A Speculative Approach: By and For the Biosignals and Systems Group

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Abstract

Dutch employees are sedentary many hours a day, which can result in health problems according to de Gezondheidsraad [2]. Currently, many lifestyle interventions are moving towards E-health [4], but how do we know current methods of lifestyle intervention are the best? The BSS group at the University of Twente works on lifestyle interventions of the future, so by building a speculative design for them, a conversation can be started on what lifestyle interventions targeting sedentary behaviour can look like. To best cater to the BSS group, two co-creation sessions were performed, one to brainstorm ideas for a speculative design and one to evaluate two prototypes based on these ideas. This resulted in a device attached to the bottom of the sit-stand desks available at the BSS group, automatically raising the height after 45 minutes of sedentary time, only allowing the user to lower the desk after some standing time. This prototype was tested by five members of the BSS, showing the final design to be relatable and speculative. This research concludes speculative design and co-creation can go hand in hand.

Contents

1 Introduction

Many people in the Netherlands work in office jobs, where sedentary work from 9 to 5 is the standard. Sedentary behaviour is defined as waking behaviour taking less than 1.5 metabolic equivalent of a task (MET), where 1 MET is the energy it takes to rest sitting [37]. On average Dutch employees sit at work for 4.62 hours a day, but this number goes all the way up to 7.15 hours for IT jobs. Even outside of work, sedentary behaviour is the norm, like during lunch breaks, making the total amount of sedentary behaviour for an average Dutch employee 8.49 hours a day in 2021[1].

De Gezondheidsraad (Dutch health council) advised in "Beweegrichtlijnen 2017" to prevent large amounts of sedentary behaviour. Reducing sedentary behaviour lowers the risk of heart- and vascular diseases, diabetes and depressive symptoms for adults and the elderly. Especially the initial reduction of sedentary behaviour can have a lot of impact, however, bigger lifestyle changes can lower the risk of breast- and colon cancer and premature death. [2]

Previously, office workers have been financially incentivised and compensated for physical activity [3], but there are also wearables such as Fitbits and other E-health systems sending messages to promote stair use instead of the elevator for example. E-health is often used to coach healthier behaviour by electronically measuring and communicating data for and about the user. E-health is growing and increasingly more data is being collected and processed in order to improve health and healthcare. The willingness to use E-health is very high amongst medical professionals, yet only 33% of patients are enthousiastic about E-health [4]. These are all examples of ways to do lifestyle interventions targeting sedentary behaviour, but perhaps there are more desirable or effective ways to decrease sedentary behaviour.

What impact do those systems have on people and what are the end goals, what direction are we going in as a society? There are many ways to perform lifestyle interventions, how do we know iterations of current methods are best? It is important to reflect on the changes happening, how could a conversation be started about lifestyle interventions regarding sedentary behaviour?

One method to start reflection and speculation on the effects of existing lifestyle interventions and the direction it is heading is speculative design. Speculative design is a relatively new approach within design research focusing on how today's technology impacts the future, for example by posing a dilemma to start a conversation [13]. Speculative designs are not supposed to solve a problem, but rather a starting point for speculation on the existing norms. This way a conversation about lifestyle interventions targeting sedentary behaviour can be started.

Norms are subjective, to disrupt existing norms effectively through speculative design, knowledge about the user and their existing norms on a subject is required. Co-creation is a design methodology that includes the users in the design process as experts in their domain [21], which can help to convey latent knowledge such as norms, as these can be difficult to articulate. This design methodology can potentially increase the likelihood of a successful speculative

design.

Creators of lifestyle interventions targeting sedentary behaviour are a desirable target audience because starting a conversation among creators of lifestyle interventions through speculative design can potentially impact future interventions made by them. The biomedical signals and systems research group (BSS) at the University of Twente is a multidisciplinary group based in Electrical Engineering aiming to improve the quality of life in a home or self-care setting [5]. The BSS group specialises in E-Health and is, therefore, a good target group to speculate on the outcomes of the systems created. Future projects at the group could be impacted by a speculative installation, allowing for new and creative methods of lifestyle intervention.

1.1 Challenges and Research Questions

It is important to start a conversation about lifestyle interventions targeting sedentary behaviour at work with the aim of a lifestyle change, as existing solutions might not be the most preferable solutions. The target audience for this research is the BSS group, which mainly concerns people who know the effects of sedentary behaviour but may find barriers towards applying that knowledge to new lifestyle interventions.

As the research is targeted at BSS group members, the speculative design should be catered to them and their lifestyles. What are the barriers and facilitators for sedentary behaviour in the BSS group and how can a speculative design be made so the BSS researchers relate to it? To design for the BSS group a holistic picture of their current efforts towards reducing sedentary behaviour and an understanding of who they are and how they work is needed. The challenge of this research will be finding what works best to interest and provoke a conversation and how to design a user experience for the BSS group. This research tries to cater to the target group through co-creation [17], creating a design with members of the target group instead of designing for them. Some challenges with co-creation include the recruitment of participants, creating a pleasant environment for ideation and obtaining relevant data.

A desirable outcome for a speculative design is to start a conversation on the topic and start speculation among users. The final design should have a positive user experience and long-lasting impressions, as it should not only be interesting while using but also promote discussion on the topic after its use. How can these criteria be assessed?

The main question in this research is "How can a speculative installation be designed to start a conversation about the lifestyle interventions targeting sedentary behaviour? ". To answer this question successfully the following subquestions were formulated.

- What is the state of the art in the field of speculative design in health?
- What are the barriers and facilitators towards sedentary behaviour during office lunch breaks?
- How can a speculative installation be co-created with target users?
- How can the outcomes of speculative design be evaluated?

2 Background Research

This chapter reviews existing literature to gain insight into the barriers and facilitators towards reducing sedentary behaviour at the office, the existing solutions to lower these barriers, closely related design terminologies, how to motivate using speculative design and ways co-creation can be used to create a speculative design. Next, the state-of-the-art speculative designs motivating specific behaviour are explored.

2.1 Literature Review

It is important to find the dilemmas posed by E-health systems meant to prevent long sedentary sessions at work and explore ways speculative design can target those dilemmas within BSS researchers. Therefore, this review aims to gain insight into ways speculative installation can be designed to start a conversation about the lifestyle interventions targeting sedentary behaviour at work with the aim of a lifestyle change.

First, the barriers and facilitators to sedentary behaviour at the office will be explored. Then, existing solutions to reduce sedentary behaviour in the office workspace will be given and evaluated. Afterwards, different terminologies related to speculative design will be explored and evaluated. Then, ways speculative design can start a conversation will be provided. Finally, contributions co-creation can bring to the design process are explored.

There are many factors impacting the amount of sedentary behaviour at the office, barriers and facilitators are often inversely related. One of the biggest factors impacting sedentary behaviour at the workplace is the ease with which an office worker can participate in physical activity. Garne-Dalgaard et al. [7] and Halling Ullberg et al. [9] mention that most factors are related to the accessibility of physical activity, due to time constraints or organisational difficulties. In addition, Bailey et al. [6] argue the most important factor is the prioritisation of the businesses. The claimed influential factors are very similar, but the causes resulting in those factors are disputed in the literature. Factors categorised as facilitators in literature are phrased as a provision of time, information, prioritisation, availability or accessibility while factors are categorised as barriers when there is a lack of those factors.

There are two different types of solutions to promote a reduction of sedentary behaviour. The first type of solution is motivation-oriented, for example, an intervention program addressing multiple health factors at once, namely nutrition, exercise, alcohol use, smoking, stress, and seat belt use [10]. This study showed that when attention is given to multiple health factors, greater lifestyle changes are done than targetting only one health factor. However, Calfas et al. [11] showed there is already a significant impact when only physical activity is targeted.

The second type of solution is provision-oriented, one such example is a stepping device to be placed underneath the desk as described by McAlpine et al. [12]. This device was appreciated by the users and showed a significant increase

in energy use while resting. Although the device allows for more physical activity at the office, it requires motivation from the users themselves to prove efficient. Another provision-oriented solution requiring motivation is wellness allowances, where office workers can decide for themselves how they spend their time and allowance [9], which has also been proven to be effective when implemented well. Both the motivation-oriented solutions and the provision-oriented solutions show success when reducing sedentary behaviour, however, building on the notion that provision-oriented solutions require motivated users, a combination of both solutions will most likely prove most successful.

Speculative design could be considered an umbrella term for many closely related terminologies. Different papers use different terms for closely related types of design, including speculative design, reflective design, discursive design, provocative design and critical design. Auger [15] uses the term speculative design as it relates the present to the design, however, they recognise that referring to this type of design as speculative design can lead designers to speculate on unrealistic futures and discourage reflection on current technologies. In contrast, Bardzell et al. [14] argue for the use of critical design which they define by its ability to change one's perspective, start a dialogue and be aware of its effects. Conversely, Ozkaramanli and Desmet [13] argue using the term provocative design for designs challenging conventional beliefs and outlooks by provoking debate and exposing underlying assumptions, by targeting internal dilemmas for example. Speculative design seems like it could be considered an umbrella term for these closely related terms since it describes their end goal, namely speculation on what is desirable. Provocation and reflection could be defined as means to speculation, alongside the other mentioned closely related terms.

Speculative design can start a conversation by provoking users through challenging norms. Auger J. [15] argues designs should be provocative but recognisable to elicit discussion, as the design should attract attention without eliciting repulsion. In addition, Ozkaramanli and Desmet [13] argue disputing existing norms and standards through hypothetical design can promote debate, by targeting internal dilemmas for example. Furthermore, Bardzell et al. [14] argue a desirable result of a critical design is provocation, which they believe can be achieved through disruption of norms. Although there is debate on what to call this design strategy, there is an overall agreement that challenging norms should provoke users to start a conversation.

Co-creation allows the user to become part of the whole design process and the researcher to gain more knowledge of the user. In co-creation, users are "experts on their domain" [21], in contrast to user-centred design where the researcher takes on an expert role throughout the design process, giving the users little power [17]. In addition, Ozkaramanli and Desmet [13] argue unprovocative designers can co-create a speculative design by provoking users through triggering dilemmas [13]. Co-creation can help the researcher gain more insight into the users and create speculative design by triggering dilemmas.

This review aimed to discover barriers and facilitators to sedentary behaviour at the office, existing ways of promoting a reduction of sedentary behaviour, dif-

ferent terminologies related to speculative design and ways speculative design can start a conversation. Barriers and facilitators to reducing sedentary behaviour are often inversely related as the impacting factors can be phrased as a provision of for example time or a lack thereof. Researchers agree that the most impactful factors influencing sedentary behaviour at the office are time, information, prioritisation, availability and accessibility, but there is debate on the causes impacting those factors.

The solutions targeting these barriers and facilitators can be divided into motivation-oriented and provision-oriented, both prove successful in reducing sedentary behaviour. Motivation-oriented solutions include intervention programs and other lifestyle programs and provision-oriented solutions include among others gym subscriptions, stepping devices and wellness allowances. Although both types of solutions show success in reducing sedentary behaviour, a combination of both solutions will probably have the most impact, as provision-oriented papers mention motivation as a requirement for success.

Even though different papers disagree on terminology for a speculative design approach, their methods and end goals are very similar. All agree that speculation and debate are desired outcomes of the design approach, and therefore it seems like it could be considered an umbrella term for all related design strategies.

Speculative design can start a debate through the provocation of users by challenging norms. Although researchers disagree on the terminology for this design approach, there is agreement that speculation and debate are desired end goals which can be achieved through provocation. There are multiple methods to provoke users according to the literature, but all are based on the disruption of norms through hypothetical design.

Co-creation can help gain a deeper understanding of the users and allow them to take part in the whole design process. By targeting dilemmas to trigger, unprovocative designers can create speculative designs.

These insights provide most of the required information to continue preparing the co-creation sessions meant to design a speculative design to start a conversation about the lifestyle interventions targetting sedentary behaviour. Some further research could be done on ways to do co-creation sessions efficiently resulting in speculative designs for that research. In addition, there hasn't been a lot of research on the field of speculative design, but using these guidelines and methods should help come to a design related to sedentary behaviour at the office.

2.2 State of the Art

This section looks at the existing speculative designs motivating specific behaviour. What are the things done right in the state-of-the-art designs, and what has room left to improve? There aren't many sedentary-specific motivating speculative designs so other health-related designs are included as well.

The Chairwave designed by VOUW aims to fight loneliness by forcing users to take seats next to each other. This is done by tilting the seating areas everywhere except for those seats directly surrounding sedentary users, making it impossible to sit elsewhere. This idea seems fairly simple but showed success when demonstrated at the Amsterdam Light Festival, where complete strangers interacted with one another when using the installation. Forcing users to perform certain behaviour outside of their comfort zone by making an installation with similar looks to a well-known entity, but changing one key property about it with significant effects on its use. This behaviour outside its users' comfort zone makes users speculate on the impacts of their habitual behaviour.

Figure 1: Chairwave by VOUW [24]

The Compression carpet by Lucy McRae [25] aims to improve the well-being of its users by providing artificial hugs. This design shows a possible future scenario to make its users speculate on the effect of the current technological advancements and what will happen when all human interactions happen digitally.

Figure 2: Compression carpet by Lucy McRae [25]

Thornback by Martin Naumann is a packaging project implementing nature-like warning signs as a way to show the effects of the product. This makes the user speculate what packaging should look like and tell the user about products in the future.

Figure 3: Thornback by Martin Naumann [26]

Raising Robotic Natives by Philipp Schmitt speculates on the future of robotics and the integration they might see into our ways of life. The artist mentions that robots discomfort people from our generation and if this discomfort be dissipated in future generations to truly integrate robots into our lives. The idea here is to speculate on a possible future where humans are raised by robots, what it would look like and how do people would feel about it.

Figure 4: Raising Robotic Natives by Philipp Schmitt [27]

The Netflix show Black Mirror contains many episodes with a speculative vision of the near future. For this example, the Nosedive episode will be used where the idea of social media ratings is explored when applied to humans. By showing the effects social media ratings can have on lives in a not-so-far-fetched future, the audience is left to speculate whether the direction social media is heading is desired.

Figure 5: Nosedive episode of Black Mirror [28]

The Antivanity Mirror by Neil Mendoza goes against habitual behaviour similar to the Chairwave. People tend to look at themselves in the mirror, which has been made impossible in this installation. The mirror recognises faces and moves away when one is in front of it. The users can speculate on their use of mirrors and the effects they have on them.

Figure 6: Antivanity Mirror by Neil Mendoza [29]

Ivy by 4TU tries to counter sedentary behaviour by growing an ivy plant alongside an office chair. The size of the ivy is a measurement of sedentary time, a bigger ivy plant indicates a larger amount of the poisonous act of sedentary behaviour. The goal of the project is for designers to think about the way designers make health data visualisations currently, which is similar to the aim of this graduation project.

Figure 7: Ivy by 4TU [30]

The relevant works found show many similarities whilst being very different. All examples build upon the concept of everyday objects and symbolise universally recognisable entities, like a chair or mirror. However, the installations have different ways to emphasise a dilemma to speculate on, this can be a not-so-far-future scenario leading users to reflect on its current implementation or changing the way users usually interact with it to reflect on their behaviour for example.

3 Methods and Techniques

In this chapter, the steps taken to perform this research are stated, including the Creative Technology design process, co-creation and methods of evaluation.

3.1 Creative Technology Design Process

This thesis is part of the Creative Technology bachelor and will therefore mainly use the Creative Technology Design Process [16]. This methodology by Mader and Eggink splits the design process into four phases [Figure 8], namely the ideation phase, the specification phase, the realisation phase and the evaluation phase. In this research, the co-creation process described by Sanders and Stappers [17] will be implemented into the Creative Technology design process ideation phase and specification phases, to include latent knowledge of the users into the process.

The first phase of the Creative technology design process takes input from the background research and user evaluation and uses a well-defined problem definition to create the first sketches and ideas. Here, the brainstorming co-creation session takes place as described in Chapter 3.2 to concretely define the problem, where participants of the research would otherwise just be considered as the users now co-create prototypes.

The output taken from the ideation phase is reviewed and iteratively combined, redefined and specified. Two Lo-Fi prototypes are then designed, and these prototypes are evaluated by the same participants of the brainstorming session in the second co-creation session as described in Chapter 3.2.

After the second co-creation session, a prototype is chosen and iterated upon in the realisation phase. This phase works towards a Hi-Fi prototype, which has taken input from the ideation and specification done during the co-creation sessions.

The final phase of the process evaluates whether requirements have been met with the realised Hi-Fi prototype. The desired outcome of a speculative design is a prototype that displays a clear and relatable dilemma and provokes previously unknown or disregarded emotions related to the dilemma. The success of the prototype is evaluated by the target group through the following qualitative questions.

- What dilemma do you think the prototype conveys?
  - How do you see that?
  - How could this be strengthened?
- Can you relate to the dilemma conveyed in the design?
- How did you feel when interacting with the prototype?

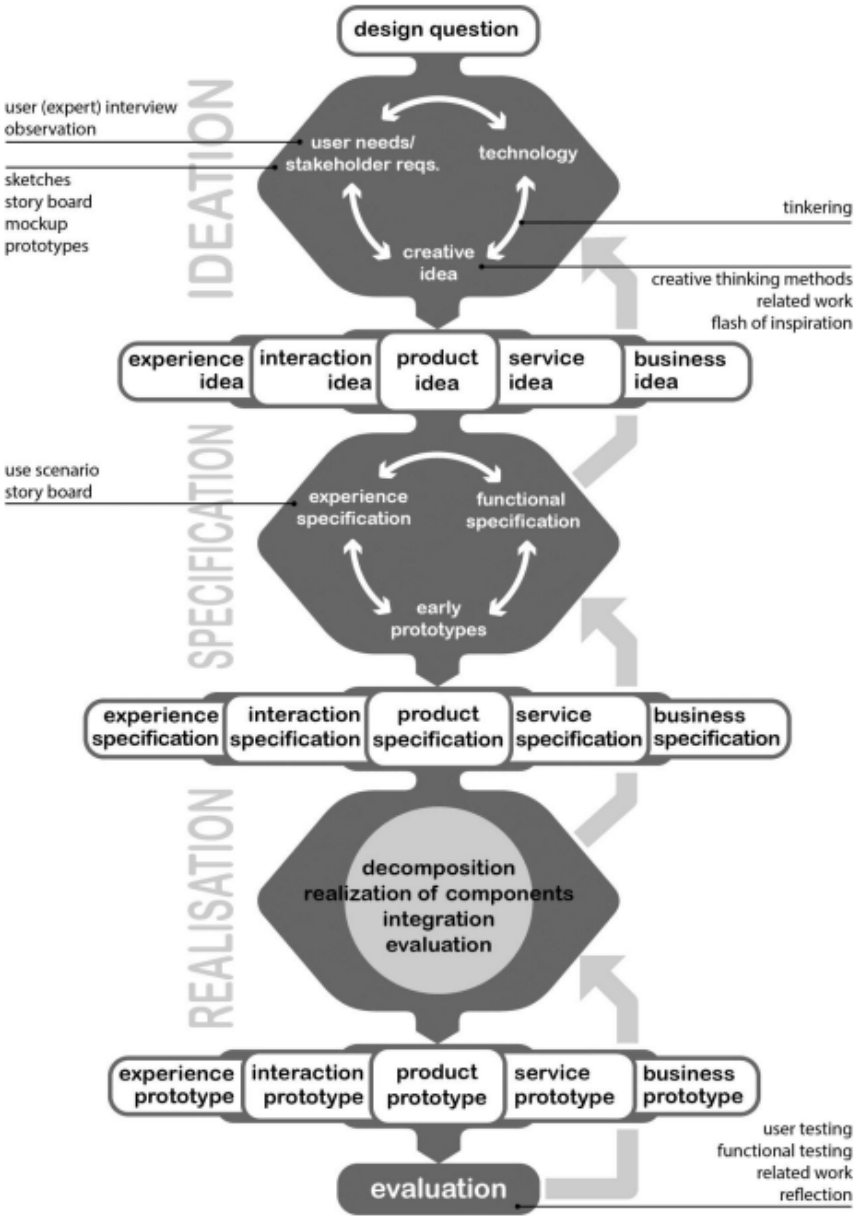


Figure 8: Creative Technology Design Process by Mader and Eggink [16]

3.2 Co-creation

Co-creation turns the target group from just communicators of insights into participators in design. The role of the researcher then becomes to facilitate and guide the creativity of the target users, instead of gathering knowledge and leaving the design process to themselves.

Co-creation falls under the segment generative sessions in Figure 9, generative sessions can help articulate latent and tacit knowledge of the targeted audience [31]. To effectively gain this knowledge, the main goals of the researcher are to find the right participants, facilitate a pleasant environment for them and provide the right toolkit for expression.

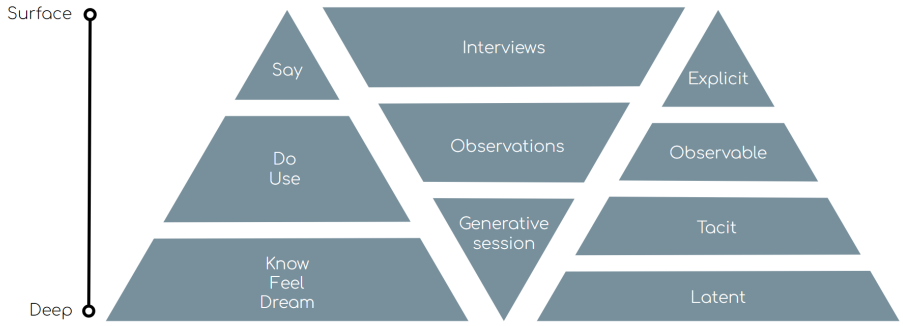


Figure 9: Knowledge gathering by Sanders & Stappers [31]

The first co-creation session is part of the Creative Technology Ideation phase and is therefore exploratory. The goal of this session is to find a fitting problem definition and receive some speculative design ideas from the participants. This session starts with an energizer, after which the participants are asked to illustrate their barriers and facilitators to reducing sedentary behaviour.

Participants receive white A2 papers, a stack of Post-it notes, pens, pencils and markers in a variety of colours, a stack of varying magazines, a pair of scissors, a glue stick and a block of clay with tools to sculpt it. After a cool-down from the first part of this session, a presentation about speculative designs is given to inspire the second part. In the second part, the participants are asked to create their speculative designs answering the question of how they would reduce sedentary behaviour at the office in 2050, in a world where money, ethics and technology are not a problem but sedentary behaviour is. This way of formulating the question is inspired by the superhero brainstorming method [22], which can help to think outside of the box.

The second co-creation session is meant to receive extra insight and feedback on the Lo-Fi prototypes based on the designs created by the participants. The participants are asked to give feedback on two Lo-Fi prototypes, so iterations can be made upon the one that resonates best with the participants for the

Hi-Fi prototype.

All six participants from the first co-creation session were also present at the second session and showed interest in the research, this allowed them to provide feedback on their own ideas as they are experts on their ideas. Participants of the first session already understand the subject in the second session, making for great feedback on how to improve. One participant joined all three sessions, testing the final prototype as well [Table 1].

The co-creation research has been approved by the ethics committee Computer & Information Sciences (CIS) of the University of Twente under application number 240140.

Participant	**BSS member**	**Brainstorm**	**Lo-Fi evaluation**	**Hi-Fi evaluation**
1	X	X	X	
2	X	X	X	
3	X	X	X	X
4	X	X	X	
5		X	X	
6		X	X	
7	X			X
8	X			X
9	X			X
10	X			X

Table 1: Participants

4 Ideation

This chapter describes the process of brainstorming with co-creation, designing Lo-Fi prototypes and evaluating said prototypes with co-creation, after which the selection process for the Lo-Fi prototypes is described.

4.1 Co-creation brainstorming session

Activity	**Description**	**Location**
Inform	Orally inform the BSS group about co-creation	BSS group meeting
Recruit	E-mail the sign-up form to the whole BSS group	Online
Recruit	Personally ask two Creative Technology students to join	University of Twente
Information letter	Send information letter to participants of co-creation	Online
Consent	Participants ask questions and fill out informed consent	Brainstorming session
Energizer	Participants do word association energizer	Brainstorming session
First brainstorm	Participants illustrate personal barriers and facilitators to sedentary behaviour	Brainstorming session
Break	Participants receive coffee, tea and homemade cookies	Brainstorming session
Presentation	A presentation of five previously drawn speculative ideas	Brainstorming session
Second brainstorm	Participants provide ideas to reduce sedentary behaviour at the office in 2050, in a world where money, ethics and technology are not a problem	Brainstorming session

Table 2: Tasks brainstorming session

In Table 2, all tasks leading up to and during the co-creation brainstorming session are concisely described in chronological order.

Participants were orally informed about the co-creation sessions at a group meeting of the BSS and were then further notified and recruited by E-mail. Four staff members agreed to take part, in addition to two students of Creative technology who were asked personally.

Before the brainstorming session, participants received an information brochure with an informed consent form by E-mail. Then, they were invited to a physical workshop which took place at the BSS groups department of the University of Twente. At the beginning of the session, the participants were asked whether

they had any questions, after which the session started.

In the first 5 minutes, a short introduction to the activities of the session was given.

Next, the participants did the "word association" energizer for 3 minutes. In this energizer, the participants say the first word that comes to mind when hearing the previous word, rotating clockwise to the next participant. It took a bit before everyone stopped overthinking and could quickly reply with the first thing to come to mind, after roughly 2 minutes some major progression happened and the goal of the energizer was achieved.

After the energizer, the first brainstorming session started in which participants were asked to illustrate their barriers and facilitators to reduce their sedentary behaviour. This should get the participants to stop thinking about the solutions that are currently out there and rather focus on the factors to address in such solutions. Another benefit of this first brainstorm is the ability to take these factors as a starting point for ideation during the second brainstorm. Participants received white A2 papers, a stack of Post-it notes, pens, pencils and markers in a variety of colours, a stack of varying magazines, a pair of scissors, a glue stick and a block of clay with tools to sculpt it. This brainstorming session took 15 minutes.

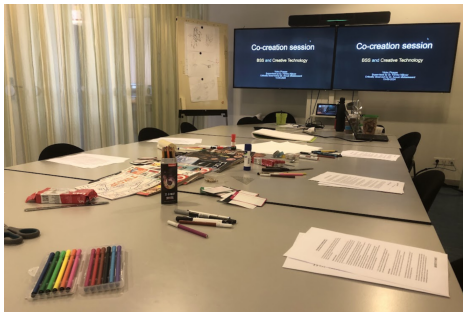


Figure 10: Co-creation brainstorming session setup

After the first brainstorming session, there was a 10-minute break, during which coffee, tea and homemade cookies were provided.

Next, a presentation of 5 minutes was given where the basic idea of speculative design is explained through the cone of possibilities [Figure 11]. Iterations of existing technologies are a probable future, however, there are many more possible futures by ideating new technologies, one of which might be preferable. The main findings from the literature review were quickly mentioned, namely the requirement of provocation through challenging norms. Afterwards, some previously prepared speculative designs were shown to inspire the second brainstorm [Table 3, Figures 12-14].

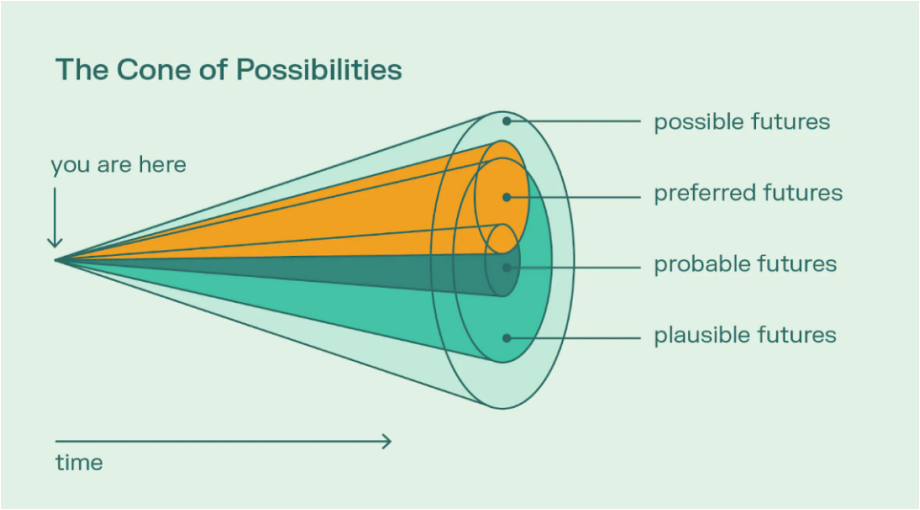


Figure 11: The cone of possibilities [32]

Concept	**Dilemma**	
Talking chair	A sedentary desire or habit	The uncomfortable feeling of sitting on an audibly uncomfortable face
Electric chair	A sedentary desire or habit	The scary thought of slowly killing the body
Shrimpmeter	A sedentary desire or habit	Belittlement via scary posture effects likely resulting from such behaviour
LISTEN!	A sedentary desire or habit	The impracticality of barely seeing
FLIPPING CHAIR!	A sedentary desire or habit	The scary thought of rocket launching

Table 3: Dilemmas of concepts

The first speculative design prepared for the co-creation is a talking chair concept [Figure 12], this chair has a face on the seat talking to you. Some minor moans are audible when the user starts sitting in the chair, as sedentary time increases more moans and complaints can be heard that are increasingly more persuasive. This design is supposed to make its users feel uncomfortable about sedentary behaviour and nudge them to different behaviours by belittlement.

A second design shown in the presentation is a sinister electric chair [Figure 12], slowly tying the user up and preparing them for a fake execution during sedentary sessions. This design symbolises the health issues that come with sedentary behaviour to scare its users into a decrease in sedentary behaviour.

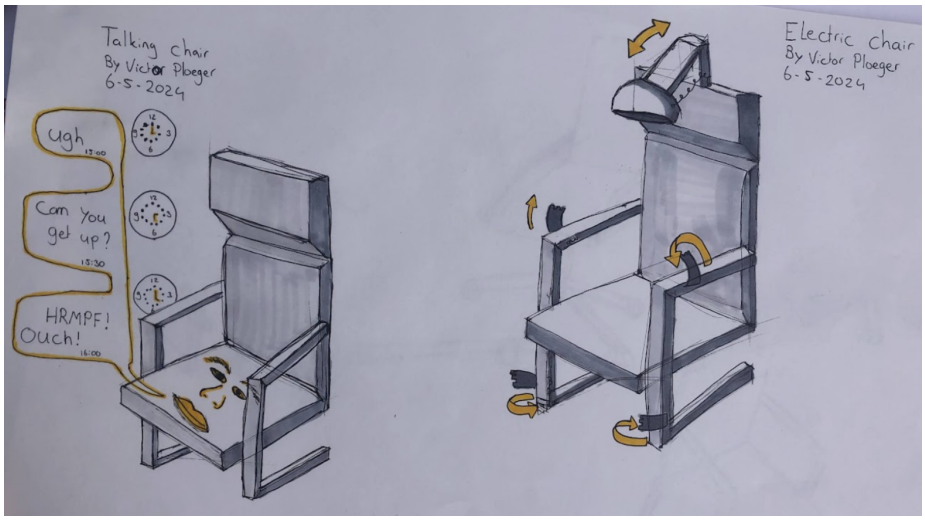


Figure 12: Talking chair and Electric chair sketches

Third, a design was shown of a Shrimpmeter [Figure 13], a small device to put on the desk, visualising a shrimp slowly curling up during sedentary sessions. This design is meant as a cute way to remind users about their posture and sedentary behaviour, nudging them to make minor lifestyle changes by pleasantly shaming them.

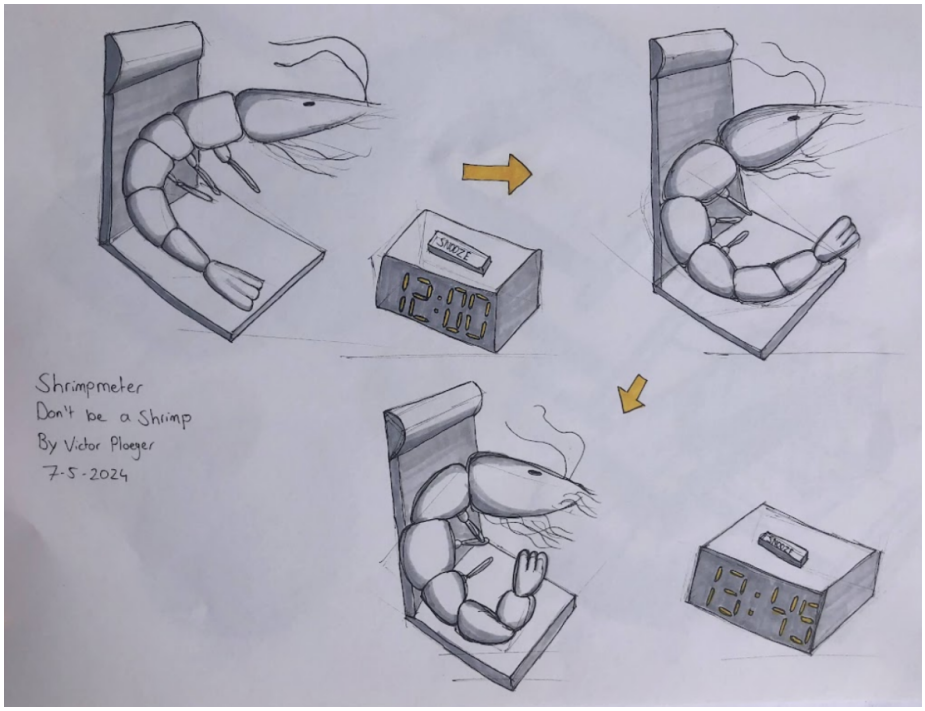


Figure 13: Shrimpmeter sketch

Fourth, a wearable design was shown that emphasizes fatigue through increasingly polarising glasses as sedentary time increases [Figure 14]. Removing the users' right to ignore unhealthy behaviour in favour of demonstrating its unhealthiness. A human body can indicate sedentary fatigue but most people at the office are trained to disregard these messages from the body, this pair of glasses makes it near impossible to disregard sedentary fatigue. The impracticality here is intentional, reminding the participants not to worry much about usability and not to overthink when brainstorming.

The fifth and final design was a simple but effective flipping chair [Figure 14], rocket launching its user after some sedentary time. This design was shown because it reminds participants that simple ideas can be a good starting point for further ideation.

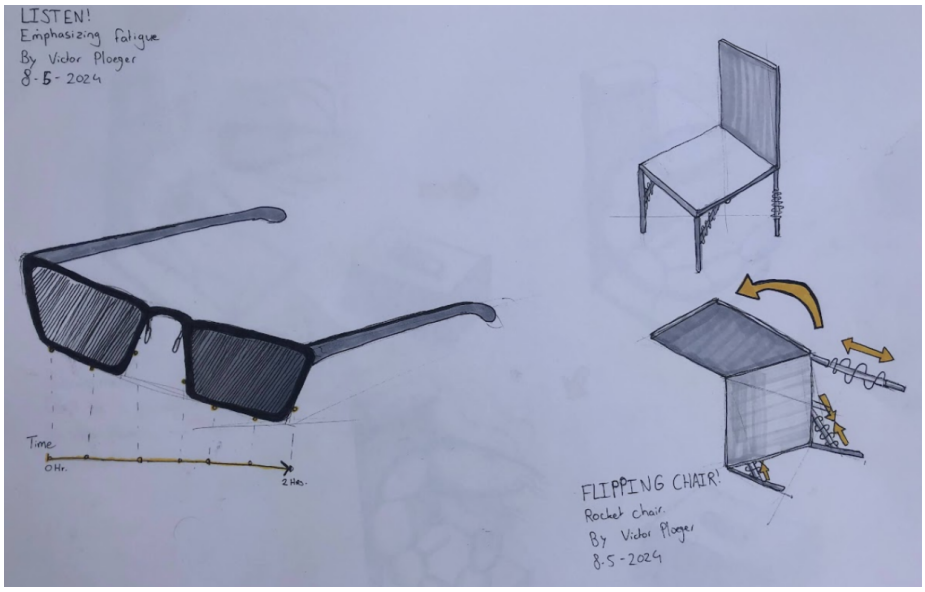


Figure 14: LISTEN! and FLIPPING CHAIR! sketches

Finally, a second brainstorm of 15 minutes focused on how participants would reduce sedentary behaviour at the office in 2050, in a world where money, ethics and technology are not a problem but sedentary behaviour is. Participants again received white A2 papers, a stack of Post-it notes, pens, pencils and markers in a variety of colours, a stack of varying magazines, a pair of scissors, a glue stick and a block of clay with tools to sculpt it. This resulted in many different ideas per participant, as shown in Figure 15, mostly written down, drawn or based on images found in magazines. Users indicated that other forms of ideating on ideas were time-consuming, given the fast-paced nature of the brainstorming session. When one of the participants had some difficulty coming up with new ideas, another mentioned they should forget about money, ethics and technology, showing how letting go of these factors can be difficult but crucial in the quick ideating process. The outcomes of this brainstorming session were mind-mapped, combined and used to make the two Lo-Fi prototypes for the co-creation evaluation session.

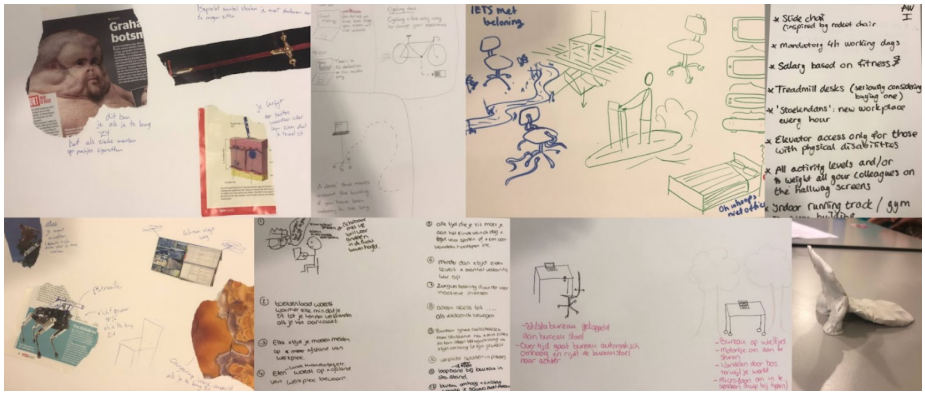


Figure 15: Ideas from the co-creation brainstorming session

Participants were fond of the co-creation brainstorming session, asking what would happen next and when they could further aid the research. When preparing for the brainstorming session, getting the participants in a creative mindset was one of the main concerns, which is why two Creative Technology students were invited to join. The group dynamic felt more casual than expected, making it easier to start ideating speculative ideas. Most participants gravitated towards the magazines for inspiration, a good starting point for expression. Almost all ideas were articulated using varying tools, except clay or Post-its, showing how preferences for expression can differ and the importance of allowing participants to choose their preferred tools.

4.2 Prototyping

In the next phase, Lo-Fi prototypes were made based on the insight from the co-creation brainstorming session. The prototyping phase does not focus on a technically advanced system, as its purpose is to evaluate whether the targeted dilemma is strongly conveyed. The results are two Lo-Fi prototypes to evaluate in the co-creation evaluation session.

This process started with making an overview of the input from the co-creation session and categorizing ideas, for this purpose, a mindmap was made. The mindmap [Figure 16] shows many ideas related to a moving work environment, tasks to be completed for access grants and some push and pull factors to adhere people to these tasks.

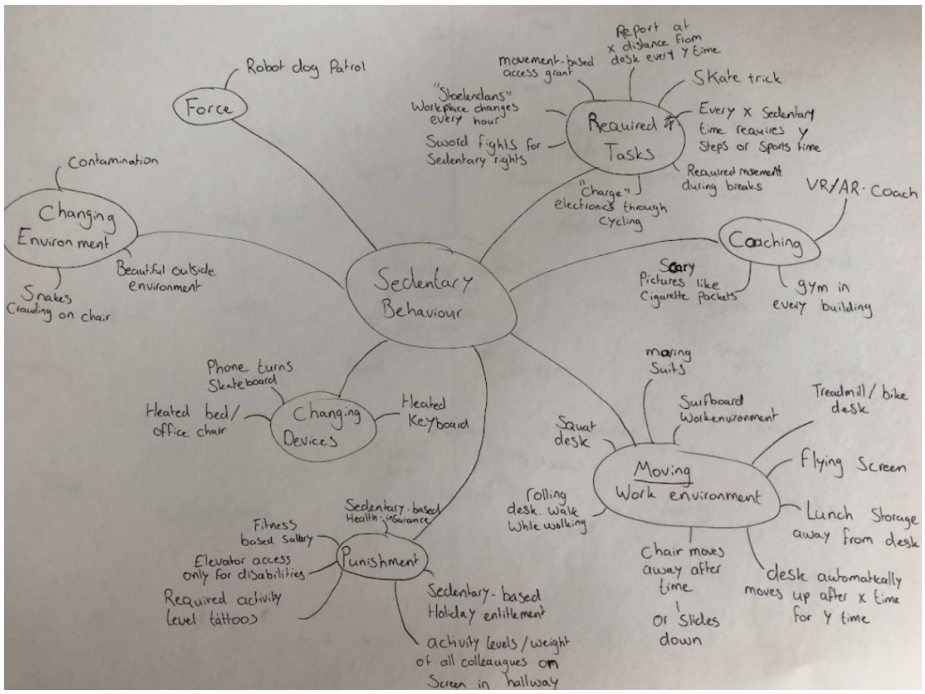


Figure 16: Mindmap of ideas from the co-creation brainstorming session

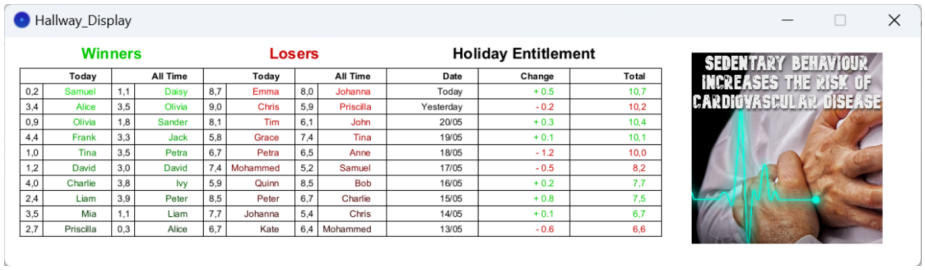
Some of the most interesting ideas are combined to form a couple of prototype ideas, of which two were chosen to be developed as lo-fi prototypes for the co-creation evaluation.

4.2.1 Lo-Fi prototype 1: Hallway display

This prototype is based on two punishment ideas from the brainstorming combined with one idea labelled as coaching.

- Sedentary-based holiday entitlement
- Activity levels of all colleagues on a hallway display
- Scary warning pictures like on cigarette packages

These are combined to make one provoking design in which the sedentary hours of all colleagues are divided into winners and losers, and shown on a leaderboard. All colleagues' average amount of sedentary time is used to determine the holiday entitlement of the whole group, which could result in colleagues encouraging each other to be less sedentary. Another addition to this prototype is a picture with cautionary text to scare people away from sedentary behaviour. This prototype is programmed in Processing, so real-world values from sensors can easily be implemented, however, these values are randomly generated in this early prototype.



Today		All Time		Today		All Time		Date	Change	Total
0,2	Samuel	1,1	Daisy	8,7	Emma	8,0	Johanna	Today	+ 0.5	10,7
3,4	Alice	3,5	Olivia	9,0	Chris	5,9	Priscilla	Yesterday	- 0.2	10,2
0,9	Olivia	1,8	Sander	8,1	Tim	6,1	John	20/05	+ 0.3	10,4
4,4	Frank	3,3	Jack	5,8	Grace	7,4	Tina	19/05	+ 0.1	10,1
1,0	Tina	3,5	Petra	6,7	Petra	6,5	Anne	18/05	- 1.2	10,0
1,2	David	3,0	David	7,4	Mohammed	5,2	Samuel	17/05	- 0.5	8,2
4,0	Charlie	3,8	Ivy	5,9	Quinn	8,5	Bob	16/05	+ 0.2	7,7
2,4	Liam	3,9	Peter	8,5	Peter	6,7	Charlie	15/05	+ 0.8	7,5
3,5	Mia	1,1	Liam	7,7	Johanna	5,4	Chris	14/05	+ 0.1	6,7
2,7	Priscilla	0,3	Alice	6,7	Kate	6,4	Mohammed	13/05	- 0.6	6,6

Figure 17: Hallway display Lo-Fi prototype [33]

4.2.2 Lo-Fi prototype 2: Autonomous desks

This prototype is based on an idea marked as a required task and one marked as a moving environment.

- Required to change workspace every hour
- The desk automatically moves up after some time

This prototype changes the sit-stand desks in the group to standing desks until the user is logged in with their University of Twente card, after which the user receives one hour of sedentary time at this desk.

The timer starts when the desk is used at a height below a certain threshold, after one hour of sedentary time the desk automatically raises to a standing height again. The desk tells the user to work standing or to move to another

desk to work sedentary there. Rescanning the same University of Twente card will show this message again, but the desk can be lowered once again when another University of Twente card is provided. This Lo-Fi prototype is made using an Arduino with an RFID scanner and a button, hooked up to a laptop to run processing code to visualise the table and prompts.

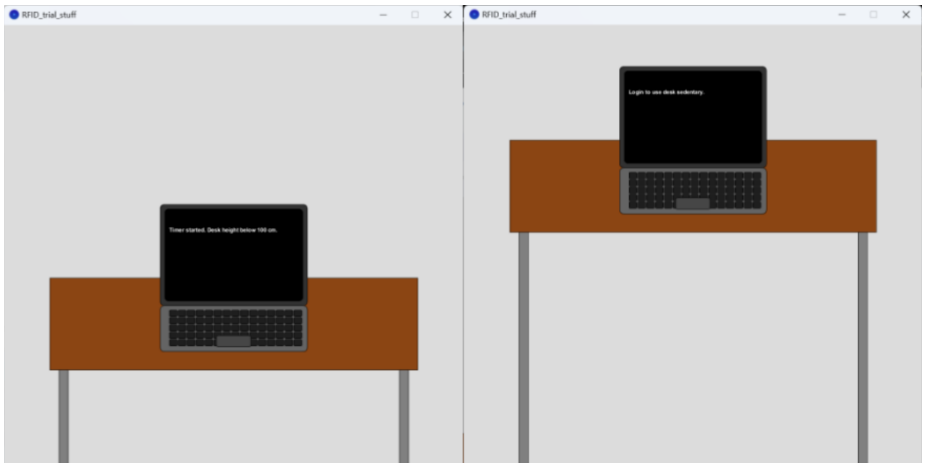


Figure 18: Screenshot autonomous desks prototype

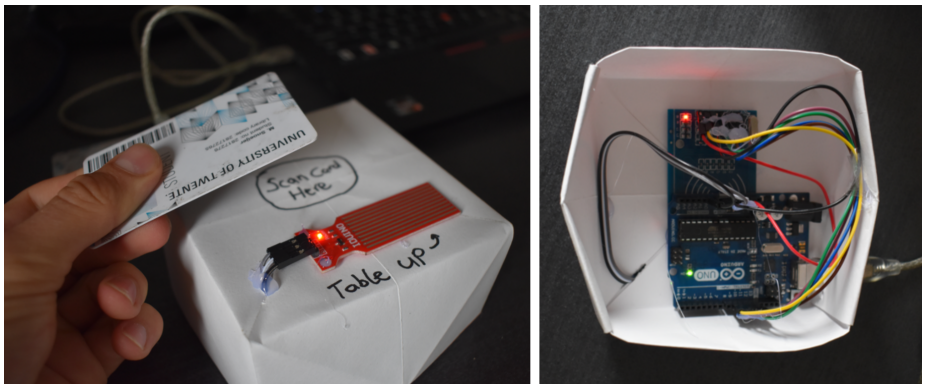


Figure 19: Autonomous desks physical prototype

4.3 Co-creation evaluation session

A second co-creation session aims to provide some of the required knowledge to select an idea for the final prototype and ways it can be improved upon. The same participants from the brainstorming session are brought back to evaluate prototypes based on their ideas, making sure they are interpreted the right way and giving room for further feedback. They are asked what dilemma the prototype conveys, the aspects that show this dilemma, whether the participants can relate to this dilemma and the user experience while interacting with the installation. The session once again started with informed consent, after which a recap of the previous session was given. Next, the Lo-Fi prototypes were shown and interacted with by the participants for 10 minutes. All participants wrote down their answers to the evaluation questions after which an open discussion started on the prototypes. This resulted in some valuable feedback on the Lo-Fi prototypes that will be discussed in Chapter 4.4

In Table 4, all tasks leading up to and during the co-creation evaluation session are concisely described in chronological order.

Activity	Description	Location
Recruit	E-mail meeting form to participants of the brainstorming session	Online
Recruit	Ask participants of the brainstorming session personally to join the evaluation session	Brainstorming session
Information letter	Send information letter to participants	Online
Consent	Participants ask questions and fill out informed consent	Evaluation session
Recap	Recap activities of the brainstorming session	Evaluation session
Clarify	Clarify prototypes are tested, not participants	Evaluation session
Explain	First prototype explanation	Evaluation session
Evaluation	Individual written evaluation of first prototype	Evaluation session
Discussion	Group discussion on first prototype	Evaluation session
Explain	Second prototype explanation	Evaluation session
Evaluation	Individual written evaluation of the second prototype	Evaluation session
Discussion	Group discussion on the second prototype	Evaluation session
Inform	Inform participants what will happen next	Evaluation session

Table 4: Tasks evaluation session

4.4 Final idea

Input from the co-creation evaluation session is used alongside other factors to select one final idea. Other factors that play a role here are the technological feasibility of the project, the feasibility of the project within the given time-frame and the recognition and relatability of a desired dilemma. Both Lo-Fi prototypes are technologically feasible and feasible within the given timeframe, as the rudimentary basics were quickly ideated for the Lo-Fi prototypes and can be used to further develop the final prototype. Participants of the co-creation evaluation preferred the autonomous desks prototype, as they believed it to be more effective and was generally liked better. The dilemma of the first design was not conveyed as intended to all participants of the co-creation evaluation, as some thought it to be about maximizing physical activity rather than reducing sedentary behaviour, others thought it to be about personal preferences versus

the collective pressure while only two out of six participants interpreted the design to be about their sedentary behaviour with regards to the groups holiday entitlement. All participants identified the autonomous desks prototype as a choice between sedentary and standing behaviour, which is a desired outcome of the prototype. The recognition of the conveyed dilemma and the overall preference from the co-creation participants, my supervisor and I led to selecting the autonomous desks prototype for further prototyping.

The co-creation evaluation session not only gave insight into which Lo-Fi prototype showed more promise but also resulted in a lot of feedback for further specification of the prototypes. One addition the participants would like to see is the ability to sit at the same desk once again after some standing time at the desk, a reward for standing behaviour and sticking to this desk. The cooldown period for this should be linked to the amount of sedentary time given per desk, which was another topic for debate.

Some participants argued the amount of sedentary time should be based on the attention span of the user, as standing behaviour could help blood circulation. Another participant proposed to change the cooldown period to be equal to the sedentary period, meaning more standing behaviour would allow the user to more sedentary behaviour. My supervisor proposed one more sedentary period, based upon Scherder [36] explaining that every 30 minutes, 5 minutes of physical activity is recommended. As this prototype is supposed to be used in an office setting, a design where the user could be distracted by their standing period to determine whether to use up their sedentary period is not optimal, but the participants asking for a reward for their standing behaviour will be taken into account for another feature. Instead, the sedentary period will be 45 minutes upon request of the co-creation participants, to avoid the prototype distracting from work while staying close to Scherders proposed 30 minutes.

The participants enjoyed the thought of competition amongst colleagues in the hallway display prototype, especially if it could result in a small reward. One participant mentioned a weekly winner would be rewarded with a fruit basket, a small yet rewarding trophy. Such a reward system could be implemented into the autonomous desks prototype too, clocking the time every user has been sedentary versus standing at the office. This system would incentivise to log in using the University of Twente card even when the user has no desire for sedentary behaviour, allowing for another feature brought up multiple times by participants to be very useful.

Currently, due to the limited amount of workplaces, it can be difficult to know whether there are any workplaces still free and where to find them. An application providing this information could simplify this process, showing what rooms have free tables based on desk usage. When a user logs in using the University of Twente card, the application will show one less available desk and update the remaining rooms containing free workplaces. This system would be heavily dependent on the users logging in to their desks, luckily another proposal for a feature made by one participant can incentivise users that don't care much about the competition and reward.

Logging in with the University of Twente card could automatically raise the

desk to the preferred height for standing or sedentary work of the user. A user could set their preferred heights once and let the system save these settings for all desks the user logs in to, making switching desks a minor inconvenience.

In Figure 20, an illustration of the use case of the final idea is given. Figure 21 shows the final ideas functions, possible user actions and their outcomes.

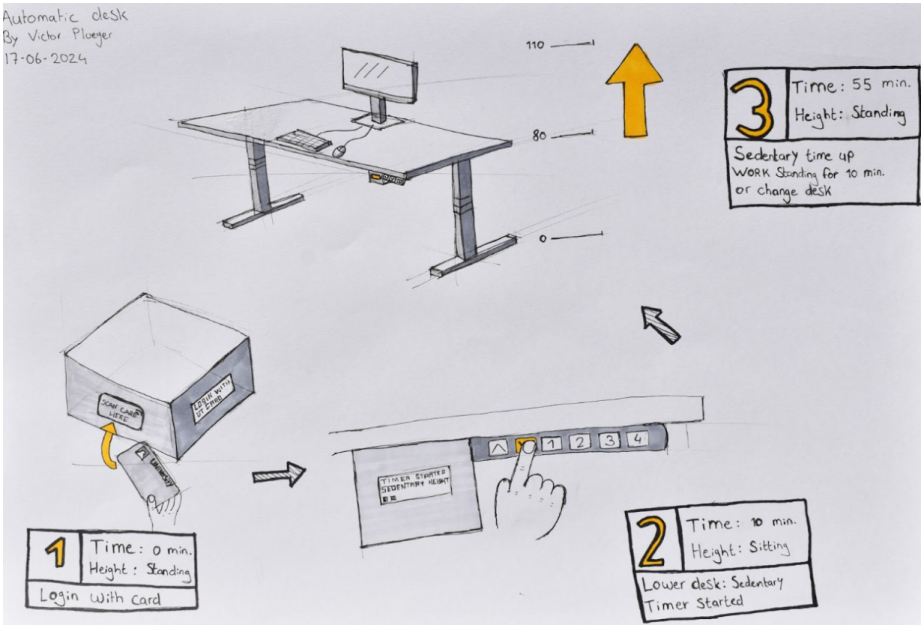


Figure 20: Automatic desk Hi-Fi prototype user interaction sketch

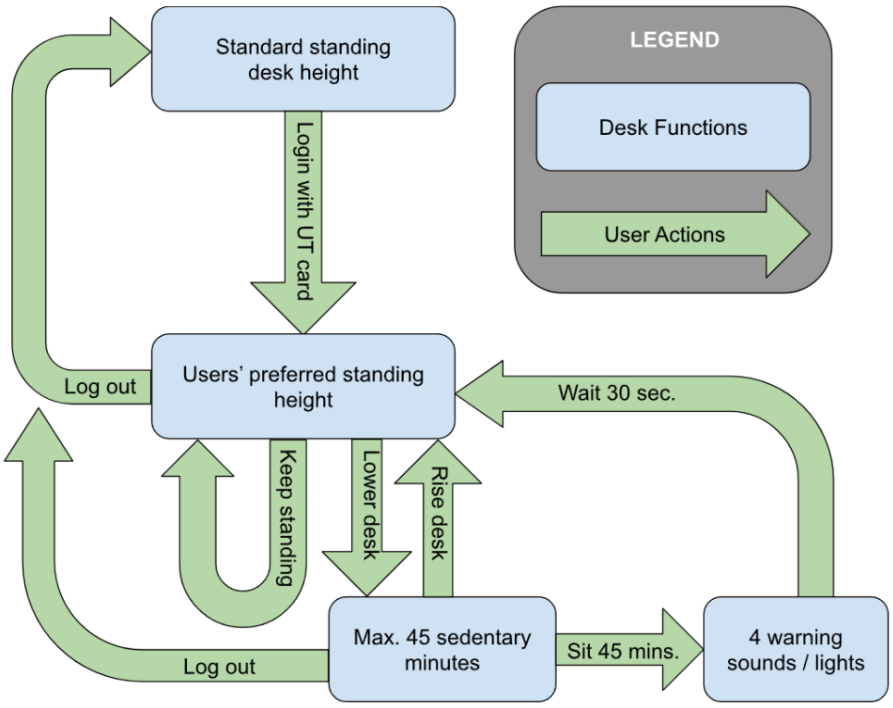


Figure 21: Automatic desk Hi-Fi prototype user interaction and functioning

5 Specification

This chapter covers the criteria that the chosen prototype from the ideation phase should meet to answer the research questions. Feedback from the co-creation evaluation is used to further specify its requirements using the MoSCoW method. Other design choices regarding the user experience are explained.

5.1 MoSCoW method

To determine what functionalities should be prioritised to have a functioning prototype and what functionalities would be nice to have or won't be included, the MoSCoW method (Must have, Should have, Could have, Won't have) is used [Table 5]. This way it is easier to have an overview of what the prototype can be like and know when to start working on different components. Some of the requirements can be assessed without any qualitative testing with users, these are marked as technical.

MoSCoW	**Requirement**	**Technical**
Must	Provoke conversation on the topic	
Must	Convey a clear and relatable dilemma	
Must	Have a satisfying user experience	
Should	Automatically raise the desk after a sedentary period	X
Should	Allow desk controls after scanning the University of Twente card	X
Should	Be easy to use	
Could	Save and apply user preferences for desk height	X
Could	Have an application allowing for a competition on sit-stand behaviour	X
Could	Have an application showing available workplaces	X
Could	Have a video explaining the concept	
Won't	Target maximizing physical activity	
Won't	Be a solution in itself as it should inspire new solutions	
Won't	Take away desk space	X

Table 5: MoSCoW method

5.2 Electronics

The Lo-Fi prototype is made using RFID sensor input translated by an Arduino Uno to show how the Hi-Fi prototype could work, visualised in Processing. The final design is also based on Arduino input, but rather than visualising in Processing, the final prototype outputs the required desk heights to a sit-stand desk. As the BSS group already owns sit-stand desks, further research into their workings is done. The existing desk controls are done over ModBus, an application standard connecting electronics in many industrial systems. To read out what messages are sent between the controller and the motor system, a serial readout is done where the message are analysed. A simple LCD attached to the Arduino is used to display prompts to the user, such as "Log in to use desk sedentary" and a simple timer.

Before the desk moves up, the user is warned by four beeps and a blinking red light, after which the user has 30 seconds to prepare for the desk moving up, this is added for safety reasons. The final design saves desk height preferences for the user, this is done by linking desk heights to user IDs on their University of Twente card.

If there is time, a simple text-based UI can be created to run on the LCD to allow the user to save their preferences. This UI is controlled by two buttons, one to cycle through the options onscreen and one to hit the selected field onscreen. If there will be an application to show the available workplaces or one allowing for a competition on sit-stand behaviour, WiFi modules can be added to connect data from different desks and save it on one Raspberry Pi in the lunchroom. This Raspberry Pi is therefore not a distraction while working and allows for interaction amongst colleagues during lunch breaks. It will have a display with a simple UI to show either competition statistics or desk availability.

In Figure 22, a simple wiring diagram is given, illustrating which components are connected and the communication they have.

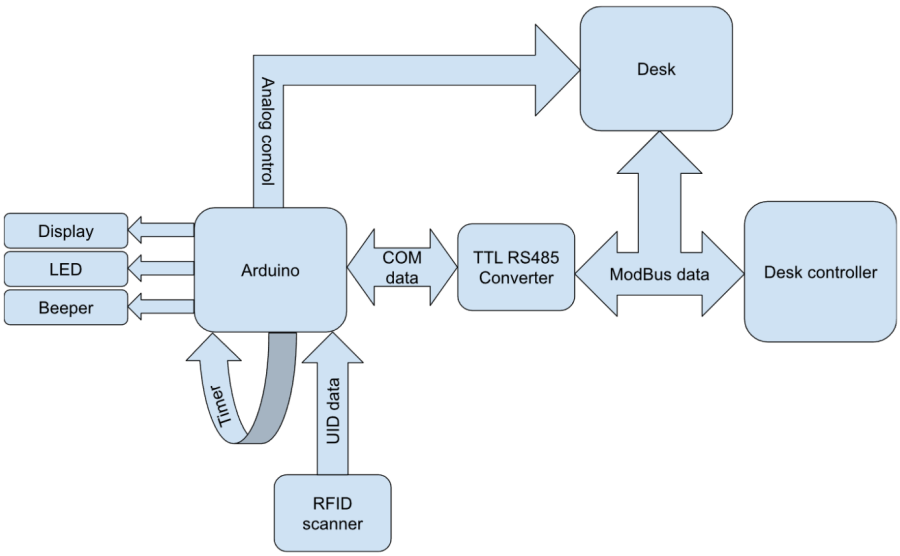


Figure 22: Automatic desk Hi-Fi prototype hardware wiring

5.3 Physical design

The design is a wooden box attached next to existing sit-stand controls, to ensure the final design is only obtrusive where intended. This box has a simple LCD and a red LED at the front for text outputs and warnings respectively, and a card reader on its side. Wood does not stand out here next to the rest of the desk and is easy on the eyes, and because it is out of sight for most of its usage there is little chance of distracting users from their work. To make sure all electronics fit without getting in the way of legroom, the box size is 20x20x10 cm.

6 Realisation

Now a design has been chosen and its characteristics are specified, it is time to turn the concept into a final prototype for Hi-Fi evaluation.

6.1 Electronics

The prototype made for the co-creation evaluation session already contained some of the basic functionalities, these will now be explained further. The MFRC522 library was imported into the code to work with the RC522 RFID scanner, this is used to scan the user identification and match it to users stored in an array. This makes the cardScanned boolean true, which starts a sequence checking whether the desk height is below a sedentary threshold, starting a timer when it does and pausing when it is not. When the timer is up, a signal is sent to set the table height to standing mode. Next, different from the Lo-Fi prototype, a second timer for 10 minutes starts during which the desk cannot be lowered.

Other functionalities implemented in the Lo-Fi prototype cannot be transferred to the final prototype as they were mainly for the visualisation of the idea. Most of the code explained above can however be reused for further realisation. This time the Arduino will have to interface with the sit-stand desk, receiving its current height and sending signals to alter the height.

The available desks at the BSS group showed Laing Innotech LTC302-EU-ZIT-STA 65-130cm G-0 on the product stickers. The site for the product showed versions of the desk that can communicate with WiFi, BLE, analogue input, wireless control panels and RS485 / ModBus. After looking at the specific models at the BSS group, it was clear these desks don't have BLE, WiFi or other wireless connectivity. Further research went into RS485 / ModBus, a communication standard used in many industrial devices. The project was intended to be controlled by an Arduino, however, it cannot communicate over RS485, so an RS485 to TTL module was ordered [Figure 23].

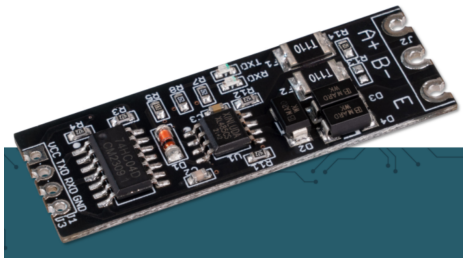


Figure 23: RS485 to TTL module

It was stated in the Laing Table Control document [19] that this communication was done over the RJ12 cable connecting the desk controls to the desk itself. After finding the Modbus Interface Specification document for a newer version of the desk online [18], a custom RJ12 male and female connector was made. There is not much data to be found about the internal functioning of the Liang Innotech desks, which seemed intentional. So data found about the new version of the desk was assumed here to apply to the older version too. The connection between the desk controller and the desk was made to continue over RJ12, but the Arduino with the RS485 to TTL module now intercepts the line. Pins 9 to 14 in Figure 24 illustrate the intercepted RJ12 line.

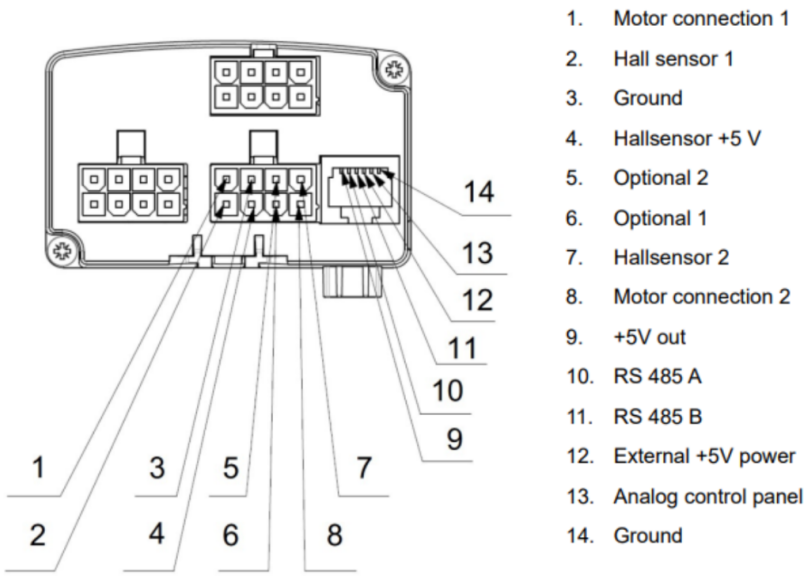


Figure 24: Laing Table Control [18]

The Interface Specification document [18] provided the required baud rate to communicate with the desk (57600), the ModBus slave address (1), supported commands to communicate with the desk (read holding registers, write multiple registers and read-write multiple registers) and addresses for communication. This information was implemented into the Arduino code using the ModBusMaster library [20], making reading out the height of the desk possible. Other codes such as moving the table did not seem to do anything, either these new codes don't apply to the old desk or more communication is required to fulfil these tasks. After trying to communicate with the desk, it became clear that the ordered RS485 to TTL module is not made for two-way communication, as there are no Latch Enable and Receiver Enable pins on the module.

Another method of control was tried for moving the desk, namely analogue control. No documentation was found on the workings of this input, but after some experimentation with potentiometers, it was clear the desk moves up when grounding the analogue connector with 10.5K resistance in between. This is controlled using a relay in the final prototype.

The LCD in the prototype is a 2004A with a PCF8574 module on it, this LCD is easy to work with, has enough space to show the text-based UI and will not distract as it is not visually straining. For this display to work correctly, the NewLiquidCrystal is installed and used making for easy control of the onscreen information.

To warn the user about the desk moving up, a red LED and a buzzer are attached. When logged in or out, the LED blinks once and the buzzer beeps once. When the desk warns it will move up in 30 seconds, four beeps and blinks are given.

The system takes power from the ModBus cable over the 5-volt power, this is not much for an Arduino but it does work. The LCD is a little less bright and the beeper makes a little less noise, however, the system remains usable and is easy to install. No external power cable or battery makes the system as a whole easier to install and maintain. This design choice makes testing the prototype on varying tables at the BSS group possible, as the prototype can be attached within a minute.

The wiring of the Hi-Fi -prototype is shown in Figure 25.

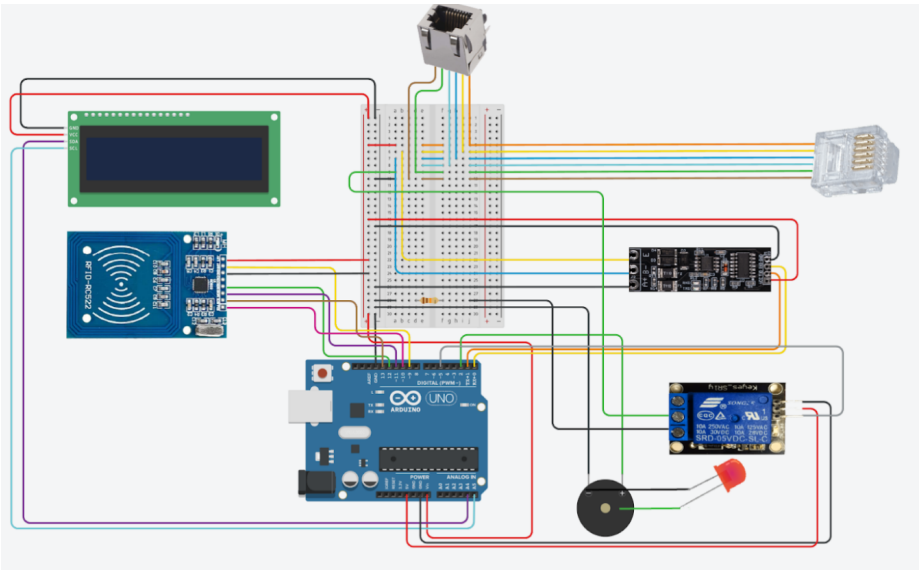


Figure 25: Illustration of the wiring of the Hi-Fi prototype

6.2 Physical design

The casing of the box is laser cut out of 6mm wood, an elegant and simple wooden box design with holes for the cables and display suffices. The RFID scanner is capable of scanning through small layers of material and power for the Arduino can be taken from over the RJ12 cable, making it possible to hide all the electronics inside the box. The box is intentionally simple in design with only a laser-cut engraving on the side to show where to hold the University of Twente card. This is on the left side of the box that is easy to reach for usability. The LED and screen are at the front for ease of access, while remaining out of sight when working at the desk. To avoid permanently attaching the prototype to a desk, a wooden plank is attached that hooks underneath the middle strut of the table.

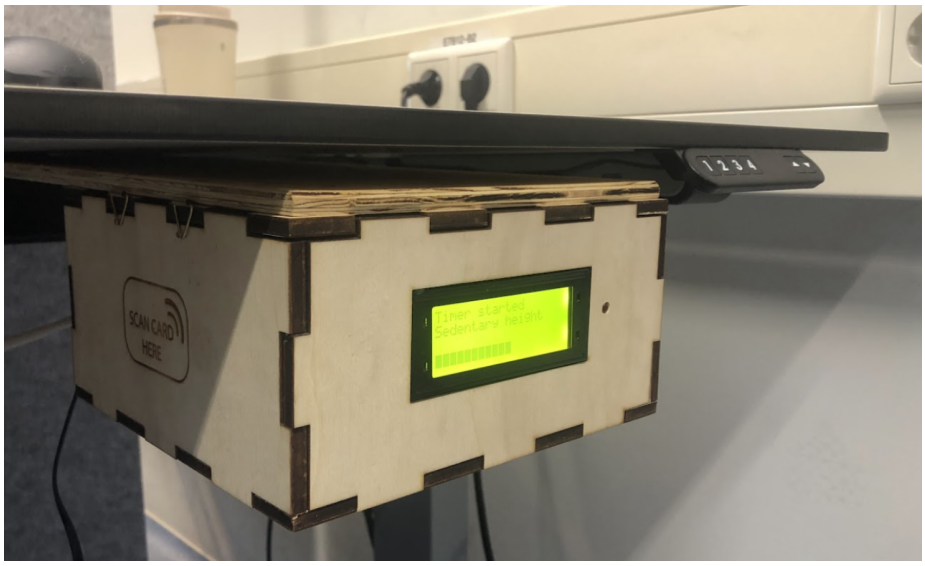


Figure 26: Picture of final prototype

7 Evaluation

Once the whole installation is assembled, the outcome is evaluated on criteria specific to speculative design. The goal is to start a conversation about lifestyle interventions targeting sedentary behaviour, it is evaluated whether the desired dilemma is conveyed. This chapter is separated into three parts; assessing whether the technical requirements are met, a qualitative analysis of the user experience and a qualitative analysis of the effectiveness of the speculative design.

7.1 Technical evaluation

In Chapter 5.1, requirements were written down using the MoSCoW method. Now the technical requirements can be evaluated on their level of completeness. Unlike the qualitative requirements, these requirements can be answered without any user testing.

In Table 6, the technical requirements are evaluated.

MoSCoW	**Requirement**	**Result**
Should	Automatically raise the desk after a sedentary period	Completed
Should	Allow desk controls after scanning the University of Twente card	Desk controls are always available for safety reasons, however, the desk will return to a standing height when the standing timer is not yet completed.
Should	Not take away desk space	Completed
Could	Save and apply user preferences for desk height	Completed
Could	Have an application allowing for a competition on sit-stand behaviour	Only a sit/stand ratio is shown when logged out
Could	Have an application showing available workplaces	Not included due to time limitations
Could	Have a video explaining the concept	Not included due to time limitations

Table 6: MoSCoW evaluation

7.2 Qualitative evaluation

At the end of June, a small presentation is given to the BSS group about the research. Here the BSS group is introduced to the concept of the speculative design, attendees are asked to try a desk with the installation attached. Those testing the installation are allowed to use the table for two hours. A two-hour window is chosen for evaluation because it gives time to experience at least one interrupted sedentary session while keeping the bar low to test the prototype. According to a five-day schedule, BSS members could fill in a sheet for participation. Participants testing the final prototype are asked to answer the same three questions from the co-creation evaluation.

1. What dilemma do you think the prototype conveys?
   (a) How do you see that?
   (b) How could this be strengthened?
2. Can you relate to the dilemma conveyed in the design?
3. How did you feel when interacting with the prototype?

In Table 7, all tasks leading up to and during Hi-Fi evaluation are concisely described in chronological order.

Activity	**Description**	**Location**
Inform	Present co-creation work and inform BSS group about prototype testing	BSS group meeting
Recruit	E-mail the sign-up form to the whole BSS group	Online
Information letter and explanation	Send information letter and prototype explanation to participants of testing	Online
Consent	Participants ask questions and fill out informed consent	Testing
Attach	Attach prototype to desk	Testing
Explain	Prototype functions are explained to the participant	Testing
Test	Sit in a room closeby while testing for questions or emergency	Testing
Explain	Provide explanation for evaluation (after first participant)	Testing
Evaluation	Written evaluation of prototype	Testing
Detach	Detach prototype from desk	Testing

Table 7: Tasks Hi-Fi evaluation

Participant	Interesting notes	Dilemma	Relatability	User experience	Comments
7	Overall language barrier, words sedentary and dilemma not know, very low sit-stand ratio	The healthy thing versus freedom of behaviour	Does not like standing while working	Focus was disrupted, easy to use, would like a choice in behaviour	Would like a low sit-stand ratio to be rewarded with a longer sedentary time allowance
8	Explanation of speculative design helped	Wanting to sit but unable to do so	Walks in breaks to stand more	Enjoyed using prototype	Would like to see the effects of sedentary behaviour
9	Recognizes freedom being taken away	Knowing a lot of sedentary behaviour is bad but finding barriers to standing	Tries to work standing for an hour every day	Works well, nice that the automatic height is personal	Could be emphasized why you should stand, add another cue for moving up
3	Took part in co-creation brainstorming and evaluation	To continue working sedentary or work standing for a while	Wants to work standing more but doesn't out of convenience or forgets	Positive, would probably help to stand more	Would like a feature to take meetings into account
10	Intrinsic motivation doesn't align with external motivation, very low sit-stand ratio	The easy choice versus the healthier choice	Finds sitting easier	Afraid to interact much with the prototype, sitting feels like failing	Would like more control

Table 8: Qualitative results

7.3 User experience

Part of the qualitative analysis is user experience, what emotions are felt when interacting with the installation? Are the controls and interactions intuitive and unobtrusive where necessary? Does the design language fit the message it tries to convey? This part of the evaluation is a qualitative analysis of the user experience of five BSS'ers when interacting with the installation, their reactions, opinions and answers to the same three questions from the evaluation form are noted to assess the user experience and effectiveness of the installation.

The user experience was described by participants 8 and 3 as joyful and positive respectively, and participants 7 and 9 wrote that the prototype was easy to use and worked well. Participant 10 was careful with the prototype as they didn't know what would happen when interacting with it, the explanation in Appendix 2 may not have been clear to them. Overall, users know the desks the prototype is implemented on and have fairly little interaction with the prototype itself, keeping it simple and digestible. The response shows the prototype is a strong foundation to iterate on.

All of the participants recommended seeing an addition, like an explanation of why you should be less sedentary or a way to avoid the desk moving up during meetings. These features could be added in the next prototype, to make the user experience more pleasant. These additions should not be in the way of provocation, which is still an important goal of the installation.

Participant 7 was disrupted in their focus by the prototype which is an undesired user experience. Different users have different attention spans and the desk could take that into account, the participant proposed a longer sedentary time allowance while maintaining a low sit/stand ratio. This might not be the only solution to solve this issue, but the next iteration could try to be less obtrusive while conveying the same dilemma.

When evaluating the Lo-Fi prototypes, participants had some prior knowledge about the goals of a speculative design and showed little difficulty with answering the questions about conveyed dilemmas within the prototypes. The first participant (participant 7) testing the final prototype was not present at the co-creation sessions, nor did they attend the presentation at the BSS group meeting. The participant had difficulty answering questions about the prototype, a language barrier made this even more difficult for them, as the participant did not know the words sedentary or dilemma. A small introduction [Appendix 3] was created to help new participants answer the evaluation questions without influencing their responses or guiding them in any particular direction.

Participants 8, 9 and 3 went on walks to the toilet, lunch break or to the coffee machine when the desk moved up, this was not intended in the design but should not be seen as a bad response to the prototype. Walking can be seen as a disruption of sedentary behaviour just as much as standing at a desk.

All participants, except for participant 3, stood longer at their desks than the timer required them to. The prototype does not alert users when the standing time is up, nor does it automatically lower the desk, so the user has to check themselves whether they can lower it again. The prototype also shows a

sit/stand ratio when the user logs out, incentivizing users to sit less and have a lower ratio. It has not been tested whether these design decisions influenced this behaviour or if this response could be linked to the test setting.

7.4 Dilemma recognition

Measuring the qualitative aspects and effectiveness of a speculative design is difficult to do metrically, however, some important values were discovered during the background research to evaluate. Speculative design should make users think about possible future scenarios, mostly by disrupting norms through provocation. One of the way of doing so, as explained by Ozkaramanli & Desmet [16], is by triggering personal dilemmas. Thus, part of the evaluation will be the recognition of the conveyed dilemma and the relatability of it. The intended dilemma of the installation is between the healthier choice of decreasing sedentary behaviour and the barriers towards doing so.

Asking users what dilemma they think the prototype proved to be a difficult question to ask. Although the introduction to speculative design [Appendix 3] helped, participants took some time to answer this question.

Participants 7, 8, 9 and 10 recognized their freedom being taken away by the installation. This is intentional in the design, based on Ozkaramanli & Desmet's [16] method of provocation by barricading habitual behaviour. Users are unable to perform their habitual behaviour of working sedentary, provoking existing norms on sitting. At the University of Twente, it is never difficult to find a place to be sedentary nearby, lowering the bar to perform sedentary behaviour. When a desk forces the user to work standing, this norm of sedentary allowance is disrupted.

Participants 7, 9 and 10 recognized the effects of sedentary behaviour as unhealthy but found barriers towards working standing. They believed the dilemma conveyed in the installation to be this choice between "the healthy thing" and their barriers towards working standing. This is the dilemma that was targeted by the installation and was conveyed to these participants. Other participants did not explicitly write down this dilemma but showed in their other answers to recognize this dilemma, this may be due to the questioning or the explanation of the questions, as some participants answer similar results underneath different questions.

All of the participants testing the Hi-Fi installaton work mostly sedentary, but 3 out of 5 participants would like to stand more. Participants 7 and 10 do not like working standing but recognize it to be a healthier behaviour. The dilemma in the installation is therefore relatable to all participants, showing the importance of finding a solution to reducing sedentary behaviour at the office.

8 Discussion

This chapter aims to take a step back to assess the quality of the research, things that could have been improved and what future work in the field could look like.

The final installation intends to start a discussion among designers of lifestyle interventions to speculate what desirable intervention methods could be. The method of achieving this is an installation disrupting existing norms on how lifestyle interventions should be to provoke users to speculate whether current advancements in the field are desirable and whether different advancements could be preferable.

Speculative design is a relatively new field of research, allowing many discoveries to be made. What makes this research special is the use of co-creation to create a speculative design, which has proven to be a good addition to the process. Speculative design is a subjective field, as norms are not universally shared and the dilemmas conveying them are neither. Therefore, gaining latent knowledge [21] through co-creation sessions to best target the intended audience is a welcome addition when creating a speculative design. Recognition of the conveyed and relatability to it were both very high, these metrics were targeted during this research as a result of the literature review. The effectiveness of the speculative design proved to be very high according to these metrics.

Participants of the co-creation sessions were very involved in making this design, all attending both co-creation sessions, some joining the final presentation at the group and one also testing the final prototype. This resulted in a great amount of output to be included in the final design and allowed it to be well-catered to the target audience. Although participants had no prior experience in creating speculative designs, they quickly picked it up when introduced to the concept similar to how Ozkaramanli and Desmet [13] described it.

A very prevalent issue throughout the research was terminological confusion, articles about maximizing physical activity were often confused with reducing sedentary behaviour. For this research, any amount of MET above sedentary behaviour is targeted, including light-intensity physical activity ranging from 1.5 to 3 METs [37]. Even after clearly stating the research to be about reducing sedentary behaviour rather than maximizing physical activity at the co-creation sessions, ideas and conversations often jumped to maximizing physical activity.

When presenting the Hi-Fi prototype at the BSS group meeting, some BSS'ers argued that the prototype might actually be a solution in itself rather than a starting point for conversation, and therefore not be speculative design. Ozkaramanli and Desmet [13] argue disputing existing norms and standards by targeting internal dilemmas can promote debate. Bardzell et al. [14] argue a desirable result of a critical design is provocation, which they also believe can be achieved through disruption of norms. Participants testing the final prototype recognised the conveyed dilemma, related to the dilemma and were forced to perform different behaviour than their habitual sedentary behaviour. Auger J. [15] argues designs should be recognisable to elicit discussion. The prototype is based on the sit-stand desks and University cards already used by the BSS staff, so the de-

sign is mostly recognisable for the users. The final prototype targets a relatable dilemma through a recognisable design that provoked them to perform different behaviours, indicating the final design can be categorized as speculative design.

Finding participants for Hi-Fi testing proved to be more challenging than expected. Testing is supposed to be mostly unobtrusive, requiring little extra time, yet participants had difficulty finding a two-hour window. There was little time between the presentation at the BSS group and the week of testing, resulting in few available spots in calendars. Personally asking members of the BSS to participate showed great success, making for a total of five participants. A bigger amount of participants would be preferable, but this was not feasible within the scope of this research.

The final prototype did not include all the features it could have. It would benefit from further creation, functions such as recording which rooms have available desks and inter-desk communication were not added, as they were not feasible within the timespan of the research. These features were not required for a minimum viable product, however, they could have helped incentivise the use of the prototype. Communicating with the desks for collision detection was also not within the scope of this research, the best way to do so would be to communicate more with the desk over ModBus. ModBus communication for raising the desk and other functions such as collision detection turned out to be too difficult for the timespan of the research. A possible explanation for this could be the fact that the company making the sit-stand desks most likely disagrees with the tinkering done onto their product as there are many warnings present in their installation and operation instruction manual [35].

The evaluation questions proved to be quite difficult to answer during Hi-Fi testing, when evaluating the Lo-Fi prototypes with participants who were also present at the brainstorming this went alright. However, participants only testing the Hi-Fi prototype had some difficulties answering the questions, especially the participants who were not present at the presentation at the BSS group meeting. The introduction to speculative design [Appendix 3] helped, yet some questions were not answered in the intended text fields.

8.1 Future work

After finishing this research and discovering things that work or don't, here are some recommendations for future work in the field.

Co-creation has proven to be valuable in creating speculative designs targeted at a specific group of people, but some alterations on how to do this can be made. Explaining the concept of speculative design without planting ideas on what they should look like is a difficult task. In this research, participants of co-creation were asked to identify their personal influencing factors regarding the subject before being introduced to the concept. Although this seemed like a simple and unnecessary task, participants later looked back at these factors for inspiration, decreasing the possibility of basing new ideas on existing speculative designs. Another method to minimise inspiration from existing designs applied to this research was the creation of a set of widely varying self-made

designs, this aimed to show the wide range of ideas that could be useable as input from the participants. Participants ideated many different kinds of ideas, yet it cannot be said that these designs had no impact on the ideas created. For future research, it could be interesting to try to explain the concept without showing any other speculative designs and conveying the concept another way.

The co-creation evaluation session and the Hi-Fi evaluation proved to be more fruitful than expected, resulting in useful feedback on the prototypes shown as well as tons of ways to improve upon them. Future co-created speculative designs may very well improve more from a second medium fidelity prototype evaluation, as many new insights were gained here. This will make the ideation process longer but can result in better-targeted designs.

This version of the installation is functional, but some functionalities could be implemented and others could be perfected. Reading out the height of the desk over ModBus works great, so controlling the height over ModBus would be a great addition. Currently, there is little communication between the prototype and the desk except for the height and a rudimentary analog method of raising the desk. When the desk detects a collision, the prototype does not respond and keeps trying to raise the desk, a reset of the prototype is required to fix this. When implemented well, the existing desk controls can be removed, implementing controls into a next prototype to make the setup less complicated and look cleaner.

9 Conclusions

Two co-creation sessions have led to the design of one final speculative prototype, targeted at creators of lifestyle interventions to speculate on desirable interventions regarding sedentary behaviour. Lifestyle interventions are currently moving towards E-health [4], but this is not the only method of lifestyle interventions and should not be seen as such.

From literature research, the relationship between barriers and facilitators was found to be inversely related, which is why they are called factors from that point onwards. Even though researchers disagree on what to call speculative design, they agree that speculation and debate are desired outcomes of the design approach.

Co-creation and the Creative Technology design process go hand in hand in this research, ideation and specification are the first two phases of this design process and both rely heavily on the information gathered from the intended target audience during co-creation sessions. When adding co-creation to these phases, tacit and latent knowledge come to the surface, resulting in better targeted design.

After creating and assessing two prototypes based on input from the co-creation sessions, the final prototype is a device to attach to the bottom of the sit-standing desks at the BSS group, reading and controlling their heights and forcing users to be less sedentary. The prototype makes the default height of the desks a standing height and only allows lowering to a sedentary height for 45 minutes when the user logs in using their University of Twente card. After some sedentary time, the desk automatically raises to the preferred standing height of the logged-in user, prompting them to either work standing for 10 minutes or change to another desk to work sedentary there. The standing durations are recorded per user, adding some competition to be least sedentary at work.

The co-created Hi-Fi prototype was tested by five members of the BSS group, evaluating whether participants could recognize the conveyed dilemma and whether they could related to it. Dilemma recognition and relatability are the metrics used to describe an effective speculative design. The prototype was recognized by all five participants to convey the desired dilemma between "the healthier choice" of standing at work and the barriers towards doing so. All five participants could relate to the dilemma, all of them work mostly sedentary and three out of five would like to sit less, the other two recognize standing to be healthier behaviour but find barriers towards standing. Three out of five participants wrote that their freedom to choose their preferred behaviour was taken away by the installation, this is a method of barricading habitual behaviour as a means of provocation [16].

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11 Use of AI

11.1 ChatGPT 3.5

This research used the ChatGPT 3.5 model for ideating programming functions and error checking programming code

11.2 Grammarly

This paper was spellchecked and grammar checked by Grammarly

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13 Appendices

13.1 Arduino code

```
#include <SPI.h>
#include <MFRC522.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <ModbusMaster.h>

#if defined(ARDUINO) && ARDUINO >= 100
#define printByte(args)  write(args);
#else
#define printByte(args)  print(args,BYTE);
#endif
#define RST_PIN         9          // Configurable, see typical pin layout above
#define SS_PIN          10         // Configurable, see typical pin layout above

MFRC522 mfrc522(SS_PIN, RST_PIN);  // Create MFRC522 instance
LiquidCrystal_I2C lcd(0x27, 20, 4); // set the LCD address to 0x27 for a 16 chars and 2 line
ModbusMaster node;

const int controlPin = 5; // pin for controlling desk height
const int beepPin = 2; // pin for controlling desk height
const int beepSound = 1760; // tone for beeper
const int beepLength = (1000 / 4);  // length of beeps
int deskHeight; // int for storing read out desk height
int loopCounter = 0;  // loop counter for reading desk height
int currentUserNumber;

uint8_t block[8]  = {0b11111, 0b11111, 0b11111, 0b11111, 0b11111, 0b11111, 0b11111, 0b11111]
uint8_t emptyBlock[8]  = {B00000, B00000, B00000, B00000, B00000, B00000, B00000, B00000};

// Arrays to hold UIDs and corresponding names
String uidList[] = {"1224DF2C", "84ED92C0", "56E98DF6", "E6E45509", "36E76932", "D4EF7FC0"};
String nameList[] = {"Sam", "Levina", "Victor", "Margot", "Casper", "Menno"}; // names on ca
int heightList[] = {1050, 950, 1150, 1000, 1100, 1200}; // heights corresponding to names
unsigned long sedentaryTimeList[] = {0, 0, 0, 0, 0, 0};
float ratioList[] = {0, 0, 0, 0, 0, 0};
int numCards = sizeof(uidList) / sizeof(uidList[0]);  // Number of cards in the lists

unsigned long startTime = 0;   // Timer start time
unsigned long startTimeLoggedIn = 0;   // Timer start time
//unsigned long sedentaryInterval = 20000; // allowed time to be sedentary
unsigned long sedentaryInterval = 2700000; // allowed time to be sedentary
```

```
//unsigned long standingInterval = 20000; // minimum time to be standing
unsigned long standingInterval = 600000; // minimum time to be standing
bool sedentaryTimeUp = false; // boolean for checking for sitting cycles
bool timerRunning = false;     // Timer state
bool cardScanned = false; // Flag to indicate if a card is scanned
unsigned long elapsedTime;  // total elapsed time this timer
String currentUser; // name of current user
int currentHeight = 1000;  // standing desk height of current user
String lastUser;  // name of previous user
bool shownOnce = false;

uint8_t result; // data received from desk
uint16_t data[6];

void setup() {
  Serial.begin(57600);   // Serial baud rate for communicating with desk
  while (!Serial);    // Do nothing if no serial port is opened (added for Arduinos based or
  SPI.begin();      // Init SPI bus
  mfrc522.PCD_Init();   // Init RFID scanner
  pinMode(controlPin, OUTPUT);  // Init control pin
  node.begin(1, Serial); // 1 is the slave address for ModBus
  digitalWrite(controlPin, LOW);  // don't rise te desk on startup

  lcd.init(); // initialize the lcd
  lcd.backlight();  // turn on backlight of the lcd
  lcd.createChar(0, block); // create block to display
  lcd.createChar(1, emptyBlock); // create empty block to display

  lcd.clear();
  DisplayText("Login with UT card", "for sedentary use ", "");
}

void loop() {
  loopCounter++;  // Increment the loop counter for reading out desk

  if (loopCounter % 50 == 0) {  // Check if the loop counter is divisible by 50
    loopCounter = 0;  // reset loop counter
    node.clearResponseBuffer(); // Clear the response buffer
    result = node.readHoldingRegisters(2000, 1);  // Request table height
    if (result == node.ku8MBSuccess) {
      deskHeight = node.getResponseBuffer(0); // store received desk height
    }
  }

  if (cardScanned) {  // If user logged in
    shownOnce = false;
```

```
  if (!sedentaryTimeUp) { // If user still has sedentary time
    if (deskHeight < (currentHeight - 100) && !timerRunning) { // Check if desk height is
      startTime = millis(); // start the timer
      timerRunning = true;
      DisplayText("Timer started     ", "Sedentary height  ", "                  ");
    } else if (deskHeight > (currentHeight - 100)) { // If desk height is above threshold
      if (timerRunning) {
        DisplayText("Timer paused      ", "Standing height   ", "                  ");
        timerRunning = false;
        sedentaryInterval -= elapsedTime; // store elapsed time on timer
        sedentaryTimeList[currentUserNumber] += elapsedTime; // add time sedentary to reco
        elapsedTime = 0;  // reset elapsed time on timer
      }
    }
  }
  else {  // if user is out of sedentary time
    if (!timerRunning) {
      startTime = millis(); // start standing timer
      timerRunning = true;
      sedentaryTimeList[currentUserNumber] += elapsedTime; // add time sedentary to recor
      elapsedTime = 0; // reset elapsed time
    }
    if (deskHeight < (currentHeight - 100)) { // if user has the desk down
      TableUp();  // move desk to preferred standing height
      //        standingInterval = 20000; // 20 seconds standing timer
      standingInterval = 600000; // 10 minutes reset standing timer
    }
  }
}
else {  // if no user logged in
  TableUp();  // move desk to preferred standing height
  if (shownOnce == false) {
    DisplayText("Login with UT card", "for sedentary use ", "                  ");
    shownOnce = true;
  }
}

if (timerRunning) {  // Check if a timer is running
  elapsedTime = millis() - startTime; // set elapsed time

  if (!sedentaryTimeUp) {
    DisplayTimer(elapsedTime / (sedentaryInterval / 20)); // display timer progress
    if (elapsedTime >= sedentaryInterval) { // if sedentary timer is up
      timerRunning = false;
      sedentaryTimeUp = true;
      TimeUpDisplay();
```

```
      TableUp();    // move desk to preferred standing height
    }
  }
  else {
    DisplayTimer(19 - (elapsedTime / (standingInterval / 20))); // display timer progress
    if (elapsedTime >= standingInterval) { // if standing timer is up
      timerRunning = false;
      sedentaryTimeUp = false;
      DisplayText("Standing timer up ", "keep standing or  ", "use sedentary     ");
    }
  }
}

if (mfrc522.PICC_IsNewCardPresent() && mfrc522.PICC_ReadCardSerial()) { // Check for card
  String uidStr = ""; // Save UID

  for (byte i = 0; i < mfrc522.uid.size; i++) {
    uidStr += String(mfrc522.uid.uidByte[i] < 0x10 ? "0" : ""); // Add leading zero if nee
    uidStr += String(mfrc522.uid.uidByte[i], HEX); // Convert to HEX
  }
  uidStr.toUpperCase(); // Convert to uppercase for consistency

  bool nameFound = false;
  for (int i = 0; i < numCards; i++) {

    if (uidStr == uidList[i]) { // if the UID is in the list
      lastUser = currentUser; // store a new last user
      currentUser = nameList[i];  // save the current user
      currentHeight = heightList[i];  // save standing desk height for current user
      currentUserNumber = i;
      nameFound = true;
      if (lastUser != currentUser) {  // check if the user is a new user
        cardScanned = true; // log in
        //          sedentaryInterval = 20000;  // 20 seconds
        sedentaryInterval = 2700000;  // 45 minutes
        tone(beepPin, beepSound, beepLength);
        delay(500);
        lcd.clear();
        DisplayText(currentUser + " Logged in     ", "", "");
        delay(3000);
        if (currentHeight > (currentHeight - 100)) {
          TableUp();
        }
        DisplayText("Timer paused      ", "Standing height   ", "                  ");
        if (timerRunning) {
          timerRunning = false;
```

```
            sedentaryTimeUp = false;
            elapsedTime = 0;
          }
          startTimeLoggedIn = millis();   // Timer start time for ratio
        }
        else {  // let users log out if it is the same user
          tone(beepPin, beepSound, beepLength);
          delay(500);
          ratioList[currentUserNumber] = (float)sedentaryTimeList[currentUserNumber] / (mill
          startTimeLoggedIn = 0;
          sedentaryTimeList[currentUserNumber] = 0;
          lcd.clear();
          DisplayText(currentUser + " Logged out    ", "Sit/Stand ratio:  ", String(ratioLis
          delay(3000);
          DisplayText("Login with UT card", "for sedentary use ", "                  ");
          currentHeight = 1000;
          cardScanned = false;
          timerRunning = false;
          sedentaryTimeUp = false;
          currentUser = "";
          elapsedTime = 0;
        }
        break;
      }
    }
    if (!nameFound) { // if the UID is not found
      DisplayText("Sedentary time up ", "                  ", "                  ");
      delay(2000);
    }
  }
  mfrc522.PICC_HaltA(); // Halt PICC to stop reading the same card over and over again
  mfrc522.PCD_StopCrypto1();  // Stop encryption on PCD
}

void TimeUpDisplay() {  // display time is up
  int blocks = 0;
  DisplayText("Sedentary time up ", "change desk or    ", "work standing     ");
  while (blocks < 20) {
    lcd.setCursor(blocks, 3);
    lcd.write(byte(0));
    blocks++;
  }
}

void TableUp() {
  if (deskHeight < currentHeight && deskHeight > 100) { // only move table up when a height
```

```
    DisplayText("Desk moving up!   ", "                    ", "                    ");
    int beeps = 0;
    while (beeps < 4) {
      tone(beepPin, beepSound, beepLength);
      delay(500);
      beeps++;
    }
    delay(30000);
    tone(beepPin, beepSound, beepLength);
    delay(500);
    while (deskHeight < currentHeight) {
      node.clearResponseBuffer(); // Clear the response buffer
      result = node.readHoldingRegisters(2000, 1);  // Read table height
      if (result == node.ku8MBSuccess) {
        deskHeight = node.getResponseBuffer(0);
      }
      digitalWrite(controlPin, HIGH);
      delay(20); // check if height is more accurate?
    }
    digitalWrite(controlPin, LOW);
    if (cardScanned) {
      if (!sedentaryTimeUp) {
        DisplayText("Timer paused      ", "Standing height   ", "                    ");
      }
      else {
        DisplayText("Sedentary time up ", "change desk or    ", "work standing     ");
      }
    }
    else {
      DisplayText("Login with UT card", "for sedentary use ", "                    ");
    }
  }
}

void DisplayTimer(int number) { // display timer progress
  if (sedentaryTimeUp) {
    for (int i = 19; i > number; i--) {
      lcd.setCursor(i, 3);
      lcd.write(byte(1));
    }
  }
  else {
    for (int i = 0; i < number; i++) {
      lcd.setCursor(i, 3);
      lcd.write(byte(0));
    }
```

```
  }
}

void DisplayText(String firstRow, String secondRow, String thirdRow) {
  if ( firstRow != "") {
    lcd.home();
    lcd.print(firstRow);
  }
  if ( secondRow != "") {
    lcd.setCursor(0, 1);
    lcd.print(secondRow);
  }
  if ( thirdRow != "") {
    lcd.setCursor(0, 2);
    lcd.print(thirdRow);
  }
}
```

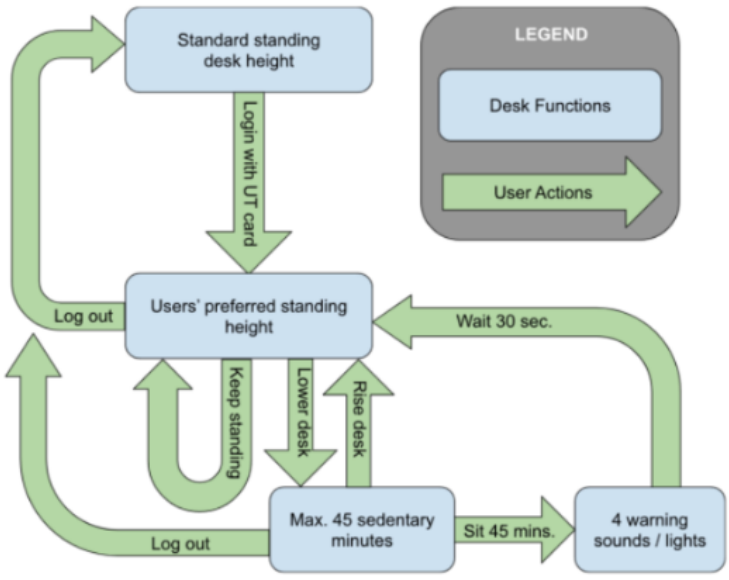
13.2 Explanation desk functioning

My first automatic desk

This document explains the functioning of your automatically moving desk and how you can interact with it!

What does it do?

- Automatically rise to:
  - Standard 1-meter height when no user logged in
  - Your preferred standing height after sedentary time is up
- Scan your UT card to:
  - Allow 45 minutes of sedentary time
  - Record your sedentary/standing ratio
  - Log out when logged in
- When sedentary time is up you can:
  - Work standing for 10 min. to regain 45 sedentary minutes
  - Change to another desk



13.3 Explanation evaluation

Speculative design

This prototype is **not meant to be a solution**, it is supposed to make people **think about possible solutions.**

Speculative design **provokes speculation** by posing dilemmas:

- Objects **symbolizing** conflicting concerns.
- Objects **force a choice** between two behaviours
- Objects **barricading** habitual behaviour

13.4 Informed consent

Information letter for graduation project

YOU WILL BE GIVEN A COPY OF THIS INFORMATION LETTER

You have been invited to help answer how a speculative installation can be designed to start a conversation about the sedentary behaviour at the BSS research group with the aim of a lifestyle change. This research is done for a graduation project in Creative technology conducted by Victor Ploeger and Dr. Femke Nijboer.

Purpose of the research

Many people in the Netherlands work in office jobs, where sedentary work from 9 to 5 is the standard. On average Dutch employees sit at work for 4.62 hours a day, but this number goes all the way up to 7.15 hours for IT jobs. Even outside of work sedentary behaviour is the norm, like during lunch breaks, making the total amount of sitting for an average Dutch employee 8.49 hours a day [1].

De Gezondheidsraad (Dutch health council) advised in their 2017 report "Beweegrichtlijnen 2017" to prevent large amounts of sedentary behaviour, to live longer, healthier and happier [2]. Especially the switch from no physical activity at all to some minor activity can have a lot of impact.

At the biomedical signals and systems research group (BSS), researchers know all about eHealth but not all apply that knowledge to themselves.

E-health is often used to coach healthier behaviour by electronically measuring and communicating data for and about the user. What impact do those systems have on people and what are the end goals, what direction are we going in as a society?

Speculative design is a relatively new approach within design research focusing on how today's technology impacts the future, often by showing extremes or making connections to start a conversation. This way a conversation about sedentary behaviour of the researchers at the BSS group can be started with the aim to change lifestyles.

[1] L. M. C. van Dam et al. (2022). Nationale Enquête Arbeidsomstandigheden 2021 [Online] Available: https://www.cbs.nl/-/media/_pdf/2022/16/nea2021_methodologie_dt.pdf

[2] Kernadvies Beweegrichtlijnen 2017, Gezondheidsraad, Den Haag, 2017

During the session

Before the brainstorming session, participants are sent an information brochure with an informed consent form. At the beginning of the session, we ask participants if there are any questions and after the informed consent procedure is completed we start with the session.

In the first 5 minutes, an impression of what the brainstorming session will be like will be given.

Next, the participants will do the "word association" energizer for 5 minutes. In this energizer, I start by saying a word and the participants will go around the clock saying the first word that comes to mind when hearing the previous word.

After the energizer, I will start the first brainstorming session where the participants will be asked to illustrate their barriers and facilitators to reducing their sedentary behaviour. Participants will receive white A2 papers, a stack of Post-it notes, pens, pencils and markers in a variety of colours, a stack of varying magazines, a pair of scissors, a glue stick and a block of clay with tools to sculpt it. This brainstorming session will take 15 minutes.

When the first brainstorming session is done, 5 minutes will be given to cool down during which I will provide coffee, tea and cookies.

I will then give a small presentation of 5 minutes in which I show some state-of-the-art speculative designs to inspire the second brainstorm.

I will finish with a second brainstorm of 15 minutes where I ask participants how they would promote physical activity at the office in 2050, in a world where money and technology are not a problem but a lack of physical activity is. Participants will again receive white A2 papers, a stack of Post-it notes, pens, pencils and markers in a variety of colours, a stack of varying magazines, a pair of scissors, a glue stick and a block of clay with tools to sculpt it.

Benefits and risks of participation

There are no risks nor personal benefits in participation. This research has been reviewed by the Ethics Committee Computer & Information science of the University of Twente.

Procedure for withdrawal from the study

You have the right to withdraw from the study at any time. Please inform the researchers when you choose to do so, this does not require a reason why.

Collection and processes of personal data

Only the bare minimum of personal data is required for this studies. These include your age, gender and weight. This information will be secured and will only be used for this study and it will be anonymized before publication of the study. You have the right to remove or adjust this data at ay time throughout the studies without further reasoning.

Data usage, safeguarding, confidentiality, control, dissemination and archiving

The data collected in this research will be used for this study only. It may be used for publication and presentation purposes, but in an anonymized state. The data will be securely archived and only accessible by the researchers. Written notes will be destroyed six months after the collection.

Contact details

Any questions regarding the research can be directed to v.s.ploeger@student.utwente.nl.

For any concerns regarding the ethical conduct of this research, contact the Ethics Committee Computer & Information science of the University of Twente via ethicscommittee-CIS@utwente.nl**.**

Consent Form for Co-creation brainstorming session

YOU WILL BE GIVEN A COPY OF THIS INFORMED CONSENT FORM

Please tick the appropriate boxes	Yes	No
Taking part in the study		
I have read and understood the study information dated [28/03/2024], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	○	○
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	○	○
I understand that taking part in the study involves participating in a co-creation brainstorming session	○	○
Use of the information in the study		
I understand that information I provide will be used for a graduation project, including a speculative designed prototype and the presentation of that project	○	○
I understand that personal information collected about me that can identify me, such as [e.g. my name or where I live], will not be shared beyond the study team.	○	○
I agree that my information can be quoted in research outputs	○	○
Use of media		
I agree that pictures of the designs created by me at the brainstorming session can be used to aid in designing a speculative prototype	○	○
I agree that pictures of the designs created by me at the brainstorming session can be used in the graduation projects presentation	○	○

Signatures

_____	_____	_____
Name of participant [printed]	Signature	Date

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

_____	_____	_____
Researcher name [printed]	Signature	Date

UNIVERSITY OF TWENTE.

Consent Form for prototype evaluation

YOU WILL BE GIVEN A COPY OF THIS INFORMED CONSENT FORM

Please tick the appropriate boxes	**Yes**	**No**
Taking part in the study		
I have read and understood the study information dated [28/03/2024], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	○	○
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	○	○
I understand that taking part in the study involves interacting with prototypes and thinking out loud while using them	○	○
I understand that taking part in the study means written notes will be taken of the interview, these will be destroyed six months after the interview	○	○
Use of the information in the study		
I understand that information I provide will be used for a graduation project, including a speculative designed prototype and the presentation of that project	○	○
I understand that personal information collected about me that can identify me, such as [e.g. my name or where I live], will not be shared beyond the study team.	○	○
I agree that my information can be quoted in research outputs	○	○

Signatures

_____	_____	_____
Name of participant [printed]	Signature	Date

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

_____	_____	_____
Researcher name [printed]	Signature	Date

UNIVERSITY OF TWENTE.