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Bachelor thesis

Stand Up for Yourself

A product concept to support elderly with mobility issues to stand up and sit back down independently in an active environment

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Abstract

Currently, 35% of people over 70 years old world wide suffer from mobility issues. Not only does this relate to their physical wellbeing, the limited mobility issues also affect the mental wellbeing. Mobility issues may limit the freedom, and with this, the independence a person may have. Literary research found that many products that provide more independence already exist, yet most of these are made to be used in less active environments. Interviews with the most important stakeholders show the need for a product that gives the user more independence in an active environment does exist. A structured approach through morphological schemes is taken to generate ideas which fulfil the functional requirements. These are filtered, after which initial concepts are created. The final concept presents itself as a chair which may support the user in the sitting and standing motion, and is highly customizable for the user's size and needs. A design brief is composed in which design- and material consideration are listed. Recommendations include using styles from the 70s, and material that is durable and easy to clean. Finally, important future steps include more detailed ergonomic studies, deciding on the materials and testing the prototype.

1. Introduction

35% of 70-year-old people, and the majority of people over 85 suffer from mobility issues (Freiberger, Sieber, & Kob, 2020). This can present itself in many ways. A person may need assistance when getting out or lowering themselves into a chair, which greatly limits their independence, and with this the freedom of a person. It could lead to depressive symptoms, social isolation and anxiety (Karakaya, Bilgin, Ekici, Köse, & Otman, 2009). In addition to the mental problems this limitation brings, physical issues have also been proven to be caused by extended periods of sitting. This includes the degradation of muscles in the legs, which increases fall risk (Okino, Aoki, Yamane, & Kohmura, 2021). People that sit longer often have more joint pains in the knees and hips, as well as back pain (S. D. Kim, 2019). An overall lower health-related quality of life in elderly people has also been found to be related to prolonged sitting (Choi et al., 2021). All in all, sitting for a prolonged time has a detrimental influence on the mental health, and physical well-being of a person. Standing up more regularly could lessen these issues.

Although solutions are available (more information can be found in section 2.1), these solutions often either provide sufficient support, increased independence, or the ability to participate in active environments. The user cannot have it all. In this case, active environments are defined as settings where the user may stand up more frequently compared to a lounge setting. Moreover, the user may want to perform social activities in this setting. An example of this is playing a game with others at a table.

An attempt shall be made to create a solution where the user no longer needs to choose between sufficient support, increased independence, or the ability to participate in active environments. This will be done in two phases: the research phase and the design phase. Each phase shall have its own research/design question, as they each have a different goal.

Research question:	"Which aspects do currently available products lack to support the elderly to independently perform the sitting and standing motion in an active environment?"
Design question:	"How can the missing aspects be integrated into a safe design concept that supports the user in the sitting and standing motion in an active environment?"

The independence that can be gained from the product may also result in elderly people being able to live in their own homes for longer without needing as much help, which will help the nursing homes as in the Netherlands, there is not enough space in these homes ("Peiling: 72% Nederlanders wil het bejaardentehuis terug!," 2021). Furthermore, these nursing homes are often understaffed, resulting in nurses experiencing a working pressure much too high ("Studenten verpleegkunde werken liever niet in verpleeghuis," 2016). By relieving the nurses of the task to assist the elderly people with getting in and out of their chairs, they might have more time to perform other tasks. Moreover, a significant number of caretakers in elderly homes experience physical stress (Galea & Knox, 2017). Not having to assist the elderly with getting in and out of their chairs could relieve some of this stress as well.

2. Research

To address the aforementioned problem, a comprehensive analysis of the currently available substitutes is performed. This is done through a literary review of how each product supports the independence of the user, and how this product may function in active environments. Furthermore, an analysis of the stakeholders and their needs is performed as well, through stakeholder analyses and interviews. These analyses will act as a base for identifying important factors that may influence the design of the solution.

2.1. Substitutes

The substitutes (or competitors) for the product are divided into direct and indirect substitutes. Direct substitutes are products which may work in similar ways to reach the goal, whilst indirect substitutes use different methods to achieve the same goal (Jeffries, 2017). In this case, the goal is to support the user in sitting down and getting back up in an active environment.

2.1.1. Direct substitutes

The first direct substitute to discuss is the "classic" recliner chair (fig. 2.1). Of anything, what customers seek most in a recliner chair is comfort (Kim, Ko, Rhiu, & Yun, 2019), as they are often used in living rooms as a replacement for a couch or comfortable chair, which is why these chairs are commonly large. Over the past years, the recliner chair has evolved quite a lot. There currently is a large range of options to choose from, as one can decide between the level of support the chair gives, price, extra functions (i.e. a footrest, the ability to turn, etc.), and more ("Relaxfauteuils," n.d.). One of the downsides of this chair is that it is not suitable to use at a table. A solution for this has been thought of in the shape of small side tables. Once more, these come in many shapes. Tables that have a base which can slide under the chair and are adjustable in height and angle seem most convenient ("Vaunn Tilt Top overbed Table," n.d.). However, this solution increases the sitting time of the user, as they no longer need to get up to use a table, which can lead to physical problems (Choi et al., 2021).

Figure 2.1: Recliner chair with side table ("Ievshop," n.d.).

The second direct substitute is a lift cushion (fig. 2.2). This consists of only the seating part of the chair with a built-in electric mechanism that supports the user in sitting down and standing up. This cushion can be attached to a regular chair ("UpEasy Power Seat Elektrisch," n.d.). Compared to the first substitute, this option has the advantage of being flexible when it comes to where to use it, as it can be attached to many different chairs. However, due to the power it needs to work, there will always be a cord on the ground, and there must be a power outlet available within reach. This may also introduce a tripping hazard. Furthermore, the lift cushion may not bring enough support, be as comfortable, or is good for the posture of the user, as the chair the cushion is attached to, is not designed with the cushion in mind.

Figure 2.2: Lift cushion ("UpEasy Power Seat Elektrisch," n.d.).

The final direct substitute to mention is a chair lift (fig. 2.3). This product can be attached to the bottom of the chair and lifts it a few centimetres, already making it easier to stand up and sit down. The rocking motion of the chair lift, provided by springs to ensure a stable feeling when sitting, gives the user extra support when standing up ("Stander Recliner Risers," n.d.). Compared to previous substitutes this option is not electric, resulting in no cords on the ground, or the need to be close to an outlet. However, the chair lift can only be attached to one chair, which may need to be a lounge chair. This results in the same issues as mentioned for the first substitute.

Figure 2.3: Chair lift ("Stander Recliner Risers," n.d.).

2.1.2. Indirect substitutes

The first indirect substitute is a gait belt (fig. 2.4). These belts are secured around the user, after which the caregiver uses the belt to pull the user towards themselves (Walker, 2022). This belt is meant for people who need support getting up from the chair yet are still able to carry some of their weight (Walker, 2022). Although this is a cheap substitute, it does present significant limits to its abilities. One can only be assisted in the getting-up motion, not when sitting down, and the user is not able to get up independently. Moreover, the caregiver has to make sure they are using the right technique, as otherwise, it can cause physical issues (Walker, 2022). Solutions have been thought of to erase the physical stress a gait belt causes on the caregiver. The tililift does all the heavy-lifting for a caregiver ("Tililiften," n.d.). However, the lack of independence for the user remains. A tililift needs a minimum of one caregiver to operate the machine ("Moet je een actieve/passieve tillift met 1 of met 2 mensen bedienen? Zijn hier wettelijke richtlijnen voor?," n.d.).

Figure 2.4: Gait belt and tililift ("Mobility-Aids," n.d.; Motmans, 2019).

The second indirect substitute is a bar typically used to help people in and out of bed ("Adhome Bed Transferbeugel," n.d.) (fig. 2.5). This option allows to user to independently get up, however, it does not offer as much support as one of the direct substitutes does. Furthermore, the FDA (U.S. Food & Drug Administration) reports many injuries caused by using these sorts of products ("Safety Concerns about Bed Rails," 2018). This mainly concerns people who are too weak to use it, as they may fall between the bar and the bed or on it, and are not able to get back up alone ("Safety Concerns about Bed Rails," 2018).

Figure 2.5: Transfer bar ("Adhome Bed Transferbeugel," n.d.).

The third indirect substitute is a cane (fig. 2.6). Although this product is not typically made with the goal of getting in and out of chairs in mind, the EZ-get-up-from-seat cane was ("Stay Home in Style with the EZ-Get-Up-From-Seat Walking Cane," 2020). The two handles, together with the add-on stabilizing base, can ensure the stability the cane needs for the user to put their weight on it when sitting down and standing back up. The largest positive aspect of this cane is that it is very flexible in use. It can be used to sit, walk, get out of bed, and use the stairs. However, it is important to note that the user must be mobile and strong enough to use this cane. According to the CDC, a large number of fall injuries treated in the emergency room had to do with walking aids, including canes ("47,000 Older Adults Treated in Emergency Departments Annually for Fall Injuries Related to Walkers and Canes," 2009).

Figure 2.6: EZ-get-up-from-seat cane ("Stay Home in Style with the EZ-Get-Up-From-Seat Walking Cane," 2020).

The final indirect substitute is an ergonomic desk chair (fig. 2.7). This product is not associated with supporting the user in standing up and sitting down, however, it is known for ensuring a healthy posture and is often used in an active environment – at the desk. Often, standard criteria apply concerning ergonomics and anthropometrics (Groenesteijn, Vink, de Looze, & Krause, 2009). This way, the chair gives the user ample opportunity to keep a healthy posture. Although this product does not help the user with the sitting and standing motion, an important aspect to the final concept should be how comfortable, and healthy it is to use. Hence, this product offers examples of how this goal could be realized.

Figure 2.7: Ergonomic desk chair (Pariso, 2022).

2.2. Stakeholder analysis

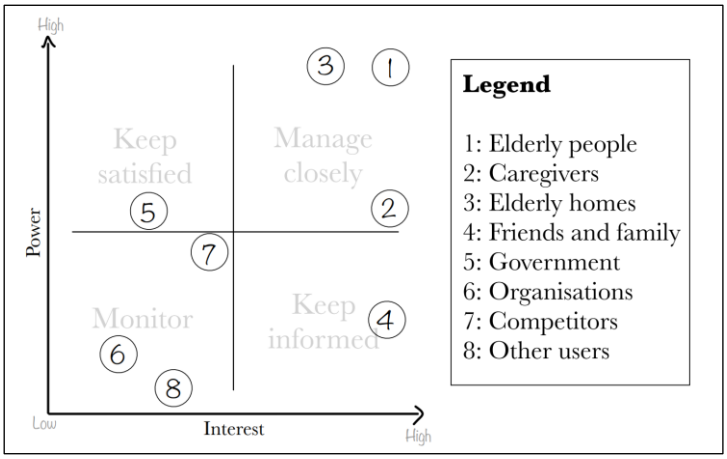


Figure 2.8: Stakeholder map.

The stakeholders mentioned in table 2.1 have been mapped in a power/interest-grid (see fig. 2.8), as this gives greater insights into how the stakeholders should be prioritized (Thompson, 2015). This grid is divided into four categories: *Manage closely*, *keep informed*, *monitor*, and *keep satisfied*.

People in the quadrant *manage closely* are people who have a lot of interest in the product (they may gain personal benefits), and also have a lot of power. The user, elderly homes, and caregivers have been classified in this corner. They all hope the user benefits from the product, and have relatively much power. The caregivers have high interest as this influences their work. Moreover, they work closely with the user, and may have an emotional connection to them. The elderly homes may have a bit less interest, although they still care highly for their staff, who are experiencing physical stress. The elderly homes do have more power than the caretaker, as the caretaker can only advise the user on their purchases, whilst elderly homes and users have the power themselves to purchase a product.

People in the quadrant *keep informed* care greatly but have less power. In this case, this only includes the caregiver, as they hope to gain personal benefits in that they will experience less physical stress. However, they do not have much power as they have little influence on whether people will buy the product.

Multiple stakeholders are classified in the *monitor* quadrant, including organizations supporting the elderly, competitors, and other users than intended. These people are less interested, and also do not have much power. This is because they are not the user for which the product is designed, nor do they have a person close to them that is.

The final category is *keep satisfied*, in which only one stakeholder belongs: the government. This stakeholder has a bit more power but does not have much interest. The government belongs in this category as they have power over the purchase of this product seeing they can subsidize it. However, the government does not have a high interest as they are not the user for which the product is designed, nor do they have a person close to them that is.

Nr.	Stakeholder	Reasoning
1	Elderly people with mobility issues	This stakeholder is identified as the user, meaning they will interact most with the product.
2	Caregivers (including friends, family, and paid care services)	Although not the user, the caregiver is normally the person to help the user in and out of a chair. Hence, caregivers are interested in this solution as they will experience less physical stress.
3	Elderly homes	Elderly homes may purchase this product to be used in their facilities, as this will increase the quality of life for their residents. Next to this, it is also beneficial for the caregivers working in the elderly home, as they will experience less physical stress, and will have more time to perform more meaningful tasks for the residents.
4	Friends and family	Friends and family will indirectly benefit as they care about the user, and wish for a safe and happy life for them. As this solution shall help in achieving this goal, friends and family may urge the potential user to purchase the product or purchase it for them.
5	Government	The Dutch Government supports the elderly in living at home for as long as is safely possible, and mention products designed for this reason may greatly support the elderly in this ("Living Independently for Longer," n.d.). One of the ways the government shows support is in the shape of subsidies called WMO (Social Support Act). A person can request this when needing to purchase a product that supports them with their daily tasks ("Social Support Act (WMO 2015)," n.d.).
6	Organizations supporting the elderly	Numerous organizations strive for a better life for the elderly. An example is ANBO (Algemene Nederlandse Bond voor Ouderen, general Dutch association for elderly), which works towards giving its members more information on income, digitalisation, health, living, and safety ("ANBO," n.d.). This product may create a healthier and safer living environment for its members (the user of the product).
7	Competitors	Competitors are businesses with similar products or products that may aim to achieve the same goal. Putting this product on the market may cause the competitors to lose customers.
8	Other users than intended	Although this product is designed for the elderly struggling with mobility issues, other potential users may discover this product and deem it useful for themselves as well. These other users can for instance be people with knee or hip issues. The product may also be used in other environments, such as certain recovery rooms of a hospital. An example is the oncology department, as patients often feel fatigued or experience weakness after treatment ("Fatigue and Weakness," n.d.).

Table 2.1: An overview of the stakeholders involved.

2.2.1. Interviews

Interviews were conducted with 3 participants, of which 1 elderly person and 2 caregivers. In these interviews, people were asked about the physical and mental health of the elderly. They were also asked about how often the elderly participates in social activities, and whether possible mobility issues affected this. They were presented with the goal of this project, after which the participant could share their opinion on this product. Finally, they were asked whether there are any functions they believe should or should not be present in the product a full list of questions can be found in appendix B.

The overall consensus was that people did believe a product in line with what was presented to them, would have significant value. The elderly that participated mentioned valuable points, such as the fact that they may feel scared to use a complicated machine. They would also like this product to fit with their interior design. The caregivers that participated gave more practical suggestions on what the final product should look like. For instance, one participant mentioned the importance of support in drawing up to a table. Currently, the caregivers in the elderly home often need to help the elderly with this. Another participant noted that elderly homes would not purchase a product like this if it can only be used for one person. As the elderly will eventually pass and no longer be in need of the product, it would be highly beneficial if the chair can then be used for someone else. Finally, a comment was made on the body dimensions of the elderly. Often times, these people have more fragile bodies that have specific needs. It is therefore even more important to ensure they keep a healthy posture.

2.2.2. User scenarios

User scenarios have been created to visualize a clear picture of how the product may be of use in certain situations and/or environments. With this, a greater understanding of how the stakeholders may interact with the product can be achieved. The following scenarios have been created, with each left image being the current situation, and the right scenario being what the product proposed in this report will change in the situation.

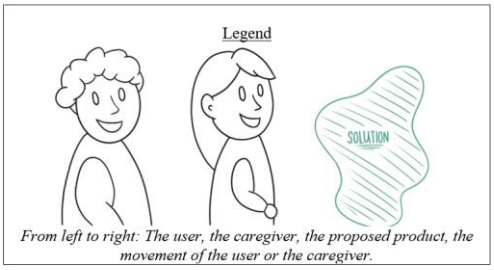


Figure 2.9: Legend.

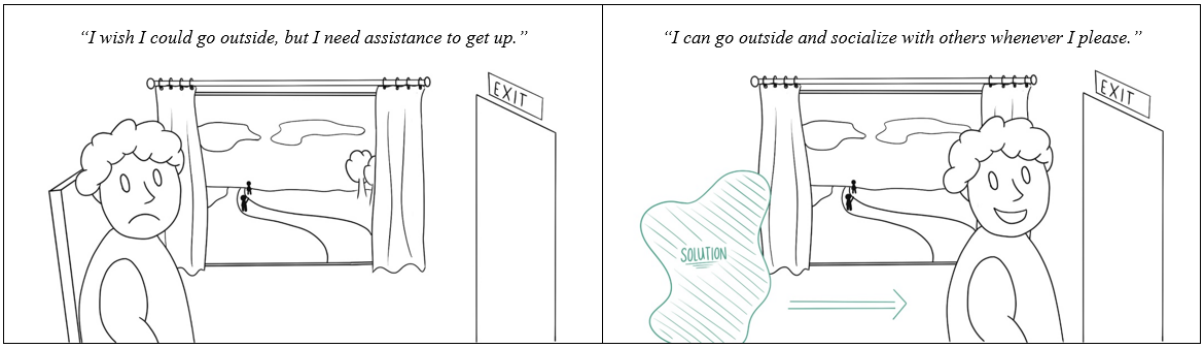


Figure 2.10: Scenario 1 – Freedom.

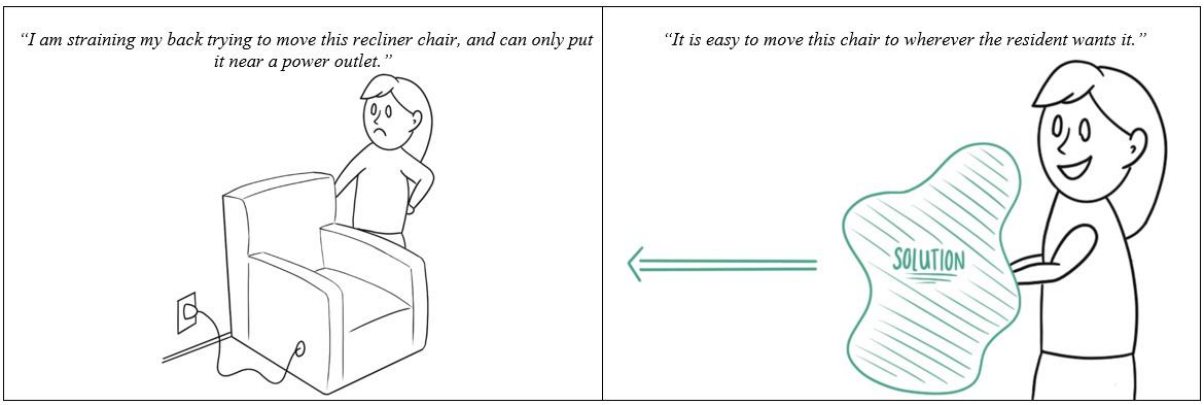


Figure 2.11: Scenario 2 – Flexibility.

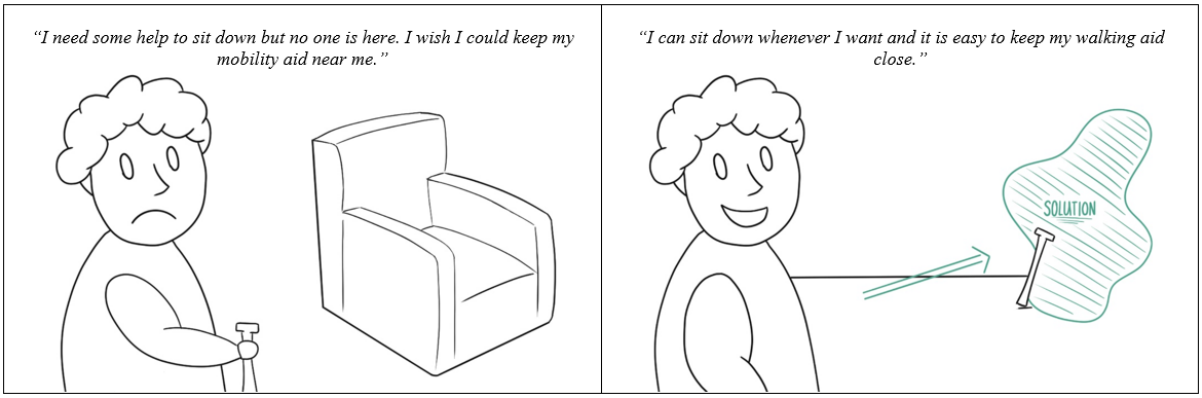


Figure 2.12: Scenario 3 – Mobility aids.

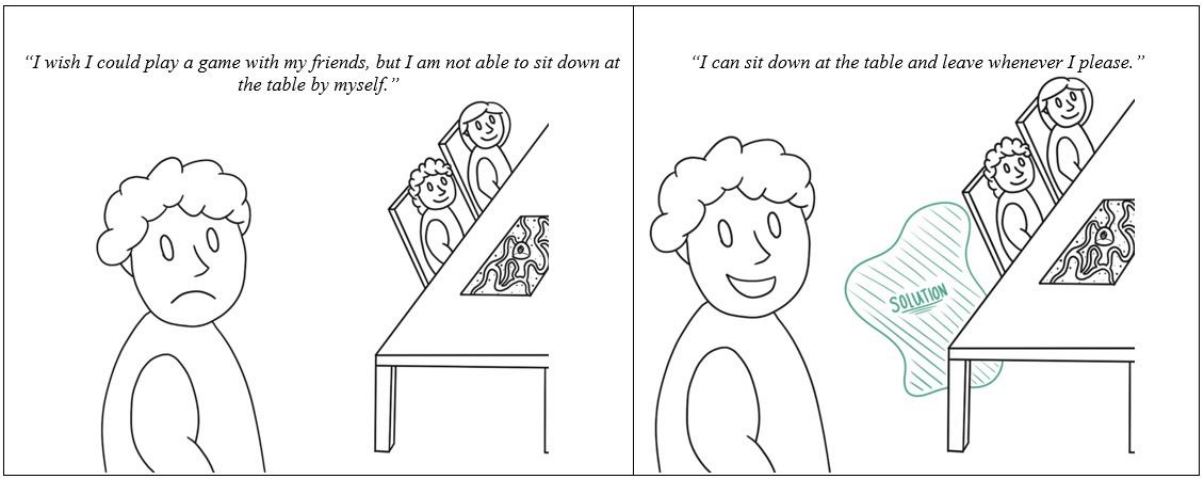


Figure 2.13: Scenario 4 – Active environment.

2.3. Sustainability

In section 2.1, the advantages and disadvantages of electronic and mechanical chairs have come up multiple times. The scenarios also show it may be beneficial for the solution to be useable in different places, as the solution may need to be moved often, and outlets may not always be nearby (example: Fig. 2.11).

In addition to the convenience a "wireless" solution may bring, a fully mechanical solution may also be a more sustainable solution to the problem. It is argued that innovation may be harmful to the environment, as this only increases consumption (Dietrich, 2022). This is in line with the notion that

simplicity and sustainability go hand in hand; one must think of simple solutions to complex problems to achieve long-term sustainability (Massoudi & Vaidya, 2018).

Moreover, sustainability is an important factor to take into account in other aspects of the design, for instance, the material. Durable material lasts longer, meaning a user would not purchase a new product to solve their issue as quickly. Although the product should be able to last long, at some point the user shall dispose of it. Therefore, the materials used must be of a material that is not armful for the environment, or maybe even recyclable or upcyclable. Further elaboration on this can be found in section 8.4.

2.4. Key findings

Even though the substitutes show there are many options with each their benefits, it is also clear these options are often missing an important aspect. The direct substitutes are either not made for an active environment, or do not provide the needed support. Although the indirect substitutes can provide this support in a more active environment, a similar problem appears: the user has to choose between enough support and independence.

The stakeholder analysis shows valuable insights on the needs and wishes of the stakeholders. The elderly people, the caregivers, and the elderly homes seem the most important stakeholders, meaning their opinion should have much value. Moreover, identifying the stakeholders and the user already focusses which functions may need to be incorporated in the final concept. This also aids in finding the right people to interview.

The interviews, together with the user scenarios, have been useful tools with regard to the functional requirements. For instance, the importance of drawing up to a table was pointed out here, amongst others. A full list of requirements can be found in section 3.

Lastly, sustainability was found to be an important point by the researcher. Besides the convenience a “wireless” solution possibly brings, in the broader picture, a “simple” solution may be better for the environment as well.

3. Functional requirements

The following shows an overview of the functional requirements. These may be defined as factors the final design must adhere to (Privitera, 2015). The functional requirements (FR) are based on literary research, interviews with stakeholders, and user scenarios. To quickly gain understanding of the source of the requirement, an overview of how all sections contribute can be found in figure 3.1. The precise source of the design requirement can be found by clicking the hyperlinks in table 3.1.

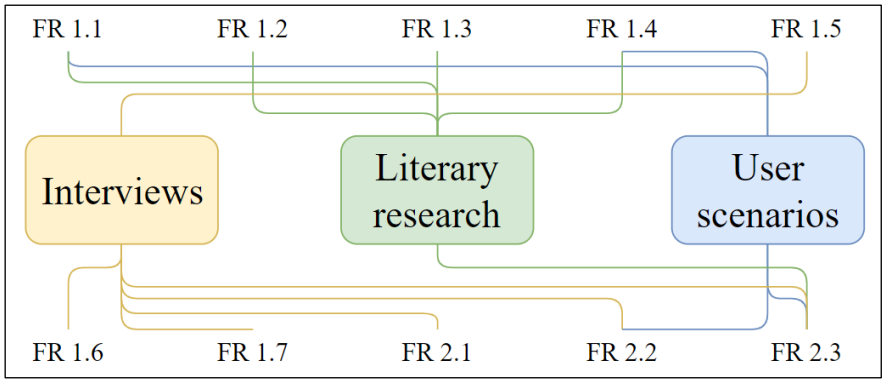


Figure 3.1: Functional requirements connection map.

1.	**The product should allow the user to independently sit down and stand up in an active environment.**
1.1	The product should assist the user in transitioning independently between sitting and standing.
1.2	The product should assist the user to independently draw up to a table.
1.3	The product should promote standing up regularly.
1.4	The product should ensure the user can independently perform activities whilst sitting down at a table.
1.5	The product should be usable for people of different body dimensions.
1.6	The product should be usable (as intended) for people with different levels of needed support.
1.7	The product should enable the user to keep a healthy posture.
2.	**The product should be easy to use.**
2.1	The product should be intuitive in its use for the user.[1]
2.2	The product should allow possible mobility/walking aids to be kept within reach.
2.3	The product should allow the caregiver to easily[2] move it around.

Table 3.1: Functional requirements.

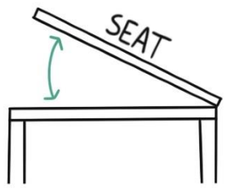
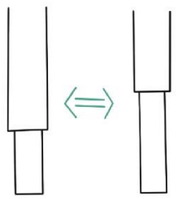
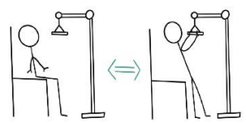
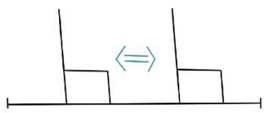
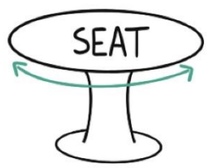
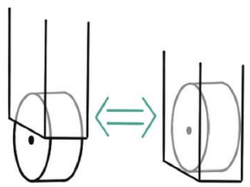
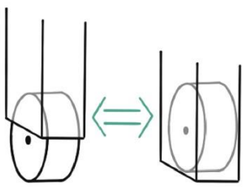
[1] Important is to keep in mind who the user is. In this case, the user is of age, and may therefore may not be comfortable using electronic devices with many different functions. Moreover, many people of this age suffer from dementia ("Working together internationally to tackle dementia," 2017), meaning their cognitive performances are not as strong as that of an average adult.

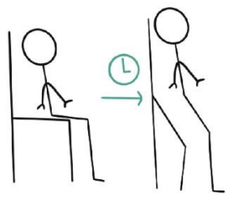
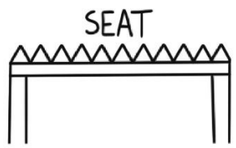
[2] Without physically straining themselves.

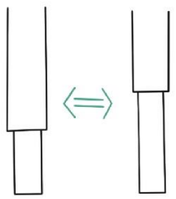
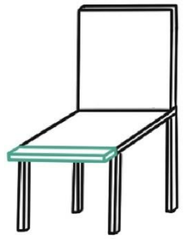
4. Ideation

During the ideation phase, multiple solutions are thought of for each requirement. These shall serve as a base to create the concepts. The concepts will then be compared, and a final concept is chosen. To assess the effect each solution has on all requirements a morphological scheme is used (table 4.1). In this table, all functional requirements can be found on the left. Requirements 1.6 and 1.7 have been left out, as the way in which these requirements can be achieved is highly dependent on the design of the concept. On top, the initial ideas can be found.

The morphological scheme shows solutions 1.1a, 1.2a, 1.3a, 1.3c, and 2.2d are interfering with certain requirements (red indicates the idea works against a requirement), hence these will no longer be taken into consideration. With the remaining solutions, possible combinations will be thought of in section 5, concepts.

Functional requirements	Initial solutions								
Legend: Meets requirement Does not apply to requirement/is neutral towards requirement Works against requirement	*FR 1.1: The product should assist the user in transitioning independently between sitting and standing.*	1.1a Chair with lifting seat 	1.1b Chair with lifting legs 	1.1c Pull up/forward system 	*FR 1.2: The product should assist the user to independently draw up to a table.*	1.2a Rails 	1.2b Turning seat 	1.2c Mechanical wheels 	1.2d Electronic wheels 
1.1									
1.2									
1.3									
1.4									
1.5									
1.6				The user may lack arm strength.					
1.7									
2.1									
2.2									
2.3						The rails make for a large and heavy product that is not easy to move around.			

Functional requirements	Initial solutions						
Legend: Meets requirement Does not apply to requirement/is neutral towards requirement Works against requirement	*FR 1.3: The product should promote standing up regularly.*	1.3a Forcing the standing motion 	1.3b Personalized notifications 	1.3c Uncomfortable seat 	*FR 1.4: The product should ensure the user can independently perform activities whilst sitting down at a table.*	1.4a Adjustable and/or removable arm rests	1.4b Lowering and heightening seat electronically
1.1							
1.2							
1.3							
1.4		The user is forced to stand up, even when doing something.		The user is forced to stand up, even when doing something.			
1.5							
1.6							
1.7							
2.1							
2.2							
2.3							

Functional requirements	**Initial solutions**							
Legend: Meets requirement Does not apply to requirement/is neutral towards requirement Works against requirement	*FR 1.5: The product should be usable for people of different body dimensions.*	1.5a Adjustable legs 	1.5b Extendable seat (in width) 	1.5c Adjustable seat depth 	*FR 2.1: The product should be intuitive in its use for the user.*	2.1a Minimal actions to perform tasks	2.1b Visual cues	2.1c Interactive parts are in eyesight
1.1								
1.2								
1.3								
1.4								
1.5								
1.6								
1.7								
2.1								
2.2								
2.3								

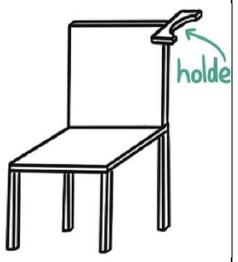
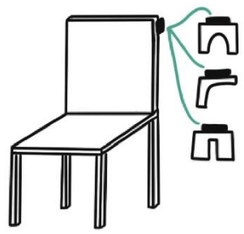
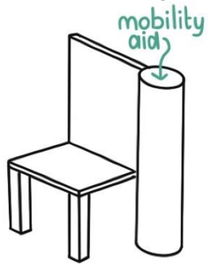
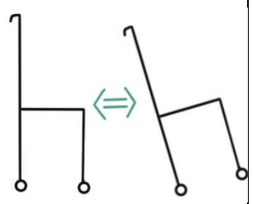
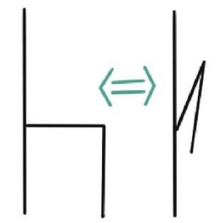
Functional requirements	**Initial solutions**							
Legend: Meets requirement Does not apply to requirement/is neutral towards requirement Works against requirement	*FR 2.2: The product should allow possible mobility/walking aids to be kept within reach.*	2.2a Generic holder 	2.2b Add-ons for specific mobility aid 	2.2c Vertical storage tube 	2.2d Horizontal storage tube 	*FR 2.3: The product should allow the caregiver to easily move it around.*	2.3a (Partial) wheels 	2.3b Foldable design 	2.3c Continuous track 
1.1								
1.2								
1.3								
1.4								
1.5								
1.6								
1.7								
2.1								
2.2								
2.3								

Table 4.1: Morphological scheme of all ideated solutions.

5. Concepts

From all ideas presented in section 4, many different combinations were attempted. Two different kinds of concepts finally seemed to let the ideas fit into one product. These concepts are shortly evaluated by placing them in the scenarios shown in section 2.2.2, and altered based on this evaluation. The following section shall present and compare these concepts. The figures show visualisations of each concept, with a simple explanation of the function of each component of the solution.

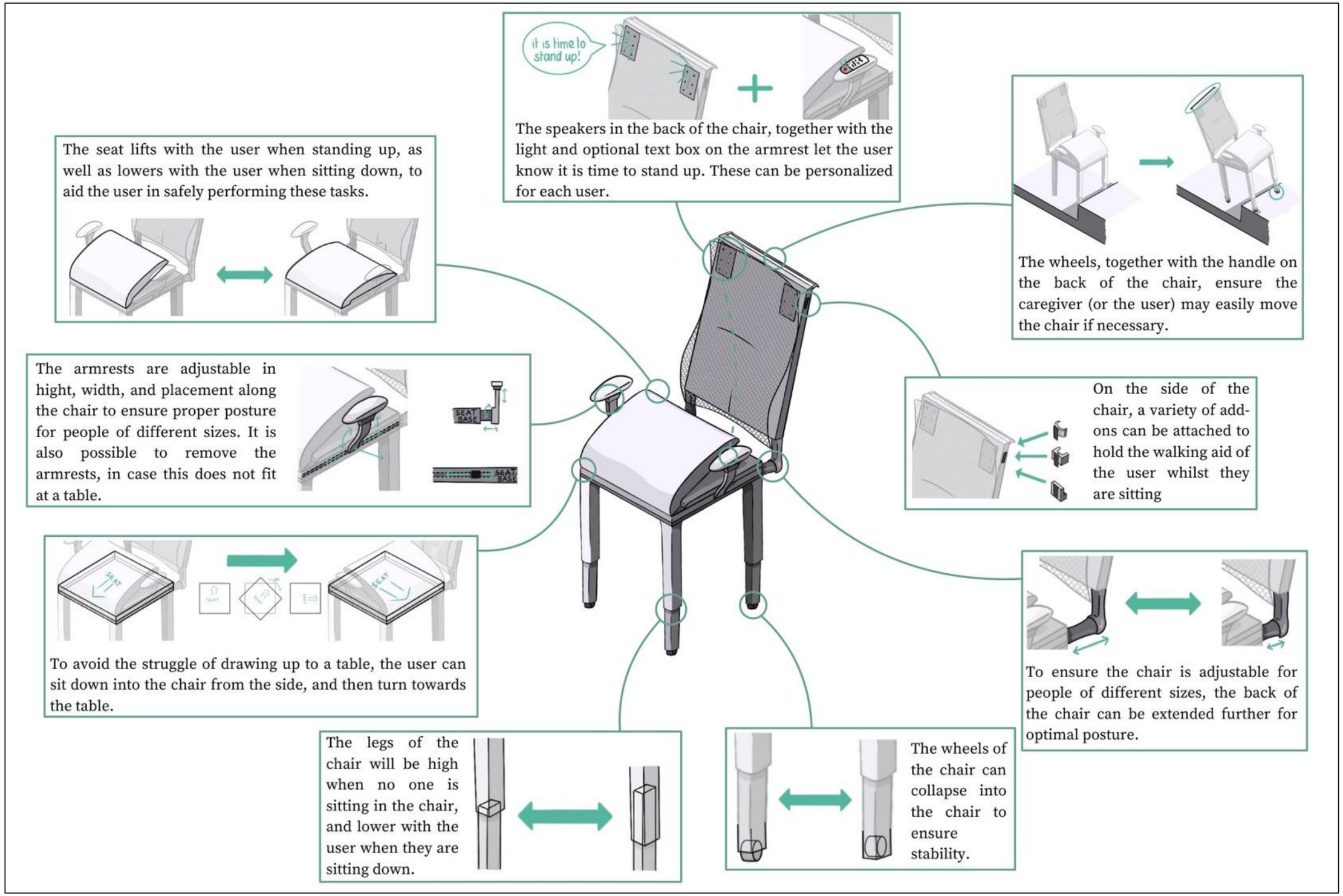
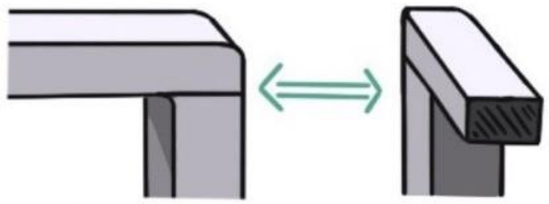


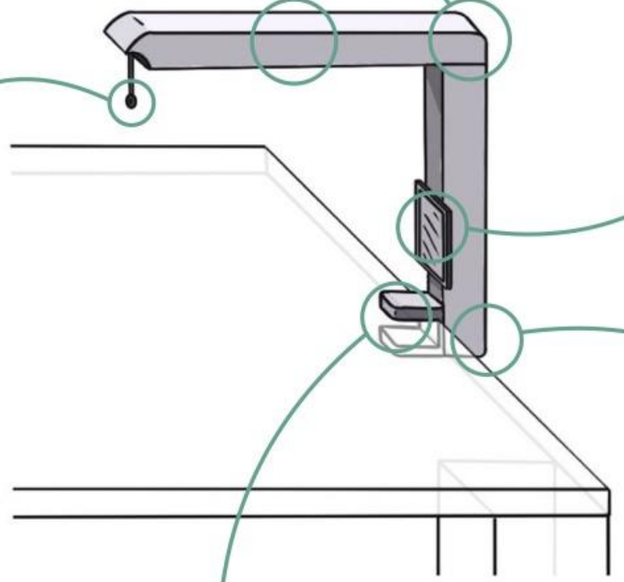
Figure 5.1: Concept sketch 1.1.

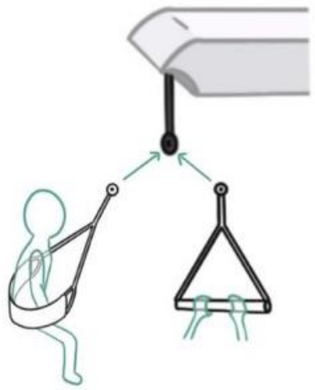
This image shows how the device works on the inside. The cable is carried on multiple pulleys, and rolled up at the end. The pulley system ensures there is minimal force needed to pull the user up, and carefully put them down.



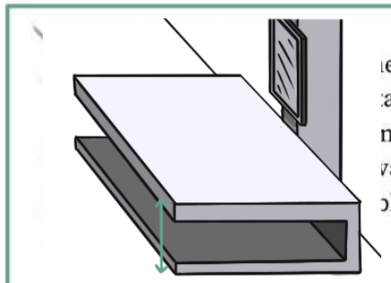
The device can turn, to ensure the user can be seated wherever they please.

The screen can show personalized notifications. It can also make a sound.

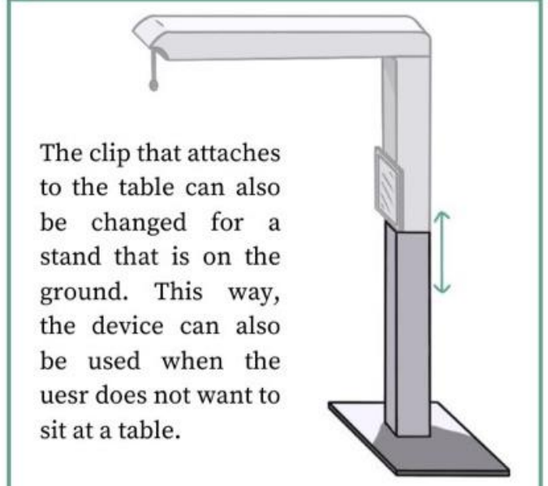




To accommodate for people with different levels of needed support, various add-ons can be attached to the wire. A seat can be added for a more supportive experience, whilst people with more strength may be able to pull themselves up.



ıe clip that ıached to the table n be adjusted to fit variety of different ɔles.



The clip that attaches to the table can also be changed for a stand that is on the ground. This way, the device can also be used when the uesr does not want to sit at a table.

Figure 5.2: Concept sketch 2.1.

5.1 Concept 1.1

Fig. 5.1 shows a visualization of the first concept, as can be seen, this has taken the shape of a traditional chair. The wheels, together with the handle at the back, ensure it is easy to move the chair. These wheels are also useful when drawing up to a table, and by making these wheels collapsible, the chair maintains stability. The adjustable distance from the seat to the back, the adjustable legs, and the adjustments that can be made in the armrests make for a chair that is adjustable for people of different sizes. The legs, together with the seat, support the user in standing up and sitting back down. Finally, the seat can turn 180° to ensure it is easy for the user to sit down at the table.

Initial solutions incorporated from section 4: 1.1a, 1.1b, 1.2b, 1.2c, 1.3b, 1.4a, 1.5a, 1.5c, 2.2b, 2.3a

5.1.1. Disadvantages

Two main disadvantages can be expected to occur from this design. Firstly, if one imagines using a walking cane, and wants to sit down on this chair, one would have to make an unnatural movement to be able to store the walking aid in the designated place. Secondly, the design has many different functions to fulfil the requirements. It may be difficult for the user to understand, and correctly use all these functions. Next to this, it is important to take into account how the user may respond to the many functions of the chair. Currently, about 260 000 people are living with dementia in the Netherlands, and this number is expected to almost double within 30 years ("Working together internationally to tackle dementia," 2017). Lately, more research has been done on the therapeutic role design can play in improving the mental health of people suffering from dementia. One of the factors to take into account is that people with dementia often experience sensory overstimulation (Day, Carreon, & Stump, 2000). Therefore, the large number of possibilities in this design may harm the mental well-being of the user, if said user suffers from a form of dementia. Although this important factor is currently not highlighted in the functional requirements (but touched upon in FR2.1), this has translated to a technical requirement underneath FR2.1, more on this can be found in section 8.2. Finally, the design may not be the most efficient when looking at costs of labour and materials. A clear example is the legs of the chair. One could argue a single leg with multiple wheels (similar to office chairs) may be easier and cheaper to manufacture.

5.2 Concept 2.1

To ensure a broad range of concepts, a second concept that is not in the shape of a chair is created (fig. 5.2). This solution is comparable to a crane that is often used in construction. The solution is still simple in the sense that it does not have many functions. This is because the product no longer has to ensure the user keeps a healthy posture whilst seated, as the product only interacts with the person when they stand up or sit down. To accommodate people with different levels of needed support, different add-ons can be attached to the product. Some people may need a seat that lifts them, some people may have enough support by just being able to hold something that will pull them up. The users will still be able to receive notifications, through a screen faced towards them. The top of the product can turn to increase flexibility in terms of where it can place the users. To increase this even further, a stand that will be on the ground can also be attached instead of the clip on the table.

Initial solutions incorporated from section 4: 1.1c, 1.3b, 1.4b

5.2.1. Disadvantages

Although not part of the design requirement, the aesthetics of the product start playing a significant role here. A large crane in the middle of the room may be distracting or overbearing. Besides the aesthetics, before the realization of this product, a lot of calculations must be done to ensure it can safely carry the load of people ranging in size. These calculations may show that a clip on the table alone is not enough,

or the base of the stand may need to be much larger. Thus, to ensure enough security, the product may be even more overbearing, or simply in the way. This relates to the final point; safety. The safety of the user remains a high priority in this project, and this product is meant to be used independently. Compared to a chair, this product requires more steps to ensure safety, and people suffering from a form of dementia may not be able to safely use the product.

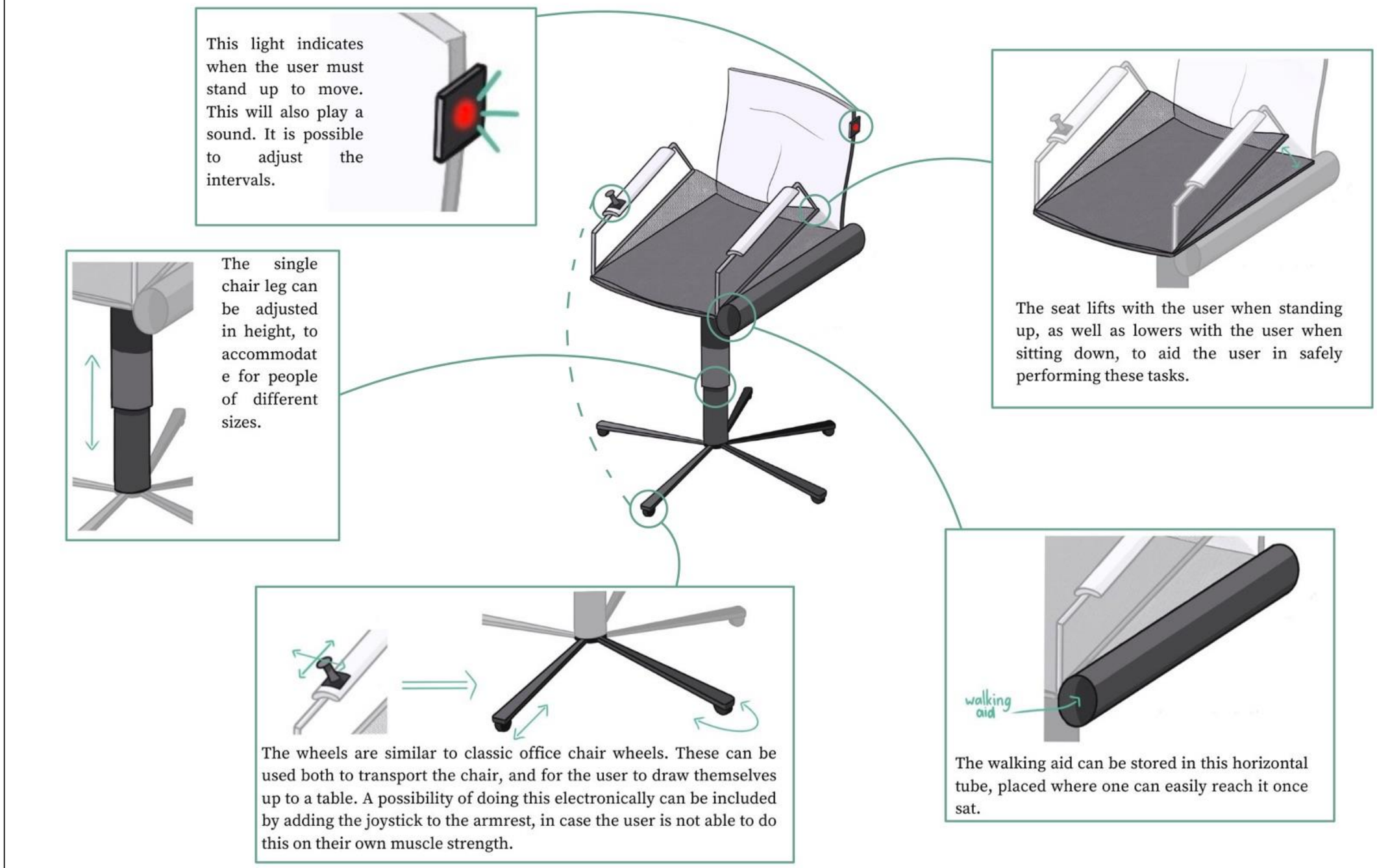


Figure 5.3: Concept sketch 1.2.

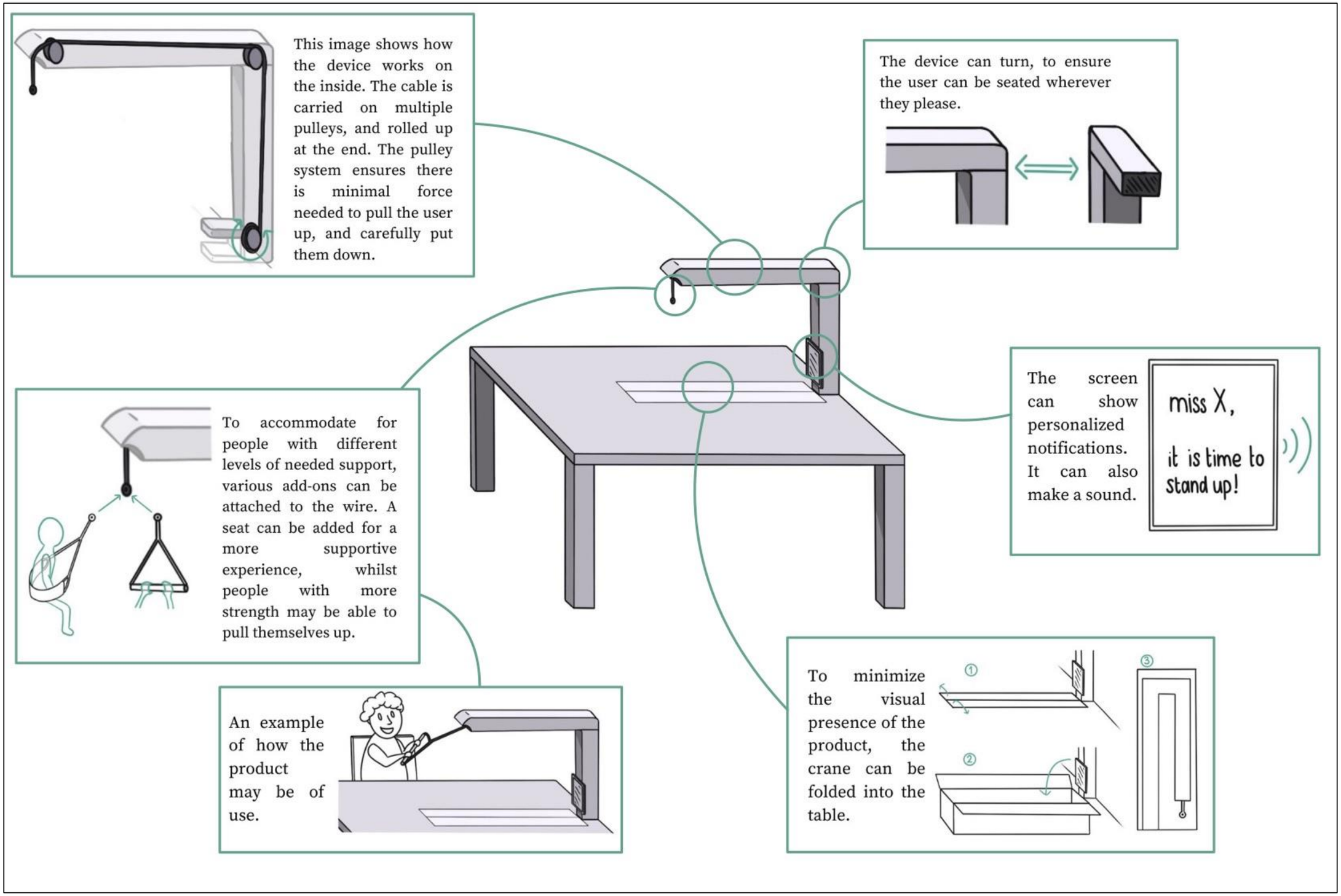


Figure 5.4: Concept sketch 2.2.

5.3 Concept 1.2

After shortly evaluating the positive and negative aspects of the first concept, it is clear that improvements can still be made to this design. This design (fig. 5.3) shows some similar functions, although this solution has a larger focus on simplicity and intuition. This is because simplicity will often lead to a better user experience (users will not struggle to use the product). Moreover, a simpler design may also be better for the environment, as discussed in section 2.3. The simplicity is noticeable in the number of functions of the solution, and can also be found in the wheels. These should be used to draw up to the table (which can be done with minimal force, using the joystick on the armrest), and it ensures the solution is easily moveable. The notification remains, this is something that can light up, or make sounds. Next to this, the seating is still raised and lowered in the same manner as in concept 1.1, except is the design more modern, and are lighter materials used. The walking aid can now be stored in a horizontal tube next to the chair, this should be more easily reachable.

Initial solutions incorporated from section 4: 1.1a, 1.2d, 1.3b, 2.1a, 2.2d, 2.3a

5.3.1. Disadvantages

The simplicity of this design also comes with downsides, of which the largest is the few possibilities to personalize the chair. Although the walking aid storage seems to be in a more convenient spot compared to concept 1, one would still need ample space in front of them to put the walking aid in the storage tube. This is an inconvenience, as the product will be used in an active environment, where the space will not always be available. Moreover, the user would still need to have proper control over their motor functions, as they would need to put the walking aid into the tube independently. Finally, research is pointing out how an at-home feeling may be beneficial to people who suffer from dementia (Day et al., 2000). To many people who are currently classified as elderly people, the style they feel at home in is not that of a modern ergonomic desk chair.

5.4 Concept 2.2

To solve a large issue in concept 2.1 (the fact that the product may need to be quite large to be able to safely carry a person) the crane concept has been altered to be incorporated into a table (fig. 5.4). In this case, it is assumed the caregivers will not move the product, as it may also function as a normal table. Another improvement is that the aesthetics of the product will not come across as overbearing at all times, seeing the crane can be folded into the table.

Initial solutions incorporated from section 4: 1.1c, 1.3b, 1.4b

5.4.1. Disadvantages

The largest disadvantage to this design is that it is made with a group of users in mind, instead of just one. This could be an advantage for nursing homes, however, this project is also done with the goal of people being able to live at home for longer in mind as well. It is still possible to use this product in as an individual, but it is not likely this will happen. Furthermore, the design has limited the active environment to sitting at a table. Although this may be what the final solution will largely be used for, one may also want to use this product when sitting with larger groups on and around the sofa (an example being the “typical” Dutch birthday parties, where people sit in circles).

5.5 Comparisons of the concepts

The aforementioned concepts will be compared in multiple ways. First, the concepts are compared through a morphological scheme. To create a more tangible comparison, later on, a weighting factor is added to each requirement, and each concept is given a score.

5.5.1. Morphological scheme

The above-presented concepts are compared to each other through a morphological scheme (table 5.1). Here, it is visible that concepts 2.1 and 2.2 perform the worst overall. It is also interesting to note that concept 1.1 scores great generally, except for FR2.1. As previously mentioned, this is due to the complexity of the product. However, it should be noted that although this solution entails many functions, quite a few of these functions can be set to the correct setting by the caretaker once. Concept 1.2 does seem to fulfil all requirements to some extent, however, more requirements are not optimally fulfilled. Hence, it seems an optimal final concept would possess all functions the first concept possesses, whilst also incorporating the simplicity in which the second concept can be used.

Functional requirements	**Concepts**			
Legend: Fulfils FR, does not fully fulfil FR, does not fulfil FR				
The product should…	1.1	1.2	2.1	2.2
1.1 … assist the user in transitioning independently between sitting and standing.				
1.2 … assist the user to independently draw up to a table.				
1.3 … promote standing up regularly.				
1.4 … ensure the user can independently perform activities whilst sitting down at a table.				
1.5 … be usable for people of different body dimensions.				
1.6 … be usable for people with different levels of needed support.				
1.7 … enable the user to keep a healthy posture.				
2.1 … be intuitive in its use for the user.				
2.2 … allow possible mobility/walking aids to be kept within reach.				
2.3 … allow the caregiver to easily move it around.				

Table 5.1: Morphological scheme of all concepts.

A notable observation about the design requirements concerns FR2.2. This seems the most difficult requirement to fulfil, as no concept was given a fully positive score. Looking at the evaluations in sections 5.1 to 5.3, the reoccurring issue was that there is no place on the product itself that the user can easily reach once seated, or standing in a position to sit down safely. This raises the question of whether it is possible to satisfy this requirement to the level that was originally planned. Moreover, there may be other solutions outside of this project that is better suited to solve the issue. An example is a foldable tabletop cane holder by a company named WalkingSticks (“Reflective Folding Tabletop Walking Stick and Cane Holder,” n.d.), see fig. 5.5. This leads to the conclusion that FR2.2 may not be as important as other requirements. Therefore, a weighting factor should be added to the design requirements to fairly judge the concepts through said requirements (Eger, Bonnema, Lutters, & van der Voort, 2013b).

Figure 5.5: A foldable cane holder by WalkingSticks ("Reflective Folding Tabletop Walking Stick and Cane Holder," n.d.).

5.5.2. Scoring system through weighting factors

The weighting factors are added to the functional requirement similarly to how this is described in the book "Product Design" by Eger, Bonnema, Lutters, and Van der Voort (2013). A weighting range between 1 and 5 is chosen. This way, the FRs are prioritized in importance. Although the decision on which weight is given to each requirement is ultimately made by the researcher, the decision is partially based on information gained from interviews and user scenarios, and made with logical reasoning. An example is that the researcher decided that FR1.1 is more important than FR2.2, as the design question cannot successfully be answered without FR1.1, whilst FR2.2 is not absolutely essential for this. The assessment can range between 1 and 3 and is based on the colours given in table 5.1 (green = 3, orange = 2, red = 1). The score is calculated by multiplying the weighting with the assessment. The total score is the sum of all scores in the column.

Functional requirements		Concept 1.1		Concept 1.2		Concept 2.1		Concept 2.2	
The product should…	***Weighting***	*Assessment*	*Score*	*Assessment*	*Score*	*Assessment*	*Score*	*Assessment*	*Score*
1.1 … assist the user in transitioning independently between sitting and standing.	**5**	3	15	3	15	3	15	3	15
1.2 … assist the user to independently draw up to a table.	**4**	3	12	3	12	2	8	2	8
1.3 … promote standing up regularly.	**4**	3	12	3	12	3	12	3	12
1.4 … ensure the user can independently perform activities whilst sitting down at a table.	**5**	3	15	3	15	3	15	3	15
1.5 … be usable for people of different body dimensions.	**5**	3	15	2	10	3	15	3	15
1.6 … be usable for people with different levels of needed support.	**5**	3	15	3	15	3	15	3	15
1.7 … enable the user to keep a healthy posture.	**4**	3	12	2	8	3	12	3	12
2.1 … be intuitive in its use for the user.	**5**	1	5	3	15	2	10	2	10
2.2 … allow possible mobility/walking aids to be kept within reach.	**2**	2.5	5	2.5	10	1	2	1	2
2.3 … allow the caregiver to easily move it around.	**3**	3	9	3	9	2	6	1	3
	Total	115		121		110		107	

Table 5.2: The total scores given to each concept by using weighting factors.

5.5.2.1. Reflection on the requirements

A significantly lower score was given to FR2.2 and FR2.3. FR2.2, as during the creation of the concepts it became clear that adding this to the design in a sensible way (i.e. the user should be able to reach this function without any strange or unnatural movements, and the mobility/walking aid should not be in the way) proves difficult. Moreover, as previously mentioned there are many different substitutes to solve this problem, which would work well in combination with concepts 1.1 through 2.2.

FR2.3 was given a lower score after shortly evaluating the origin of this design requirement. When looking at the morphological scheme (table 5.1), it is clear that the second concepts (the crane) score worse than the first concepts (the chair). However, in the case of concept 2.2, it does not seem useful for this product to be easily moved around, as one would not need this function in a standard table either. This leads to the question of how applicable the functional requirement is. Looking back at the nature of this project, the goal is to create a product that can support the user to independently sit down and stand back up in various environments. This entails both a nursing home and an independent living situation. Within these environments, the product should also be usable in different scenarios. In section 2.2.2. one can already see it being used at a table as well as near a window. Nevertheless, the product should also be usable in other active environments, such as at a typical Dutch birthday party, where

everyone sits in a circle. This short analysis shows that indeed, concept 2.2 should score low on the requirement, as it may not be as useful in an independent living situation, or a few of the other examples that have been listed. Notwithstanding that this requirement may be much less important compared to requirements that have received a higher weighting, seeing the previous analysis does show the requirement may be slightly biased towards solutions in the shape of chairs.

5.5.3. Interpretation of the results

Table 5.2 yields similar results to the morphological scheme in table 5.1: Concepts 1.1 and 1.2 seem to perform better than concepts 2.1 and 2.2. Therefore it can be concluded that the final design shall take the shape of a chair, not a crane. Due to the weighting factors, one can now also conclude that concept 1.2 has performed best overall, even though concept 1.1 is still a close second. Thus, the final concept will largely be based on concept 1.2, with concept 1.1 in mind.

6. Final concept

Based on the comparisons in section 5.5 a final concept is created based on the results shown in section 5.5.3, concept 1.2 will be the baseline, whilst trying to lessen the negative aspects that have been identified in section 5.2.1. In short, these are:

- Due to the desired simplicity (a goal stated in section 2.3), there is limited personalization possible.
- The modern design of the product possibly harms (some) people suffering from dementia.
- The mobility/walking aid storage seems to not be convenient in use, based on section 5.5.1.

Therefore, improvements should be made in greater personalization possibilities, and the mobility/walking aid placement on the product should be reconsidered. It should be noted that although the styling of the concept is an important factor, this is outside the scope of the current project. More information on the styling of the concept can be found in section 8. Next to this, it is also important to think back to the goal(s) the product should reach, as stated in the introduction. This can be found in fig. 6.1. With these points in mind, the final concept shown in fig. 6.2 is proposed. It should be noted that even though the concept is visualized, the design (or styling) of the concept is not finalized. This visualisation focuses on the functions the product should have, and shows possible mechanics that could realize this.

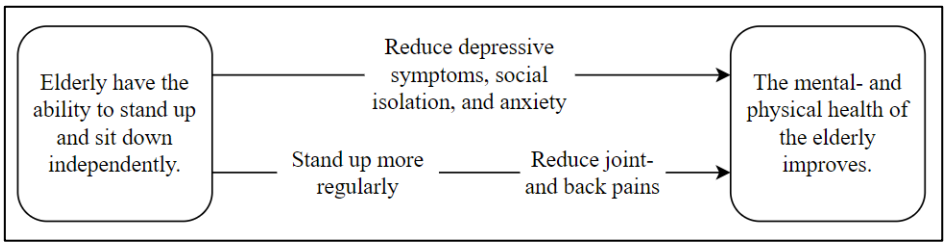


Figure 6.1: Schematic of the goals this project intends to reach.

Figure 6.2: Front and back visuals of the final concept, with the seat raised and lowered.

FR1.1 The product should assist the user in transitioning independently between sitting and standing.

The seating area shows a piece of fabric suspended between two bars. These bars can move up and down to support the user in sitting down and standing up. Additionally, the leg of the chair has a small amount of suspension, which reacts to the weight of the user. See fig. 6.3 for a visual.

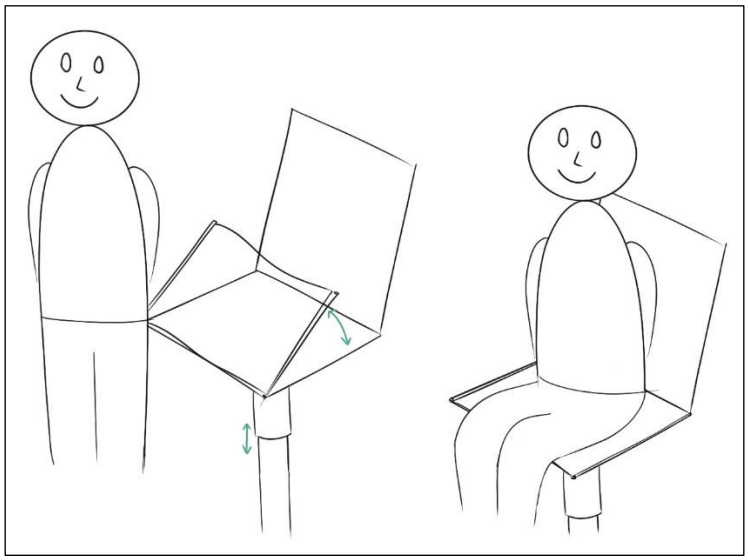


Figure 6.3: A person using the sitting and standing function on the chair.

FR1.2 The product should assist the user to independently draw up to a table.

The wheels ensure the user can use their feet to ‘walk’ towards a table whilst seated. Next to this, the seat could possibly be turnable, similar to a traditional desk chair.

FR1.3 The product should promote standing up regularly

The final concept shows visual and auditory indicators should be placed where the user can easily see and/or hear them. In this case, the armrest is chosen. This indicator should both be visual and auditory, as 13.5% of the people over 65 years are visually impaired, and about 33% of people over 65 years experience hearing loss (“Hearing Loss: A Common Problem for Older Adults,” n.d.; “Research navigator (2016): Statistics about Seniors with Vision Loss,” 2016). To accommodate for this, both options can be presented to the user. The visual indicator could be a light, or a small timer (an example could be something similar to an egg timer, as people currently classified as elderly often used these) showing that the time is up. The auditory indicator could be a soothing sound, an alarm, or a voice telling the user to stand up.

FR1.4 The product should ensure the user can independently perform activities whilst sitting down at a table.

As the concept is similar to that of a standard desk chair, it can be assumed it is possible to use the product at a table.

FR1.5 The product should be usable for people with different body dimensions.

The back of the chair can be moved backwards and forward as shown in fig. 6.4. Next to this, it is possible to alter the height of the chair by changing the height of the leg of the chair. The armrests can be moved up or down with one simple movement as they are connected at the back of the chair. It is also possible to alter the distance between the armrests. Finally, the armrests can be moved backwards and forwards. Fig. 6.4 visualizes these mechanics.

All aforementioned functions should only be altered once for each person. To ensure the user will not accidentally change the settings, the aforementioned functions can be locked.

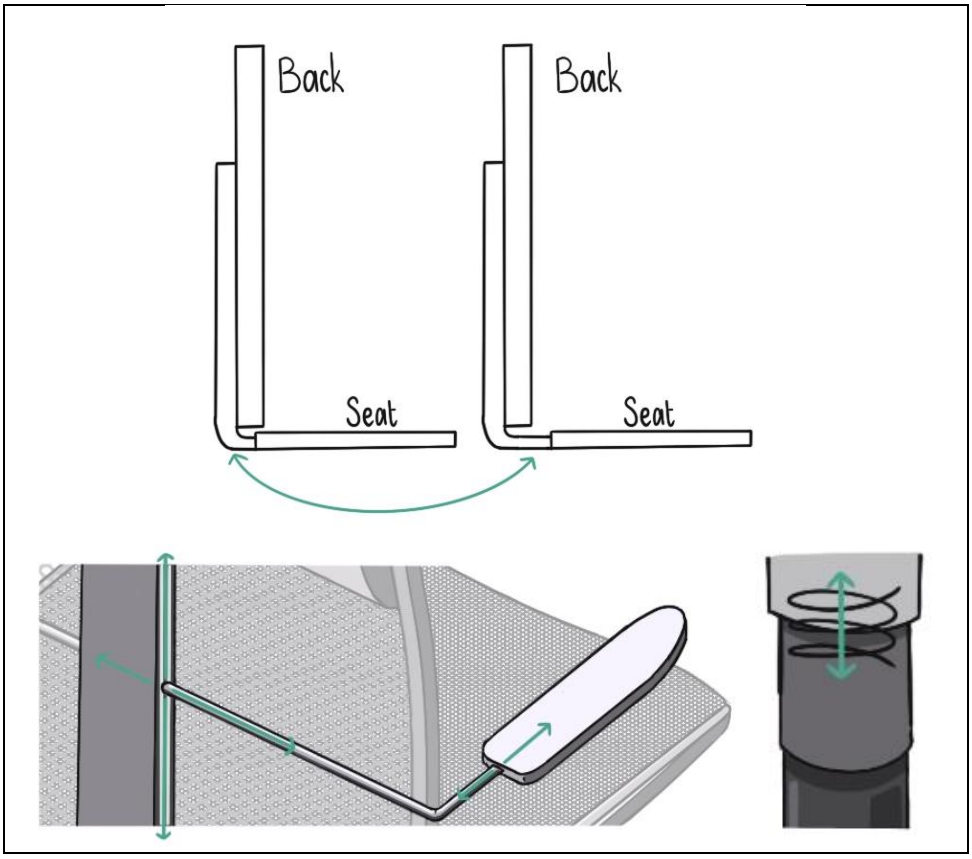


Figure 6.4: The mechanics in place for DR1.5.

FR1.6 The product should be usable for people with different levels of needed support.

The mechanics shown in fig. 6.3 can be adjusted to use more or less force when supporting the user. As mentioned in section 2.3, it would be beneficial if this chair does not need to be close to an outlet. To ensure the chair will always be usable, batteries or other chargeable solutions undesirable. Although no specific mechanism is chosen, the researcher suggests using springs of which the stiffness can be adjusted. An example is proposed by González Rodríguez, Chacón, Donoso, and González Rodríguez. They designed a spring of which the stiffness can be altered by using an electric motor to adjust it (González Rodríguez, Chacón, Donoso, & González Rodríguez, 2011). Although this means the caretaker needs an electric device to alter the stiffness of the springs, this only needs to be done when there is a change in users.

FR1.7 The product should enable the user to keep a healthy posture.

The curves in the chair are derived from the typical ergonomic desk chair, as these are designed with a healthy posture in mind (Groenesteijn et al., 2009). Together with the alterations that can be made as described for FR1.5, the user can use the product whilst keeping a healthy posture.

FR2.1 The product should be intuitive in its use for the user.

By creating a more coherent design, the product gained functions that were part of concept 1.1, without losing the simplicity similar to concept 1.2. All functions the user should make use of are in sight and intuitive. It should be noted that without testing a prototype, this cannot be said with certainty. More information on this can be found in section 8.

FR2.2 The product should allow possible mobility/walking aids to be kept within reach.

As shown in fig. 6.5, a walking/mobility aid can be attached to the chair by using a magnetic system. The placement of this function is in a more sensible place compared to concept 1.1. The user should easily be able to attach it to the chair whilst standing in front of it (before sitting down), and can easily reach it whilst seated, or after standing up. The caregiver can place this magnet on either the left or right side of the chair, depending on the preferences of the user. It should again be noted that without testing a prototype, this cannot be said with certainty.

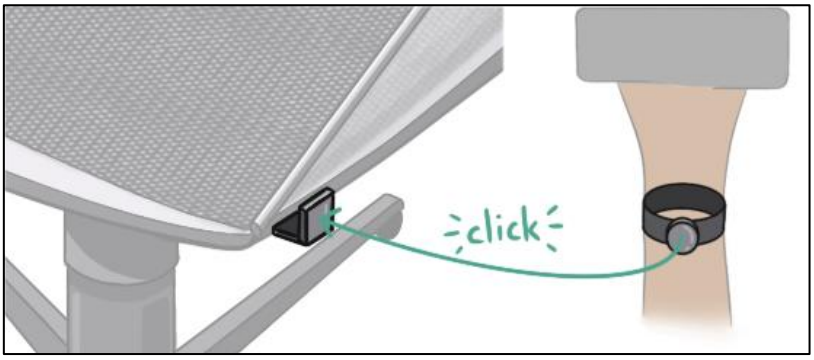


Figure 6.5: The solution for FR2.2.

FR2.3 The product should allow for the caregiver to easily move it around.

The wheels that fulfil FR1.2 are also used to fulfil this requirement. Together with the bar on the back of the chair, a person can easily move the product to different places. This concept may be less moveable than concept 1.1, as it is not as easy to get it on and off ledges. However, in a nursing home, this should not be an issue, as these homes are (almost) always also accommodated p eople in wheelchairs or using a walker. Additionally, it is expected that in individual living environments, the product will likely be used in the dining- and living rooms, rooms that are often on the same floor.

7. Evaluation

The evaluation of the final concept is done in three sections. First, the final concept is put in the scenarios that were created in section 2.2.2. After this, stakeholders are interviewed to receive their opinion. Finally, the final concept is given a score for each functional requirement, of which a total score is given through the weighting factors. As a prototype has not been created, it is not possible to perform any tests. This is something that should be done at a later stage, as described in section 8.5.

7.1. Evaluation through scenarios

The scenarios shown in this section are based on those presented in section 2.2.2. Visualizing the concept into these scenarios makes for a better understanding of how the concept may function in the situations that were deemed important during the research phase.

7.1.1. Scenario 1: Elderly home

In the first scenario, the user lives in an elderly home. They are currently sitting at a table with others, playing a card game.

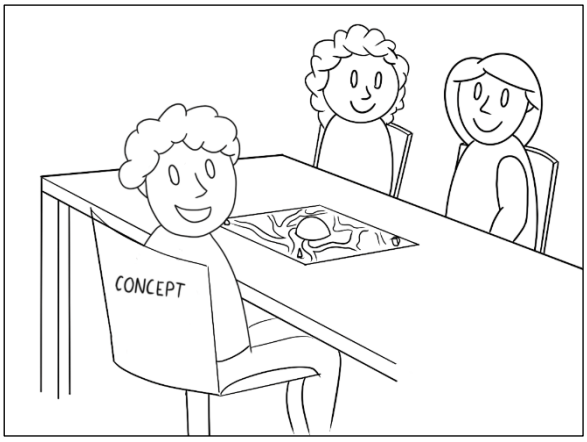


Figure 7.1: Scenario 1, part 1.

The user is starting to get a bit tired, and decides to go to their room to rest. Although the caretaker is busy helping others, they do not need to wait and can simply get up themselves.

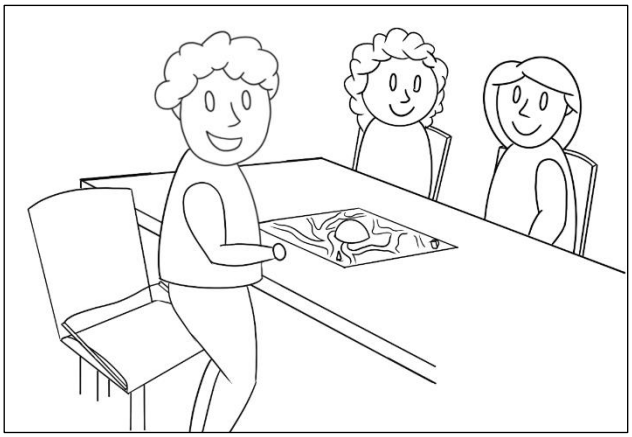


Figure 7.2: Scenario 1, part 2.

A few minutes later someone would like to move through the space, but the chair is slightly in the way. The caretaker quickly rolls the chair away to a corner.

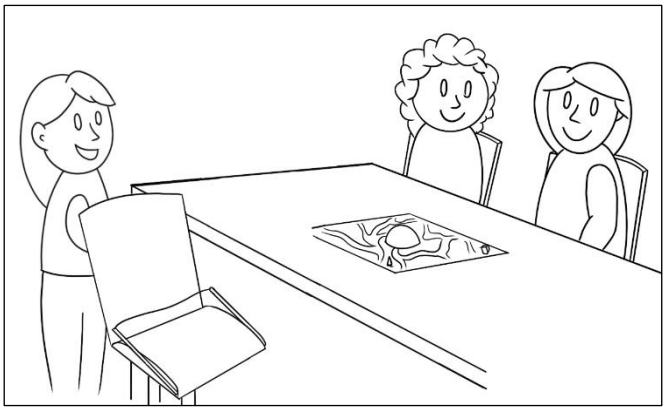


Figure 7.3: Scenario 1, part 3.

7.1.2. Scenario 2: Private home

In the second scenario, the user lives alone. Normally they would not use their dinner table very quickly, as this chair is difficult to sit down in, and get out of. Instead, the user often only uses a recliner chair. This limits the freedom they have in their own home. With the proposed solution, the user is able to have a bit more freedom in their own home, and is no longer restricted to the one recliner chair.

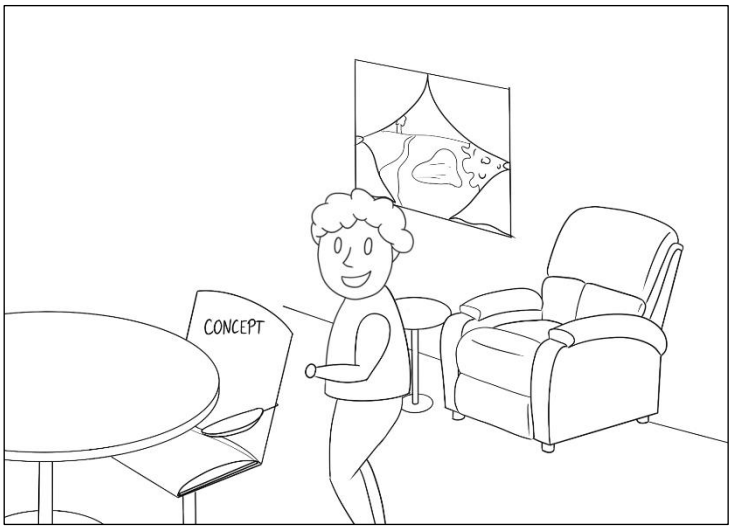


Figure 7.4: Scenario 2

7.2. Evaluation through interviews

The interviews are held with stakeholders that have been identified in section 2.2. Currently, the product is still in an early stage, meaning the goal of these interviews is to gain some insight in the opinions of people on this concept. As the testing stage is of much greater importance, it was decided that for these interviews, the user and the caregiver, the most important stakeholders, will not be bothered. Moreover, it is difficult to get in contact with these people, as they are often busy or would simply not like to participate. Instead, the friends and family of the potential users are interviewed, as they will still be aware of the living situation of the potential user, and are more approachable.

2 stakeholders were interviewed, and asked about their relationship with the potential user, and what they believe the mental and physical health of the user to be. They were shown the concept and what functions it has, after which they gave their opinion on how well the potential user could understand this product, and how this concept could possible improve the overall quality of life for the potential user. More information can be found in appendix B.

Overall, people understood the concept and believe a product like this would help the potential user in daily life. However, concerns were raised about how well the potential user would be able to make use of all functions. This is something that should be tested elaborately. Someone also made an interesting comment about the function that stores the walking aid: This may be a redundant function, as often times people who use walking aids would be used to simply leaning it against a table, or they would already have another solution in place. This supports an earlier observation made in section 5.

7.3. Evaluation through functional requirements

The final concept is concretely evaluated by assessing how well the concept performs each functional requirement. This is done (by the researcher) in a similar manner to how the concepts were compared in section 5.5. A weighting is given to each requirement (as has been done previously), showing how important this is. Information on how the researcher bias is limited can be found in section 9.3. The final concept is assessed on each requirement. The score that is received for each requirement is the weighting times the score. The final score is the sum of all scores.

Functional requirements		Final concept		Reasoning
The product should…	***Weighting***	*Assessment*	*Score*	
1.1 … assist the user in transitioning independently between sitting and standing.	**5**	3	15	In theory, there is no reason this function should not work.
1.2 … assist the user to independently draw up to a table.	**4**	3	12	In theory, there is no reason this function should not work.
1.3 … promote standing up regularly.	**4**	3	12	In theory, there is no reason this function should not work.
1.4 … ensure the user can independently perform activities whilst sitting down at a table.	**5**	3	15	The chair should be able to fit at a table, hence there is no reason this function should not work.
1.5 … be usable for people of different body dimensions.	**5**	3	15	Interviewees mentioned they could imagine this chair to fit many different people.
1.6 … be usable for people with different levels of needed support.	**5**	2	10	This is limited due to the fact that this function is mechanic, but still has a broad range of options.
1.7 … enable the user to keep a healthy posture.	**4**	3	12	The concept is similar to that of an ergonomic desk chair, which are designed with a healthy posture in mind.
2.1 … be intuitive in its use for the user.	**5**	2	10	Although this cannot be said with certainty, concerns were raised during the interviews.
2.2 … allow possible mobility/walking aids to be kept within reach.	**2**	3	6	Interviewees mentioned this function would likely work, although they questioned how useful this would be.
2.3 … allow the caregiver to easily move it around.	**3**	3	9	In theory, there is no reason this function should not work.
	Total	116		

An interesting observation is that in section 5.5, concept 1.2 scores higher than this concept (121). The largest difference can be found with FR2.2. Although this was first deemed an important requirement, after reconsideration and further research, it was found that this product likely doesn't needs to accommodate for mobility aids, as many other products already exist for this (section 5.5.1). Further comparison of the scores of concepts 1.1, 1.2, and the final concept, show that the scores of FR2.1. actually seem lowest for the final concept. A reason behind this may be that the more in-depth evaluation of the final concept shows more accurate results, meaning that if the concepts would all be evaluated this way, concepts 1.1 and 1.2 may also be given a lower score. Another possibility is that the final concept may come across as less intuitive due to its many functions. On a positive note, the final concept did excel in FR1.3 and FR2.3.

8. Design Brief

The following section is aimed at people that will continue this concept towards the next steps. A summary of the report, an updated list of requirements, design and material considerations, as well as a list of possible next steps can be found.

8.1. Summary

This project aims to design a product that supports elderly people with independently standing up and sitting back down in active environments. An example of this active environment is the dinner table. In this project, the user is defined as elderly people with mobility issues. It is important to note these people should still have some motor control, for instance: The user should be able to walk (this could be with a walking/mobility aid).

The final concept has taken the shape of a chair, as can be seen in fig. 8.2. The seat can lift the user from a sitting to a standing position, as well as support them in lowering into the seat. As this should also be adjustable to the level of needed support of the user, the researcher recommends using springs of which the stiffness can be adjusted. The chair can be altered in height (through the leg), depth (through the backrest), and width (through the armrests) to ensure the user can keep a healthy posture. The wheels ensure the user can draw up to a table. Together with the bar on the back of the chair the wheels also provide the ability to easily move the product. Finally, a magnet can be attached to the chair and a walking/mobility aid, to give the user a place to store this once seated.

The chair should be used by one person for a while, as it is fully adjusted to their body dimensions and needed level of support. However, once the current user can no longer make use of the chair, it can be adjusted for a new user.

Figure 8.2: The final concept.

8.2. Updated requirements

Based on the final concept, specific requirements are made to which the final design should adhere. Table 8.1 shows an overview of the original requirements in the first column as well as technical requirements in the second column. Another functional requirement is added as well, FR2.4.

	Functional requirements	Technical requirements
	1. The product should allow the user to independently sit down and stand up in an active environment.	
1.1	The product should assist the user in transitioning independently between sitting and standing.	
1.2	The product should assist the user to independently draw up to a table.	The user should be able to use the wheels of the chair with their legs without straining themselves.
1.3	The product should promote standing up regularly.	The notifications should be alterable to how often the user should stand up.
1.4	The product should ensure the user can independently perform activities whilst sitting down at a table.	-
1.5	The product should be usable for people of different body dimensions.	The chair should be able to carry a weight of 115 kg.
		The dimensions of the chair should be adjustable within the ranges shown in fig. 8.3.
1.6	The product should be usable for people with different levels of needed support.	The mechanics of the lifting seat should be adjustable to how much support is desired.
1.7	The product should enable the user to keep a healthy posture.	-
	2. The product should be easy to use.	
2.1	The product should be intuitive in its use for the user.	The lever to initiate movement in the lifting seat should be easy to reach and operate.
		The functions of the chair that aren't used by the user during each use (i.e. adjusting the chair height, armrests, and seat depth) should be lockable.
		The design should take into account the effects it may have on people suffering from dementia (i.e. some features may not be intuitive for people suffering from dementia, whilst for others it is).
2.2	The product should allow possible mobility/walking aids to be kept within reach.	-
2.3	The product should allow the caregiver to easily move it around.	-
2.4	The product should be durable.	The product should be made of materials that last long.

	The product should be made of materials that are easily cleaned.
	The flexible materials (e.g. fabrics) should be removable to be washed.

Table 8.1: The updated requirements.

8.2.1. Technical requirements

The rough dimensions of the chair are created by using anthropometric data. More information on how this data is translated into dimensions can be found in Appendix A. The base dimensions of the chair (as can be found in fig. 8.3) are calculated by taking the average of the numbers taken from table 11.6. One of the functions of the chair is that it can be altered for people of different body dimensions. The range in which the chair should be alterable can be found in fig. 8.3.

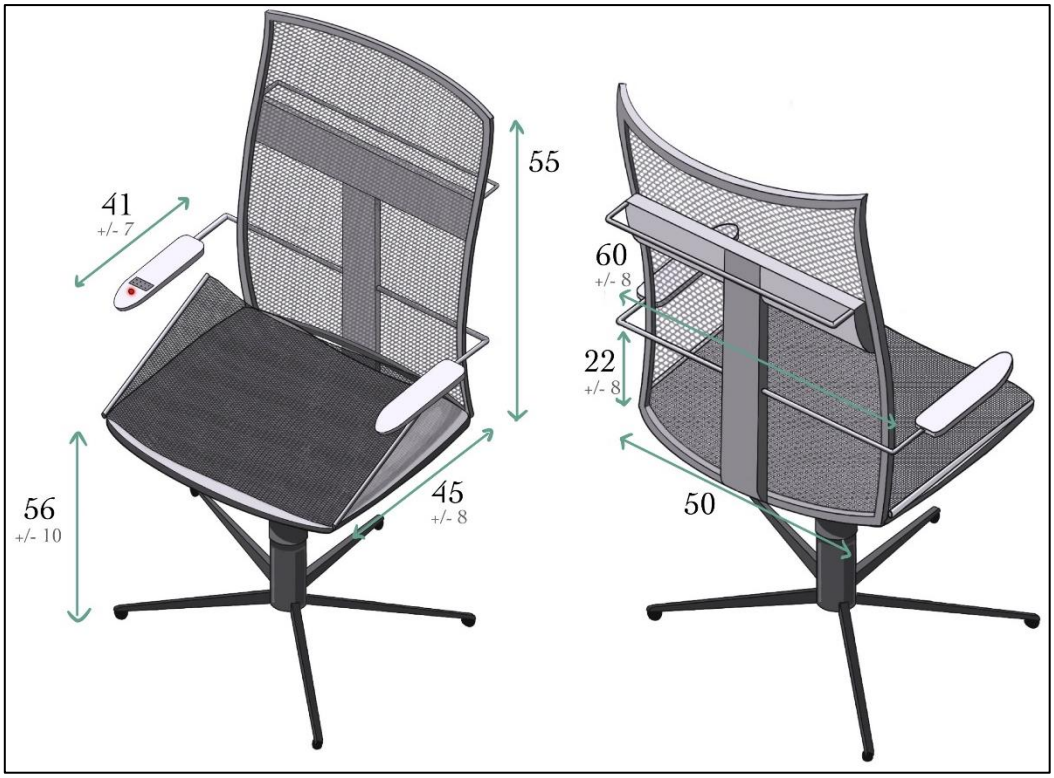


Figure 8.3: The dimensions of the final concept.

The maximum weight measured in the dataset that was also used to create dimensions is 105kg (Kothiyal & Tettey, 2001). According to Bifma, an institution that provides standards to create healthy, safe, and comfortable furniture ("What we do," n.d.), certifies all chairs that can hold a maximum weight of 115kg.

8.3. Design considerations

People with dementia seem more comfortable and at ease in a familiar environment (Son, Therrien, & Whall, 2002). This also leads to more social interactions, which is a positive stimulant for the mental health of a person (Day et al., 2000). Although the product proposed in this project is only a small part of the environment of the user, it may still affect how they perceive the environment (Son et al., 2002). Therefore, although a simplistic view, an ideal situation would be where the final design is in the style of the '80s (and '70s), as the people that are currently classified as elderly (>65 years), were above the age of 20 at that time. Of course, this is with the assumption that the user did experience this style at that time, as this may differ per culture. Moreover, another assumption is made here that the user felt

comfortable with this style and in this time period. Fig. 8.4 shows a collage of styling ideas that could be taken into account.

Figure 8.4: A collage of style inspiration from the '70s and '80s.("1980's Pair Teak with Wool Cushions Lounge," n.d.; "80s Chair Freischwiner Thonet," n.d.; "Alpha Brass Chair," n.d.; "Eichholtz Aristide Chair - Brown," n.d.; "Vintage Danish Design Desk 60s 70s," n.d.)

As can be seen, elements that can be used as inspiration are wicker, wood, and brass. Furthermore, a lot of chairs from this period seem to have low backrests. Future steps could include checking whether a high backrest has a significant influence on the posture of the user, or whether low backrests could be a possibility.

8.4. Material considerations

The chair will consist of both sturdy and flexible materials. The lifting seat section should be made out of a flexible material that is sturdy enough to lift and slowly lower a user of 115 kg.

It is important to keep the user in mind when considering which materials would work well for this product. An example is that 51% of people over 65 years deal with bladder or bowel incontinence (Reinberg, 2014). To prevent this from becoming an issue, the fabric of the seat should be easy to clean and removable.

Another important factor to keep in mind is how the product will be used. The chair should be used by one person, as it is also set to this person's dimensions. However, in elderly homes, the product may be used for a new person if the previous user can no longer use it. For elderly homes, a significant benefit would be if the product is durable, and can last a long time. Additionally, sections that are in contact with the user (i.e. the backrest and seat) should be breathable and easily cleanable materials to remain good hygiene.

Although this does not provide a direct benefit for many stakeholders, in the broader context it is of high interest to create this product sustainably. This means that the material is not harmful to the environment, and/or could even be re- or upcyclable. This is in line with the twelfth UN sustainable development goal: Responsible consumption and production. In this goal, the aim is to achieve more sustainable ways of producing products ("12 Ensure sustainable consumption and production patterns," n.d.).

Combining the above-mentioned points with design considerations mentioned in section 8.3. can already show a few options. Wicker may be a good contender as a material for the backrest, as this is a durable, sustainable, breathable, and easy-to-clean option. The chassis of the chair could be made out of wood, as the right kind can be strong enough to carry the minimum weight and be sustainable and durable. Brass highlights can be implemented by creating the bar that carries the armrests out of this material, and other small components.

8.5. Process plan

The following section shows an overview of the process plan that has been used through this report, as well as the future steps that would be suitable to this product. Although a design process is always iterative, a general design process can be derived from the steps shown in this project. The general design process consists of six phases, as can be seen in fig. 8.5. In phase one the general idea of the product is created, and a gap in the market is identified. In phase two, the preliminary phase, the users are defined with their wishes. A set of requirements is also made at this stage. In the third phase, the design phase, it is time to sketch up concepts, of which one concept is chosen. In this phase, extra research can be done on for instance ergonomics and the environmental footprint of the product. Some ideas concerning suitable techniques and materials can also be shared. In this phase, the testing of the concept can also start. It is often during this phase that progressive insight is gained, due to problems surfacing. In phase four the shape of the final product is designed, and a production method is chosen. A prototype can be made. During phase five a first batch is manufactured and tested. This is then evaluated extensively. In phase six, the final phase, the decision should be made on whether to continue to manufacture and sell the product. Here, a closer look at the market is also taken.

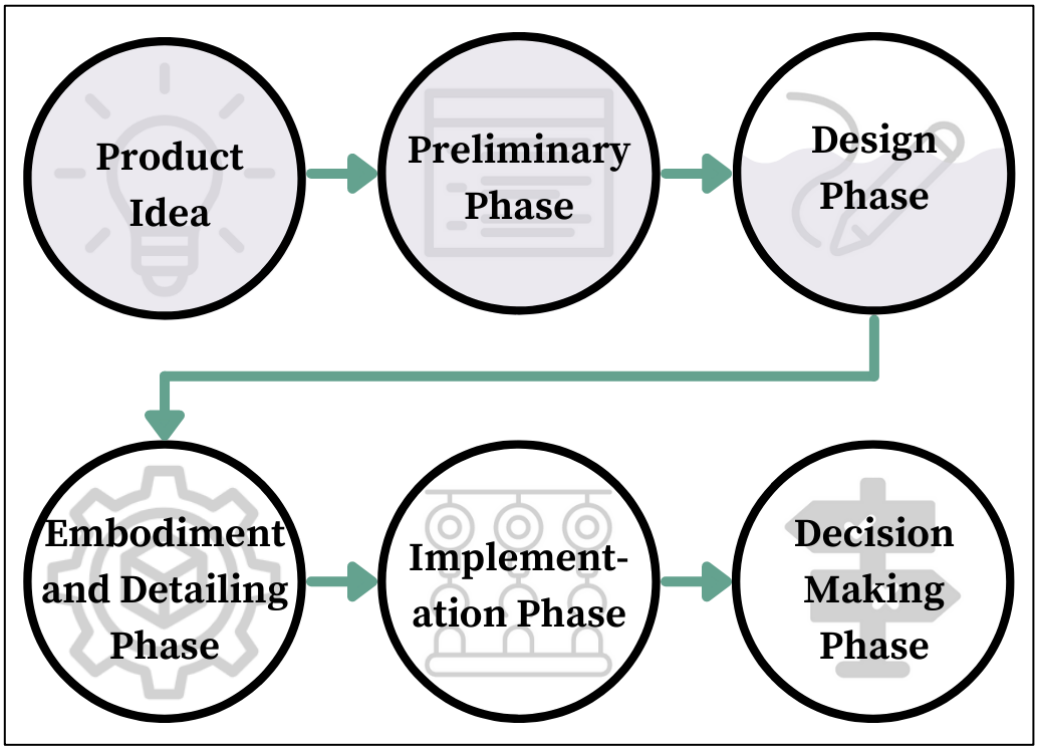


Figure 8.5: The general design process (Bonnema, Eger, & Lutters, 2013)a.

As can be seen in fig. 8.5, currently, this product is in the third phase: The design phase. The product idea was generated and a gap in the market was identified in the literary research. The preliminary phase has also been completed: The user(s) and their wishes were found in the stakeholder analysis, and the list of requirements can be found as functional requirements. The design phase is not fully complete. Concepts were created and an initial design was realized. The ergonomic studies have also started, as

the anthropometric data has already influenced the final concept. Some material- and design considerations are also provided in sections 8.3 and section 8.4. The final step in this phase is testing the concept, which has not yet been done.

9. Discussion

9.1. Academic Exploration

Besides industrial design engineering, other disciplines included in this project are healthcare sciences and mechanical engineering. Healthcare sciences is involved in this project as the product is designed to improve the health of the user. It is important to understand the needs of the user in terms of their health and medical care, before creating the product (e.g. the user must not be supported fully, as this will only weaken their body). The mechanical engineering discipline is currently not as involved, as this only starts during/after the final concept. The technical requirements mentioned in section 8.2 are created with the realisation of functions kept in mind. The mechanics that are currently described to perform the desired functions are inspired by the field of mechanical engineering. As this is not a field the researcher is experienced in, involving a mechanical engineer at an earlier point may show earlier which mechanics are and are not possible.

9.2. Possible negative impacts

This product is designed to try to improve the living conditions of elderly people with mobility issues. Nonetheless, one should always consider the negative effects a product may have on the stakeholders, the environment, and people who seemingly don't have any interest in or power over the product.

A first assumption that is made, and later confirmed through interviews, is that people like to be independent. Although this is true for the majority, in elderly homes, oftentimes caregivers can provide some social contact whilst performing simple tasks for the elderly, such as helping them stand up and sit down. Removing this moment of contact may greatly lessen the social interaction the user has, working negatively on their mental health (Karakaya et al., 2009). Moreover, products that are designed to do tasks that can be automated replace the people that work there, leaving these people without an income (Dautovic, 2022). Some do question whether this is not nuanced enough, as with the loss of certain jobs, other jobs, such as developers, increase (Vermeulen, Kesselhut, Pyka, & Saviotti, 2018). Although this product does not directly replace an entire function, it may still have contributed to this result later on.

A reoccurring issue in product design is the gap between the design intention, and the user using the product (Hyun, Lee, & Kim, 2017). The user may not be aware of all functions and doesn't use them, or may use functions differently than intended. Not only does this change the impact the product has, but it may also present safety issues. As outlined in section 8, a lot of testing still needs to be done to ensure people are using the functions as they are meant to. If this is not done properly, it may endanger peoples' safety.

9.3. Limitations

Throughout the process, the researcher experienced multiple limitations. Firstly, many steps of this project are easily influenced by the researcher's opinion. Starting off with the user scenarios, although the researcher did not have a specific product in mind yet, they may already have thought of ideas before creating the scenarios. Even though the researcher did their best to use a structured approach to minimize the effect of a researcher bias, in hindsight it is visible how a solution in the shape of a chair may fit the scenarios better than other solutions. A similar point can be made for the functional requirements. In hindsight, a few of these seem bias toward chairs. For instance, FR1.2 (the product should support the user in drawing up to a table), is not very applicable to concepts 2.1 and 2.2. Moreover, the substitutes that were researched, were mainly chairs. This makes sense, as most of the solutions already available are simply in the shape of chairs. The researcher found that other solutions, such as the tililift, were more difficult to find. This could simply be due to the fact that there are limited

products that are not in the shape of a chair that work towards the goal presented in this project, or because the researcher may have used terms biased towards chairs when searching for these substitutions.

Secondly, due to time limitations, the researcher conducted limited interviews during the research phase. Although the results show similar results from all participants – implying these results should be in line with the general thoughts of the target group – more interviews may have led to a broader range of opinions, possibly resulting in a more complete and detailed picture of the needs and wishes of stakeholders. The same goes for the interviews during the evaluation phase, more interviews possibly result in a different result. A similar point concerning interviews can be made for another phase: The concepts are currently only evaluated through the functional requirements, and simple logic (i.e. in concept 1.1 it is difficult to put the walking/mobility aid in the designated spot). Although a structured approach was taken once again whilst 'grading' the concepts, involving the stakeholders more intensely in this phase may have yielded points a person without experience in the environment might not notice. This could lead to a different score on the functional requirements, or inspire the researcher to search for different solutions.

Thirdly, these time limitations pressurize the researcher to quickly continue to the next steps. This can be seen as both a positive and negative aspect. In design, there is never just one correct answer, which means one can endlessly continue to draw up designs in search of "the best one". Eventually, the researcher must decide to move on. For example, there may be more functional requirements that would have suited this project well. To minimize overlooking important requirements, a structured approach was taken (the literature research, interviews, and scenarios all contributed to at least one requirement). The requirements were also revised throughout the process. Weights were applied to prioritize the requirements in section 5, and another functional requirement and the technical requirements were added in section 8. A second example is the idea generation in section 4, ideation, and section 5, concepts. An infinite number of ideas could have been created, out of which many concepts could be generated. It was decided to take a structured approach by brainstorming ideas for each requirement and using these ideas as building blocks for the concepts. Two different concepts were created, concepts 1.1 and 2.1. These were shortly evaluated by scoring them against the functional requirements, after which improvements were made on each concept. These were then evaluated and compared, out of which the final concept was created.

This method of working was chosen because a structured way of working limits accidentally overlooking important aspects. However, it also limits creativity. A different method of working could have yielded more interesting results, although important aspects may have been overlooked, resulting in a sloppy final concept. Even though a structured approach was taken throughout the process, whether the approach was correct, was constantly reconsidered throughout the process. Initially, the ideas were compared by putting said ideas and the functional requirements in a morphological scheme. When comparing the concepts, it became noticeable that some requirements may not be as important as others. Hence, the weighting factors were added to create a more concrete and accurate scoring system. Adding these weighting factors at an earlier stage may have given a clearer picture of how well each idea in section 4 would perform in a possible final concept.

Fourthly, within the anthropometric data, 70% of the participants were Australian (Kothiyal & Tettey, 2001), meaning the current dimensions are mainly based on the average Australian person over 65 years. Although a specific area in which the product should be sold was never defined, other data was retrieved from European and American sources (i.e. the number of people with hearing and vision

struggles was retrieved from American sources, whilst the information on the fullness of elderly homes was retrieved from Dutch sources), meaning that possibly not all information aligns.

Finally, the knowledge and skills in the field of industrial design engineering of the researcher should be discussed. Due to the limited courses that were taken in this field, the researcher does not have much experience in executing design projects, nor do they have much theoretical knowledge on how to approach this. Hence, other researchers could possibly come to different, maybe better, results. As the researcher has had contact with an expert in the design process throughout this project, they believe the influence this limitation has on the result has been minimized.

10. Acknowledgements

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12. Appendix A | Anthropometric Data

To determine the dimensions the final design should take, an existing anthropometric dataset is used. These are measurements taken of the target group (in this case, the user). The data was taken from a total of 171 participants, of which 33 males and 138 females, all 65 years and above (Kothiyal & Tettey, 2001). Fig. 12.1 shows which measures are taken in this study. Of these, the following measures are used:

- 3 – Stature
- 7 – Sitting height
- 9 – Sitting shoulder height
- 10 – Sitting elbow height
- 13 – Buttock-popliteal length
- 19 – Elbow-fingertip length

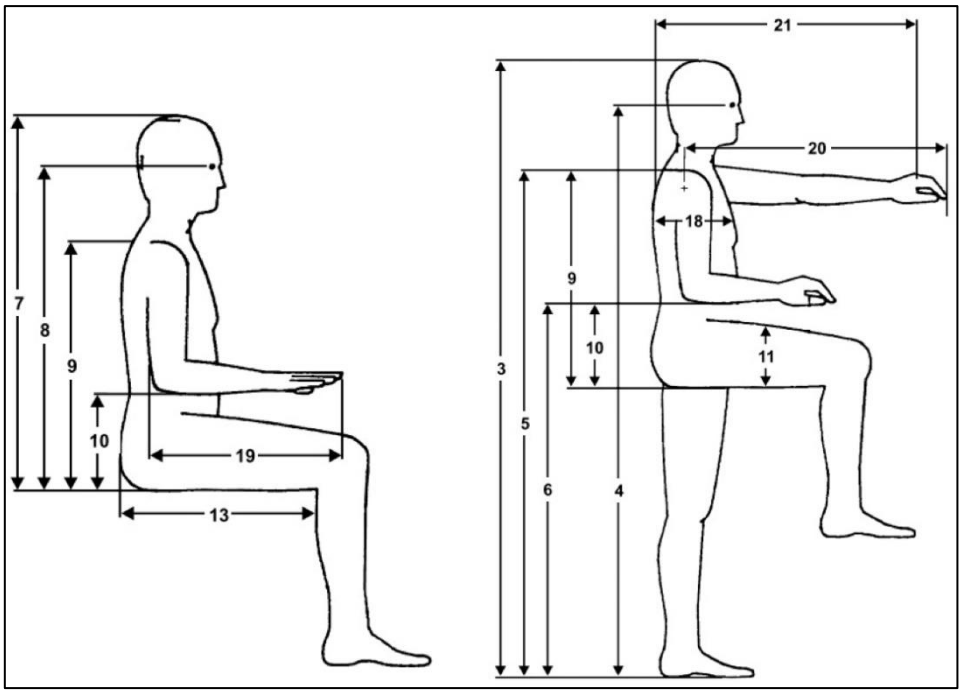

Figure 12.1: Anthropometric measures taken on people over 65 years old (Kothiyal & Tettey, 2001).

To limit the dimensions, 2.5% of the shortest people and 2.5% of the tallest people are taken off the data set, resulting in a range of 95%. This was done using the following formulas:

$$P_{2.5} = P_{50} - Z_{47.5} * SD$$

$$P_{97.5} = P_{50} + Z_{47.5} * SD$$

Next to this, Eger et al. mention clothes and shoes may add to the body height (Eger, Bonnema, Lutters, & van der Voort, 2013a). Appropriate numbers are added to the correct measurements. Tables 12.1 to table 12.5 show the results. Some constants that are used in these tables are:

- $Z_{ab} = 1.96$, taken from the 47.5% surface (Eger et al., 2013a).
- Clothes add approximately 10 mm to the measurements (Eger et al., 2013a).
- Shoes add approximately 30 mm to the measurements (Eger et al., 2013a).

Nr.	P = 50 (mm)	SD (mm)	$Z_{ab}*P_{50}$ (mm)	P = 2.5 (mm)	P = 97.5 (mm)
3	1530[3]	70	137.20	1392.80	1667.20
7	788	40	78.40	709.60	866.40
9	535	35	68.60	466.40	603.60
10	211	34	66.64	144.36	277.64
13	440	36	70.56	369.44	510.56
19	380	36	70.56	344	450.56

Table 12.1: The 95% range of lengths for females over 65 years.

Nr.	$P_{2.5}$+10 (mm)	$P_{97.5}$+10 (mm)	Mean+30 (mm)[4]
Clothes			
9	476.40	613.60	NA
10	154.36	287.64	NA
13	379.44	520.56	NA
Shoes			
nr. 3 - nr. 7	NA	NA	767

Table 12.2: The alterations made to lengths for females over 65 years.

Nr.	P = 50 (mm)	SD (mm)	$Z_{ab}*P_{50}$ (mm)	P = 2.5 (mm)	P = 97.5 (mm)
3	1650	79	154.84	1495.16	1804.84
7	843	56	109.76	733.24	952.76
9	585	37	72.52	512.48	657.52
10	235	35	68.60	166.40	303.60
13	450	38	74.48	375.52	524.48
19	418	30	58.80	388.00	476.80

Table 12.3: The 95% range of lengths for males over 65 years.

Nr.	$P_{2.5}$+10 (mm)	$P_{97.5}$+10 (mm)	Mean+30 (mm)
Clothes			
9	522.48	667.52	NA
10	176.40	313.60	NA
13	385.52	534.48	NA
Shoes			
nr. 3 - nr. 7	NA	NA	845

Table 12.4: The alterations made to lengths for males over 65 years.

[3] The original paper shows a number of 153, which is incorrect. By calculating the true value using the same formulas as mentioned, except starting at P_5, a value of 1528 mm was found. Of all numbers ranging between 1530 and 1539, 1530 is closest, hence this is the number chosen.

[4] There were no measurements taken of the height of the lower leg and foot. A close estimation can be made by subtracting the sitting height (7) from the stature (3). However, because there is no standard deviation of the height of the lower leg and foot, the 95% range could not be calculated. Therefore, the mean of 3 and 7 are used instead.

	Females		Males	
	Minimum (mm)	*Maximum (mm)*	*Minimum (mm)*	*Maximum (mm)*
3	1392.80	1667.20	1495.16	1804.84
7	709.60	866.40	733.24	952.76
9	466.40	603.60	512.48	657.52
10	144.36	277.64	166.40	303.60
13	369.44	510.56	375.52	524.48
19	344.00	450.56	388.00	476.80
3-7		*Mean* = 767 mm		*Mean* = 845 mm

Table 12.5: 95% ranges of lengths for females and males.

As can be seen in table 12.5, the females consistently have the lowest minimum, and the males have consistently the highest maximum (the green cells). Therefore, these numbers will create the range that is used to decide on the dimensions of the product (table 12.6).

Nr.	Measurement of…	Minimum (mm)	Maximum (mm)
3	Stature	1392.80	1804.84
7	Sitting height	709.60	952.76
9	Sitting shoulder height	466.40	657.52
10	Sitting elbow	144.36	303.60
13	Buttock-popliteal length	369.44	524.48
19	Elbow-fingertip length	344.00	476.80
3-7	Lower leg and foot height		

Table 12.6: The range that is taken into account when creating the final design.

13. Appendix B | Interviews

13.1 Initial interviews

The initial interviews are the interviews that were conducted at the start of this project. The goal of these interviews is to learn more about the stakeholder and their experience with the researched problem. Below the questions can be found.

13.1.1 Interview questions to the caregivers

1. What is your occupation?
2. Do caretakers ever experience problems when supporting the clients with sitting up and standing down?
3. Do caretakers ever experience stress due to time limitations?
    a. Do you believe a product supporting the client with independently standing up and sitting down would relieve some of this stress?
4. Do clients ever sit longer than they are supposed to / want to because the caregivers are busy?
5. Do the clients ever feel alone?
    a. Would the independence in sitting and standing help in this?
6. Do you think the idea that is proposed in this project would be a positive addition to elderly homes, and could this possibly support people to live at home for longer?
7. Do you have any specific ideas of which functions should be incorporated in this product?
    a. Which of the mentioned functions are in your opinion essential, and which would be more of an added bonus?
    b. Are there any functions you can think of that you would not like to have on the product?
    c. Do you think the ideas you mentioned could be implemented in an elderly home?
8. Do you have any other comments or questions?

13.1.2 Interview questions to the user

1. Do you currently live alone/with someone else/in an elderly home?
2. On a scale from 1-10, how mobile would you say you are?
3. Do you ever have trouble with standing up from a chair or couch, and sitting back down?
    a. Does this trouble result in longer sitting periods?
    b. Do you ever feel like this limits your independence?
4. Do you think you would benefit from the proposed idea?
5. Are there any functions you think the product should have?
6. Are there any functions you think the product should not have?
7. Do you have any other comments or questions?

13.2 Evaluation interviews

The evaluation interviews are interviews that are conducted to evaluate the final concept. The goal of these interviews is to assess how well the concept fits the requirements, according to the stakeholders.

13.2.1 Interview questions

1. What is your relation to the potential user?
2. Does the user have a caretaker? How involved is this caretaker?
3. Does the user live independently?
4. Does the user have trouble with standing up and sitting back down?
5. Does the user have a social life?
   [explain product, also show pictures and functions]
6. Is there anything that is unclear about this product?
7. Do you think the user would benefit from this product?

8. If yes, how do you think they could benefit?
9. Do you think the user will understand how to use this product?
10. Do you think some functions are redundant?
11. Are there some things you think we could add to this product that would make it better?
12. How mentally healthy do you believe the user is, and why?
13. How physically active do you think the user is, and why?
14. Do you think their mental and or physical health will be affected by this product?
    a. If yes, how and why?