stripped (top left) to find the negative and positive wire with a multimeter (top right). The wiring of the stepper motor needed to be soldered (bottom left). The attachment of the buttons onto the circuit was rather straightforward (bottom right).

The Arduino code used to control the system can be found in appendix AA. For controlling the motor the following buttons were implemented:

- rotate clockwise to lower the platform
- rotate counterclockwise to raise the platform
- stop button at lowest setting to prevent damage
- stop button at highest setting to prevent damage

Image 8.1. Collage of scissor frame assembly.



Collage 8.2. Assembly of electronics.

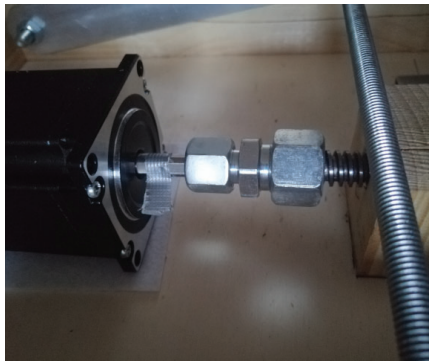


Image 8.3. Shaft coupling.

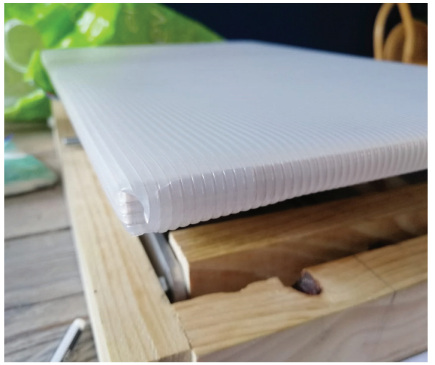


Image 8.4. Plastic cover.

The point where the scissor frame is merged with the electronics is at the connection between the axis of the stepper motor and the axis of the spindle. Image 8.3 shows the combination of the two subsystems. This shaft coupler was quite a challenge to get right because that dedicated component was ordered wrongly. Eventually, a water pipe connector was used to connect the axes.

Reflection

Making this prototype made me really enthusiastic. I wanted to explore and develop my prototyping skills in this project and through this design I certainly did. I had to use numerous machines in the workshop that I had previously never used, which was a great experience. The employees in the workshop were kind and patient in helping me and giving some construction advice too. Appendix AB shows some of the machines that were used for creating the prototype.

Test

The goal of the prototype was to test the mechanism on several topics:

- Is the stepper motor able to lift 35Kg in vertical direction? And how much current is needed for that?
- Is the construction stable enough in horizontal direction when placing your feet on it.
- How smooth is the upward motion? And are the frictional forces all around manageable?
- What is the influence of the starting angle on the weight lifted?

As for the method of the test, the obvious first step was making the prototype. Hereafter different steps were taken to answer the proposed questions.

Weight lifting

- Put weight on the top platform, starting at 1 Kg.
- Use the stepper motor to lift the weight.
- Increase the weight to 30 Kg, with increments of 1.
- Increase the current of the stepper motor when it is unable to lift a weight. Starting at 1 A, with a maximum of 3.5A.
- Increase the starting height of the top when it is unable to lift a weight, starting at 12 cm.
- Note down the maximum amount of weight, with which current and from which starting height, the stepper motor is able to lift.

Stability and motion

- Set the platform to lowest, middle, and highest setting, without any weight.
- Add 10, 20 and 30 Kg on top (separately).
- Push the top platform in all horizontal directions (sideways + rotational).
- Note down the occurrences, overall stability and maximum displacement.

- Place the prototype in front of a chair and place feet onto the platform.
- Raise the platform to its highest point.
- Note down the stability and any other remarkable occurrences.

Results

There were plenty of interesting results, discussed below:

- The scissor mechanism is able to hold 30 Kg on its own at a height of 30 cm. Image 8.5 shows the weights on the top plate. First, the plate was raised to 30 cm, then weight was added with increments of 5 kg. When 30 Kg was added, it stood for 15 minutes without lowering, assuming it will not drop after longer than this time. No counterforce was needed to keep the spindle in place, because the downward force locks itself in place. This means that no power is required during the sitting period of usage.

- While on a height of 30 cm and 30 Kg on top, the top plate was subjected to sidewards forces, from all directions. The prototype was well resistant to all forces except for exertion perpendicular to the scissor arms, shown in image 8.6. There is some slack in the moving joints (image 8.7), which allows for some movement, but definitely needs to be limited to avoid large horizontal movements. For this particularly vulnerable movement, the maximum displacement was 9 mm. Appendix AC shows more images on horizontal force exertion.

Image 8.5. Spindle handles 30 Kg downward force.

- When gradually increasing the lifting weight, it was found that the maximum amount that the prototype was able to lift was 18.6 kg, shown in image 8.8. The stepper motor settings were, naturally, rather important when trying to lift the most weight. The output current was set to 3.5A, the maximum that

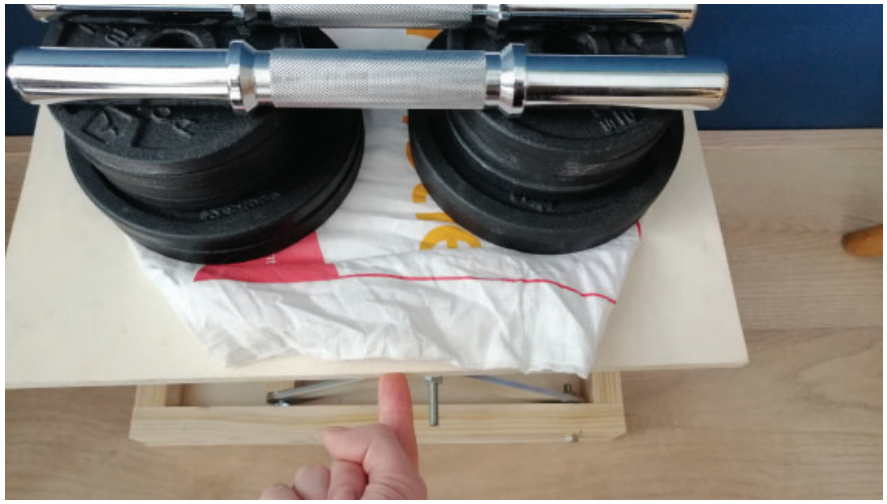


Image 8.6. Horizontal force exertion.

Image 8.7. Joint slack.

the driver is able to deliver. As mentioned earlier, the rotation speed heavily influences the torque it can deliver. No exact RPM vs. Torque graph was available of this specific stepper motor, only a maximum torque. Through trial and error, it was found that 50 RPM was able to deliver the most torque (equaling to a 3000 microsecond delay between stepper motor coils in the Arduino code).

- The starting angle of the scissor arms is of great importance for lifting weights; with the arm angle relating directly to the platform height. It was found that when lifting 9kg, the platform needed to start at a height of 13.5 cm in order to be able to lift that amount. The motor was unable to lift 9kg starting below this height. Overall, a starting height of 16 cm was used for all weights.

Image 8.8. Lifting 18.6 Kg.

- Due to the prototype being able to lift only 18.6 Kg, it was not entirely possible to test the prototype in a real use situation, because when leaning forward just a bit the motor failed. However, one test person (who has a body mass of 55 kg) used the prototype to lift their legs. It showed that the working principle does work, as portrayed in image 8.9. It became clear that the weight needed to be placed central, to avoid horizontal displacement of the plateau.

Some additional testing images can be found in appendix AC.

Image 8.9. Using the prototype for its intended goal.

Prototype flaws

Even though the prototype gave a fairly good idea of how the envisioned scissor mechanism is supposed to work, it had a number of flaws.

The end of the spindle was not completely flattened (image 8.10), so with each rotation it made the platform go upwards unevenly. Flattening the end with sanding paper was only done limitedly, because it still needed to get through the nut, which got increasingly difficult during the flattening. This was measured with a level tool.

The scissor arms did their job in the prototype, howeve,r they could have used some more guidance in their motion and horizontal movement. The axis that went through the arms' centres was not enough to prevent wobbling (as tightening the nuts there would increase the friction). Therefore, the weight on top needed to be placed rather centralised, to avoid tilting the platform.

The height of the spindle axis was a little lower than the height of the stepper axis. To compensate for this, the moving bar was placed on top of a heightened aluminium platform. However, then the support block holding the spindle axis was a few (image 8.11) millimetres too high, which caused a lot of friction.

Conclusions

The following takeaways were derived from the physical prototype testing:

- The prototype was able to give a good idea of how the scissor mechanism needs to work.
- The chosen stepper motor was unable to lift the desired amount of weight in this configuration.
- The horizontal displacements that are allowed by scissor arms need to be considered carefully to guarantee a certain level of stability.
- The vibrations of the stepper motor produce more sound than expected (may be caused by wooden components).

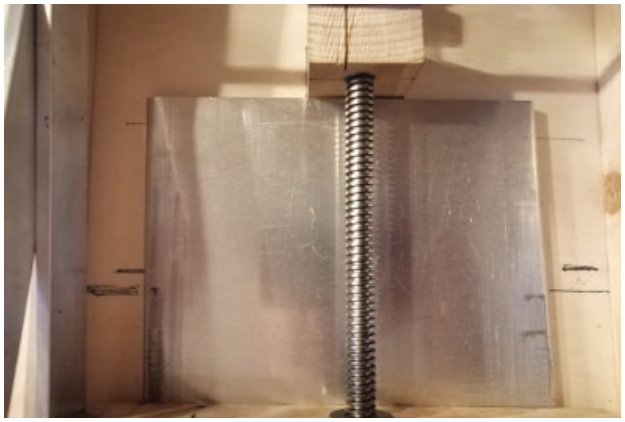


Image 8.10 Spindle angled cut-off. *Image 8.11. Compensation height difference.*

Target group

All in all, the end users are the ones who actually need to use the product. Therefore it is important to involve them in the design process in the best way possible. To evaluate the EasyRaise, the concept was proposed to a number of end users, to gain more insight into their opinion on desirability and understandability.

Test

The goals of this user evaluation were the following:

- Does the user understand the general working principle of the EasyRaise and what the goal is?
- Does the user understand the functionality of the buttons of the remote? (Without telling the button functions upfront).
- What is the user's evaluation of the safety of the EasyRaise?
- Would the user see the EasyRaise in their toilet environment? What aesthetic features are (un)desirable?

The method of testing was through qualitative interviews. Eventually, five members from TU elderly panel that also participated in the earlier user study were available for an interview. Only elderly people were asked to participate because their empathy for their peers is the greatest, and therefore the most relevant. The participants were presented illustrations during a phone- or Zoom call. Questions and follow-up questions were asked based on the provided illustrations. The questions and follow-up questions were aimed to be as neutral as possible, in order to avoid a total Hawthorne effect, however this cannot be assured as the author was the interviewer. Appendix AD shows the list of initial questions asked, so the spontaneous follow-up questions are not included.

The images that were provided to the participants are presented in collage 8.3. Two images were used to describe the general working principle (top left & top right). Three different aesthetic versions were shown in order to gain more insight in the user's preferred appearance (neutral in middle left, high contrast in middle right and Delfsblauw print in bottom left). The hand remote button configuration was the final image shown (bottom right).

Results

The results of the interviews were summarized into a list of bullet-pointed findings. Due to the low amount of participants no significance or quantitative results were abstracted. However, through the follow-up questions a lot of unexpected insights were gathered.

- All participants understood the general working purpose of the EasyRaise and what benefits it can offer to users.

- The upper triangular buttons were correctly interpreted by everyone. The bottom numbered buttons functions were correctly interpreted by everyone but one. That one participant thought it had something to do with the speed of the vertical motion. It was noticed four times that the simplicity of the remote is important, and that it needs to have a decent size to accommodate for reduced vision users.

- The height of the platform was not interpreted as dangerous. However, four participants mentioned that the edge should be sloped to avoid tripping.

- Having the possibility to personalize the EasyRaise with a

Collage 8.3. Images presented to participants.

certain print was received well, all of them would use it. Having contrast at the edge to remind the user of the platform was also preferred; depending on the colour of the bathroom floor.

Appendix AE contains the interview notes. Overall the participants were enthusiastic about the EasyRaise, which was great to see.

Conclusions

The following takeaways were derived from the user evaluation:

- The general working principle and benefits of the EasyRaise were clear.
- Personalisation of the EasyRaise is a good addition.
- The layout of the buttons needs to be kept simple.

Medical professionals

The purpose of the EasyRaise is based on theoretical knowledge and practical insights from professionals as explained in the early chapters. However, it is important to find out whether the design of the EasyRaise would work in practice, in the eyes of medical professionals, since they would be the ones recommending this product to potential users.

Since the project is in collaboration with the ErasmusMC, the opportunity was taken to discuss the project with medical professionals from the urology department, to take the collaboration to a higher level. Head of department and member of this project's supervisory team dr. Bangma was able to gather a variety of medical staff to come and take a look at the proposed concept.

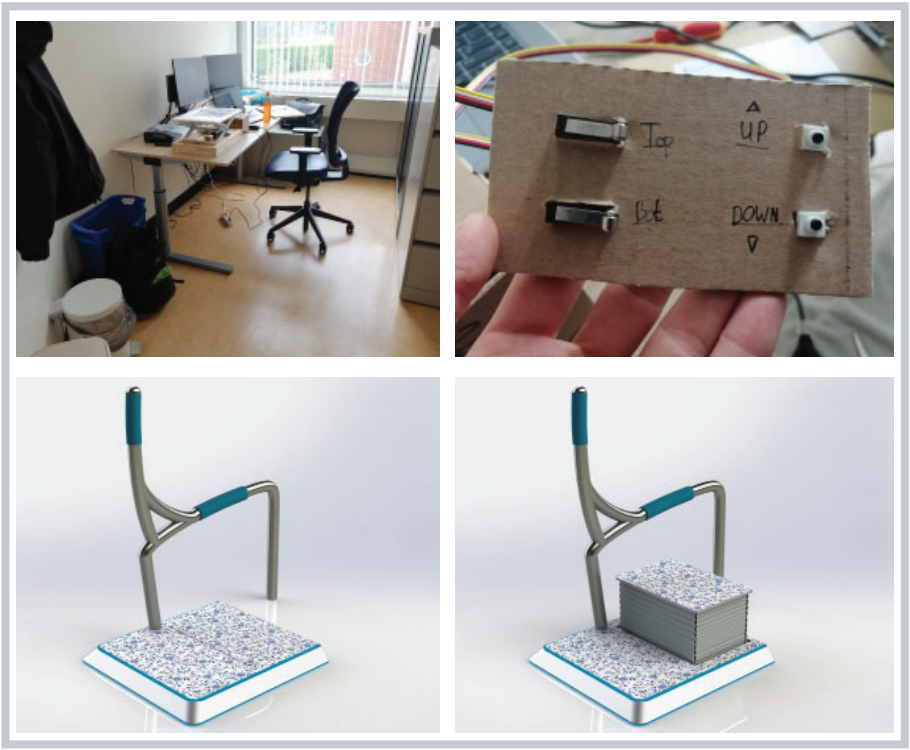
Test

The goal of going to the ErasmusMC was to get more insights from medical professionals on the following topics:

- Is the general working principle of the EasyRaise advantageous for battling constipation and urine retention complaints?
- Is the EasyRaise safe to use?
- Is the EasyRaise understandable for the target group?
- Would they recommend the EasyRaise, in its final form, to their patients?

Once the prototype was brought to the ErasmusMC and the medical staff was present, they were interviewed individually. The method of this evaluation consisted of letting them experience the prototype and having an interview. Unfortunately, the prototype was considered not safe enough to be used as intended, however, they were able to control its heights with a remote. The questions and follow-up questions were aimed to be as neutral as possible, in order to avoid a possible Hawthorne effect, however this cannot be assured as the author was the interviewer. The full list of prepared questions can be found in appendix AF.

Collage 8.4 gives an overview of the ErasmusMC visit. Top left shows the test room inside the ErasmusMC urology department. Top right shows the remote to operate the prototype. In addition to the visuals shown to the target group, the renders in bottom left and right were shown.



Collage 8.4. ErasmusMC tools.

Results

Eleven ErasmusMC employees showed up to the interview room throughout the day and were each interviewed. The attendance was more than expected so that positively influenced the test day.

The participants that showed up had a whole variety of occupations; for example pelvic floor therapist, functional bladder researcher and urologist nurse. The variety of participants ensured a wider range of perspectives, which was positive for the test day too.

The most interesting findings are listed below.

- The general working principle of the EasyRaise was understood and supported by almost all participants. However, two participants explained that they did not immediately saw this concept being used, as it would be "too much of a hassle".

- The platform's target height of 10 cm was questioned by almost all participants. Once explained why the decision was made to avoid implementing the system into the floor, they could understand that. They mentioned the need to have the platform as low as possible, to avoid stumbling over it. However, they did appreciate the contrast and led strip on the edges to make the user alert.

- With respect to safety, the support handles were generally well-received. It was pointed out multiple times that they need to be sturdy enough to also function for heavier users.

- Most participants would recommend a certain plateau height to the user, or take a look at the preferred height together, instead of letting the user decide on the right height independently. Some research on which height would be recommendable, for example in the form of an advice sheet. However, they pointed out that each individual user has their own independent needs, so a combination would be the best way to go.

- The functions of the buttons '0', '1', and '2' on the remote were guessed correctly in the first try by only four participants. They were mostly confused with 1 being half-height and 2 being maximum height.

- The most prominent target group that was mentioned besides the elderly was children. This was in line with expectations, as in the beginning of the project this option was also considered. The child specialists mentioned that

All notes that were taken during the interviews can be found in appendix AG.

Conclusions

The following takeaways were derived from the medical staff evaluation:

- The general working principle and benefits of the EasyRaise were clear. There is a need for this product.

- The step height needs as low as possible, the 10 cm needs to be checked on usability.

- Recommendations on which height is best for the user will be given by the practitioner, in consultation with the user.

Concept adaptations

The evaluation phase was conducted to gain more insight into the value of the proposed concept. This subsection elaborates on the adaptations that are made to the EasyRaise, based on the findings from the evaluation phase.

Scissor mechanism

The stepper motor made quite some noise when it was powered on and rotating. All vibrations that were created were directly transferred to the wooden base. The wooden components most likely amplified the vibrations, however other stiff materials might show the same results. Therefore, a rubber cushion needs to be added to support the stepper motor and intercept the vibrations (image 8.12).

The stepper motor was not strong enough to lift the desired 30 Kg. The prototype being not perfectly aligned, unnecessary frictions and material choices influenced the lifting power. However, in order to be on the safe side, using a stronger stepper motor is recommended. In this case a NEMA 23, but there are NEMA 34 stepper motors available with much more torque (image 8.13). This does have pricing consequences though.

The displacement on the horizontal plane was not optimal in the prototype. It is absolutely necessary that minimal horizontal motion is possible in the final design. A solid option is having the rolling components strictly guided. Image 8.14 shows such a mechanism. The scissor mechanism is an already existing mechanism, so the challenge is implementing it into this application.

Image 8.12. Anti-vibration pad (RS, n.d.)

Image 8.13. Different sizes stepmotor (JVL, n.d.).

Image 8.14. Guiding rails (Sek Autria, 2019).

Remote

The remote design was kept pretty simplistic trying to make its functionalities easy to understand. The triangular up and down buttons were mostly interpreted correctly. The preset buttons however were not. Having the buttons diagonal upwards and numbered 0, 1 and 2 made it seem like their functions are consecutive enlarging. Therefore, the buttons are now placed horizontally, with symbols instead of numbers. The goal is to take away a feeling of chronology (that is not there). Image 8.15 shows the renewed remote design.

Image 8.15 Renewed remote design.

Height recommendation

Initially, it was envisioned that the practitioner was in full control of the recommendation on plateau height; possibly with a clear guiding sheet. However, the user's comfort must be the highest priority. The practitioner should visit the home of the user to collaboratively determine the best use case per individual.

Reflection

Doing a total evaluation of the EasyRaise was fun and very insightful. It is a rather classical step in the design cycle, where the concept is exposed to outside opinions and essentially gets thrown to the wolves, which can be a scary phase for the designer.

All parts of the evaluation phase were exciting to execute because plenty of unexpected findings came forward. The physical prototyping allowed me to develop skills in the workshop, which has not come forward in other courses.

Going to the ErasmusMC to get feedback from medical professionals was also something completely new. It was sometimes a challenge to keep up with their feedback, because some topics and terminology are obvious for them. Nevertheless, the value that is added to the project by such a visit is huge; and it was great to see their enthusiasm.

Doing the evaluation interviews in a one-on-one format allowed me to ask follow-up questions, which gave the most interesting information. It was fun to hear the participants speaking out their opinions on it. In future studies, I would try to have more participants for such evaluation interviews because I feel like I did not yet reach the new information ceiling after interviewing five people.

9. Discussion

This chapter concludes the report with an evaluation of the overall design process, design limitations, future work, and a personal reflection. The goal of the discussion is to provide a foundation for further development steps that will help bring the EasyRaise closer to actual product development. Additionally, some reflection on this project's activities helps understanding its limitations.

Conclusion

The EasyRaise is the result of this master thesis, after a process of roughly twenty weeks. The EasyRaise effortlessly raises the legs of the users towards a squatting position, to help relax their pelvic floor muscles. The lifting platform is controlled by the user with a wireless remote, that can be stored within reach.

The hand support provides more autonomy to elderly users, as they can use it to stand up from the toilet and to balance while sitting on it. Additionally, regular laxative usage can be reduced to save on healthcare costs.

The EasyRaise is a stand alone product that can be placed without the need to make permanent changes to the toilet space. It is easily cleanable and allows for aesthetic customisation to fit the toilet interior. The EasyRaise aims to normalize the conversation on toileting problems by its permanent presence.

For further research

Even though many people were involved in this master thesis, the whole design process was executed individually. Therefore, within the project's timespan, some aspects of the project were less explored than others, setting limitations on the project's content. There are a number of aspects to the EasyRaise that need to be further researched.

Hand support

The hand support was described as an inseparable part of the EasyRaise. However, plenty of additional knowledge is needed on this component. First of all, in how many cases does a user opt for the EasyRaise without having any hand support near their toilet? Quantitative research is needed on the actual desirability of having such hand support. Secondly, the forces that are exerted onto the hand support in a variety of use cases, ranging in extremity, will heavily affect the strength properties necessary for safe hand support. Its construction and connection to the plateau and ground needs to be thoroughly calculated, to ensure safe usage.

Height settings

Setting the height of the EasyRaise can be done by both the user and the health professional recommending it. It would be interesting to know if there is a certain comfortable height per person, that could be predicted by the practitioner. One way of gathering knowledge on preferred heights is doing quantitative research where participants choose the height themselves. From such research a prediction model can be developed to be used by the practitioners.

Additionally, it might also be relevant to see what variance there is between different days, in terms of height comfort. When on 'a good day' a user can set it to height 25 cm, without having any muscle straining, and the next day 20 cm is their absolute maximum, setting preset heights is a major challenge.

Target group

The EasyRaise was developed primarily with elderly users in mind as the target group. However, this should not necessarily limit its accessibility to other target groups as well. Children were also considered to gain major benefits from such a product, which also came forward during the ErasmusMC visit.

It would be interesting to see if, and how, the EasyRaise could be put to good use for non-elderly users. Possibly, its appearance would be altered to fit younger users. The maximum height for younger users might be higher.

Safety

As mentioned earlier, elderly people tend to fall the most in bathrooms. Therefore safety around and while using the EasyRaise is of utmost importance. From the evaluation interviews alone, no definite conclusions can be drawn regarding the safety for the elderly to use. It must be extensively researched how the EasyRaise can be made as safe as possible. Special use cases like intoxication and unwellness also need to be researched. In such a case the concept needs to be strictly reconsidered.

Target use location

Making permanent changes in a private setting was ruled out due to the increased costs and purchase threshold, among others. However, making such adaptations might be a realistic option in use locations like a hospital or nursing centre. Such an investment can be reconsidered when it is made to help a wider range of people.

Manufacturing

This project did not reach the phase where exact component sizing and manufacturing opportunities were investigated and concluded. It is important to gather more knowledge on how certain components need to be produced, for example the steel base frame. If possible an experienced manufacturing company can be contacted to explore such possibilities. A more detailed cost price estimation can then be set up.

Stigma

From user research it could not be concluded that the EasyRaise was considered a stigmatizing product, however, it can also not be excluded either. Having a helping product within sight can feel uncomfortable when other people are around. Primarily, it would be of great help to remove this stigma altogether. However, as this is probably hard to achieve in a short timespan, the EasyRaise should be made as non-stigmatizing as possible. A first step was made with customization options with coloured patterns, as described. In future work it should be explored how the EasyRaise can battle the stigma. Possible directions could be changing the colour or shape of the hand support or providing an informative pamphlet with information on toileting complaints.

Data capturing

The EasyRaise also has the potential to be utilised in data capturing, with respect to toileting behaviour. For the recommendation sheet of the plateau height or for medical research in general it could be interesting to see which height is preferred, and what body posture goes well with it. One of the options for such data capturing is implementing pressure sensors in the plateau, to find out more about weight distribution on different platform heights.

Project continuation

So what happens now that this thesis is completed? This subsection aims to explain some initial steps that could be taken after the project ends.

The first step would be to find a party that is interested in continuing with this project. A new master student could pick it up and bring the concept to a higher development stage, where more attention goes towards manufacturing and materialization instead of problem definition. Another option is making it a research project in name of the TU Delft or ErasmusMC, where a small development team could pick it up. A third option is collaborating with a commercial third party that is interested in such a product for their portfolio. An example of such a party could be BanoBenelux; who are quite experienced in developing bathroom helping tools.

The next phase would be looking into all further research topics that were aforementioned. Thoroough research on the safety of the platform is the recommended first step, as this is a big part of the concept. Additional topics that need extra inspection will probably come forward during this phase too. It is important to create the maximum amount of clarity on the details of the EasyRaise in this phase to make sure that the target group gets the most valuable product.

The final development stage revolves around making the concept production-ready. Exact component materialization and assembly is required before production can start. This report only discussed a portion of what needs to be known. The last step would be the actual manufacturing and getting the product to the right users.

Reflection

Looking back at the overall course of the project, I am satisfied with the achieved process and goals of this graduation thesis. The proposed concept was evaluated positively and is making way for an ergonomic improvement in toilet usage. The goal of the project was to propose a solution that is able to improve the user's toilet posture; which was accomplished. The proposed solution and its representing prototype are a mere proof of concept, rather than a final product. It is therefore that the future could have much in store for the EasyRaise, with all future work mentioned left to do. The quadruple aim structure mentioned as a foundation for the report was kept in the back of the mind throughout the process, but arguably not visible enough in the report. When the EasyRaise were to be developed further, taking a step back and seeing how the design influences other parties, like nursing staff, would be recommended.

Additionally, walking through an entire design process individually was quite challenging. Especially in combination with special circumstances like a global pandemic. In hindsight, the amount of topics that were discussed detracted from the content quality

of those topics; for example the materialization section. In future projects I would try to go more in-depth in a smaller amount of topics. Though there is room for improvements and elaborations, the process-driven results feel satisfactory. I am glad a possible continuation process was started up in the collaboration between TU Delft and ErasmusMC; only will time tell what it has in store for the EasyRaise.

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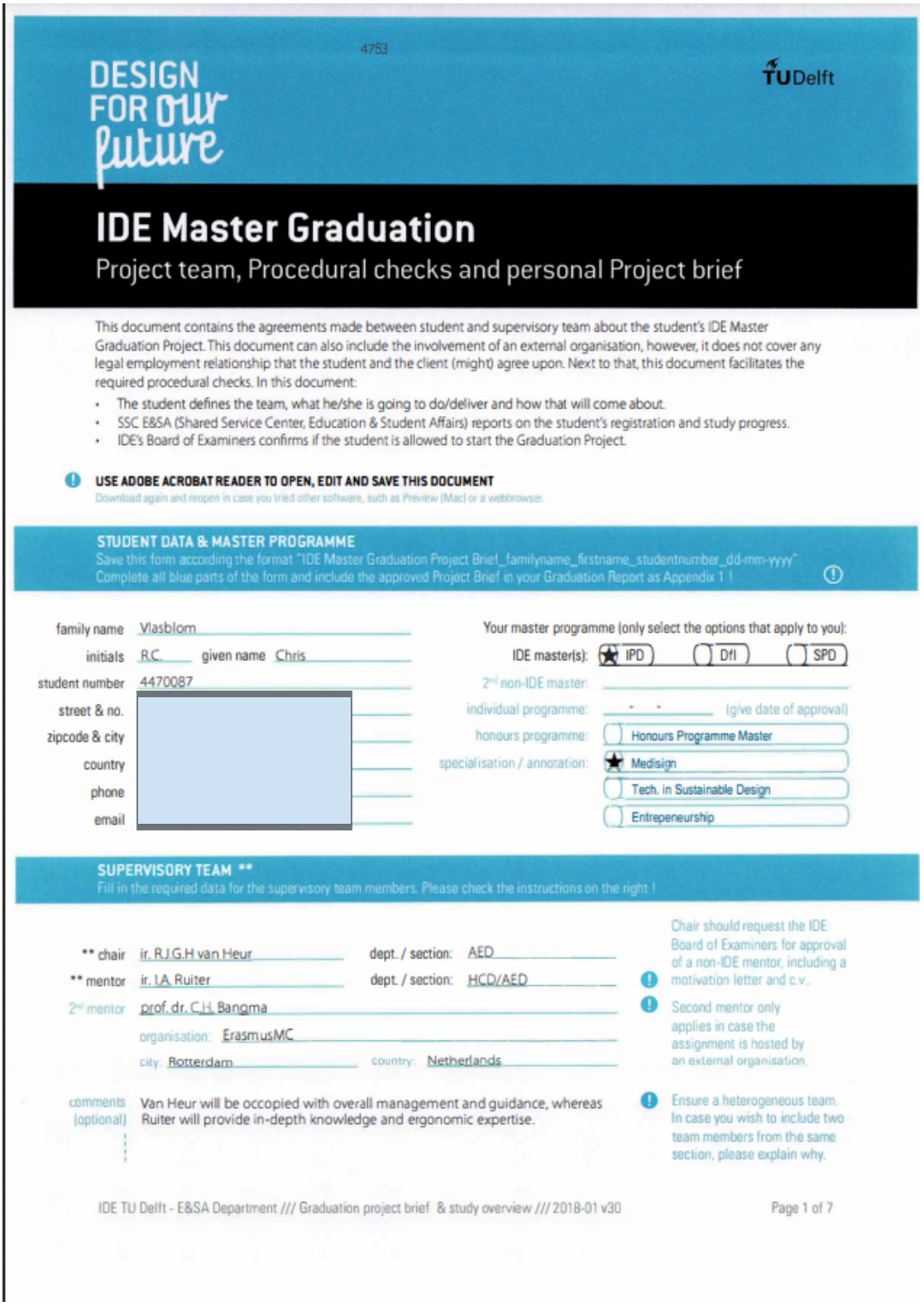
Appendices

Appendix A. Project brief



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DESIGN FOR our future

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT

Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy".
Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name: Vlasblom
initials: R.C. given name: Chris
student number: 4470087
street & no.:
zipcode & city:
country:
phone:
email:

Your master programme (only select the options that apply to you):
IDE master(s): ★ IPD ( ) DfI ( ) SPD
2nd non-IDE master:
individual programme: - - (give date of approval)
honours programme: ( ) Honours Programme Master
specialisation / annotation: ★ Medisign
( ) Tech. in Sustainable Design
( ) Entrepeneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair: ir. R.J.G.H van Heur dept. / section: AED
** mentor: ir. I.A. Ruiter dept. / section: HCD/AED
2nd mentor: prof. dr. C.H. Bangma
organisation: ErasmusMC
city: Rotterdam country: Netherlands

comments (optional): Van Heur will be occopied with overall management and guidance, whereas Ruiter will provide in-depth knowledge and ergonomic expertise.

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v.

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

IDE TU Delft - E&SA Department /// Graduation project brief & study overview /// 2018-01 v30 Page 1 of 7

TU Delft

Procedural Checks - IDE Master Graduation

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair ir. R.J.G.H van Heur date 19 - 02 - 2021 signature

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: 30 EC

Of which, taking the conditional requirements into account, can be part of the exam programme 30 EC

List of electives obtained before the third semester without approval of the BoE

(x) YES all 1st year master courses passed

( ) NO missing 1st year master courses are:

name C. van der Bunt date 23 - 02 - 2021 signature CB

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **.
Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: (V) APPROVED ( ) NOT APPROVED

Procedure: (V) APPROVED ( ) NOT APPROVED

- Also approved for Medisign

comments

name Monique von Morgan date 2/3/2021 signature MvM

Initials & Name R.C. Vlasblom Student number 4470087

Title of Project Adaptable toilet feet rest

Personal Project Brief - IDE Master Graduation

TU Delft

Adaptable toilet feet rest

project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 08 - 02 - 2021 09 - 07 - 2021 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

The urology department of the ErasmusMC in Rotterdam, coordinated by C.H. Bangma, initiated this graduation project. From their own experience they identified a gap in the home healthcare when it comes to autonomous and healthy toileting. They experience their patients having major difficulties using the toilet in an ergonomically healthy way, with consequences such as constipation.

Generally, for an optimal process of both micturition and defecation on a standard toilet, the pelvic floor muscles need to reach a certain level of relaxation. The body posture heavily influences this relaxation and is related to individual body dimensions (for example leg length).

Image 1A shows the 'standard' body position on a western toilet. Image 1B shows an alternative squatting defecation body position where the knees are located above the hips. Image 1C shows a possible body position of an elderly person that needs a toilet seat raiser to be able to get on and off the toilet more easily. In this case the product needs to support the feet to decrease the hip-leg angle.
In the case of small adults or children that are too small to reach the floor, image 1D shows that a feet support is needed to prevent dangling of the legs, which is disadvantageous for defecation due to muscle tightening. These images show the different scenarios in which the new product is required for a healthier body position.

An adjustable toilet feet rest that adjusts the 'height of the floor' was proposed by the ErasmusMC as a possible design direction. Adjustable in this sense would mean a fitted adaptation for each user to have the optimal body position and muscle relaxation. Verification of the adjustable toilet feet rest design direction will be the start of this graduation project.

The solution is interesting for both at home as well as in the hospital situation, therefore both scenarios and its stakeholders involved should be taken into account.

The goal of this graduation assignment is to provide a solution that allows the user to reach this ergonomic body position. The specific target group of this project will be chosen after analysing the problem scenario more thoroughly, because there are more than one potential target groups. Specifically, both elderly and children may benefit from such a product.

space available for images / figures on next page

Initials & Name R.C. Vlasblom Student number 4470087

Title of Project Adaptable toilet feet rest

introduction (continued): space for images

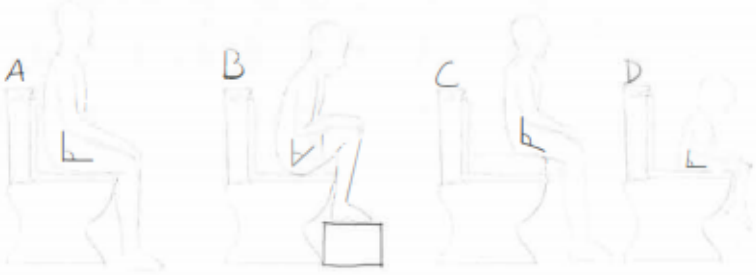


image / figure 1: Different body positions on a western toilet.

image / figure 2: Example of a currently available toilet feet rest.

Personal Project Brief - IDE Master Graduation

TU Delft

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

The main problem in this project is that some people, for example children and low-mobility elderly, cannot reach a body position with enough pelvic floor relaxation on current western toilets.

Current existing solutions that help relaxing the pelvic floor muscles generally do not suffice for these groups. Image 2 on the previous page shows such an existing solution, a simple and plain toilet feet rest. The user-friendliness and safety of use can be drastically improved for autonomous usage. For the elderly target group, such a product can be obstructing and unsatisfying to use, because it does not provide the support needed. The fixed height makes it unhandy for children.

It is important that the designed product will guarantee, among others, at least the following: ergonomic advantages, safety and ease of use. Ergonomic advantages are the sole purpose of this product, enabling a healthy toilet habit for the user. Safety and stability are also important factors to avoid dangerous falling situations for both fragile elderly and busy children. Therefore, sufficient support needs to be provided. Additionally, the product needs to not be a burden to use; a seamless and intuitive use scenario is envisioned to be most pleasing for the user.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

The main design challenges of this graduation project are verifying the design direction of the adjustable toilet feet rest for a specified target group, and developing it to a proof of concept.

In order to complete the main challenge, a number of sub challenges will be addressed. The most prominent sub challenges are: figuring out what ergonomic body position is optimal and how can a product provide this position; which target group is the most suitable for this project; how to keep the design as safe to use as possible without compromising on ease of use; how to make sure the product adapts optimally to each user's individual needs; how to setup clear and effective communication between user and product; and defining the general working principle of the proof of concept by making a prototype.

Secondary challenges that will be addressed less in-depth are: exploring design aesthetics that avoid stigmatizing elderly-bathroom aesthetics; exploring manufacturing possibilities (in relation to costs, durability, etc.); and exploring the relevancy for ErasmusMC or other parties to produce the product and find out what their requirements are.

The aspired end deliverable of this project is a working proof of concept prototype that showcases the intended use of the product and allows for testing of a number of design requirements. In addition, a report will support this proof of concept including the theoretical background behind the design, and an explanation of the design choices that were made. I am aiming to give recommendations on how to continue with this product for future use, relating to use scenario, materialization and manufacturing.

Initials & Name R.C. Vlasblom Student number 4470087

Title of Project Adaptable toilet feet rest

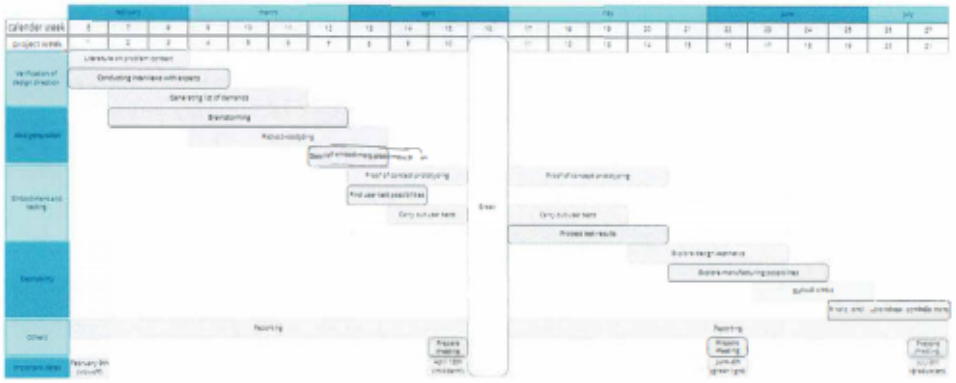
Personal Project Brief - IDE Master Graduation

TUDelft

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 8 - 2 - 2021 9 - 7 - 2021 end date



As shown in the Gantt diagram above, the project is split up into several sections. The activities within the sections may flow into each other, but the division was made to implement decision points. On such decision points, critical choices will have to be made to prevent dwelling on hard decisions and to keep a nice flow and speed in the project.

In the first few weeks the design direction of the adjustable toilet feet rest will be examined in relation to a specified target group. Ergonomic factors that need to be taken into account are at the foundation of this project. I would like start prototyping and trying out mechanism as soon as possible, in order to reach a working proof of concept in the end phase. To do so, prototyping, testing and making iterations are essential and take up quite some weeks in the middle. Carrying out user tests will be hard due to COVID-19, but I will have to see what possibilities will be present. The last phase of the project will revolve around the exploration of factors that influence the desirability of the product. If possible, contacts will be made with external companies that could have interest in this product.

After the mid-term presentation I will have a week holiday to recollect my thoughts and have fresh energy for the second half. Other days that will be taken off are: April 2 (Good Friday), April 5 (Easter) April 27 (King's Day), May 5 (Liberation Day), May 21 (Ascension Day). To compensate for these five working days, a week 21 was added to the planning.

Initials & Name R.C. Vlasblom Student number 4470087

Title of Project Adaptable toilet feet rest

Personal Project Brief - IDE Master Graduation

TU Delft

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

I think this graduation project is a perfect fit for my final project at the Technical University of Delft. Starting my bachelor Industrial Design Engineering I did not have a completely clear image of what actually interests me most. However, completing all the courses from the bachelor and master Integrated Product Design, it led me towards this project.

In my master courses I discovered that I love designing related to healthcare, hence the Medisign specialization. This project fits perfect within Medisign, and allows me to gain more experience in the healthcare field. After getting a first feel of the medical field during my internship at Crescent Technologies, it really triggered me to get more familiar with this subject. I am looking forward to get in contact with health professionals, patients and all other stakeholders to bring my medical specialization to a higher level.

Additionally, this particular graduation assignment is a quite concrete beginning for the design of a tangible product. I would not have wanted to do an academic research or service/app design graduation assignment. My interest lies in going through a concrete design process, and that is exactly what I expect to find in this project.
My personal learning goals to be explored and verified during this assignment are prototyping, healthcare experience and user centred design, and are discussed below.

Prototyping
During the bachelor and master courses there have been a number of prototyping possibilities, which I have not taken full advantage of in my opinion. However, I came to enjoy prototyping quite much so I would love to make that a significant part of this graduation project. There is so much to learn on rapid prototyping and how exactly it benefits design processes. I am excited to see how much I can progress in acquiring prototyping skills and applying them in this project.

Healthcare experience
During my internship and few master courses I have gotten a taste of what it is like to design products for the healthcare environment. It proved to me that there is a whole range of additional attention points in comparison to a regular design challenge. Not only is the design goal more meaningful in my experience, it also more challenging to truly satisfy a need. I am very interested in gaining more experience in this field to prepare me better for my future career, hopefully in the medical field.

User centred design
Making sure the product fits the user's needs is essential for any design process. For this project specifically, ergonomics is crucial for success. I want to verify my academic knowledge on this topic as well as going more in-depth and exploring new angles. By talking to medical experts and patients, doing online research and setting out surveys I aspire to integrate all stakeholders the best I can.

FINAL COMMENTS

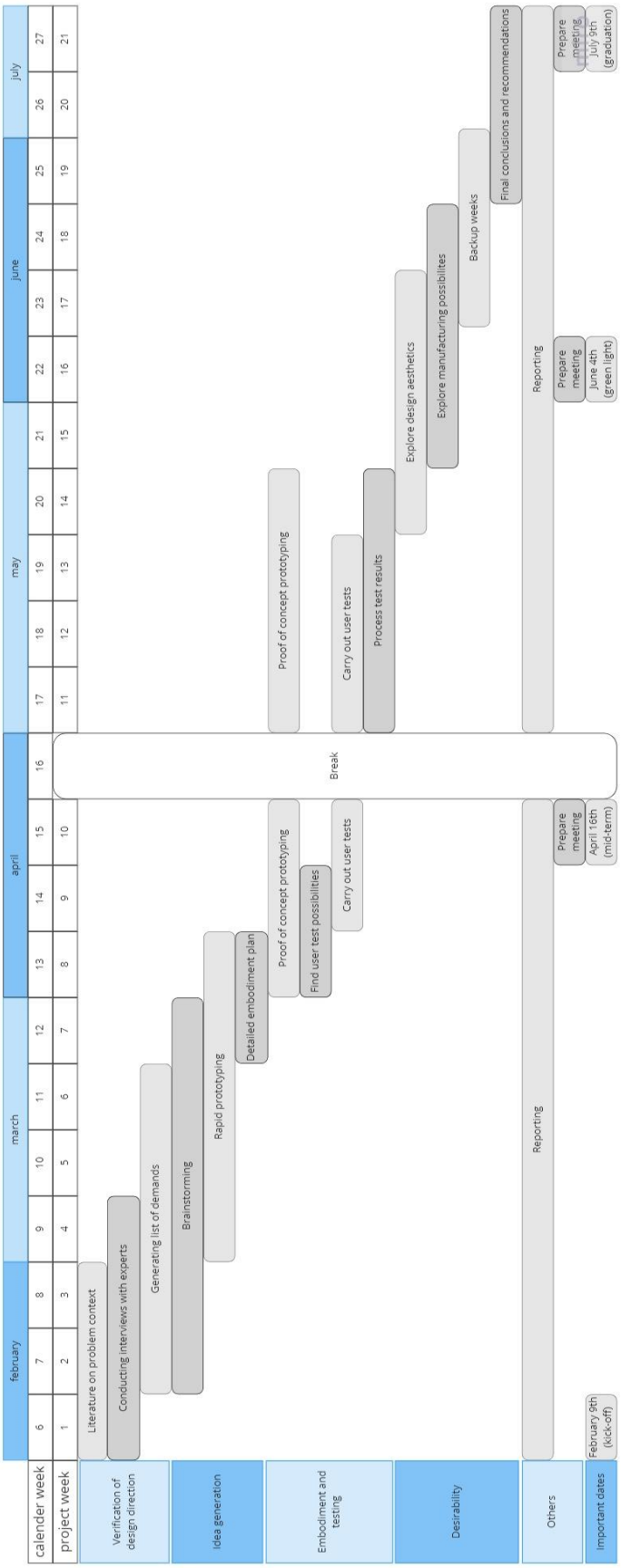
In case your project brief needs final comments, please add any information you think is relevant.

There is a prototyping budget available from ErasmusMC.

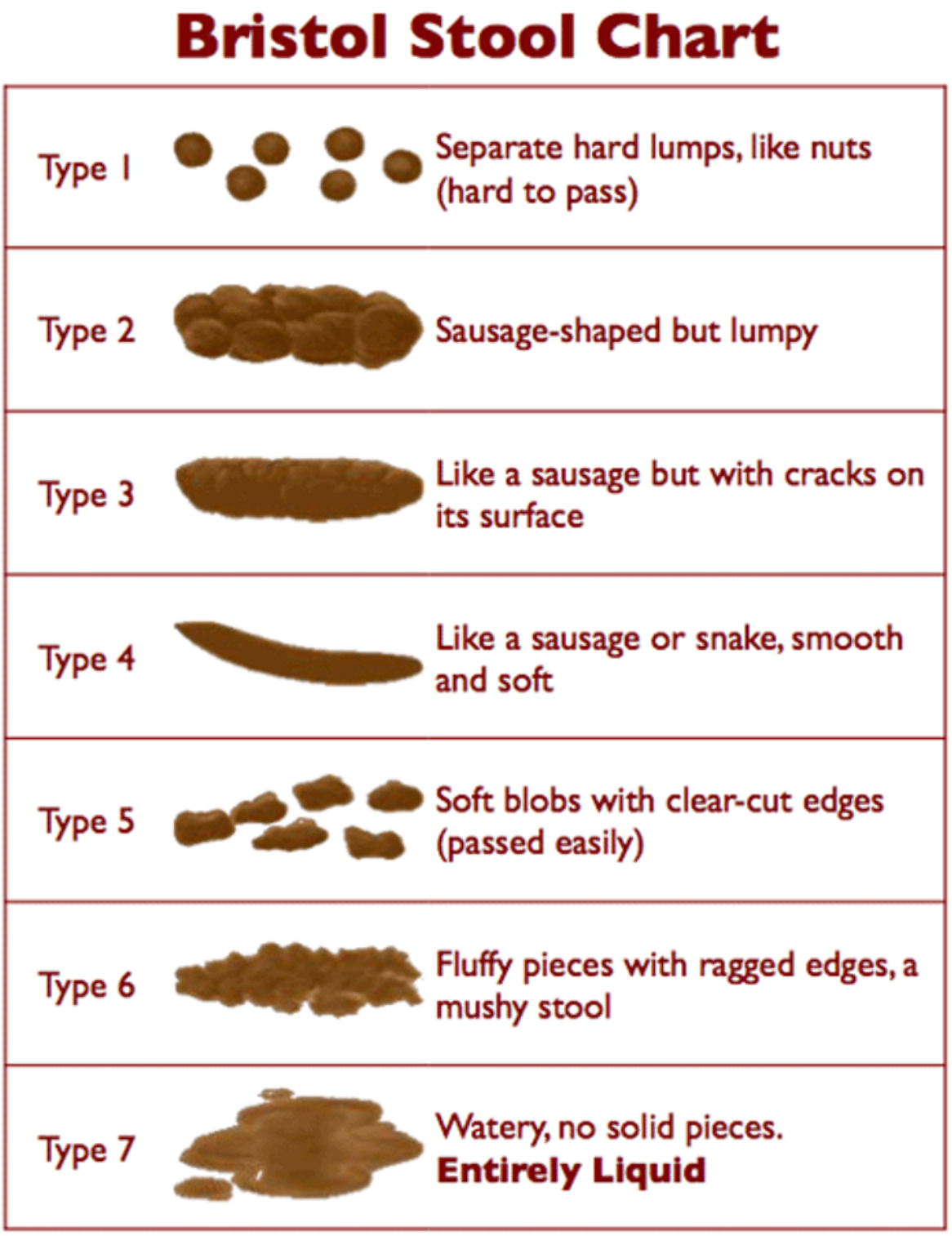
Initials & Name R.C. Vlasblom Student number 4470087

Title of Project Adaptable toilet feet rest

Appendix B. Project planning



Appendix C. Bristol Stool Chart



Nursing.nl, 2009

Appendix D. Toilet images

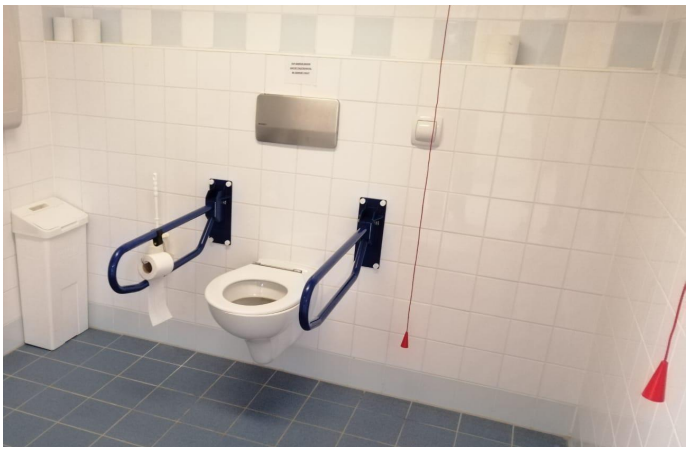
Images of toilets. What are common items to keep in mind.







leanLease




1.
2.
3.
4.

Appendix E. Support images

A mechanical support structure that moves the user upwards when descending from the toilet (FINLANDIC, n.d.)

A toilet seat raiser combined with arm support (Thuiszorg Webshop, n.d.).

The well-known arm support that can be installed right next to the toilet. It can be found in many public restrooms too (Badkamerwinkel, n.d.). These arm supports were also found during a visit to a nursing home. These toilets include the arm support on both sides of the toilet (also in the second image a toilet seat raiser is visible).

Images taken of toilets at nursing homes.

Appendix F. Primary user questionnaire

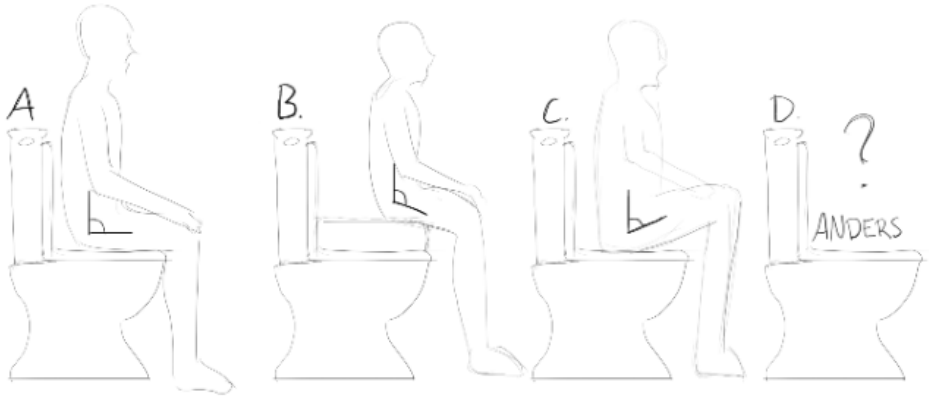
Mail to elderly panel via TU Delft contact person Bertus Naagen.

Geachte heer/mevrouw,

Mijn naam is Chris Vlasblom en ben een afstudeerder bij de TU Delft, bij de master opleiding Integrated Product Design. Als afstudeeropdracht ben ik in samenwerking met het ErasmusMC bezig aan een hulpmiddel voor ouderen om een betere lichaamshouding aan te kunnen nemen tijdens de ontlasting. Bij deze houding zijn de knieën boven de heupen gepositioneerd, in de richting van een hurk-houding. Met het te ontwerpen hulpmiddel wil ik ouderen helpen deze houding aan te nemen, om zo ontlasten makkelijker te maken en obstipatie tegen te gaan. Ik zou u hier graag een paar korte vragen over willen stellen.

U kunt de antwoorden op de vragen gewoon in een reactie-mail zetten, of telefonisch bespreken via onderstaand telefoonnummer. Belangijk om te noemen is dat alle antwoorden alleen gebruikt zullen worden voor dit project, waarbij alleen mijn begeleiders en ik de resultaten te zien krijgen.

1. Ten eerste ben ik geïnteresseerd in uw lichaamshouding als u op het toilet zit.
a. Kunnen uw voeten plat op de grond staan?
b. Leunt u met uw rug tegen de achterleuning aan, of leunt u juist naar voren?
c. Zijn er andere eigen maniertjes waar u gebruik van maakt?
d. Welke tekening (letter) lijkt het meeste op uw eigen houding? (Bij D. beschrijf uw houding)



2. Daarnaast vraag ik mij af wat er wel eens mis gaat tijdens een bezoek aan het toilet. Hieronder staan een aantal mogelijke antwoorden voor inspiratie. Wat doet u om dit deze problemen tegen te gaan?

- Richting toilet draaien
- Broek uitdoen en laten zakken
- Op toilet gaan zitten
- Balanseren tijdens het zitten
- Van toilet af komen
- Broek omhoog trekken en aandoen
- Overig (zelf invullen)

3. Ten derde ben ik ook geïnteresseerd in hoe uw toiletruimte eruit ziet. Heeft u hulpmiddelen in de toiletruimte? Zo ja, welke zijn dit en wat is hun functie? (denk aan hulpmiddelen zoals steunbeugels, toiletbril verhogers, etc.).
Mocht het mogelijk zijn voor u, dan kunt u een foto van de toiletruimte en eventuele hulpmiddelen maken en met deze mail meesturen, dit zou mij erg helpen.

Als afsluiting wil ik u een hele open vraag stellen: wat moet ik naar uw mening absoluut niet vergeten bij het ontwerpen van dit ttoilet-hulpartikel voor ouderen?

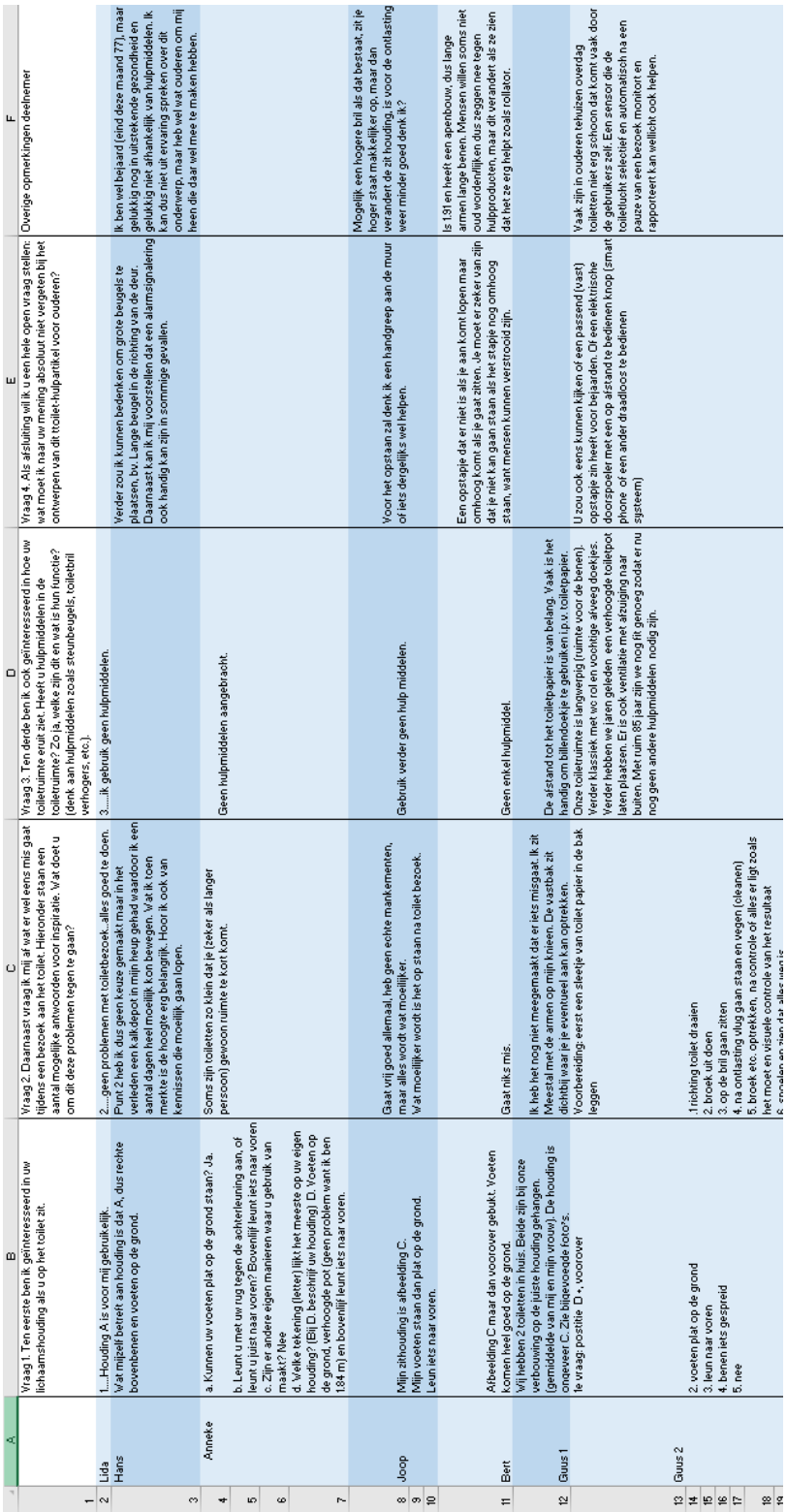
Ik wil u hartelijk bedanken voor uw tijd en moeite om mij te helpen bij mijn project. Ik kijk uit naar uw antwoorden. Ik ben natuurlijk ook te bereiken op mijn telefoonnummer 0611162698, als u dat makkelijker vind antwoorden.

Met vriendelijke groet,

Chris Vlasblom

Appendix G. Questionnaire responses

Full responses on the first questionnaire by 7 respondents.



	A	B	C	D	E	F
1		Vraag 1. Ten eerste ben ik geïnteresseerd in uw lichaamshouding als u op het toilet zit.	Vraag 2. Daarnaast vraag ik mij af wat er wel eens mis gaat tijdens een bezoek aan het toilet. Hieronder staan een aantal mogelijke antwoorden voor inspiratie. Wat doet u om dit deze problemen tegen te gaan?	Vraag 3. Ten derde ben ik ook geïnteresseerd in hoe uw toiletruimte eruit ziet. Heeft u hulpmiddelen in de toiletruimte? Zo ja, welke zijn dit en wat is hun functie? (denk aan hulpmiddelen zoals steunbeugels, toiletbril verhogers, etc.).	Vraag 4. Als afsluiting wil ik u een hele open vraag stellen: wat moet ik naar uw mening absoluut niet vergeten bij het ontwerpen van dit toilet-hulpartikel voor ouderen?	Overige opmerkingen deelnemer
2	Lida	1....Houding A is voor mij gebruikelijk.	2....geen problemen met toiletbezoek..alles goed te doen.	3....ik gebruik geen hulpmiddelen.		
3	Hans	Wat mijzelf betreft aan houding is dat A, dus rechte bovenbenen en voeten op de grond.	Punt 2 heb ik dus geen keuze gemaakt maar in het verleden een kalk depot in mijn heup gehad vaardoor ik een aantal dagen heel moeilijk kon bewegen. Vat ik toen merkte is de hoogte erg belangrijk. Hoor ik ook van kennissen die moeilijk gaan lopen.		Verder zou ik kunnen bedenken om grote beugels te plaatsen, bv. Lange beugel in de richting van de deur. Daarnaast kan ik mij voorstellen dat een alarmsignalering ook handig kan zijn in sommige gevallen.	Ik ben wel bejaard (eind deze maand 77), maar gelukkig nog in uitstekende gezondheid en gelukkig niet afhankelijk van hulpmiddelen. Ik kan dus niet uit ervaring spreken over dit onderwerp, maar heb wel wat ouderen om mij heen die daar wel mee te maken hebben.
4	Anneke	a. Kunnen uw voeten plat op de grond staan? Ja.	Soms zijn toiletten zo klein dat je (zeker als langer persoon) gewoon ruimte te kort komt.	Geen hulpmiddelen aangebracht.		
5		b. Leunt u met uw rug tegen de achterleuning aan, of leunt u juist naar voren? Bovenlijf leunt iets naar voren				
6		c. Zijn er andere eigen manieren waar u gebruik van maakt? Nee				
7		d. Welke tekening (letter) lijkt het meeste op uw eigen houding? (Bij D. beschrijf uw houding). D. Voeten op de grond, verhoogde pot (geen problem want ik ben 184 m) en bovenlijf leunt iets naar voren.				
8	Joop	Mijn zithouding is afbeelding C.	Gaat vrij goed allemaal, heb geen echte mankementen, maar alles wordt wat moeilijker.	Gebruik verder geen hulp middelen.	Voor het opstaan zal denk ik een handgreep aan de muur of iets dergelijks wel helpen.	Mogelijk een hogere bril als dat bestaat, zit je hoger staat makkelijker op, maar dan verandert de zit houding,is voor de ontlasting weer minder goed denk ik.?
9		Mijn voeten staan dan plat op de grond.	Wat moeilijker wordt is het op staan na toilet bezoek.			
10		Leun iets naar voren.				
11	Bert	Afbeelding C maar dan voorover gebukt. Voeten komen heel goed op de grond.	Gaat niks mis.	Geen enkel hulpmiddel.	Een opstapje dat er niet is als je aan komt lopen maar omhoog komt als je gaat zitten. Je moet er zeker van zijn dat je niet kan gaan staan als het stapje nog omhoog staan, want mensen kunnen verstrooid zijn.	Is 1.91 en heeft een apenbouw, dus lange armen lange benen. Mensen willen soms niet oud worden/lijken dus zeggen nee tegen hulpproducten, maar dit verandert als ze zien dat het ze erg helpt zoals rollator.
12	Guus 1	Vrij hebben 2 toiletten in huis. Beide zijn bij onze verbouwing op de juiste houding gehangen. (gemiddelde van mij en mijn vrouw). De houding is ongeveer C. Zie bijgevoegde foto's.	Ik heb het nog niet meegemaakt dat er iets misgaat. Ik zit Meestal met de armen op mijn knieen. De vastbak zit dichtbij waar je je eventueel aan kan optrekken.	De afstand tot het toiletpapier is van belang. Vaak is het handig om billendoekje te gebruiken i.p.v. toiletpapier. Onze toiletruimte is langwerpig (ruimte voor de benen). Verder klassiek met wc rol en vochtige afveeg doekjes. Verder hebben we jaren geleden een verhoogde toiletpot laten plaatsen. Er is ook ventilatie met afzuiging naar buiten. Met ruim 85 jaar zijn we nog fit genoeg zodat er nu nog geen andere hulpmiddelen nodig zijn.	U zou ook eens kunnen kijken of een passend (vast) opstapje zin heeft voor bejaarden. Of een elektrische doorspoeler met een op afstand te bedienen knop (smart phone of een ander draadloos te bedienen systeem)	Vaak zijn in ouderen tehuizen overdag toiletten niet erg schoon dat komt vaak door de gebruikers zelf. Een sensor die de toiletlucht selectief en automatisch na een pauze van een bezoek monitort en rapporteert kan wellicht ook helpen.
13	Guus 2		1richting toilet draaien			
14		2. voeten plat op de grond	2. broek uit doen			
15		3. leun naar voren	3. op de bril gaan zitten			
16		4. benen iets gespreid	4. na ontlasting vlug gaan staan en wegen (oleanen)			
17		5. nee	5. broek etc. optrekken, na controle of alles er ligt zoals het moet en visuele controle van het resultaat			
18			6. spoelen en zien dat alles weg is			
19						

Appendix H. Questionnaire nursing home staff

Vragenlijst Zorgcentrum - medewerker

1. Voorstellen (Medisign, etc.)
2. Project uitleggen (ErasmusMC, geen goede ontlast houding, onderzoekfase)
3. Dit gesprek doel (informatie verzamelen)
4. Wat vragen voorbereid
5. Over uzelf, kunt u zich voorstellen, waar houd u zich mee bezig?

Toiletruimte

- Foto nemen gehele ruimte
- Toiletpot
    - o Hoogte meten
    - o Foto nemen
    - o Is er regelgeving voor dat elke pot hetzelfde moet zijn?
    - o Raden jullie bewoners iets aan? E.g. 46 cm

- Hulpmiddelen
    - o Welke hulpmiddelen in toiletruimte?
    - o Foto's nemen
    - o Wat is de voornaamste reden voor gebruik?
    - o Nadelen van gebruik?
    - Mogen bewoners zelf beslissen over aanschaf of is alles centraal? Wat weet u over centrale aanschaf?
    - o Is er hand/arm support rondom toilet?
        - § Heeft iedereen dezelfde? Mag je zelf kiezen?

Huidige situatie

-

Wat is bij jullie bekend over obstipatie problemen?

-

Komt het veel voor?

- Hoe wordt het opgelost?
    - o
    - Worden vaak laxeermiddelen gebruikt?
    - o Worden er wel eens voetkrukjes gebruikt?
    - o
    - Wat zijn daar de goede en minder goede kanten van?

-

Welke behoeftes krijgen jullie vanuit de patiënten/bewoners te horen of te zien.

Doelgroep

- Bieden medewerkers/u hulp bij het toiletteren?
    - o Wat zijn dan moeilijkheden?
    - o Waar moet ik op letten?
    - Welke houding wordt vaak aangenomen? (kiezen uit afbeeldingen)
    - Kunnen voeten plat?
- De knieën buigen een probleem? Ook al is het een passieve beweging?

Algemeen: Waar moet ik op letten? (in de weg staan, hygiëne, etc.)

Afsluiting

- Met wie nog meer praten?
- Waar andere informatie zoeken?
- Bedankt voor uw tijd en moeite.

Appendix I. Consent form interviewees.

Toestemmingsverklaring Onderzoek Lichaamspositie Op Toilet

door Chris Vlasblom

Vink de toepasselijke antwoorden aan	**Yes**	**No**
Deelname aan de studie		
Ik heb de onderzoekinformatie van 01/04/2021 gelezen en begrepen, of het is aan mij voorgelezen. Ik heb vragen kunnen stellen over het onderzoek en de vragen zijn goed beantwoord.	□	□
Ik stem vrijwillig toe deel te nemen aan dit onderzoek en ik begrijp dat ik kan weigeren om vragen te beantwoorden, en ik kan op elk moment stoppen met de deelname zonder een reden te hoeven geven.	□	□
Ik begrijp dat deelname aan het onderzoek inhoud dat informatie die ik geef opgeslagen word. De informatie wordt opgeslagen door geschreven notities en, bij toestemming, ook met foto's. De onderzoeker zal de vragenlijst invullen. De foto's zullen verwijderd worden als het project ten einde is gekomen.	□	□
Ik begrijp dat deelname aan de studie de volgende risico's met zich meebrengt: discomfort tijdens het beantwoorden van persoonlijke vragen.	□	□
Gebruik van informatie uit de studie		
Ik begrijp dat de informatie die ik geeft wordt gebruikt voor een afstudeerproject. Dit bevat gebruik voor inspiratie bij product ontwerp, gebruik in een verslag, gebruik in een presentatie, en gebruik voor bespreking materiaal met begeleiders.	□	□
Ik begrijp dat persoonlijke informatie die wordt opgeslagen die mij kunnen identificeren, zoals mijn naam, niet gedeeld zullen worden door het onderzoeksteam.	□	□

Ik geef toestemming dat mijn antwoorden als quote gebruikt kunnen worden in resultaten.	□	□
Ik geef toestemming dat er foto's gemaakt mogen worden van mijn leefomgeving. Ik begrijp dat deze foto's alleen in dit project gebruikt worden en verwijderd zullen worden na afloop.	□	□
Toekomstig gebruik en hergebruik van de informatie door anderen		
Ik geef toestemming dat de verbale antwoorden die ik geef opgeslagen mogen worden in de onderzoekers persoonlijke notitieboek en google drive, zodat het later gebruikt kan worden tijdens het project.	□	□
Handtekeningen		
_____ _____ _____ Naam deelnemer Handtekening Datum		
Ik heb de informatie duidelijk voorgelezen aan de potentiële deelnemer, en zo goed als ik kan verzekert dat de deelnemer begrijpt waar hij/zij vrijwillig aan deelneemt. _____ _____ _____ Naam onderzoeker Handtekening Datum		
Contactgegevens onderzoeker: Chris Vlasblom, r.c.vlasblom@student.tudelft.nl		

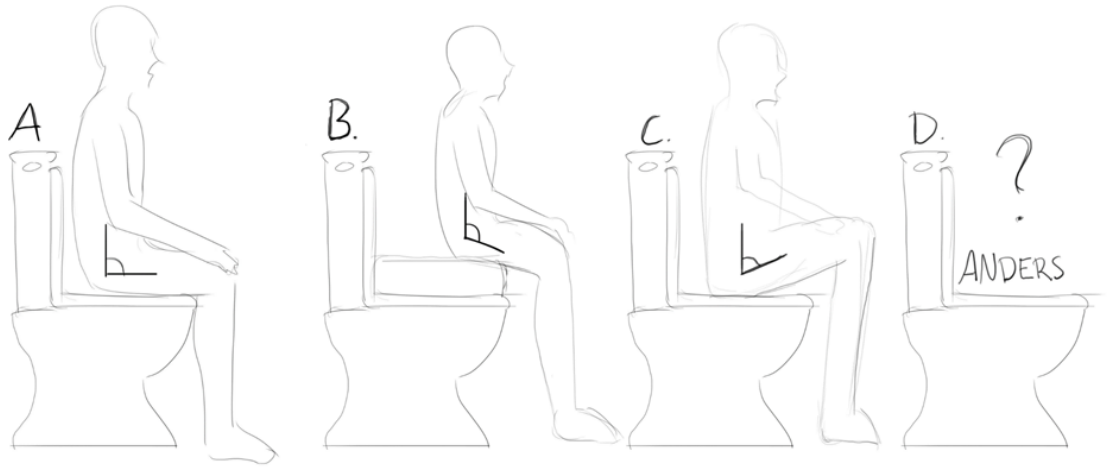
Appendix J. Questionnaire nursing home inhabitants

Vragenlijst doelgroup - gebruiker

1. Voorstellen (Medisign, etc.)
2. Project uitleggen (ErasmusMC, geen goede ontlast houding, onderzoekfase)
3. Dit gesprek doel (informatie verzamelen)
4. Wat vragen voorbereid
5. Maar eerst, uw toestemming om antwoorden te gebruiken in het project

Lichaamspositie

- Kunnen uw voeten plat op de grond?
- Leunt u met uw rug tegen de achterleuning aan, of leunt u juist naar voren?
- Zijn er andere eigen manieren waar u gebruik van maakt?
- Welke tekening (letter) lijkt het meeste op uw eigen houding? (Bij D. beschrijf uw houding)



Moeilijkheden

Daarnaast vraag ik mij af wat er wel eens mis gaat tijdens een bezoek aan het toilet. Hieronder staan een aantal mogelijke antwoorden voor inspiratie. Wat doet u om dit deze problemen tegen te gaan?

- Richting toilet draaien
- Broek uitdoen en laten zakken
- Op toilet gaan zitten
- Balanseren tijdens het zitten
- Van toilet af komen
- Broek omhoog trekken en aandoen
- Overig (zelf invullen)

Toiletruimte

Foto nemen gehele ruimte

- Toiletpot
  - Hoogte meten
  - Foto nemen

- Hulpmiddelen
  - Welke hulpmiddelen in toiletruimte?
  - Foto's nemen
  - Wat is de voornaamste reden voor gebruik?
  - Nadelen van gebruik?
  - Is er hand/arm support rondom toilet?

Algemeen: Wat mag ik absoluut niet vergeten? (in de weg staan, hygiëne, etc.)

Afsluiting

- Met wie nog meer praten?
- Waar andere informatie zoeken?
- Bedankt voor uw tijd en moeite.

Appendix K. Toilet usage observation notes

Observed by M. Loth

Participant	1.Hoe ver staan de voeten uit elkaar? 2. Hoe ver staan de voeten van de pot?	Stand van de voeten: 1.Recht vooruit 2.Naar binnen wijzend 3.Naar buiten wijzend	Hoe ver vanaf toilet draaien/oriënteren participanten om te gaan zitten?	Waar wordt rollator gezet? Strak langs toiletpot?	Is afvegen altijd de laatste stap voor het opstaan?	Opmerkingen
1/ Vrouw rollator in mock-up (kleding aan) In mock-up vonden de observaties plaats met de kleding aan.	Wisselt, soms zoals je verwacht dus voeten naar voren en dusdanig uit elkaar als op een stoel, maar ook linkervoet naar voren en vaak rechtervoet vrij ver van de pot. Soms ook beide voeten vrij ver van de pot.	Wisselt veel. Meestal naar buiten, Maar ik heb het vermoeden dat ze recht vooruit worden gehouden als ze 'echt' gebruik maakt van het toilet	In de buurt van het toilet. Ze beweegt veel, staat weer op en gaat weer zitten. In deze observatie worden de kleren aangelaten	Nee, ze zet de rollator er dusdanig vanaf dat ze er nog langs kan, wat betreft handenwassen en toiletteren. Ze maakt gebruik van de steunen aanwezig in het toilet. Een handgreep van de rollator binnen handbereik (van rechterhand). De rollator staat aan de rechterkant (daar is de ruimte). Voor het openen van de deur (dan is ze al opgestaan) pakt ze haar rollator om te steunen.	Ligt eraan of ze stabiel is. In de trein gaan ze soms weer zitten (door het wiebelen).	Deze mevrouw kon makkelijk opstaan van toilet en gebruikte daarvoor de steunen. Soms pakte ze ook een rollatorhandgreep. Er worden veel vragen gesteld en daarmee een vrij lang verblijf van 16 minuten.

2/ Man met stoma 'echte' observatie Echte observatie wil zeggen dat er daadwerkelijk geplast werd. In trein toilet van rijdende trein	Benen zover uit elkaar terwijl onderbroek om knie/onderbeen is, dus dat is de bewegingsvrijheid van de benen. Benen en daarmee voeten staan vrij ver uit elkaar. Voeten op zo'n afstand als dat hij zit op stoel. Hij zit met rug dicht tegen de muur aan, dus ver naar achteren.	Voeten rechtvooruit	Hij staat voor het toilet met rug naar de muur. Doet broek helemaal naar beneden, onderbroek net onder de knieholte en gaat zitten.	n.v.t.	Ja, laatste stap voor opstaan.	Maakt gebruik van toilet. Wast ook de handen. Dan staan de voeten anders.
3/ Vrouw rolstoel 'echte' observatie:	Onderbroek net boven de knieholte en dat bepaalt net als bij 2M hoe ver ze haar benen kan spreiden. De hiel van de voeten staan dicht bij de pot.	Ze zit een beetje schuin met haar lichaam op de pot en voeten recht naar voren	Zij staat dichtbij de WC.	Rolstoel zo gezet, ze maakt een draai met rug naar de muur, onderbroek naar beneden en ze gaat op WC zitten. Ze houdt tussen haar knieen en voorkant rolstoel ongeveer 30 cm. Ook bij deze observatie net als bij rollator, houdt ze het handvat van de rolstoel binnen handbereik.	Ze veegt zittend af, gaat staan dus laatse stap, maakt een draai en gaat weer zitten in de rolstoel.	Rolstoel kan geen draai maken. De participant kan opstaan en maakt zelf de draai met rug naar de muur.

4/ Vrouw 'Echte' observatie	Wast haar handen voordat ze naar het toilet gaat en doet ruim voor het toilet de riem los van haar broek. Onderbroek net boven de knie en broek net onder de knieholte Dit bepaalt hoever ze de voeten uit elkaar kan houden. Heup breedte is goed aangenomen. Ze rust met haar onderarmen op haar bovenbeen	Voeten recht vooruit. Ze buigt haar knieën en gaat zitten. Ze zit 'vooraan' het toilet. Daarom staan haar voeten vrij ver van het toilet. Ik schat 30 cm (hiel).	Ze doet staande haar kleding weer aan, best ver voor het toilet, maar zet geen stap naar voren. Tijdens het spoelen van het toilet staat ze erg ver van het toilet met gezicht naar de (achter) muur.	n.v.t.	Ja in dit geval, veegt ze zich af terwijl ze opstaat.	Spoelknop bevindt zich vrij hoog (25 cm.)boven opgeklapte zitting.
5/ Vrouw 'Echte' observatie	Onderbroek boven de knie en broek ruim onder de knie, benen dicht bij elkaar	Voeten recht vooruit zodra ze gebruik gaat maken van toilet. Dichtbij toilet, ik schat 10 cm (hiel).	Doet staande haar kleding aan. Voeten vrij ver uit elkaar, ongeveer 35 cm. Let ook op het spoelen van het toilet. Dat doet ze met haar gezicht naar de muur.	n.v.t.	Ja, in dit geval veegt ze zich zittend af.	Ze maakt eerst de bril schoon. Voeten dan ver van toilet zijwaarts. In een thuis situatie kan dit ook gebeuren, echter minder vaak.

Appendix L. List of wishes and requirements

A living document that is continuously updated. According to Pugh's list. Page 168 in Roozenburg & Eekels.

Demands

1. Performance
    a. The product must enable the user to take a healthy and comfortable body position on the toilet; i.e. allow for at least a 30-degree angle between upper legs and spine.
    b. The product must provide support for sitting down and standing up from the toilet.
    c. The product must provide support for balance while sitting on the toilet.
    d. The product must not obstruct the user from sitting down as they would without the product.
    e. The product must not obstruct any other activities on and around the toilet.
    f. The product must be able to serve a user up to 120 kg.
    g. The product must not add more than 2 minutes to the regular toilet ritual.
    h. The product must be designed for elderly users specifically.
    i. The plateau height must be adjustable on a millimetre level.

2. Environment
    a. The product must be resistant to urine splatter.
    b. The product must be resistant to defecation splatter.
    c. The product is to be used in a toilet area.
    d. The product must be resistant to usage in a moist space like the bathroom.
    e. The product must withstand temperatures between 0 and 40 degrees Celsius.

3. Life in service
    a. When used 4 times a day, the product must function for 5 years without any maintenance.
    b. The product must function on its own power supply or regular 220W socket power.
        i. Recharging or replacing the power supply must be done by the user.
    c. Any part of the product must be repairable, without being destroyed.

4. Maintenance
    a. The product must be cleanable with regular household cleaning products.
    b. The product must be cleanable within 15 minutes.
    c. All components of the product must be replaceable.
    d. The product must be resistant to water splashing.
    e. The product's housing must allow the replacement of internal components.

5. Target production costs

    a. The product's production price must be a maximum of €600.

6. Transport
    a. The product must withstand regular transportation conditions.
    b. The product must be carryable by one person

7. Packaging
    a. The product's packaging must protect the product during transportation.

8. Quantity
    a. Based on estimations of the Dutch target group, 50.000 pieces is the starting quantity for production (5% of the estimated amount of elderly with constipation in the Netherlands).

9. Manufacture
    a. The product must be manufacturable with existing technologies.

10. Size & weight
    a. The product must be usable for both left- and right handed people.
    b. The product must weigh less than 200kg.
    c. The product maximum dimensions are 100 x 100 x 100 cm.
    d. The product must fit in a regular toilet space and around standardized toilets.
    e. The products must fit a toilet height of 52 cm.

11. Aesthetics (form, colour, finishing)
    a. The product must be considered non-stigmatizing by the target group.
    b. The product must generally fit in a bathroom style.
    c. The product must give confidence to the user while using it.

12. Materials
    a. Only non-toxic materials can be used in the product.
    b. The materials used must be resistant to water-caused deformation.
    c. The product must consist of 70% readily available components.

13. Product life span
    a. The product is expected to be produced for the coming 10 years.
    b. The product is expected to be sold until new toilet habits or new toilet bowl shapes are the standard.

14. Norms and standards
    a. The product must comply with the Dutch and European legislation on production and distribution.

15. Ergonomics
    a. The product's usage must be comprehensible by the Dutch elderly.
    b. The product must fit the Dutch' elderly body dimensions. P1 to P99 regarding leg length.
    c. The foot plateau must fit all P1 to P99 foot sizes for the Dutch elderly.

d. The product's controls must be adjustable by the user.
e. All communication from product to user needs to be clear.
f. The product must enable intuitive usage.
g. The level of comfort must be equal for all users between P5 and P95.
h. The product must be controlled with physical buttons.

i. The product should be as easy to use as possible.
j. The product should provide the most comfort during defecation as possible

16. Chance to failure (Bedrijfszekerheid)
    a. The product must not fail to support the user.
    b. The product must not fail to guide the user.
    c. The product's controls must not fail during use.

17. Storage
    a. The product must be stored without any consequence to its functionality for 5 years after production.

18. Testing
    a. The product must conform to all Dutch and European legislative quality tests..

19. Safety
    a. The product must conform to all Dutch and European legislative safety tests.
    b. The product must avoid all causes of falling from the toilet.

    c. The product should be as safe as possible.

20. Product policy
    a. As of current, it belongs to no product portfolio.

21. Political and social implications
    a. The product must fight the stigmatizing image around constipation problems.

    b. The product should be as non-stigmatizing as possible

22. Liability
    a. The manufacturer is responsible for all assembly risks.

23. Installation & commissioning (ingebruikstelling)
    a. The product must not interfere with any other product surrounding it.
    b. With the use of the instruction manual, the user must understand the functioning of the product within 30 minutes.
    c. The product will be installed by an educated/specified installation person.

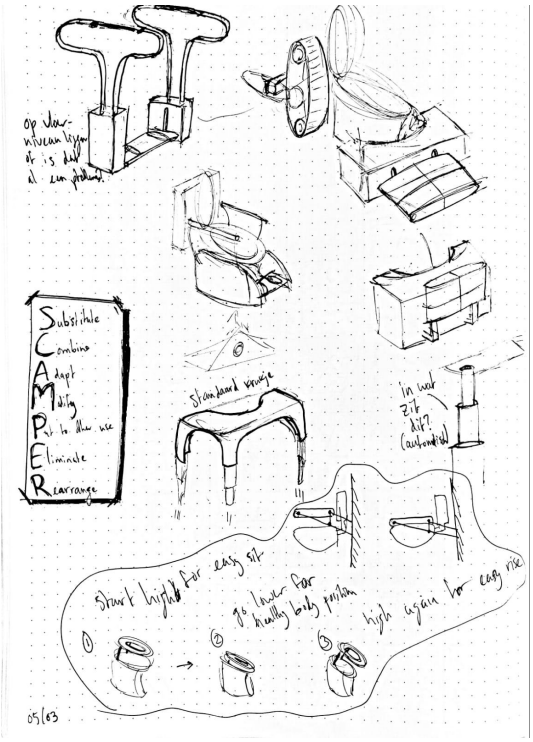
24. Disposal
    a. The product's recyclable components must be separable.
    b. The product's reusable components must be separable.

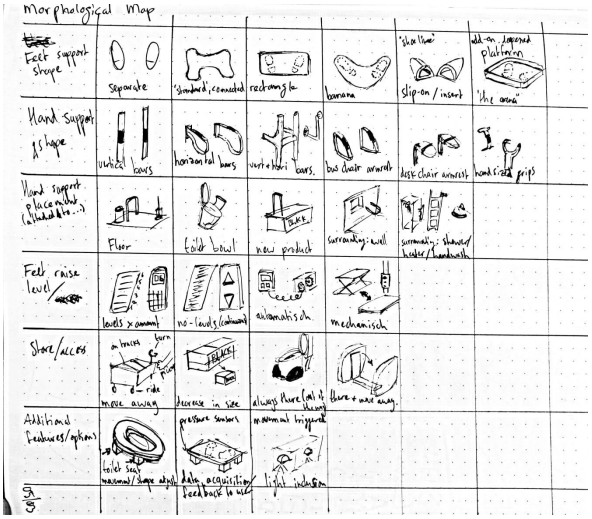
Wishes

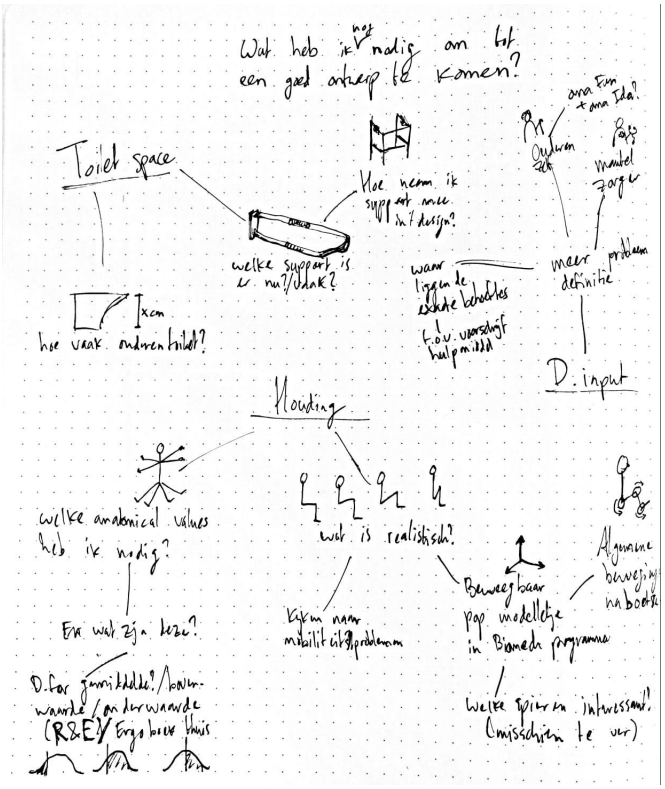
1. The product must be as safe as possible.
2. The product must be as easy to use as possible.
3. The product must be as little obstructing outside of use as possible.
4. The product must provide as much support for balancing, sitting down and standing up as possible.
5. The product must be as easily cleaned as possible.
6. The product must serve the biggest user group possible (ergonomically).
7. The product must be as durable as possible.
8. The product must be as cheap to produce as possible.
9. The product must be as non-stigmatizing as possible.
10. The product must be as easy to install as possible.
11. The product must be as environmentally friendly manufactured as possible.

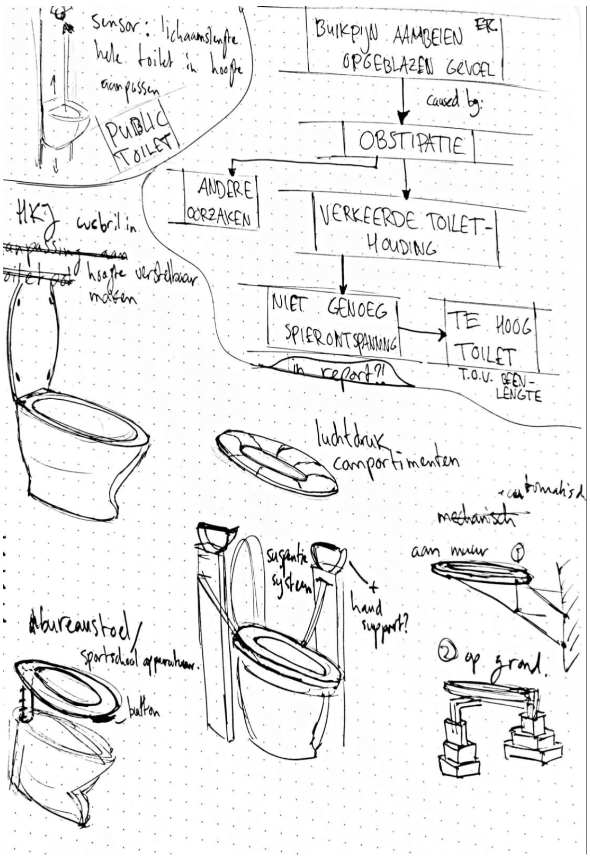
Appendix M. Ideation notebook scans

The following scans were taken from the author's notebook, to give an indication of the ideation activities.

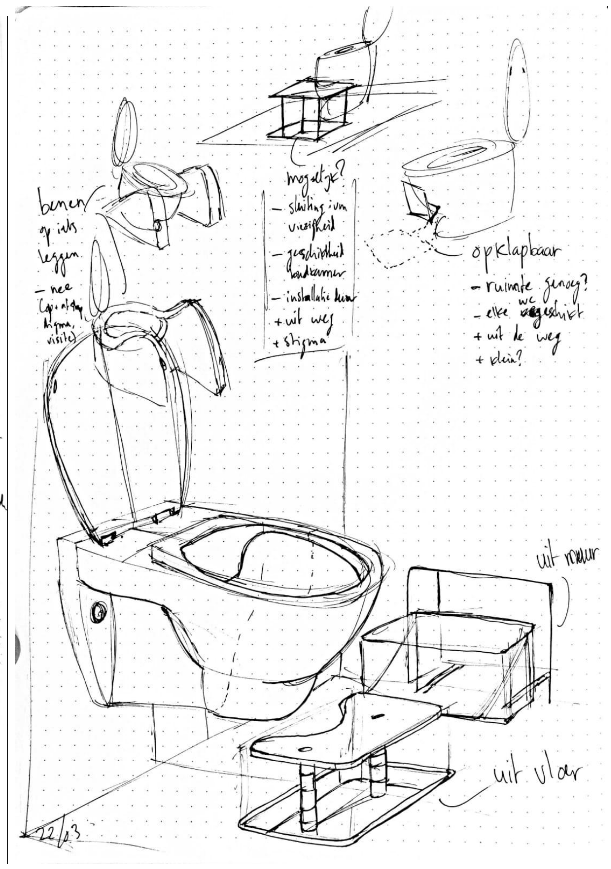




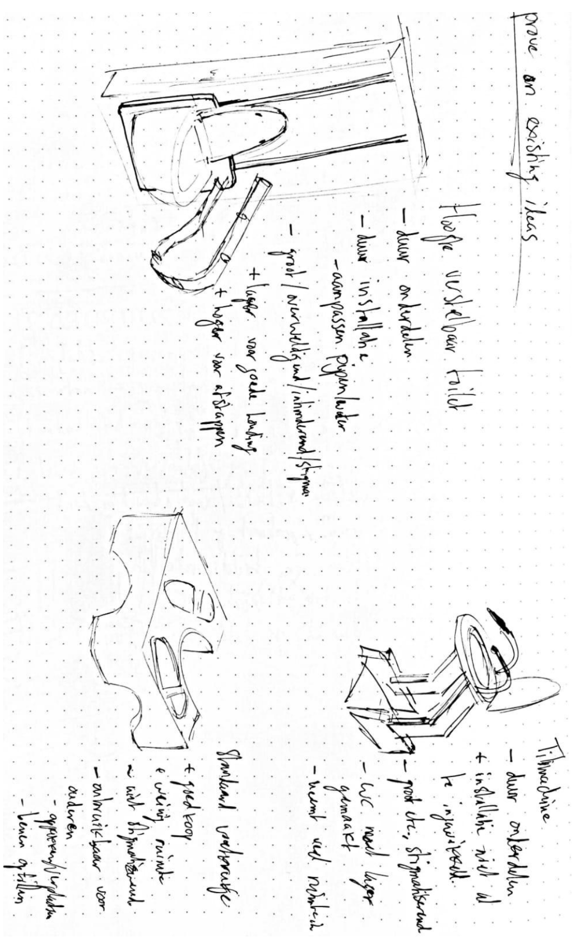


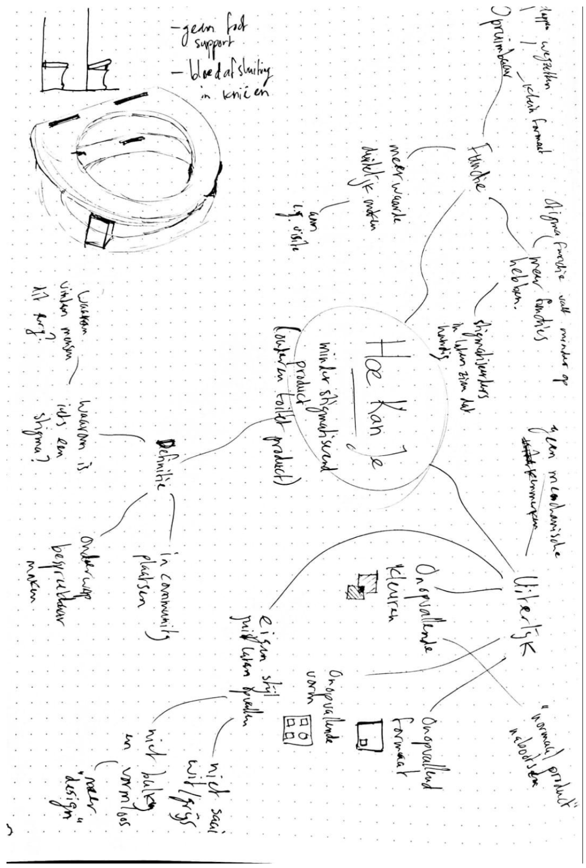


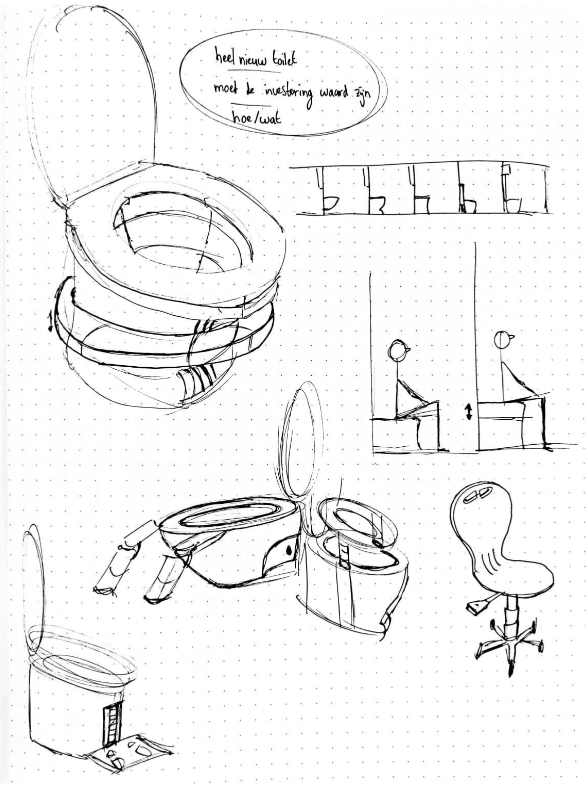
Sensor: lichaamslengte hele toilet in hoogte aanpassen
PUBLIC TOILET
BUIKPIJN AAMBEIEN ETC. OPGEBLAZEN GEVOEL
caused by:
OBSTIPATIE
ANDERE OORZAKEN
VERKEERDE TOILET-HOUDING
NIET GENOEG SPIERONTSPANNING
TE HOOG TOILET
T.O.V. BEENLENGTE
in report?!
wcbril in hoogte verstelbaar maken
luchtdruk compartimenten
mechanisch
aan muur
op grond.
hand support?
bureaustoel/ sportschool apparatuur.

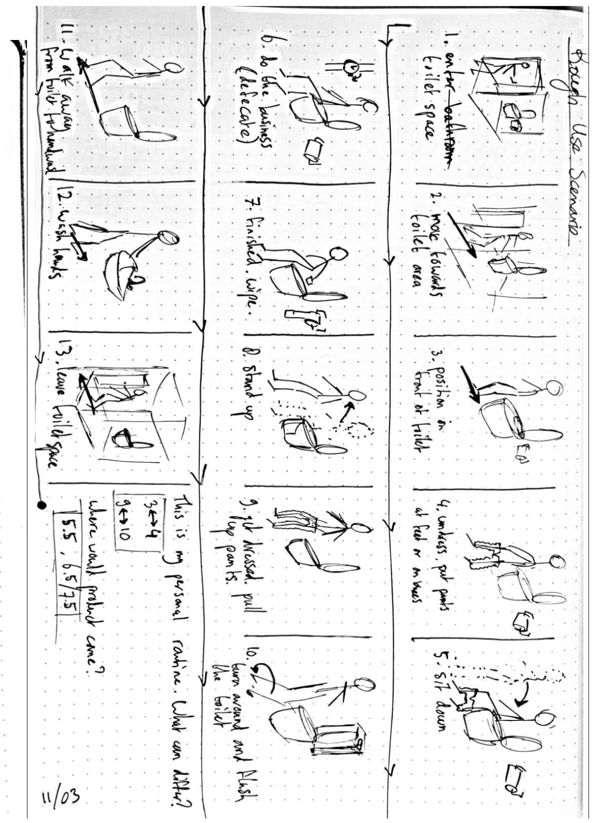


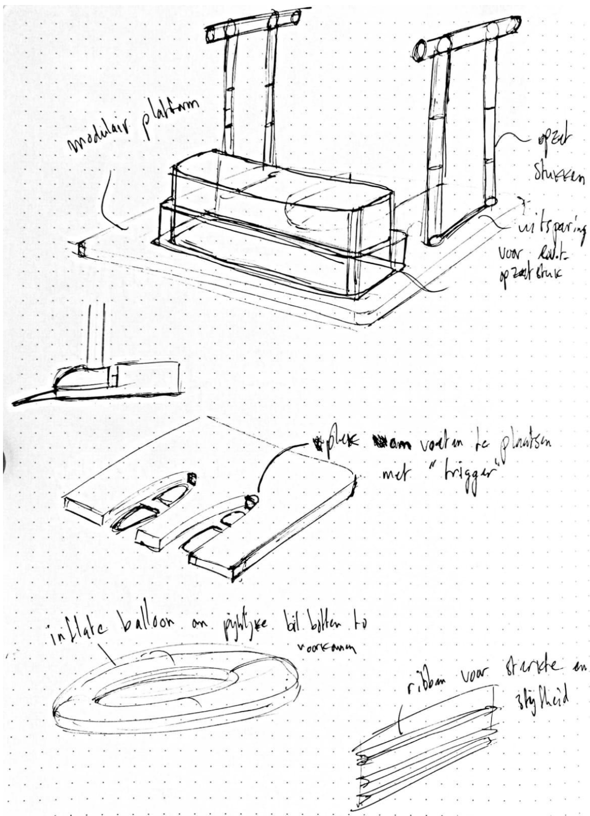
benen op iets leggen
mogelijk?
opklapbaar
uit muur
uit vloer
22/03

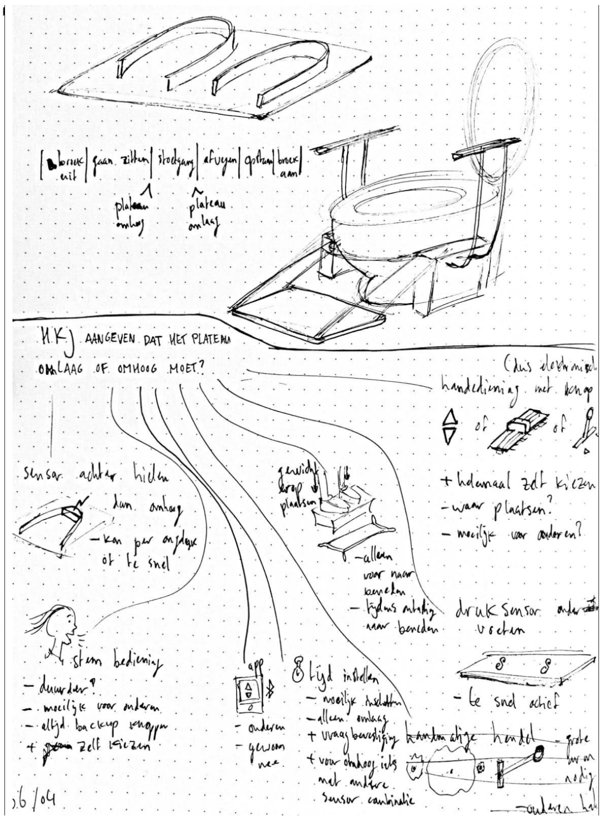





heel nieuw toilet
moet de investering waard zijn
hoe/wat

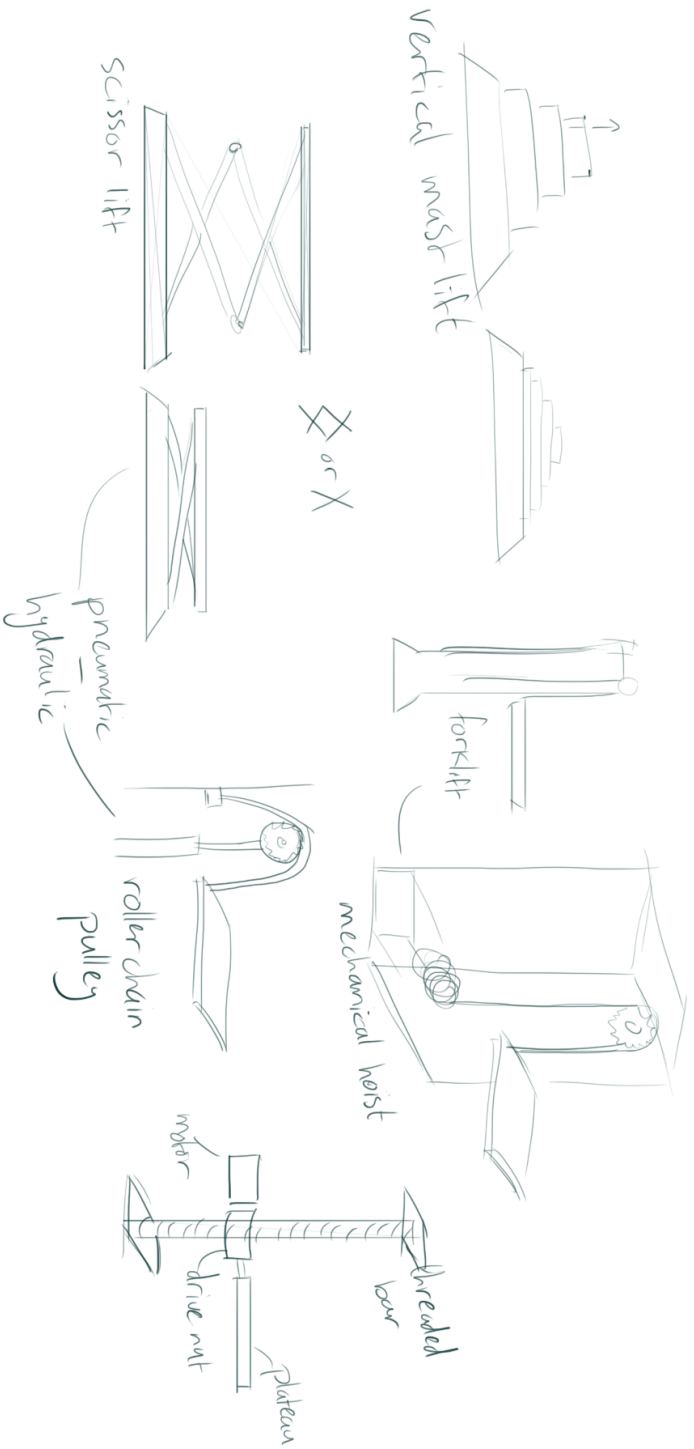

Design Use Scenario
1. enter toilet space
2. move towards toilet area
3. position in front of toilet
4. undress, put pants at feet or knees
5. sit down
6. do the business (defecate)
7. finished, wipe.
8. stand up
9. get dressed, pull up pants.
10. turn around and flush the toilet
12. wash hands
13. leave toilet space
This is my personal routine. What can differ?
where would product come?
11/03


modulair platform
opzet stukken
voeten te plaatsen met "trigger"
ribben voor sterkte en stijfheid

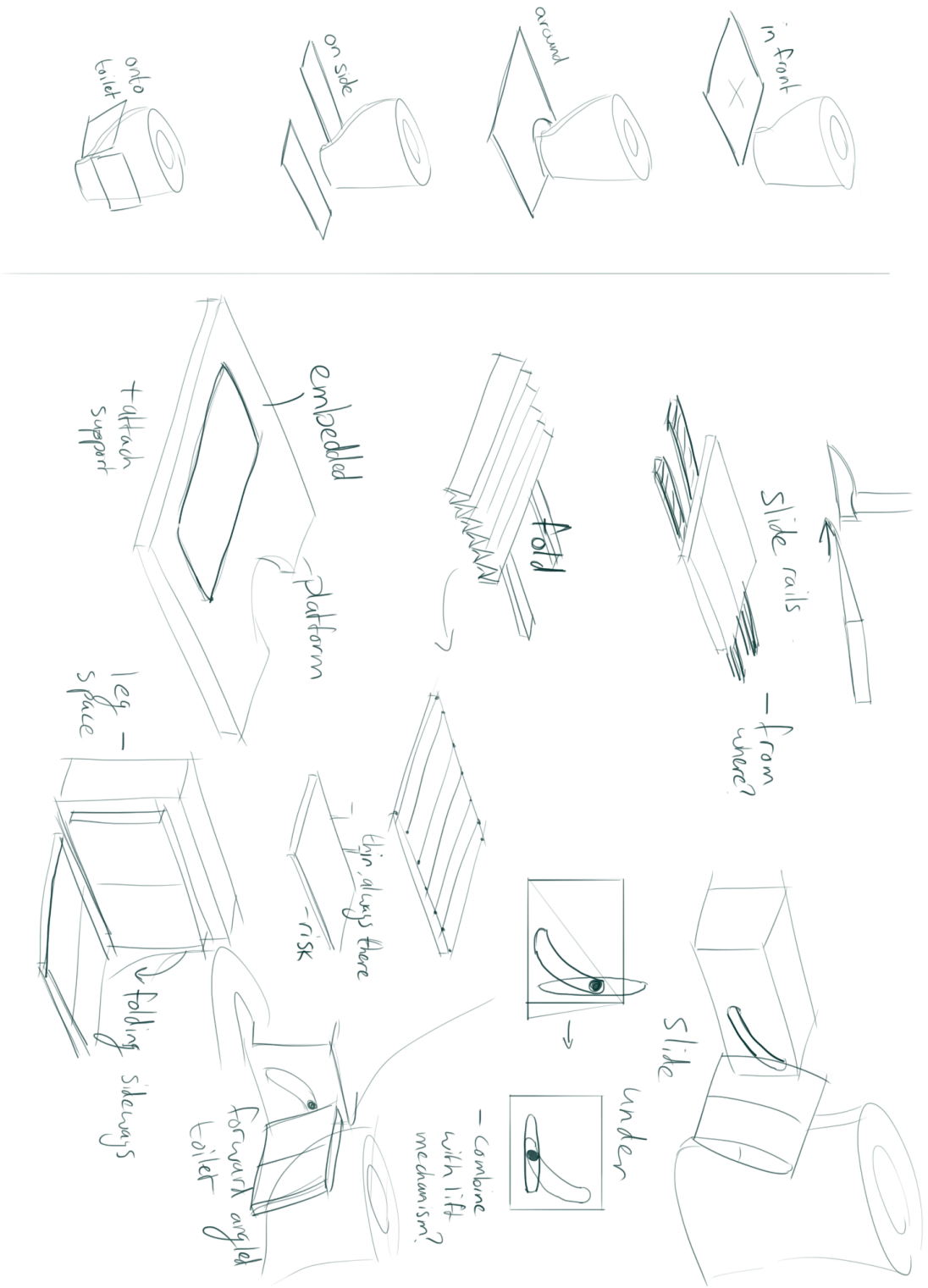

AANGEVEN DAT HET PLATEAU
OMLAAG OF OMHOOG MOET?
sensor achter hielen
stem bediening
app
druk sensor onder voeten
te snel actief
26/04

SCAMPER
automatische footrest
Adapt
feet move separate
actual foot shape
modify
put elevation in the shoes
footrest flips up from wall
goes up from under toilet
reach high places
put to other us
use as shelf for toilet paper
non moveable footrest
Combine
position wheelchair in front
toilet + wheelchair combination
elderly moveable toilet
Substitute
laxatives
catheter
toilet seat goes up and down
Reverse
make floor go up and down
make toilet go up and down
Eliminate
low toilet
solve problem
laxative
How to put a product away? (e.g. for visitors)
Put it in a bag
Re-orientate to a more beautiful side
hole in the floor
cover with blanket
ray of invisibility
put in a cupboard
Babushka doll system
Fold opklappen
flush down the toilet
use it as something else
How to raise and lower a platform?
Ropes
4 bar mechanism
explosieven
Hydraulisch
schaarplatform
Tandheugel
gears
Handmatig

Appendix N. Foot lifting mechanisms

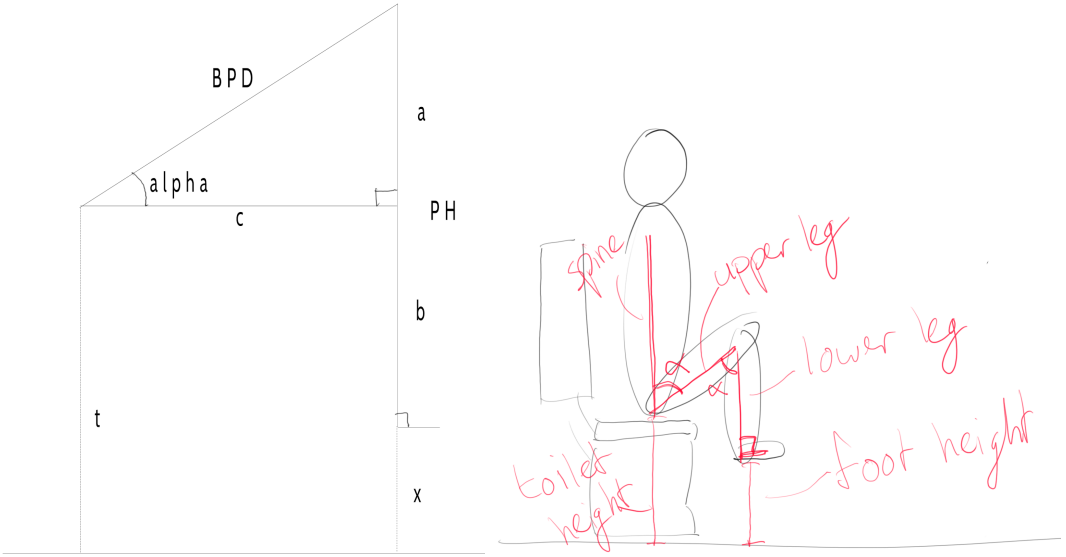


Appendix O. Plateau reach



Appendix P. Footstool maximum height

t = toilet height
x = desired foot height
a + b = lower leg = popliteal height
d = upper leg = average of BPD and BKD



For P1 the height should be 39,6 cm, however this is not realistic in combination with all toilet curvatures available. Also, in this scenario the user sits up straight perfectly vertical, but in reality the users will be leaning forward. In that case angle alpha gets naturally smaller and thus the maximum height can eventually be lower for all user percentiles.

$a = sin(\alpha) * BPD$
$b = PH - a$
$x = t - b$

Doelgroep	Percentiel	Hoogte toilet (mm)	Alpha (rad)	Alpha (degree)	upper leg (mm)	PH (mm)	Krukhoogte met upperleg (mm)
Dutch	p1	520	0,5236	30	490	369	396
adults	p50				556,5	450	348
60+ m+f	p99				623	531	301

Appendix Q. Mean Segment Weight

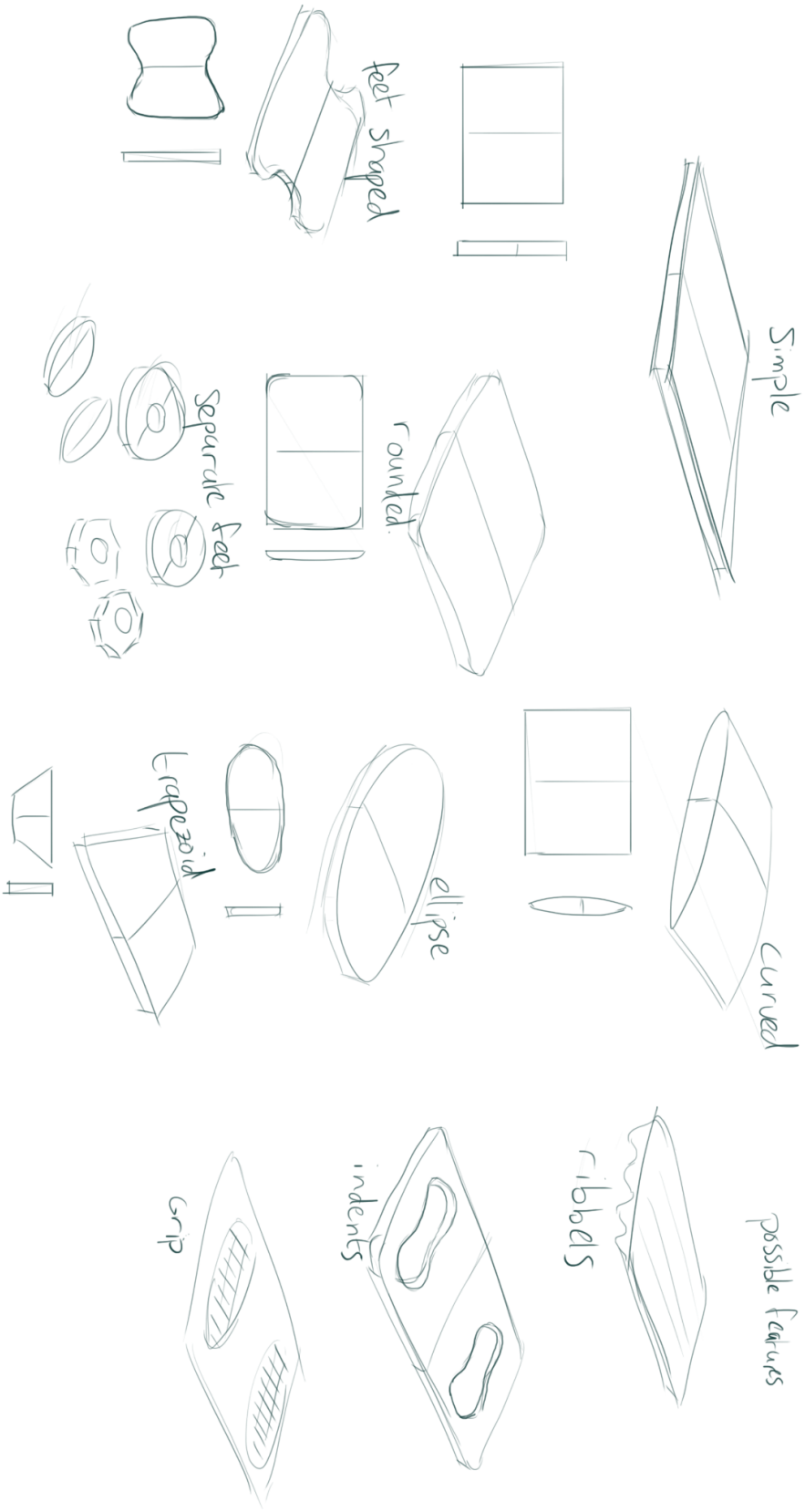
Mean Segment Weights

Percentages of Total Body Weight

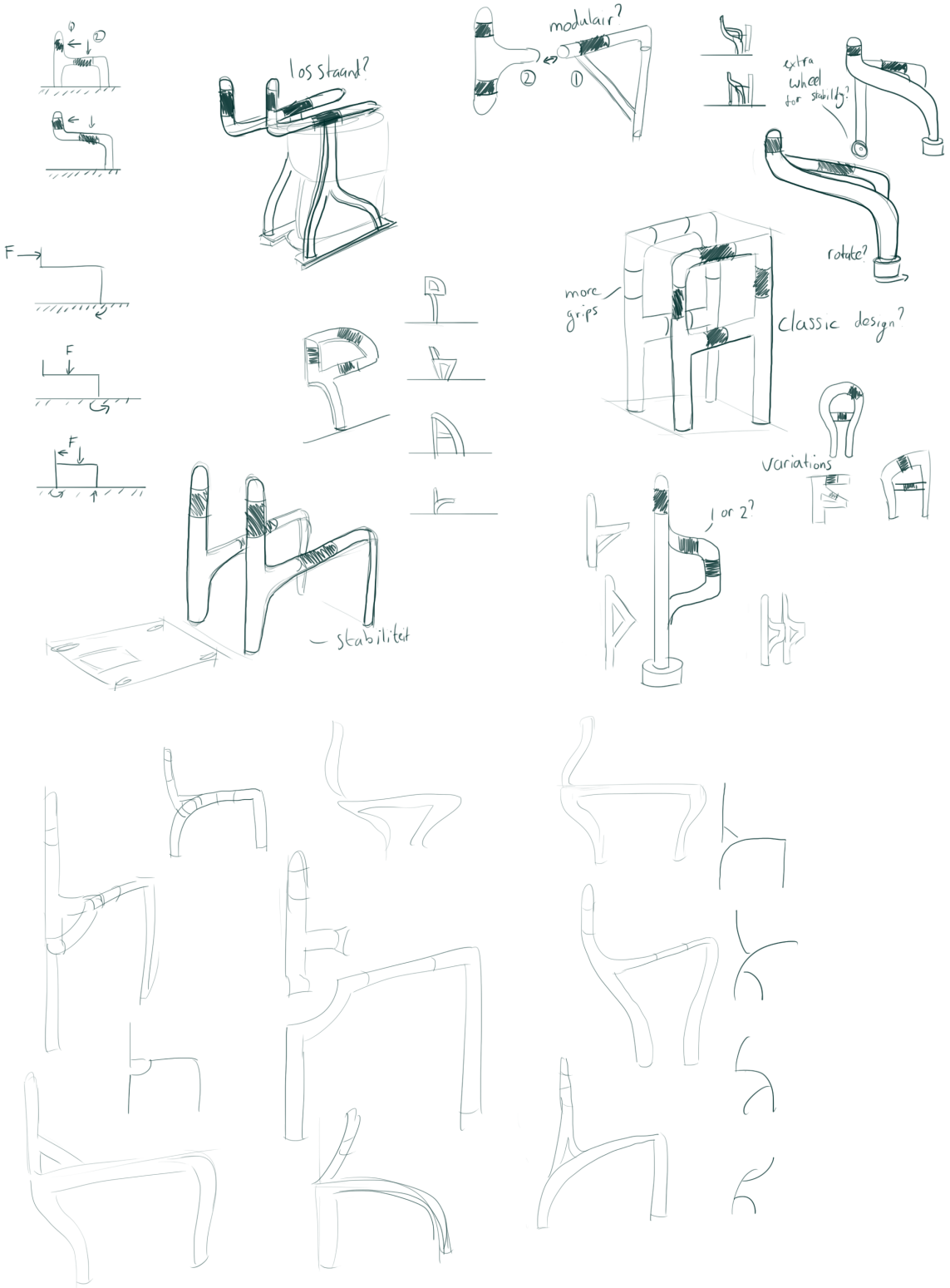
Segment	Males	Females	Averag
Head	8.26	8.2	8.23
Whole Trunk	55.1	53.2	54.15
Thorax	20.1	17.02	18.56
Abdomen	13.06	12.24	12.65
Pelvis	13.66	15.96	14.81
Total Arm	5.7	4.97	5.335
Upper Arm	3.25	2.9	3.075
Forearm	1.87	1.57	1.72
Hand	0.65	0.5	0.575
Forearm & Hand	2.52	2.07	2.295
Total Leg	16.68	18.43	17.555
Thigh	10.5	11.75	11.125
Leg	4.75	5.35	5.05
Foot	1.43	1.33	1.38
Leg & Foot	6.18	6.68	6.43

Plagenhoef et al., 1983

Appendix R. Plateau shape brainstorm

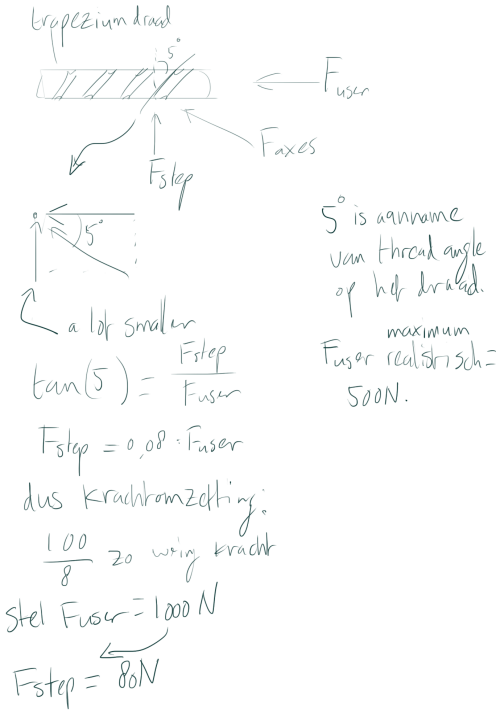


Appendix S. Hand support brainstorm

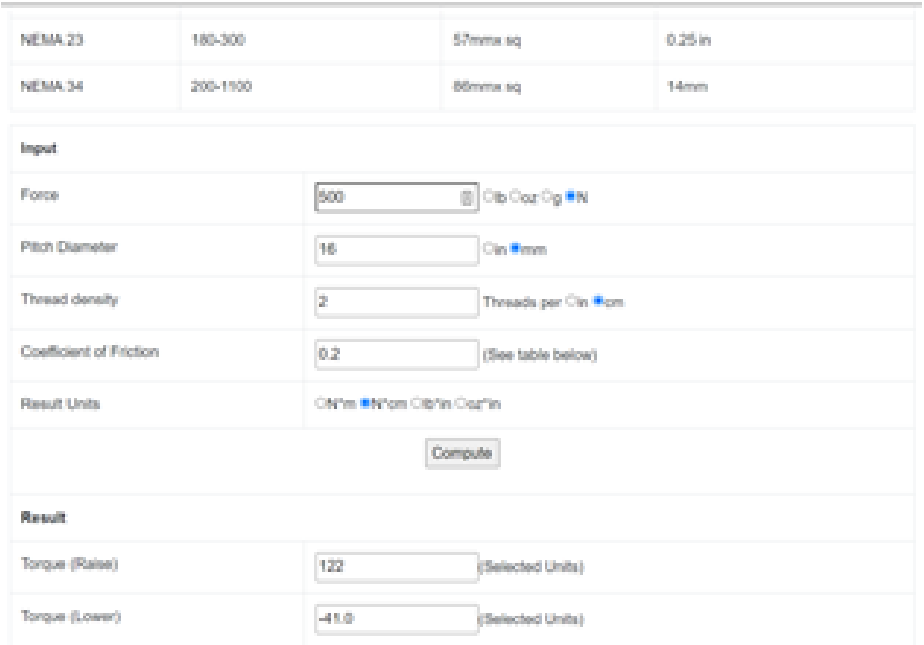


Appendix T. Mechanism component calculations

The force conversion from rotating force to upward force is very small, shown below.

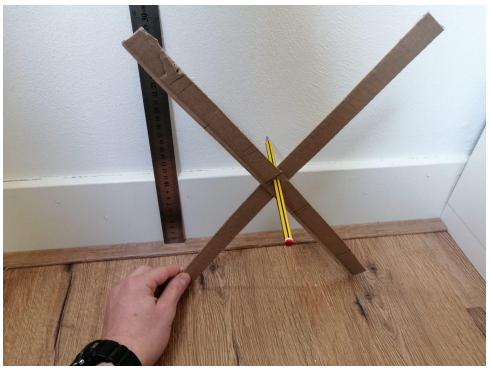
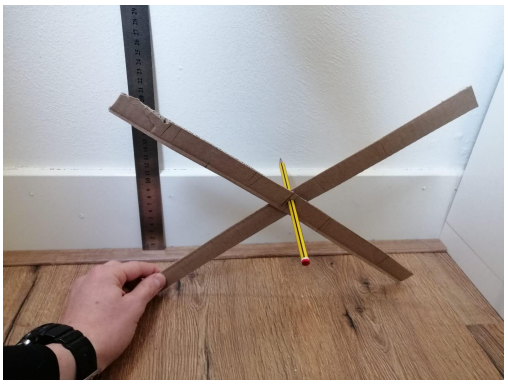


With an online tool to calculate stepper motor force required for which screw torque, stepper motor nema 23 came forward (Daycounter, 2019). The nema 23 stepper motor is able to produce 3 Nm, equalling to 30,59 Kg/cm. When filling in the screw thread specifications, a resulting torque is calculated, in accordance to the calculation above. The force is set to 500N, which is the absolute maximum the scissor needs to lift. Pitch diameter, thread density and friction coefficient are screw thread dependent. Additional frictional forces in the system are not included.



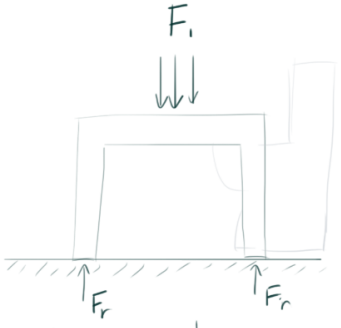
Appendix U. Cardboard self testing for mechanism



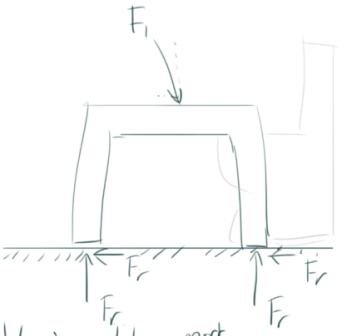





Appendix V. Hand support forces

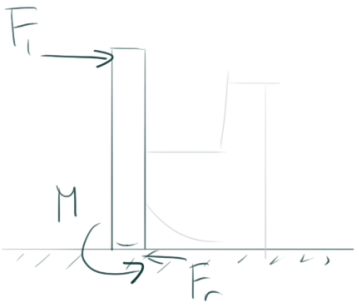


Horizontal support
"theory situation"
Standing up
- only vertical F_1
- legs only want to be compressed

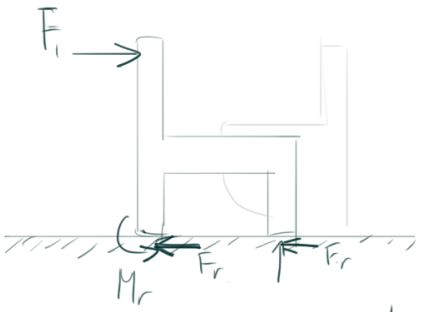


Horizontal support
"realistic situation"
- include horizontal F_1 component
- legs want to move/slide backwards
- no significant moment is created

Order of magnitude F_1 = 230 N
assuming: - two supports are used
- pg5 male weight
- arm/leg weight distribution = 50/50



1. Single vertical support pulling up from toilet
- Significant moment is created at leg connection to the ground
- big momentarm (elbow height)
- no counter component



2. Vertical support <u>onto</u> horiz. supp.
- second leg counters the moment

Order of magnitude F_1 = 330 N
assuming: - two supports are used
- pg5 male weight
- arm/leg weight distribution 70/30

Appendix W. Cost price estimation

A rough cost price estimation of the EasyRaise in current state, resulting in €571. Lower pricing due to bulk buy-in is not included. More detailed component and manufacturing information is needed for a more detailed calculation. Items without an annotation have been bought for the prototype, so their price can be assured. All items with an annotation have not been bought so their price can not be assured. These prices have been estimated based on online findings, going for the upper limit, aiming to keep the final quotation based on more detailed component information within this range.

Buy-in components	**€**	**Based on**
Steppermotor	43	123-3D
Stepper driver	21	123-3D
Chipboard [1]	5	Kiwi
Battery	33	Coolblue
Remote buttons	5	Kiwi
Remote electronics [2]	20	Numato
Spindle and nut	22	Romijn
LED strip [3]	10	Ledstripkoning
Rubber seal [4]	2	Rubbermagazijn
Shaft coupler [5]	10	Amazon
Assembling (nuts, etc) [6]	20	Gamma
	191	

[1] In the prototype the Arduino was used to connect the motor to the driver and the buttons, a replacement that is specific for this application or a smaller mini computer should be used in the final product.
[2] The remote electronics consist of a chip that accommodates the buttons, a wireless transmitter to communicate with the stepper driver, and a holder for the battery. The price of such (custom) electronics varies.
[3] The LED strip price is taken from Ledstripkoning. 10 euro is for one metre.
[4] The price of the rubber seal is based on buying a ready to use rubber seal strip of 100 meter from Rubbermagazijn.
[5] The shaft coupler that was used in the prototype functioned well but is not necessarily meant for this application. Another official 8 to 12 mm shaft coupler is recommended from Amazon.
[6] The assembling materials that were used in the prototype do not all transfer directly to the actual product, since wood was used. However, the same types of connections are needed. For components like the LED strip additional assembling methods like snapfits need to be included.

Materials for manufacturing	**€**	
Trespa platform large [7]	30	Panelzz
Trespa plateau small [7]	10	Panelzz
Steel base frame [8]	40	Onlinemetals
HDPE base sides [9]	25	Yasu
LED cover [10]	10	Yasu

Scissor arms	10	IDE workshop
Scissor middle bar	5	IDE workshop
Remote casing [11]	10	Plasticmold
	140	

[7] The price of HDL plates differs per quality, where Trespa is a brand name with a good reputation. The plates need to be cut to the right size, with rounded corners.
[8] More information is needed on the base frame that is located inside the base platform before a detailed manufacturing plan and price can be given.
[9] The HDPE plates that can be used for the slopes on the sides of the platform need to be cut to the right size. The corner pieces need to be milled for the correct fit and attachment. More detailing is needed on the assembly of the base platform.
[10] The LED strip needs to be protected from outside forces from sources like feet. A see-through PMMA strip can be used for this.
[11] The casing from the remote is made of ABS. If no ready to purchase casings can be bought, injection moulding is an alternative.

Manufacturing & Operation
Cutting to size
Correct shaping
Rounding corners
Drilling holes

Hourly rate of 40€/h		Mijnzzp
Estimated hours work: 4h [12]	160	

Assembly

Hourly rate of 40€/h		Mijnzzp
Based on complexity of assembly		
Estimated hours of work: 2h [12]	80	

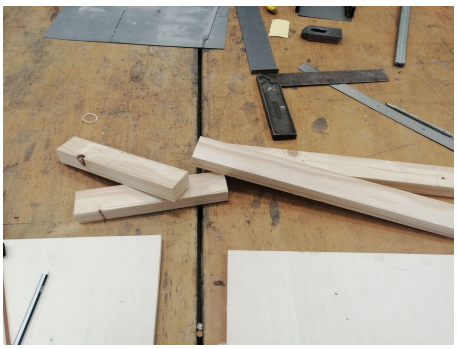
Total	**€571**

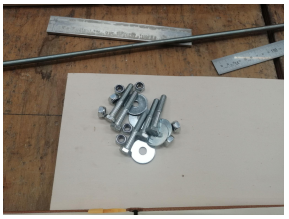
[12] Estimation is very rough, based on assumed complexity of actions.

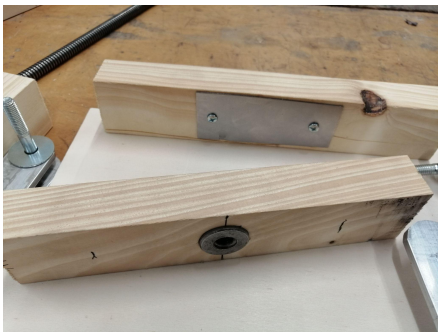
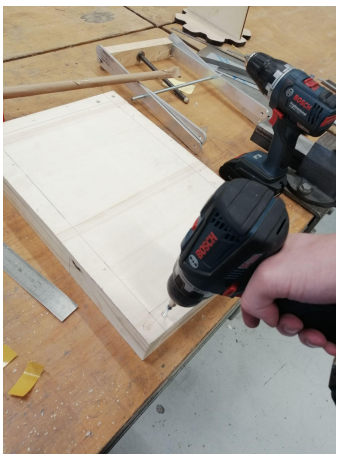
Costs for support handles are not included because not enough is known about its final construction.
Possible estimate:

Support frame	15
Support grips	5
Support plate	10
Operation	40
Assembly	20
	€90

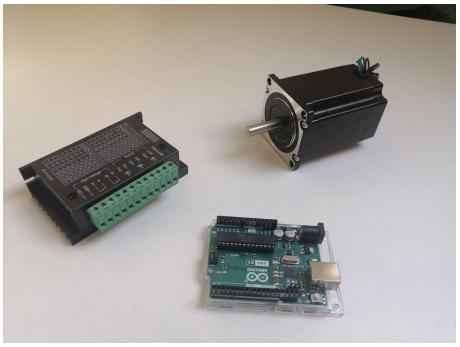
Appendix X. Scissor frame materials



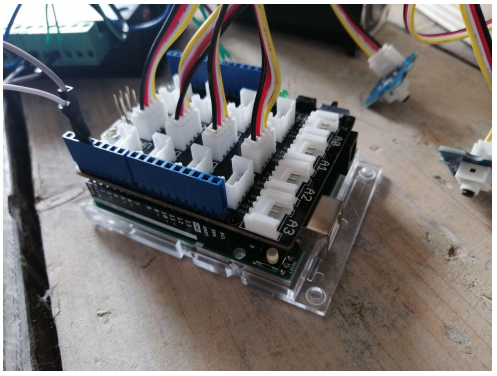



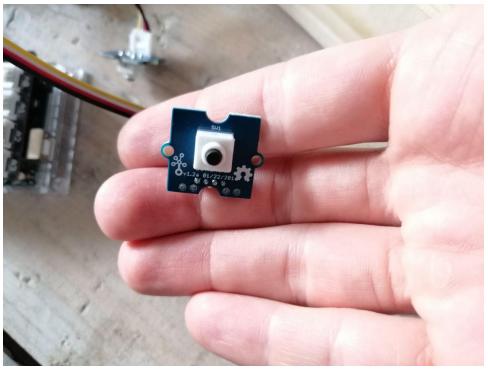
Appendix Y. Electronics components


Left: stepper motor driver. Top: stepper motor. Bottom: Arduino Rev3.

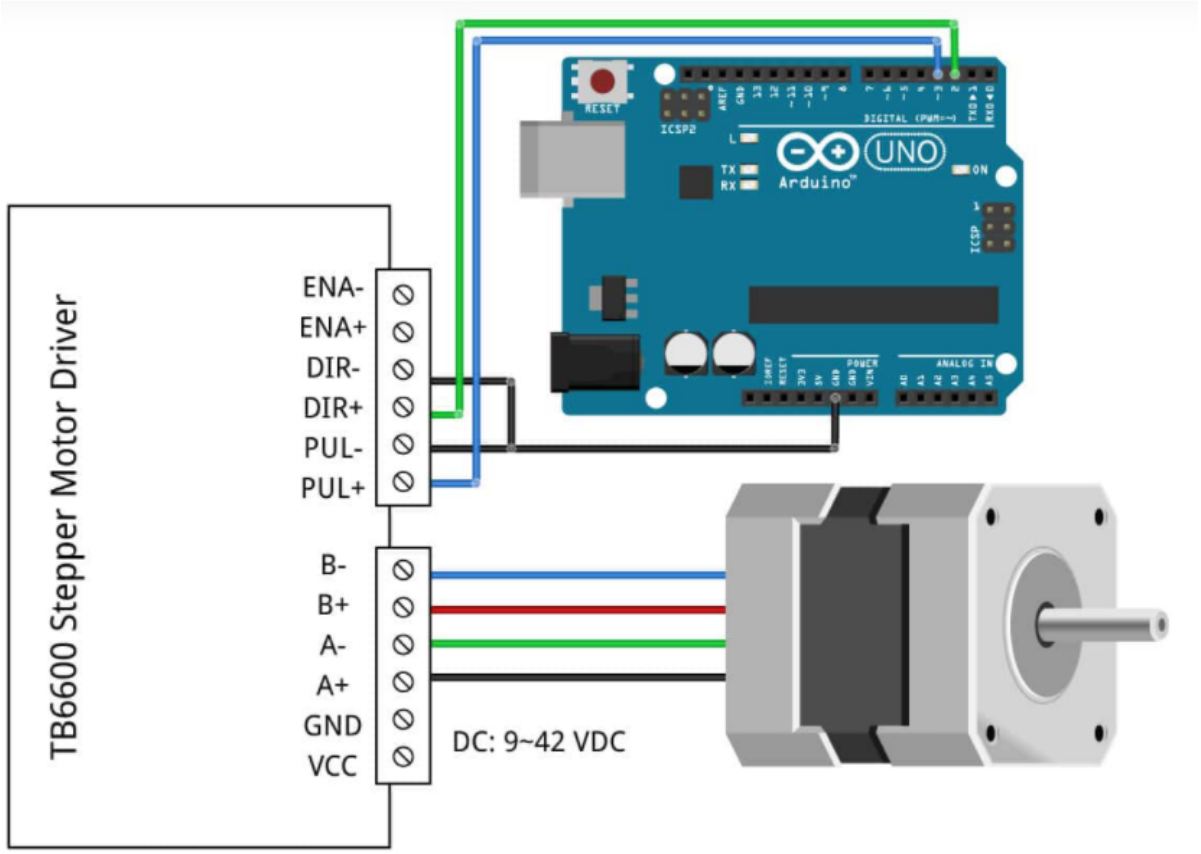
Power adapter.



grove shield on top of arduino


push button

Appendix Z. Electronics circuit



Basic setup for stepper motor. Visualisation from Benne de Bakker from Makerguides.com

In the final prototype additional buttons were added on the grove shield to port D5 to D8.

Appendix AA. Arduino code for stepper motor

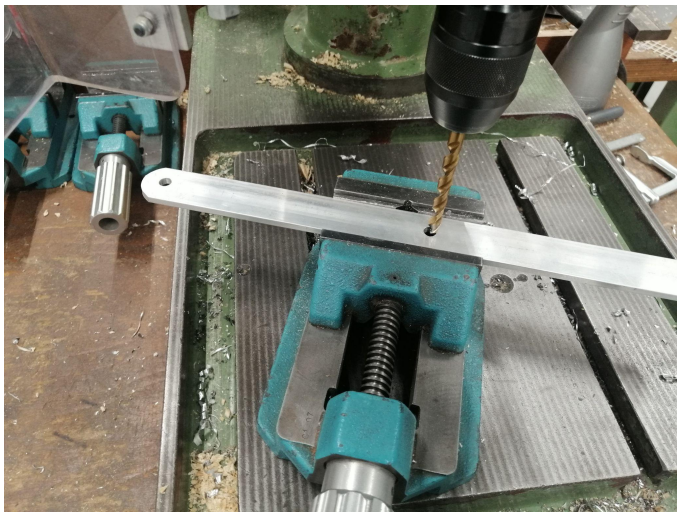
```
// Define stepper motor connections:
#define dirPin 2
#define stepPin 3
#define stepsPerRevolution 100
#define buttonONE 5
#define buttonTWO 6
#define buttonSTOPTOP 8
#define buttonSTOPBOTTOM 7

// driver setting      power = 3.5A output
// driver setting      revolutions = 3200 --> 200

int platformheight;
int maximumheight = 8;  //how many rotations allowed
int minimumheight = 0;  //set back to zero

void setup() {

 // Declare pins as output:
 Serial.begin(9600);
 pinMode(stepPin, OUTPUT);
 pinMode(dirPin, OUTPUT);
 // Declare buttons input
 pinMode(buttonONE, INPUT);
 pinMode(buttonTWO, INPUT);
 pinMode(buttonSTOPTOP, INPUT);
 pinMode(buttonSTOPBOTTOM,INPUT);

  // Put the stepper motor to home position if it's not there

  while (!digitalRead(buttonSTOPBOTTOM)){
  digitalWrite(dirPin, HIGH);

  for (int i = 0; i < stepsPerRevolution; i++) {
  // These four lines result in 1 step:
  digitalWrite(stepPin, HIGH);
  delayMicroseconds(500);
  digitalWrite(stepPin, LOW);
  delayMicroseconds(500);
    }
 Serial.println("I'm returning to the lowest height");

  }
```

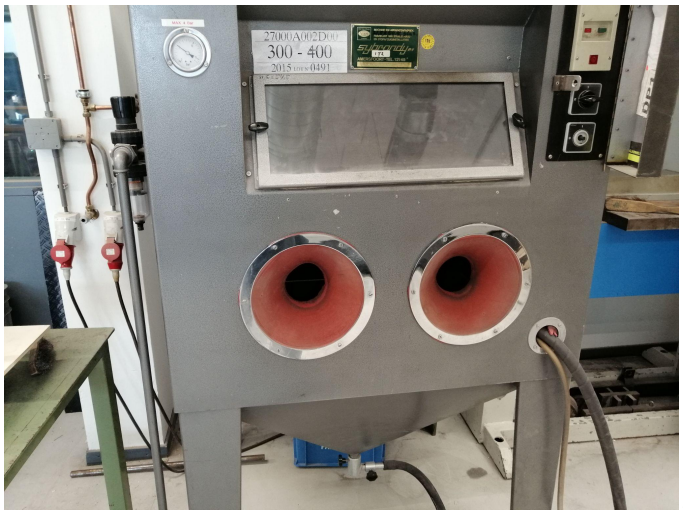
```
  // Stop the stepper motor when the home button is pressed

  if (digitalRead(buttonSTOPBOTTOM)){
    for (int i = 0; i < stepsPerRevolution; i++) {
    digitalWrite(dirPin, LOW);

  // These four lines result in 1 step:
  digitalWrite(stepPin, HIGH);
  delayMicroseconds(500);
  digitalWrite(stepPin, LOW);
  delayMicroseconds(500);
  }
  Serial.println("I have returned to the lowest height");
  }

platformheight = 0; //make sure the height is 0 again

}

void loop() {

////////////////////     clockwise button 1 - LOWERING PLATFORM     ////////////////////////

 while (digitalRead(buttonONE)){
  //if button clockwise is pressed
  Serial.println("Button CW is pressed");

  if (platformheight > minimumheight){
    platformheight--;
    Serial.print("number of button pushes: ");
    Serial.println(platformheight);

  // Set the spinning direction CW:
 digitalWrite(dirPin, HIGH);

  for (int i = 0; i < stepsPerRevolution; i++) {
  // These four lines result in 1 step:
  digitalWrite(stepPin, HIGH);
  delayMicroseconds(3000);
  digitalWrite(stepPin, LOW);
  delayMicroseconds(3000);
 }

 }
```

```
  else {
    Serial.println("Minimum height of 0 is reached");
  }

  }

////////////////////    counterclockwise button 2 - RAISING PLATFORM     ////////////////////////////////

  while (digitalRead(buttonTWO)){
    //if button clockwise is pressed
    Serial.println("Button CCW is pressed");

    if (platformheight < maximumheight){
      platformheight++;
      Serial.print("number of button pushes: ");
      Serial.println(platformheight);

    // Set the spinning direction CW:
  digitalWrite(dirPin, LOW);

    for (int i = 0; i < stepsPerRevolution; i++) {
    // These four lines result in 1 step:
    digitalWrite(stepPin, HIGH);
    delayMicroseconds(3000);
    digitalWrite(stepPin, LOW);
    delayMicroseconds(3000);
   }
  }
  else {
    Serial.println("Maximum height of 8 is reached");
  }
  }

////////////////// BOTTOM LIMIT) /////////////////
  if (digitalRead(buttonSTOPBOTTOM)){
    platformheight=0;
    Serial.println("Minimum height of 0 is reached");
  }

////////////////// TOP LIMIT) /////////////////
  if (digitalRead(buttonSTOPTOP)){
    platformheight=8;
    Serial.println("Maximum height of 8 is reached");
  }
}
```

Appendix AB. Prototype additional images

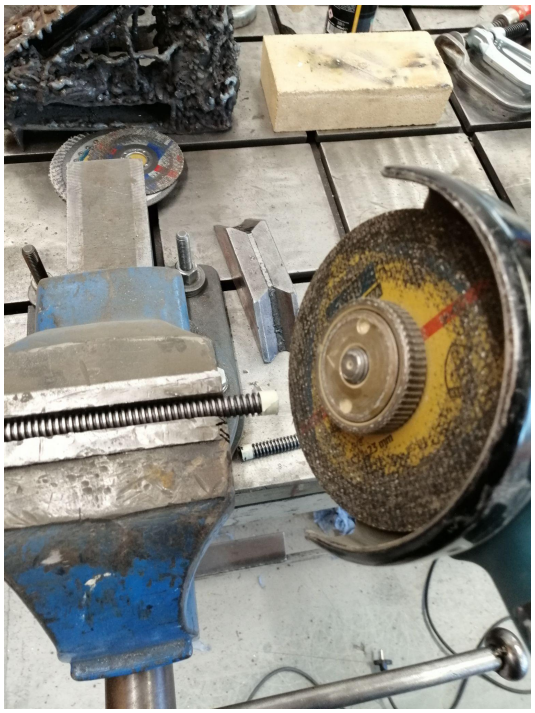
cutting aluminum staff

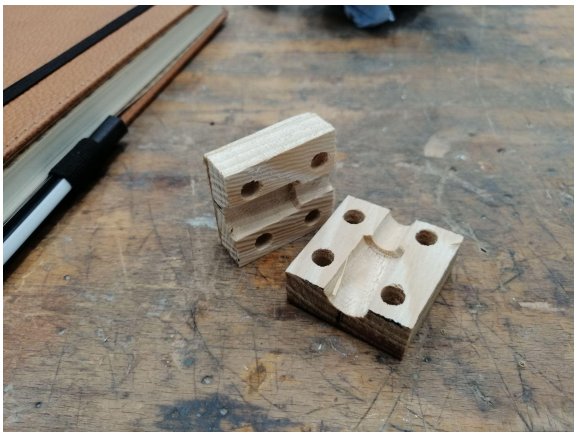

drilling holes

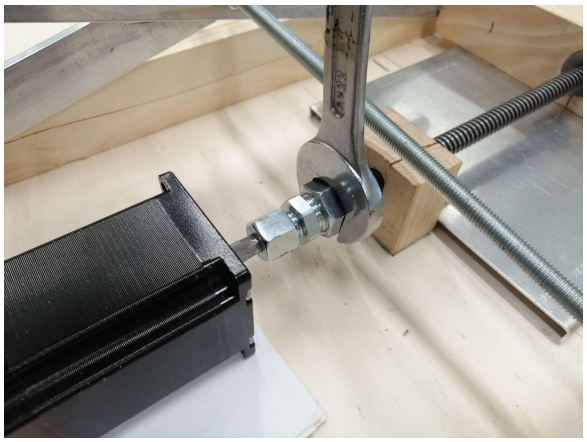


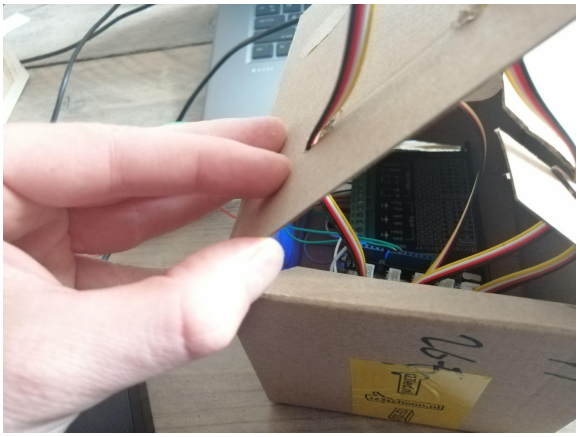
sand blasting machine

punch machine

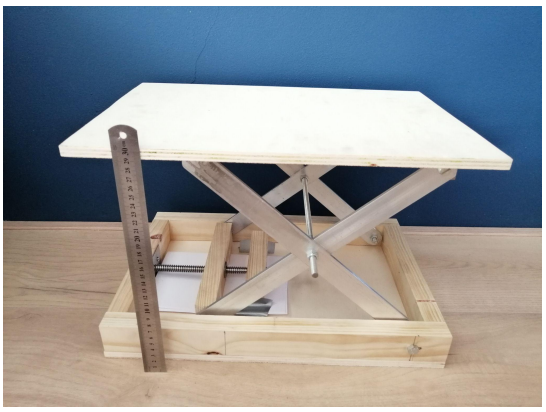

cutting the screw thread





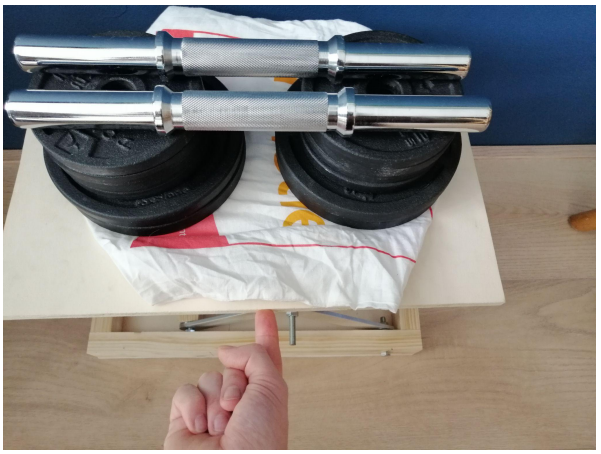


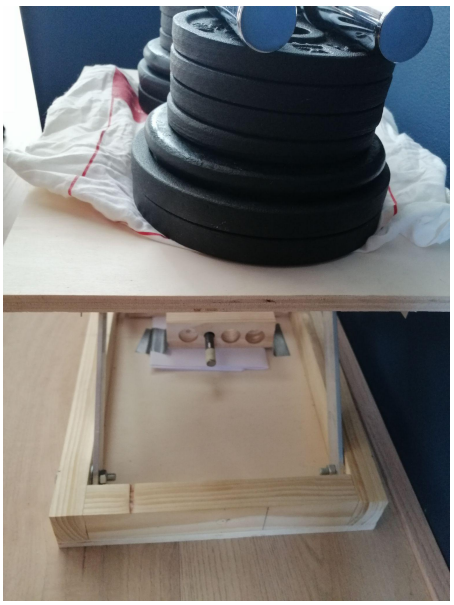
Appendix AC. Physical prototype test images









Appendix AD. Target group interview questions

Vragenlijst doelgroep concept evaluatie

Intropraatje

- Bedankt voor meedoen, erg belangrijk voor project waarde
  - “gebruiker centraal”

- Reden van dit project nogmaals uitleggen
  - “constipatieklachten, geen goede oplossing voor ouderen”

Concept uitleg

- Doel van concept uitleggen a.d.h.v. illustratie 1 + 2
  - Altijd voor toilet, in laagste stand
  - Erop staan, evt met leuning, gaan zitten zoals normaal
  - Afstandsbediening plateau stijgen
  - De boodschap doen
  - Afstandsbediening plateau dalen
  - Afsluiting zoals normaal

- U hoeft zelf niet per se in de positie te zitten om dit te moeten gebruiken, maar ik wil u vragen zich dit voor te stellen/in te leven?
  - Belangrijk dat u eerlijk bent en alles zegt wat u denkt, dat is het meest waardevolle

Algemene functie

- Wat is uw eerste reactie als u dit concept ziet en hoort?

- Ziet u het product zitten? Voelt het veilig te gebruiken?

- Zijn de voordelen duidelijk?

- Wat vind u van het opstapje? Voelt dat gevaarlijk?

Acceptatie

- En als we het hebben over de acceptatie van het uiterlijk van dit product.

- Zou het in uw toilet passen?

- Wat vind u van de vormgeving? Wat zou eraan moeten veranderen om te kunnen passen?

- Nu heb ik drie afbeeldingen waarbij het uiterlijk is aangepast.
  - Een neutrale (3), een uitgesproken kleur (4), en een delfts blauwe print (5).

  - Welke zou uw voorkeur hebben en waarom?

Afstandsbediening

- Als laatste wil ik het nog even hebben over de werking van de afstandsbediening.
  - Illustratie 6 laat een illustratie van de afstandsbediening zien.

- Wat denkt u dat de knoppen betekenen?
  - Pijlen
  - 0, 1 , 2

- Als goed, mooi. Als fout, zelf uitleggen wat het idee is.

- Er zijn ook nog audio en visuele aanwijzingen bijvoorbeeld wanneer het plateau zijn 0/basis positie heeft bereikt. Wat vind u daarvan?

Afsluiting

- Dat waren eigenlijk de vragen al, om het lekker beknopt te houden.

- Ik wil u enorm bedanken voor uw tijd en deelname. Hier kan ik zeker mee vooruit.

Appendix AE. Target group interview notes

Guus

Begrijp het, mooi

Wat betekent dit voor dikke mensen?
150 kg, benen niet tegen elkaar zetten dus breedte moet breed genoeg

Mensen hebben verschillende hoogte als ze gaan
De hoogte van het plateau niet zo hoog als 2

Advies geven adhv hoogte plateau en hoogte toilet
Toiletpot moet laag of hoog afhankelijk van hoogte toilet

Sta-op stoel, zie je dat winkel small, medium, of large heeft
Hoogte toiletpot

Hoe maak je beugel vast?
Past het product? Ja, hebt foto's gezien
Veilig moet goed zitten want beugels of muren

Goede richting dit om oplossing te bieden

Ouder bent en opstaan uit stoel dan moet je hakken naar achter zetten daarmee lichaam naar voren en sta je makkelijker op
Kniehoek 90 graden en opstaan is dan lastig, naar 60 graden is makkelijker
Omhoog hijsen alternatief
Veel mensen in toilet trekbeugel
Geen beugels met zuignappen want die vallen eraf

Verschil man en vrouw
Vrouw komt binnenlopen: ligt aan kleur badkamer, blauw is leuk, wit daarna
Twee beugels zijn op dezelfde manier bevestigd
3de prima voorstel want trekken aan twee kanten op, lijkt stabieler
Hoogte pot afhankelijk en daarbij hoogte verstelbare beugels
Fietszadel systeem
Zelf: meer van wit, meest neutraal
Dan maakt kleur tegels niet uit

Contrast rand is goede gedachte
Ouderen ogen achteruit of staar
Schuine rand

Rood en groen lichtje hij doet het of hij doet het niet
Schuifje voor aan of uit
Pijltje omhoog en omlaag
0 1 2 moelijker maar vanwege achtergrond in auto's vooringesteld

Gezellig om te sparren al leuk op zich
Facilitair manager in betalingsverkeer, oplossingsgericht, goeie richting nu op

Variant misschien te moeilijk
Kijken naar sta-op stoel
Hoe komen ze eraf?
Mechanisme op laten veren zodat mensen makkelijker eraf komen
Hoek van 30 graden maken inschatting
Voor mensen in heupen en knieën hebben letterlij keen kontje geven

Laat weten eindresultaat

Anneke

Bijzonder
Spreekt niet direct aan
Heel de wereld weet het dat je bepaalde problemen hebt
In combinatie met verhoogd toilet voelt het tegenstrijdig aan om verhoogd toilet en verhoogd plateau

Anderen moeten ook gebruik van maken
Als je 1 tiolet hebt
Visite kinderen kleinkinderen
Als je apart invalide toilet hebt is het anders

Beugel om op te trekken handig
Zou zelf liever zo'n klein krukje gebruiken

Voor verpleegkundigen of ziekenhuizen misschien beter
Het valt te veel op
Minder bewegingsvrijheid

Moet behoorlijk stevig want ook nog aan beethouden
Als je beperkter bent in beweging maakt dit het dan niet nog moeilijker?
Zeker met dubbele beugel wordt vrijheid beperkt
Je moet veel toiletruimte hebben voor dit
Van voren is echt schuifelen om niet te struikelen
2 beugels werkt belemmerend

Als je meerdere toiletten hebt dan overwegen
Bij 1 toilet te belemmerend

Ze kan zich misschien niet goed inleven in de problemen van constipatie om hier goed oordeel over te geven

Delftblauw spreekt wel aan
Maakt het gezelliger en aantrekkelijker dan medische uitstraling

Als je lang genoeg gebruikt is opvallende rand niet meer nodig
In de grond verzinken mogelijk?
Eleganter om alleen dat plateautje te hebben
Alleen beugels zien en los element onder voeten en dat wegschuiven voelt aantrkkelijker en even 5 cm benen optrekken moet lukken

Knoppen 0 volledig weg, 1 halverwege, 2 hoogste en pijlen lichten op als omhoog of naar beneden aan het gaan is of die zijn traploze werking
Traploos essentieel want zoveel mensen en zoveel lengtes

Ene dag is de andere niet dus je moet elke dag zelf kunnen bepalen hoe ver je wilt
Snapt presets

Lida

14/06 . 11.00u . Lida

Bediend door afstandbediening
Denk dat het goed is want houding bij ontlasting is belangrijk
Zelf niet nodig maar weet wel van kinderen dat bankje omhoog ging

Vind het systeem niet gek hoor!
Verhoogd toilet voor ouderen zorgt zelfs voor tegenovergestelde
Gaan zitten en staan makkelijk maar dit systeem heel mooi
En is te gebruiken voor hogere toiletten
Voor kinderen ook evt wel handig

Support voor balans heel handig
Lager toilet heb je support nodig om weer omhoog te komen
Opstaan vraagt wat meer moeite

Ziet er mooi uit
3de vierde plaatje heb je twee leuningen maar liever 1
Toegang tot toilet is minimaal
Moet achteruit op het verhoginkje komen als er 2 zitten
Met 1, meer ruimte om erop te komen
Kan ook nog draaien

Zelfstandig gebruik met 1 support handiger, lijkt haar, niet uit ervaring
Ziet ook wel eens haken aan de wand, maar in combinatie met die ene support
Meer bewegingsvrijheid

Past wel in toilet
Voorkeur aan enkele support en dan eventueel een haak aan de muur
Te smal tussen

Support kan los aan beide kanten

Niet voor printjes gaan
Voor vrolijk wel leuk
Printje op voetplaat gezellig

Afhankelijk van tegelvoer qua contrast wit of zwart
Contrast buiten gezellig ook veiliger

Hoogte opstapje moeilijk inschatten maar moet lukken
Bewegingsvrijheid met 1 support heel belangrijk

Als mensen echt niet meer zelf kunnen, optie 2 support misschien
Wc hulp kan dan beter erbij met 1 support

Pijlen omhoog en omlaag, goed
0 1 2 weet niet
Snelheid?
Ingestelde standen opzich wel logisch

Hoog en laag weghalen
0 – 5 en dan verschillende standen gewoon
Overzichtelijk houden
Altijd op 0 staat en dan naar 1-5
Voor veiligheid altijd naar 0 het beste

Hans

Eerste reactie
Toiletpot is relatief laag
Opstapje naar plateau
Neuropathie?
buurman over dorpel heenstappen is moeilijk
Voor hem is ieder toilet te laag
Tioletpot is laag

Plateautje zo laag mogelijk hebben

Metalen plaat nemen
Hydrolisch ook een optie in de buis, wel duurder

Hoe plat mogelijk
Schuine zijkant een optie

Oud huis
50 vierkant plateau zou misschien net gaan
Tegenover toilet zit wastafel
Beugel aan verkeerde kant

1 of 2 beugels ligt aan spiercapciteit
Zou makkelijk zijn als ze twee hebben, maar mensen hebben 1

Voorkant aan optrekken
2 beugels bekrompen voelen weegt minder zwaar dan het gemakt

Hogere zitting

Kunt het opleuken
Neutraal doen een soort skin erover alsof een auto pimpen
Wit of grijs laten
Je gaat er geen uur op zitten
Hou een medische kleur
Zou erin passen
Muren moeten niet te ver en niet te dichtbij

Mind your step wel geinig
Blokbandje eromheen wel nuttig
Mensen zien moeilijk en heeft staar
Na 92 geen staar behandelen
Ziet dat er obstakel staan

Bovenste knoppen omhoog en laag
Voorkeurstand
- In 1 goed
Net als autostoel

Geprogrammeerd als dos

Afstandbediening heel simpel in feite
Is 92 altijd met pc's zeer intelligent leven wrodt moeilijker
Mobach belastingbijbel – auteur
Hoort weinig
Kan geen batterij meer vervangen
Alles wordt te klein
Blij dat afstand groot is en lekker simpel
Elke knop zelfde functie zodat geen verwarring

Laat eindresultaat weten

Joop

Joop 28/6

Idee lijkt me goed
Bij twee staat omhoog maar is dat omhoog?
Vast opstelling is niet handig
Dat is handig
Goed zit
Handbeugel precies
Beweegbaar? Naar beneden buigen?
Niet insteek maar wat bereiken?”
Hendel hoog beetpakken misschien omheen draaien zodat makkelijker optrekken
Om op te trekken aan hoge kant
Iemand erop tekenen dan kan je t beter zien
In praktijk blijken of t goede maat is
Plateau op grond staat vast
Verrijdbaar zodat tegen de muur aanzetten? Dan ook weer vastklikken
Duidelijk en goed systeem
Als je erop zit misschien zit beugel te dichtbij aan de zijkant
Ronde bocht aan de zijkant
Voordelen makkelijk
Benen en knieen wat minder dus dat je moet kunnen optrekken en rustig laten zakken dus dat ziet er goed uit
Hoogte plateau lijkt me geschikt van 9 cm
Dan zit je helemaal in max verstappen houding
Hoogste stand voelt wat hoog
Smaken verschillen wat dat betreft
Voor hem belangrijkste dat het goed werkt
Goed schoon kunnen houden
Wit houden zoals toilet misschien handig
Twee beugels loop je gauw tegenaan
Een beugel als stevig genoeg is, lijkt me voldoende
Twee beugels klem op WC
Bovenste stuk draaien en naar je toe kan halen
Twee beugels recht optrekken zou mooi zijn maar wel ruimte voor hebben
Witte uiterlijk misschien ziekenhuis sfeer
Maar zelf geen probleem mee, lekker wit
Vrouw zegt kleurtje ook wel leuk, in delfsblauw
Contrast kleur zodat niet struikelen uitgelegd
In thuis dan weet je wel hoe het werkt dus niet struikelen
Als het in ziekenhuis of restaurant dan handig om herinnerd te worden
0 uit, 1 aan, 2 weet niet
Driehoeken goed
Vooraf ingestelde hoogtes handig
Begrijp na uitleg, als je t weet
Instellen zoals je zelf wilt heel prima
Verder niks extra

Leuk idee en in praktijk moet goed vormgeven zodat in toilet past en beugels niet in de weg
Stel je hebt dikke mensen, kleine toiletten
Beetje flexibel zodat niet voor elk persoon andere uitvoering
Vind het leuk idee wat je uitgevonden hebt

Appendix AF. ErasmusMC interview questions

Vragenlijst ErasmusMC concept evaluatie

Intropraatje
- Bedankt voor meedoen, erg belangrijk voor project waarde
  - Professionele inzichten
- Reden van dit project nogmaals uitleggen
  - Constipatieklachten, urine retentie, geen goede oplossing voor ouderen

Concept uitleg
- Doel van concept uitleggen a.d.h.v. illustratie 1 + 2
  - Altijd voor toilet, in laagste stand
  - Erop staan, evt met leuning, gaan zitten zoals normaal
  - Afstandsbediening plateau stijgen
  - De boodschap doen
  - Afstandsbediening plateau dalen
  - Afsluiting zoals normaal

Algemene functie
- Wat is uw eerste reactie als u dit concept ziet en hoort?
- Ziet u het product zitten? Voelt het veilig te gebruiken?
- Zijn de voordelen duidelijk?
- Wat vind u van het opstapje? Voelt dat gevaarlijk?

Acceptatie
- Acceptatie van uiterlijk
  - Past het in toilet?
  - Wat vind u van de vormgeving? Wat zou eraan moeten veranderen om te kunnen passen?

Afstandsbediening
- Werking afstandsbediening.
- Wat denkt u dat de knoppen betekenen?
- Mening audio en visuele aanwijzingen

Medici specifiek
- Zou u het aanraden aan patiënten?
  - Wat zou daar nog extra voor nodig zijn / aangepast moeten worden?

- Op welke manier zou de hoogte worden aanbevolen?
  - Eigen mening of aan gebruiker laten?

Afsluiting
- Bedanken voor tijd en deelname. Hier kan ik zeker mee vooruit.

Appendix AG. ErasmusMC interview notes

barrière niet te hoog maken
"tremoren" trillen op toilet
geluidknop om beter te ontspannen → toevoegen
↳ in japan heb je dat al
zodat spoelen → toto
minder als hulpmiddel uitzien belangrijk
visite geen probleem van 9 cm
oppervlakte anti-slip
lampje ideaal
- subsidie aangevraagd
het kwaliteit van leven aan . iedereen plast en poept.
taboe aanpakken
deze ingewikkeld onderwerp → steeds meer problemen
oplossing als deze helpt waarom
basis v. probleem aanpakken: bij toilet
moet er echt mee door!
kan / gaat bepaalde lijntjes uitzetten

kinder bekken fysiotherapie
... goed voor kinderen.
hoe simpeler hoe beter
amsterdam umc → man. obstipatie kinderen
— belangrijke
verti. trekken aan beugel super
coriena in ~~vandaag~~ UCS verpleging
gelijkvloers zou goed zijn maar begrijpelijke redenen
diepte verschil . lampjes belangrijk
hoe diep dichtbij de pot?
plassen ~~en~~ poepen hoe ver weg plateau van pot?
verschil?
Knoppen 0 gelijk
1 plas
2 squat
hangt van ~~aspect~~ patiënt af
welke voorkeur knoppen.
~~geen~~ idee over hoogte instelling
23/06 advies geven vs. haalbaar → samen kijken

'dodgroepen?'
zwangeren, ms, parkinson, neurologische,
↓
beugels

kinderen leuk om te spelen.

twee beugels optie.

---

voor ontlasting werkt sowieso.
voor plassen vraagt of
besef dat reddingsvest gewicht moet tillen
stevige.

Kees de verpleegkundig urologie.

chrome is mooier want duurder

optrekken aan beugel, moet best wel zwaar zijn

overgewicht etc.

struikelen

oma moeite omhoog te komen
rollator.

voorgeprogrammeerde standen → niet intuïtief
knoppen programmeren is moeilijk
of duidelijke programmeer

drie hoeken groter.

simpel houden - idiotproof

draadloos, als kabel wordt dikker

hoe laad je 'm op? waterdicht.

standaard door medici, daarna uit aanpassen

heeft het überhaupt nut? dit product.

vrouwen, zwanger heeft nut
→ moeite ontspannen.

wellicht voor kinderen → moet je hoog kunnen

anti-slip strip belangrijk.

voor zwaarders belangrijk.

---

duidelijk in fases er zonder komen
naar

---

arianne kinderbekkenfysio

kinderen opstapje ikea werkt.
voeten gesteund.
stabiliteit compenseren

ontspannen wc belangrijkste

betaalbaarheid?

23/01

obstipatie kant. alle leeftijden

~~squatty~~ : situatie kant niet per se vaak voor
combinatie van.
stijfheid in knieën maakt moeilijk, rustiger
40 cm plassen - 30 cm volwassen
struikel gevaar. geriatrisch therapeut mening
plateau hoger / lager.
voorgeprogrammeerd. hoogtes
aan gebruiker zelf laten - eigen inzicht
vast inzitten,
gebruiker moet essentie snappen
ja.

---

rodie.
hygiëne op toilet?
voor voorkant wop
niet eraf vallen
toiletgrootte zo groot
hoe kunnen mensen vanaf vallen

23/06

Vrij 23/06

voor kinderen moet nog hoger kunnen
hele proces moet anders
eerste halverwege zitten.
o i.z. niet gelijk maar wel logisch
kinderen houding plaatje
aftel liedje 2 minuten erop zitten.
even staan en dan weer zitten voor residu
hol bol. gebruiksaanwijzing wc. → googlen
interessant collab bedrijf

Sens u seintje dat klaar vd is.
combinatie iets?
aanbeveling door
kinderen zelfstandig kan klikken
1 plasstand
anders te ingewikkeld.
hygiëne viezigheid afwassen
geen tuutjes afwassen
alcohol bestendig.
beugel te dichtbij pot horizontaal?
beugel bevestiging.

wis spoelen, moet je ergens aan ophangen
van mooie toevoegingen
plaatjes voor pomp
haak voor in huis
haak voor katheter
urinezak, moet laag
zwaar doorzitten
toekomst ?
stevig, hygiëne, niet draaien, niet duur, hygiëne + veiligheid.

mailen info + plaatjes + formulier.
verschillende voetplateaus bij toilet voor (e.g. hangpot)

---

patienten moeten weten wat ideale hoogte
een keer bureaucratie of bezigheid en daarna 1 keer
anti-slip
• ontwerp
0 1 half 2 maximaal
tweede persoon in huishouding
gynocologen
obstipatie niet
gaat om blaas en niet om rectum

23/06

squat beter plassen
mdl dokters
kanteling voor blaas
zo laag mogelijk
support komen er niet bij
voorbij de ronding
stel je voor ze vallen
ze moeten weg kunnen
anneke chantal om toestemming.

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esther bekkenfysio.
verschil stapje en kruk
haast vaak
is opstapje gedoe?
heel goed
verhoogd toilet, aandacht !
toiletpot met spoel
verkoop aan toiletpot vast
als nieuw toilet plaatsen gelijk gebruik maken.

23/06

olaag 1 half 2 hoog
pijltjes tussen 0 naar 1.
1 nog 2 parater - verwarrend
0 1 2 naast elkaar.
simpel mogelijk.
0 12 impliceert oplopend. plaatje duidelijker
doelgroep meer moeite technologie
struikelen alleen is goed
geriatrie weer laten kijken
lichtjes goed vs van schrikken → optiES aan uit
mensen wel sturen eerste instantie
zelf aan comfort
nieuwe hoog of stijlheid eerst beoordelen voor aanschaf
zeker verhoogde bril hulp
bril hoog beginnen, laten zakken, en weer omhoog.
doelgroep die langer zelfstandig thuiswonen kunnen goed
rollatorgebruikers overpakken mogelijk of overhoe regels/manieren.
vinden mensen het 'een ding' / krukje is gedre
voor bekkenbodem zeker goed / als het er staat dan gebruik je het.
mooi systeem
geen los krukje waar over struikelt.
23/11

blok.
ziet niet functie
functionele (zie jaziet.) blaasklachten
overactieve blaas
urine retentie
neurogene blaas
geen deugt voor squat plassen beter in mannen.
[illegible] vrouwen geen last persen
vergrote prostaat moeite plassen
uitgerekt.
wat is grotere groep wiind krijgen?
symptoom bestrijding
vs.
functie teruggeven.
wat is doelgroep?
stoel straal beter krijgen, bandje voor én na
MDL - gefocuste patiënten.
in het lab. contact
onderzoekje opbinden
mail website → waar afdrukbare projecten staan.

7

blaas functie' onderzoek

blaas druk meten en dan plassen.

voeten bankje aanbieden.

hoogte instellen

voeten op krukje helpt plassen, niet lang of hoog

beugel

gevaarlijk ~~niet~~ niet zeker, struikelen

plateau grootte goed

zit voordeel eraan?

aan gebruiker overlaten hoe hoog

fijn zelf instellen

△ ▽ op knop makkelijk

rood & groen na mag je plassen

0 1 2 ~~weet niet~~

middel bovenste -> zal het niet zijn

dichter of ~~verder~~ van toilet

na uitleg mooi meegenomen, vind mooi

handig niet tekens instellen.

als je de behoefte hebt dan zit waarde in

in verzorgingstehuis zeker

risico als je hoog achterlaat

ga en kijken of het hoog

in de vloer is ideaal.

beugel erg goed. ~~oog~~ nodig

vindt het mooi

contrast kleuren. moet opvallen

afgeronde hoeken.

goed schoonmaken.

denkt aan kinderen

leuk op een neer.