DESIGNING THE ENVIRONMENT FOR A HEALTHY LIFESTYLE: REFLECTION OR CHANGE?

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Abstract

This study investigates how calm and persuasive technology can be used to create a device that motivates reflection on sedentary behaviour in an at-home working environment. The device consists of three flowers with each flower representing 20 minutes. One flower closes every 20 minutes until 60 minutes have passed and all the flowers are closed, after which they will all reopen and repeat this process. Design concepts were created and tested through an online survey, a lo-fi prototype user-test was done, and a high-fi prototype user-test was performed with a thematic analysis used to evaluate the results. The analysis showed that the device was effective in making the users reflect on how much time had passed, however they did not necessarily link this to their sedentary behaviour or think about changing it. They did find the device to be calm and in the background throughout the 20-minute intervals. Half of the users would be shocked every time a flower closed because of the sudden movement, whilst the other half would at times not even notice the flower had closed. To conclude, the device motivated reflection and increased awareness of passing time, but it did not make the users evaluate the option of changing their sedentary behaviour.

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1. Introduction

The global fitness industry was, as of 2019, valued at $100 billion, as consumers began “engaging with fitness and wellness companies more than ever before” [11]. This shows how the desire for a healthy lifestyle has increased. Physical activity and healthy behavioural choices are key components in achieving and maintaining a consistent, healthy lifestyle. While attaining a healthy lifestyle has gained popularity, obesity has tripled worldwide since 1975. In 2016 more than 1.9 million adults, were overweight, of which 650 million were obese [12]. A study has shown that there is a positive association between adult obesity and time spent watching television. The study also mentions that recommendations aiming at reducing sedentary behaviour could be more effective than promoting physical activity [13]. Sedentary behaviour is defined as “any waking behaviour characterized by an energy expenditure of 1.5 METS or less while in a sitting or reclining posture” [14], thus a lot of sitting and inactivity. Especially due to work and studying, a large number of the world’s population is spending their days sitting. To an extent, people have a responsibility to ensure they are sufficiently active; they can reflect on their behaviour and make the choice to change certain factors if they feel the necessity to do so. On the other hand, an individual’s environment and surroundings can have a substantial impact on the choices they make, therefore direct changes in an environment may provoke a behavioural change [15].

This thesis aims to examine how calm, persuasive technology can be used to create a product that motivates people in an at-home working place to reflect on making healthier behavioural choices. In a workplace environment, including offices as well as at home, people tend to lean more towards sedentary behaviour, sitting for long periods of time without moving. For those of working age, it has been shown by multiple studies that a considerable amount of their sedentary time comes from their working hours [16, 17]. Also, physical inactivity is the fourth leading cause of death worldwide and is considered to be a public health pandemic [18]. However, it is important to understand that too much sitting is distinct from exercise, even a person who exercises daily suffers from the effects of being sedentary for large amounts of time [19]. A sedentary lifestyle can lead to obesity, diabetes, certain types of cancer, cardiovascular disease, and an increased risk of early death. By changing a factor in the direct surroundings of a person working from home, they may become more aware of their inactivity and may feel the urge to make changes and will reflect on their behaviour, consequently increasing their activity and reducing their health risks [20].

1.1 Objectives

The aim of this thesis is to investigate the impact of an always-visible object on someone's motivation to reflect on their sedentary behaviour. By creating a tangible object in a home working-place environment an evaluation can be made as to whether using calm and persuasive technology is affective in motivating the user to reflect on their behaviour. The ultimate goal being for them choosing to change their behaviour and increase healthy decision-making. Through a literature study the definition and use of calm and persuasive technology will be explored to examine how they can be used as a tool for healthy behavioural change.

1.2 Challenges

There are challenges that might arise when creating a tangible technology in an environment with the goal of persuading people towards reflecting on healthier behaviour. It may be a challenge to create an object that is smoothly incorporated into the users' workplace, in the sense that it does not distract them from them work and blends into their working setting. Furthermore, persuasive technology is an important concept in facilitating behaviour reflection and change, however, to what extent does the environment unconsciously influence the user? As well as, to what extent is persuasive technology ethically acceptable?

1.3 Research Question

The main research question for this thesis paper is:

How can calm persuasive technology be used to create an object that motivates reflection on sedentary behaviour in an at-home work situation?

To be able to fully answer the main research question, multiple sub-questions should also be acknowledged and answered.

SQ1: How can persuasive technology be used as a tool? (answered through literature research and prototype testing)

SQ2: What impact does calm technology have on a user? (answered through literature research and prototype testing)

SQ3: How can an environment influence user behaviour? (answered through literature research)

SQ4: How can a combination of calm and persuasive technology influence reflection on behaviour? (answered through prototype testing)

The goal of SQ1 is to gain insight into how previous works have used persuasive to motivate change, as well as observing through prototype testing whether the persuasive technology implemented into the object actually motivates reflection. Similarly, the aim of SQ2 is to understand the application of calm technology in previous projects and evaluate through prototype testing whether the object is calm and in the background. SQ1 and SQ2 look at persuasive and calm technology individually, whereas SQ4 investigates through user-testing whether a combination of the two will motivate reflection and effectively increase the frequency of the user thinking about their sedentary behaviour. SQ3 looks into the influence an environment has on a person, the concepts of which can be implemented in the final object to increase the likeliness of it being part of the user's working environment and motivating their reflection on behaviour.

1.4 Report Outline

Chapter 1 has introduced the thesis project and has provided an insight into the overall topics that will be addressed throughout the rest of the report. Chapter 2 forms the context and background of the project, including a literature review as well as a state of the art that explores related products and projects. Chapter 3 will describe the methods and techniques that are used throughout the project. Chapter 4 consists of the ideation phase that will end with pre-liminary requirements, which will be developed into a set of specifications in chapter 5. In chapter 6 the creation of the high-fi prototype will be explained, with the final testing being explained in chapter 7. The results will be discussed in chapter 8 and chapter 9 will conclude the project.

2. Context and Background

2.1 Literature Review

Using literature, the aim is to investigate the topics and principles that can be applied to the project. This information can later be used when designing the product for the workplace environment. The principles that are focused on are persuasive technology, calm technology, ambient feedback, the environmental influence on behaviour and feedback loops.

Persuasive Technology

Firstly, persuasive technology can be defined in multiple ways and consists of different principles that influence its effectiveness. An expert in persuasive technology, Fogg [21, p.1], describes how we are living in a ubiquitous, digitalised society, surrounded by "digital products designed to change what we think and do". Designing with the aim to persuade and influence a behaviour change is challenging and often fails. Fogg [21] advises to start small and follow an eight-step process that can lead to a successful design of a persuasive technology. The first step is choosing a simple behaviour to target, one that has a small impact on a person's life and is attainable. This is a step that focuses on the behaviour of an individual and how that can be changed. The second step consists of choosing a receptive audience as this will decrease the chance of resistance. A receptive audience is one that is familiar with technology and open to changing their habits. Designers may investigate a cultural approach for this step, in order to determine cultural behaviours and if they can be changed. Finding what prevents target behaviour and choosing a familiar technology channel are the third and fourth steps. If a user has the motivation to change, then all they may need is a trigger to remind them. This can be approached through a sociocultural perspective by examining the social groups and subgroups a user is part of to understand what is preventing them from changing their behaviour and what channel would be most effective to persuade them to change. The following steps, finding relevant examples, imitating the successful ones, testing and iterating, and expanding on success are all centred around the designer and their choices [21].

Fogg [21] is confident that these steps will lead to a successful persuasive technology design. However, Khaled [22] claims that Fogg [21] focuses on an individualistic audience, whereas Khaled [22] argues that persuasion is related to cultural norms and therefore designers should make more use of collectivism-focused persuasive technology strategies. Individualist societies are more goal-oriented, using guilt to motivate and having more attitude-behaviour consistency. Whereas in collectivist societies people grow up in cohesive groups, where the group interest outweighs the

individual interest. Culture can have a strong influence on how people perceive and react to certain persuasive technology techniques, and thus taking them into account can be beneficial [22]. Thus, there seem to be two different views: focusing on an individualistic audience versus a collective audience. However, persuasion is related to cultural norms and groups, not only individuals and a persuasive technology designed with a societal approach could also be used in a more individualistic setting. Examples for designing for a collectivist setting are a platform through which user data is shared, such as a "multiplayer" function, communication between multiple users, or being able to compare data (for example behavioural patterns) between users.

Besides using the eight-step plan and deciding on designing for collectivism or individualism, it is also important to consider the personalization of persuasive technology. For a persuasive system to work efficiently, it should be able to send the right message, at the right time in the right way. However, this is difficult to do as it depends on the individual user and their context. There are many influence principles that can be used to affect a person's attitude and behaviour. Cialdini [23] mentions six tendencies of human behaviour that respond to persuasive techniques. The first, *reciprocation*, refers to a code of human conduct whereby you receive a gift (i.e. free samples or workouts) and feel the need to return the favour. *Consistency* is about getting the user to make a commitment so that they stick to their word and are consistent with their acts or statements (i.e. in a restaurant instead of saying "please call if you have to change your plans" ask "will you please call if you have to change your plans?"). *Social validation* focuses on using the principle of individuals doing what they see others around them doing, following the crowd, and by implying that others have already complied, you are likely to do the same. *Liking*, is the fourth tendency that shows how people are more likely to say yes to those they like, find attractive, or who give compliments (e.g. Tupperware parties with friends created more sales because they knew and liked each other). *Authority* is and influence principle to prove how "good" a product or service is by providing an expert's opinion, someone who knows what they are talking about is more trusted. The last tendency is *scarcity,* which has proven that items and opportunities become more desirable when they are less available [23]. Using persuasion profiles, collections of estimates of the expected effects of the different influence principles of an individual, designers can better understand which influence principle to use. Kaptein [24] mentions four requirements that a persuasive system should address for personalized persuasion: identifying individual users, presenting the influence principles to users, measuring user traits and linking behavioural observations to corresponding influence principles [24]. Thus, designing persuasive technologies has many possibilities: it could be designed in a personalized way, the eight-step process may be used, and the designer can choose between an individual or societal approach.

Persuasive technology combines behavioural science and information technology to interfere in people's daily lives, either in a conscious or unconscious way. However, it can be questioned whether persuasive technology is ethical, seen as users are persuaded by the designer through a technological intervention. Verbeek [25] challenges to what extent being unconsciously influenced by technology is acceptable and rethinks how people can be held responsible for their actions if they have been influenced by technology. There are 2 arguments when considering the moralization of technologies. The first being the fear that they endanger freedom of choice, thus transforming a democracy into a technocracy. The second is considering immorality of amorality, controlling technology makes people lazy, thus creating a threat to society's morals. Verbeek [25] also mentions at the start that technology was designed to create freedom but is actually forming a threat to it, yet he later redefines freedom as not being the absence of mediation and influence but the explicit relation to them. He says that technological influences in itself are not immoral, but it is "the refusal to deal with this inevitable influence in a responsible manner"[25, p. 238]. He believes technology and humans should not be divided and that persuasion must be transparent, allowing freedom. As humans we are technologically mediated beings and technological mediation is the basis of our existence. He concludes with stating that people should not be protected against technology but should accompany the development and implementation of technologies [25].

Berdickevsky and Nueuenschwander [26] state that it is not the technology itself that is to blame for any unethical actions or persuasions, they believe it is an important mediator and that the persuader and one being persuaded are the ones who are equally responsible if any unethical action would be committed. This is defended by the fact that humans are free beings with intentionality, whereas computers cannot make their own decisions of form intentions. According to the authors, the main focus should be on the "Golden rule of persuasion". This rule entails that "the creators of persuasive technology should never seek to persuade a person or persons of something they themselves would not consent to be persuaded to" [26]. If a person were to create guidelines for a persuasive technology without knowing whether they would be the persuader or the one being persuaded, then they would likely make sure the persuasion would be beneficial for both sides. This is how they feel persuasive technology should be designed in order to design ethically.

These show two different views on ethics and the implementation of persuasive technology. Verbeek [25] highlights that we are technologically mediated beings and people must not let technology be overpowering but should learn to responsibly deal with the impacts. On the other hand, Berdickevsky and Nueuenschwander [26] state that the morality of persuasive technology lies with the morality and choices of the persuader and the one being persuaded, thus they are separating humans and technology. For this project, Verbeek's [25] implementation of the human-technology

relationship will be used, whereby the technology is an important mediator and the persuasion is transparent to allow freedom. Specifically, this project will focus on intentionality, described by Verbeek [27] as making the connections between humans and the world more visible, these connections are relations that humans have with the world that are mediated by or directed at technological devices. Intentionality can work *through*, be directed *at*, or be placed in the *background of* technological artifacts. There are multiple forms of mediated intentionality (human-world relationships), however the *hermeneutic relation* is the most suitable for this project. According to Verbeek [27, p.389], this relation makes explicit how "technologies provide representations of reality, which need interpretation to constitute a 'perception'". An example is a thermometer that represents 'reality' by measuring temperature, which is then 'interpreted' in the form of a person reading the presented temperature and consequently 'perceived' by the person creating a relation between the given number and the temperature [27]. By creating a device that represents a factor in a workplace surrounding (for example time), an at-home working person will be given the opportunity to reflect on their behaviour [28].

Ambient Feedback

Wisneski, et al. [29] mention that ambient technology uses the environment as interface and that it manifests itself as environmental changes of the senses such as sound, colour, smell, light, and temperature. The information a designer wants to have displayed can be presented through any of these senses, choosing which one(s) to use is the first step in designing an effective interface. They also refer to the "tangible bits" vision, which is meant to blur the boundary between digital worlds and create an "interface" between humans and digital information [29]. Ishii and Ullmer [30, p.234] did extensive research into tangible bits, the goal of the concept being to "bridge the gaps between both cyberspace and the physical environment, as well as the foreground and background of human activities." They feel all interactions between humans and cyberspace are through technologies and GUIs (graphical user interfaces). Tangible bits allow digital information (bits) to be accessible in a physical environment (i.e. graspable objects and ambient media), to stimulate physical interaction and allow people to grasp, manipulate and be more aware of bits [30].

It also seems to be of importance that the user's attention is drawn towards the object, which can be difficult. Rensink, et al. [31] claim that the user's attention is required to explicitly perceive a stimulus in the visual field, and thus, visual changes in a scene are only perceived if specifically focused on. If complete attention is given to one particular object or event, then they are "blind" to any other objects

or events occurring [31]. Rensink, et al. [31] focus on visuals, however this may not be the same for other sensory applications, such as sound.

Ambient technology can also be intelligent, in that case it should be context-sensitive and should be able to monitor and learn from user behaviour. It then has the goal of effortlessly providing the user with something valuable without any direct input from the user. Such a system should be adaptive, personalized, anticipatory, and context-aware [32].

Information and behavioural changes can be facilitated through ambient displays. Fogarty, et al. [33] advice using the Kandinsky system that creates displays which are initially aesthetically interesting, and as a bonus also display information. Kandinsky is an automatic collage generator that takes images that represent information and displays them in a collage that is aesthetically pleasing to look at. This process can be used for generating aesthetic information collages, an ambient information display in a decorative object. A lot of product designers focus on the usefulness and usability of a product, however an important additional requirement is desirability, thus creating something that is both aesthetically pleasing and informative [33]. Using this concept, more people may be motivated to use a tangible, ambient persuasive technology object because it is also aesthetically appealing and can blend well into the environment. Heiner, et al. [34] also agree that ambient information displays should be aesthetically pleasing by incorporating it into decorative objects. According to them, ambient displays are created to function in the periphery of the user's awareness and only comes to the user's attention when appropriate and desirable. This can be connected back to the ethics discussion; such ambient displays are not forcefully persuasive and allow the user to pay attention only when necessary in a subtle way. Thus, if the ambient displays are combined with decorative objects, then they can easier blend into the background when not in use, thus not disturbing the user when unwanted [34].

Calm Technology

Persuasive and ambient technology have been examined and they are both useful tools to be able to influence behaviour, however, this project aims at creating a calm persuasive technology so as not to constantly disturb the user. Calm technology seems similar to ambient feedback, however the latter focuses on displaying feedback through the senses, whereas the former is aimed at technology being present in the background of the user's periphery.

Our current society is focused on the Internet of Things and having people constantly surrounded by technologies that require action and attention to be able to function. Calm technology, however, is a concept that allows technology to be present but to not require constant attention, it is present in the background and comes forward only when necessary. This allows users to be in control of technology

instead of technologies controlling the users. With calm technology, the user's attention is engaged both in the centre and the periphery allowing it to move between the two. If technology is in the user's periphery, it allows informing without overburdening, it is there only when needed. Weiser and Brown [35] mention three signs of calm technology; it can easily move from the centre to periphery and back, it enhances "periphery reach" by bringing more details into periphery, and good information visualization. We are living in a society where individuals have multiple devices, however since technology is always present, it should not control us. Calm technology puts the focus on technology being able to inform the user, but not control or continuously disturb them [35]. Tugui [36] further supports this view on calm technology and says that computers should disappear into the "background". Also, by recentring something that was previously in our periphery, we are taking control of it. Even though we are surrounded in a world where individuals own multiple computers and devices, we should have control over them when we wish, and they should not always be at the centre of our attention [36].

Environmental influence on behaviour

It has been shown that the physical environment of a workplace can have an impact on the effectiveness and behaviour of the worker. According to Wall and Berry [37], there are four main issues that are critical to an employee's environment; personal space, spatial density/crowding, workplace personalization and identity, and task/workflow independence. The ones that are most related to individual behaviour change in a working place through a tangible object are personal space and personalization and identity. People need their personal space to work more effectively, without people intruding and creating any form of discomfort. The second, workplace personalization, is of importance because people require personal distinctiveness. This makes them feel like an important individual and not part of a uniform, unpersonal group. A workplace is more than merely a physical place to work, it represents the expression of a person's identity [37]. The product being created for this thesis could also be used to personalize a workplace.

A study was done to investigate the association between worksite physical environment and employee nutrition and physical activity behaviour and weight status. The results showed that having access to an outdoor space lowered BMI, having a cafeteria and fewer vending machines lead to better eating habits, however having workout facilities available at the worksite lead to a higher BMI [38]. According to Almeida, et al. [38] this may be because people with a higher BMI might feel uncomfortable working out at the workplace. Therefore, creating a tangible object that increases

reflection on behaviour could possibly be more effective than trying to consciously increase physical activity.

Feedback Loops

Feedback loops can also be considered when designing a product for behavioural change. User's should be made aware of their behaviour and should know or become aware of what actions they can take to change their behaviour. Damian, et al. [39] investigated the use of behavioural feedback loops on social interactions. Behavioural feedback loops analyse behaviour in real-time and provide the user with live feedback on how to improve. They emphasize that the technology used to relay the user's data back to them should blend seamlessly into the environment and not be distracting. The feedback loop consists of three phases; *perception*, where information on user behaviour is acquired, *reflection*, where the information is processed and evaluated by the user, and *action*, which is when the user can decide to change their action(s) and place themselves in a more desirable state. Thus, the feedback given to the user should be subtle and aims at raising the user's awareness of their behaviour, allowing them to reflect on it and change it [39].

Reflection

Reflection is one of the main components of this project, the goal being for the user to reflect on their behaviour. Ploderer, et al. [40] investigated reflection on behaviour change and stated that reflection can provide insights that could cause individuals to change their attitude or behaviour. Bringing something that is usually unconscious to awareness makes it more available for conscious deliberation. That is what this graduation project hopes to achieve, creating an object that ignites reflection, which hopefully consequents into a change in sedentary behaviour. They go on to mention that focusing on reflection instead of speed and efficiency can be done through slow technology, by using ambiguous, abstract ambient visualizations people are able to become involved in an open-ended sense-making process. There are 5 levels of reflection, the one most relevant to this project is fundamental change, also known as transformative reflection, where change is based on taking on a different point of view. Furthermore, there are two types of reflection based on the temporal relation to an activity: reflection-in-action and reflection-on action. The former referring to contemplation at the time of doing, whilst the latter focuses on taking time to deliberately think of previous activities after they have happened [40].

When designing for reflection, Hallnäs and Redström [41] emphasize the combined use of slow technology, being continuously present as part of the environment, and calm technology, allowing the object to be in an individuals' periphery without constantly demanding a conscious effort. Reflection should be actively promoted through the presence instead of the use of a device [41].

2.2 Additional Situation Research

Currently, there is a global pandemic caused by Covid-19 which has created some unusual circumstances. One of those circumstances being the working situation of office workers, students and others who are now required to work from home.

2.2.1 "Normal" situation

There are many ways in which people are sedentary; however, this project targets users who work stationary jobs, most commonly in offices. In the "normal" situation before the rules following Covid-19, most of the users in the target audience would spend their time being very sedentary, sitting at their desk whilst working all day. There were also already people working from home before the coronavirus, however this number has largely increased since people have been advised to work from home.

2.2.2 Covid-19 situation

Since January 2020, Covid-19 has been present and impacting The Netherlands. This has caused some major changes in the daily lives of the Dutch population, including the working situation. Everyone who does not have a vital job is urged to work from home, therefore almost all the offices are closed, and many workers are working from home. A poll in the UK has shown that physical activity amongst adults has decreased by 25% since the implementation of their coronavirus lockdown [42].

In the United States, Kate Lister president of Global Workplace Analytics has stated that "our best estimate is that 25-30% of the workforce will be working-from-home multiple days per week by the end 2021" [43]. Now that people are forced to work from home companies must come up with creative solutions to do so successfully, which could lead to using such practices more in the future. Intermediair, a Dutch platform for the highly educated, found that, in the Netherlands, 2 out of 3 professionals already worked from home regularly. Those working from home found the greatest benefits being saving on travel time (80%), higher concentration level (73%), and lack of

distractions from colleagues (68%). Additionally, 70% stated they were more productive working from home and 82% mentioned taking less breaks at home than at work [44].

Through talking to other Creative Technology students and hearing their discussions during University Q&A sessions it seems many are struggling with the new situation. Several students are having difficulties with organizing their studying on their own and finding a consistent routine. A poll was created by a CreaTe student to see if CreaTe students were on track with their work, the results of 35 responses showed that 45.71% felt they were behind on their studies, 42.86% believe they are on schedule, and 11.43% predict they will need to make use of an extension [45].

By looking at social media the hashtag “workfromhome” and other similar words are very popular (Figure 1). Many people are posting videos about their working from home situation and the opinions about it are mixed, some enjoy the freedom whilst others miss their colleagues and fellow students and having home and work life separated. Google trends also shows that the interest of the search term “work from home” has increased during the time of the Covid-19 outbreak (Figure 2).

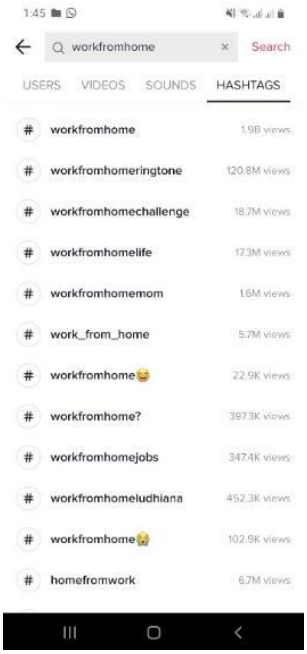


Figure 1 Tik Tok workfromhome [1]

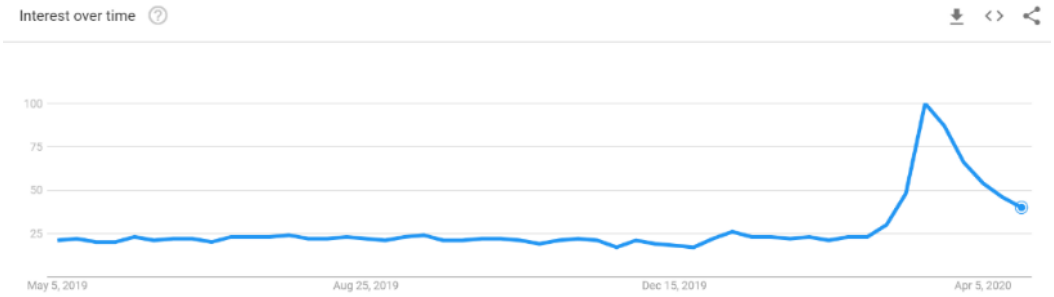


Figure 2 Google Trends keywords 'work from home' [3]

After looking on Twitter I found people were handling the situation differently. Many are using online calls for work and personal use (Figure 7) and many adults with children are working on combining their work and parent lives (Figure 5 Figure 6). Also, there are numerous posts providing tips on how to be the most productive when at home (Figure 3) whilst others feel it is stressful and prefer having work and home life separate (Figure 4).

Figure 5 Twitter post work stress [4]

Figure 4 Twitter post tips when working from home [4]

Figure 3 Twitter post working from home with a baby [4]

Figure 6 Twitter post working from home with children [4]

Figure 7 Twitter post zoom call [4]

The corona virus has increased the possibility of people working from home, but this has caused people's working routine to change. Some take less breaks, others spend more time doing small tasks other than work. This shows that there is not always a clear structure or routine. The lack of routine can make it more difficult to concentrate and divide the time between work and other activities. Creating a routine could be a possible idea for the device that needs to be developed for this project.

2.3 Related Works

Besides the related principles and concepts that have been examined, it is also important to review what similar projects and products have already been created.

One example is follow-the-lights, a design concept in which a path of lights is placed in an office floor that leads in the hallway towards the staircase (Figure 8). This concept has the goal of visually nudging the office workers to take the stairs instead of the elevator [9]. This is an interesting concept because no force is used, and it causes users to consciously follow the lights whilst being unconsciously being aware of being led to the stairs. The lack of force and use of ambient persuasive technology are aspects that can be used for this thesis.

Figure 8 Follow-the-lights design concept [9]

Figure 9 shows the concept of the feedback cube created by Börner, et al. [8]. The cube is a tangible interactive ambient display that can be used to support learning scenarios. It consists of motion sensors, visual and auditive actuators, and wireless communication possibilities. The goal of the feedback cube is to facilitate interaction and/or indicate feedback [8]. This cube is very interesting because it allows the use of different senses, visual and auditory, which I would also consider for this thesis. This cube, however, has no specific function or goal, it is an indicator concept but does not have anything specific that it is indicating, it has no clear application.

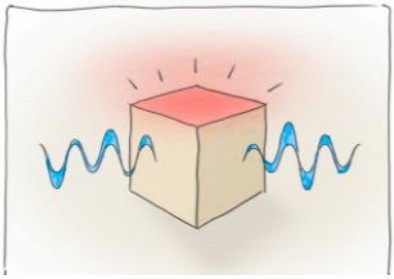


Figure 9 Feedback Cube indicator concept [8]

To address the issue of increasing sedentary behaviour, Lin, et al. [10] created the concept Fish'n'Steps (Figure 10). This social computer is aimed towards increasing physical activity. The user's daily footstep count is visualized through the growth and activity of a virtual animated character. There is also the option of seeing another person's fish in your tank, this creates a form of encouragement and can lead to cooperation and competition between multiple users [10]. The growth of one's individual fish clearly represents the activity feedback and is easy to understand. However, this is a computer application, meaning the user will always have to consciously click on the app or window in order to view his progress. My goal is to create a physical product, not an application, so that it is present in the background whilst the user is working and shows feedback when necessary, not when the user feels like it.

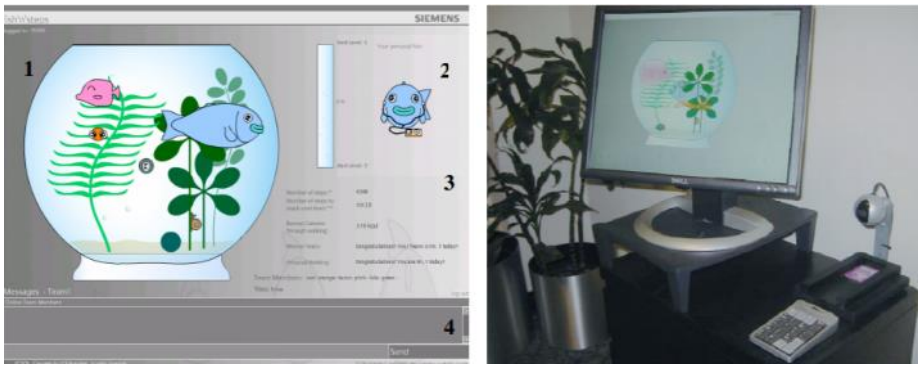


Figure 10 A participant's display during trial of Fish 'n' Step [10]

Figure 11 shows a design for the project Breakaway, an ambient display that uses information from sensors placed in a user's chair to communicate to the user how long they have been sitting. Breakaway is a sculpture that can be placed on a working user's desk and is based on animation art and theatre in the way it looks and moves. The sculpture reflects the sedentary behaviour of the user; an upright position reflects the body's refreshed pose, whereas when the sculpture is slouching it represents the user's body's pose after sitting for a long amount of time [5]. This is an interesting concept for an embodied object that physically represents the user's sedentary behaviour. Nonetheless it does not give any time indication; when it is fully slouched there is no light pulse or sound indicator that urges the user to stand up or do something, it is very passive. Also, this means it is the user's own responsibility to be motivated enough to actively pay attention to the sculpture in

order to see their sedentary behaviour, and since there is no feedback given it can easily be ignored. The object this thesis aims to create aims to be calm and in the background, but also to have a persuasive element that provides some type of sensory feedback that catches the attention of the user when necessary.

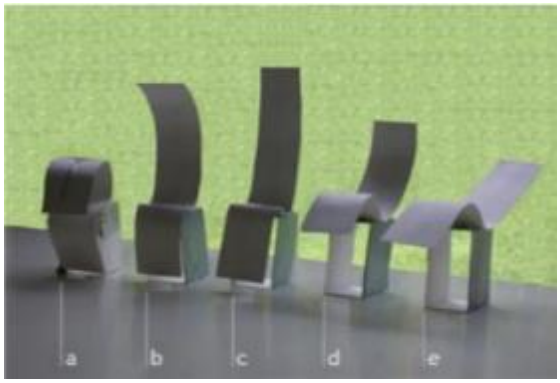


Figure 11 Incorporating line of action in the sculpture design of Breakaway [5]

Figure 12 shows the HealthBar, an ambient persuasive technology that is aimed at making office workers aware of their sedentary behaviour and nudging them to increase their physical activity. The bar in figure 5 is fully charged, however the longer the user is sitting, the more the HealthBar will de-charge and change to an orange, then red colour to indicate the user needing to take a break. After 45 minutes the HealthBar is fully discharged and the light becomes red. If the user does not take a break, then the bar will pulse twice every 5 minutes to indicate the user needing to take a break [6]. The concept of how light is being used in an ambient way to provide feedback is very interesting and could be used for this thesis product. However, the HealthBar is visually and physically inspired by the life bar in video games, whilst the previous literature research has shown that using an aesthetically pleasing or decorative object can be more affective [33]. Furthermore, the HealthBar is installed under the computer screen, always in the direct view and attention of the user. The benefit is that the user can easily see the feedback through the changes in colour, but this could also be a drawback as it may distract the user whilst the user is working. That is why this thesis aims to use calm technology, which means the object will be in the background periphery of the user and will only draw attention at certain moments when necessary.

Figure 12 HealthBar installed below the monitor of an office worker [6]

Additionally, Damen, et al. [46] created an overview of 45 studies that aim to reduce sedentary behaviour or increase physical activity. The number of studies is too large to describe here, however it is interesting to look at what behaviour changing techniques were used. A number of the studies did not specify which behaviour change technique was used, but the from those that did the most common techniques were rewards, social support/sharing, goal setting, and creating awareness/self-reflection. The last one being the behavioural technique applied to this graduation project. The fact that this technique is a commonly studied one shows that creating awareness and self-reflection is a valid way of influencing sedentary behaviour [46].

Research Conclusion

All of the above studies have focused on reducing sedentary behaviour in a workplace environment. They are good sources of inspiration to help develop a better understanding of the concepts described in the literature review. However, they are not completely the same. The sculpture Breakaway (Figure 11) might be too distracting to the user because they have to watch an object physically move and have to specifically focus their attention on it in order to process what it is reflecting and how they can or should react. The design of the HealthBar (Figure 12) is very much inspired by the design and function of the lifespan bar used in video games, which not every user may relate to or appreciate. Also, placing it directly in front of the user whilst they are working seems too intrusive and disturbing, it is consistently directly in the user's sight, which is not very calming.

For my project, I aim to create a product that is mobile, and thus can be moved to any workplace, any desk. Also, I want to use very calm and subtle sensory cues so as not to disturb the user and allow the object to remain in the background and periphery of the user. The design will also aim to be

aesthetically pleasing, perhaps through inspiration from decorative objects, using calm and comfortable shapes and colours that will not disrupt the user and will be familiar to them.

Regarding the literature review, I aim to use Fogg's eight step process when designing the product. Furthermore, the persuasive technology being created should display its information or feedback through an aesthetically pleasing manner, such as a decorative object. The calm technology factor is also very important, the technology should remain in the background and periphery of the user and they should pay attention to it only when necessary. Keeping in mind the feedback loops, the ambient tangible object should display the user's behaviour in such a way that it allows them to reflect on it in order to change their actions.

3. Methods and Techniques

This chapter will establish the different methods that will be used to design and evaluate the ambient tangible object. This includes brainstorms, interviews, and stakeholder analyses.

3.1 Design Process

For this project, a design process that was constructed specifically for the study Creative Technology by Mader and Eggink [7] will be used. This framework consists of four phases: ideation, specification, realisation, and evaluation (Figure 13).

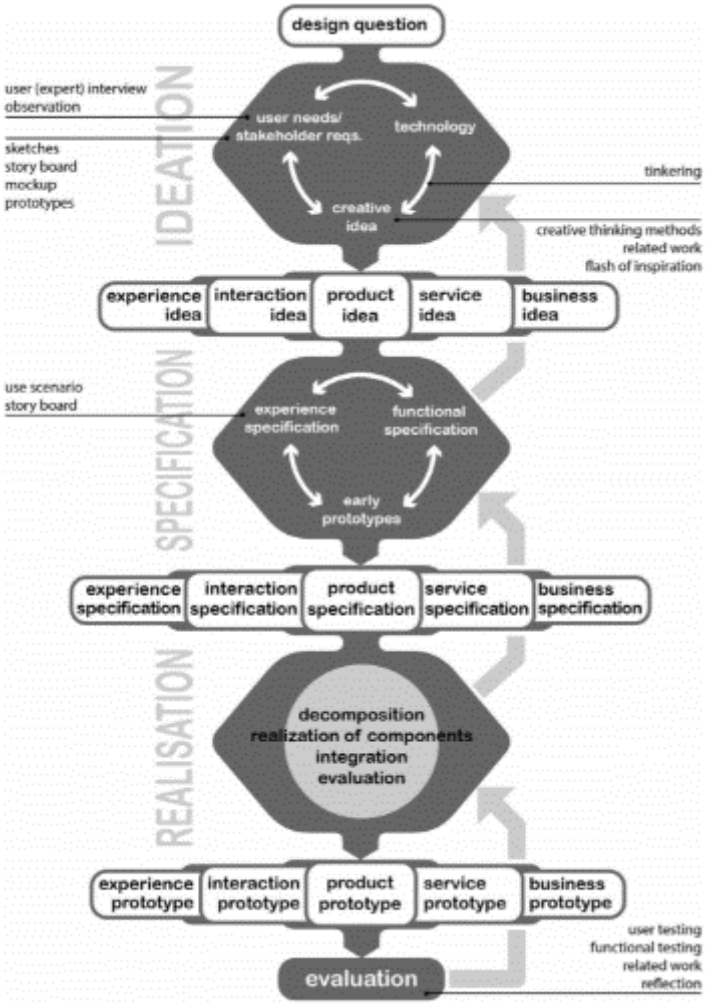


Figure 13 A creative technology design process [7]

The *ideation* is the first phase and one that focuses on the generation of ideas or a design question. These ideas are formed through research, interviews, brainstorms, and tinkering (discovering

innovative applications for existing or new technology). They also take the user's needs into account and should result in a list of preliminary requirements for the product.

The results of the ideation are then used in the *specification* phase, in which numerous lo-fi prototypes are created and tested by the designer or the user. The focus of these prototypes is the user experience and how different aspects of a product can improve this. User scenarios and storyboards can be created and in combination with the prototypes will lead to a more specific design and more detailed requirements.

This leads to the next step, *realisation*, the phase in which all the previous knowledge is combined, and a product prototype is created, one that fulfils the requirements defined in the specification phase. This prototype will be created and improved in an iterative manner, depending on user testing and feedback.

In the final *evaluation* phase, the final user and functional testing takes place and related work and research can be used to reflect on the whole process [7].

3.2 Brainstorming

Brainstorming needs to be done in order to generate a large number of ideas, which will then be grouped and later filtered. When brainstorming, the rule is "quantity over quality" in order to not rule out any crazy ideas that could turn into great projects. A human-centred design approach can be used when brainstorming and ideating, as seen in Figure 14. Diverging occurs through brainstorming, producing many random ideas that will later be converged and specified into a few small ones, which will then be narrowed down to one specific product.

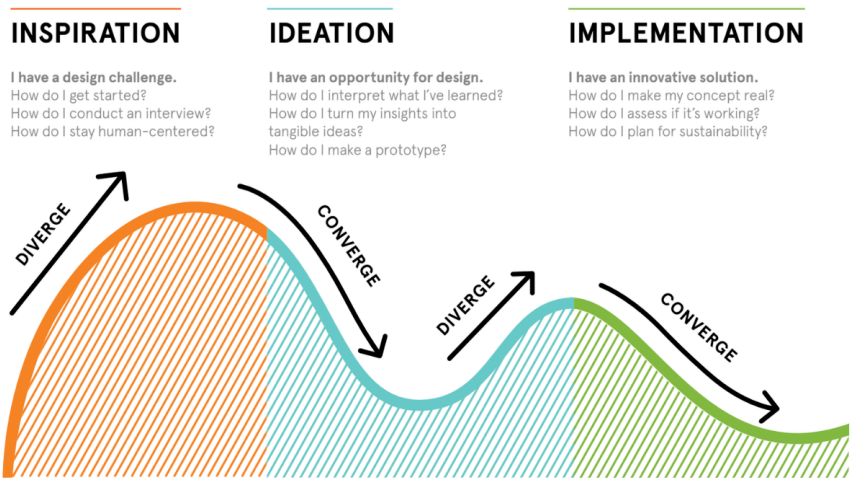


Figure 14 Human-Centered Design process [2]

3.3 Interviews/Surveys

Surveys and interviews will be used to gather more information on the topic and when evaluating the project. There are several different types of interviews that can be used to retrieve more information about the problem and possible solutions. They may include structured, unstructured, semi-structured, and focus groups.

Initially, a survey will be sent out to working from home students and workers in order to receive qualitative information on people's sedentary behaviour and clearly identify the problem and how this could lead to possible solutions.

For the evaluation of the final prototype, surveys, semi-structured interviews, where questions are pre-planned but the interviewee can elaborate and explain when they feel the need to, and a focus group will be used [47].

3.4 Requirement Analysis

Once the stakeholders have been identified, a requirement analysis should be done to determine what the requirements and user expectations of the product are. During the last evaluation phase an evaluation must be done as to whether the product has met the stakeholder's requirements.

3.5.1 Use-case scenarios

The requirements can be demonstrated through *use-case scenarios*, in which all the stakeholders are provided with a shared understanding of the purpose and use of the product. The scenario should include the input and output data, users, the steps required to achieve the activity, and the activity's structures and tools [48].

3.5.2 Functional vs Non-Functional

Functional requirements refer to the features and functions the product must perform; it is the behaviour of the product "how the system should work". Non-functional requirements are a set of standards used to ensure usability and effectiveness of the system, it is ways the product should behave and the experience it creates "how do I expect the system to interact with me" [49].

3.5.3 MoSCoW analysis

The MoSCoW analysis is a way of prioritizing ideas according to the user's view of what is essential and what is not. This is an important step when designing the final prototype. MoSCoW stands for the following:

- Must haves: features the product must have in order to function and be useful.
- Should haves: features that are not essential to launch the product but are important and valuable to the user.
- Could haves: features that are nice to have and do not take too much effort to include but will be removed if there are time issues.
- Won't haves: features that may have been requested but are excluded for the duration of the project, they may be included in future works [50].

3.5.4 PACT analysis

When designing a product, it is important to consider that the design should put people first and be human-centred. PACT is an acronym for people, activities, contexts and technologies which can be used to evaluate designs and technology from the perspective of the user [51].

4. Ideation

In this chapter, the methodology as described in the previous chapter will be implemented.

4.1 Brainstorm

Initially, a physical brainstorm was done in the form of a mind map. The brainstorm was very broad and the aim was to write down anything that came to mind related to "sedentary behaviour in a workplace" (Figure 15). This was done physically instead of digitally because physical brainstorming can increase brain activity and creativity, allowing idea generation to occur more easily [52].

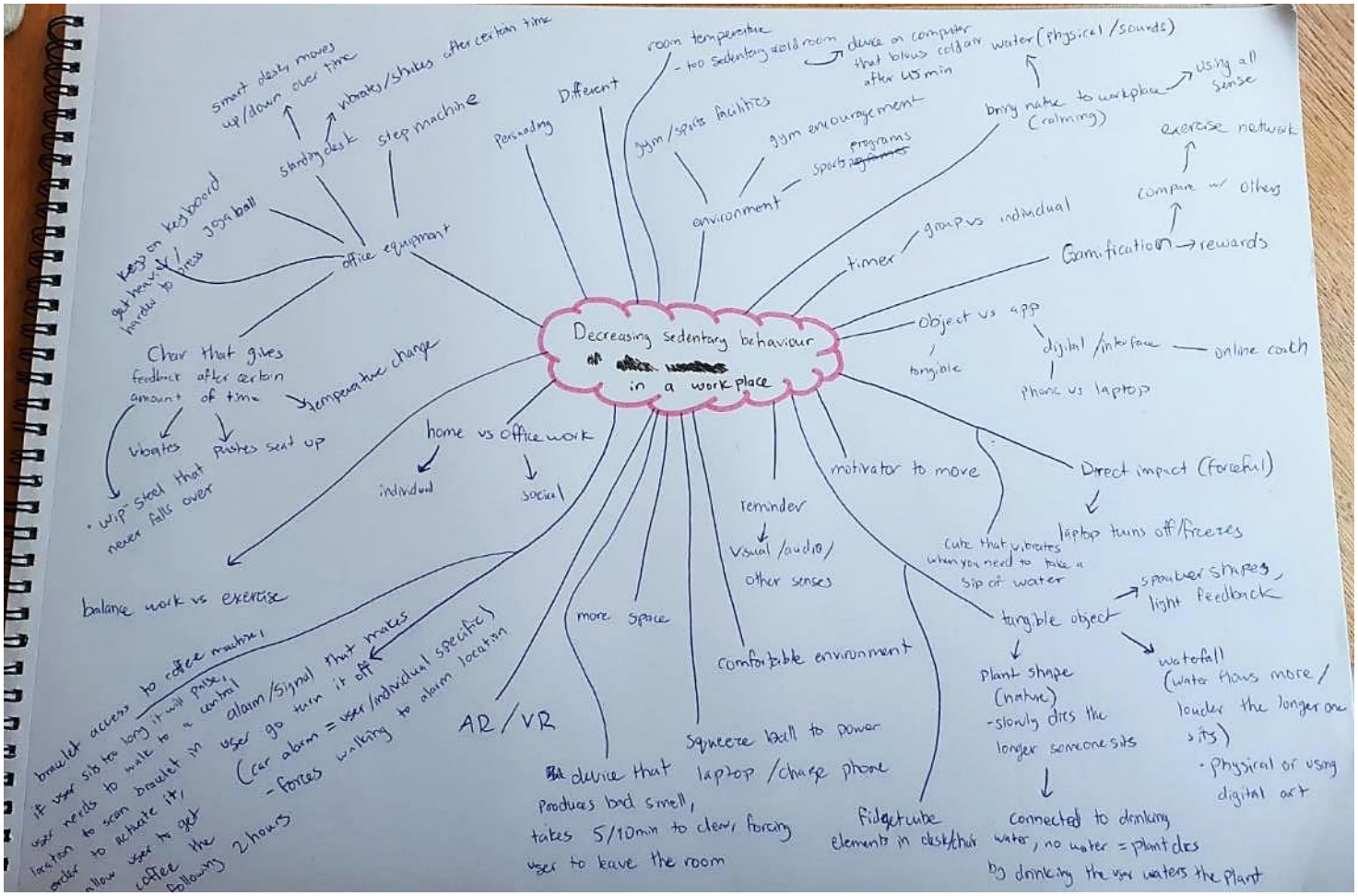


Figure 15 Brainstorm Session

Next, the brainstorm outcomes were organized into categories. This was done to create a clear overview of the many ideas and concepts and from then on see which ones are directly applicable and possible to use for this project. The following categories were created: physical health, values, environment, social, entertainment, and technology.

Physical Health

- Health
- Balance work vs exercise
- Sedentary behaviour
- Squeezing a ball/object to power laptop/charge phone
- Office equipment
    - Step machine that powers light/phone/laptop
    - Standing desk
        - Automatically moves up/down over time
        - Vibrates/shakes at specific times to remind user to take a break
    - Step counter with reward system
    - Keys on keyboard get heavier and more difficult to press the longer the user sits
    - Chair the gives feedback after certain amount of time
        - Vibrates
        - Seat pushes up
        - Some type of muscle stimulation to beat the effects of being sedentary
        - Rocking chair concept

Values

- Self-control
- Perseverance
- Efficiency
- Autonomy
- Privacy
- Determination
- Responsibility
- Culture (social vs individual)
- Object vs human
    - Combination →object with human voice to give auditory feedback on behaviour

Environment

- Comfortable
- Calming
- Space
- Home vs office
- Sustainable
- In the background
- Sports programs
- Gym facilities
- Gym encouragement through reward system from work
- Room temperature (changes when sedentary for too long)
    - Device on computer that blows cold air every 50 minutes
- Bring nature to workplace
    - Using senses (sight, hearing, touch, smell and taste)
    - Use water (physical or sounds)
- Forceful vs calm approach

Social

- Sharing sedentary/activity behaviour of others
    - Family members / friends / other from work who are working from home
- Interactive technological plant that dies/wilts the longer you sit and revives after taking a break
- Digital coach reminding you when to exercise throughout the day

Entertainment

- Motivator to move
- Stress relief
- Fun
- Different
- Creativity
- Compare with others → exercise network
- Gamification
    - Rewards and achievements for progress

Technology

- Calm
- Persuasive
- Ambient
- Gamification
- Digital vs physical
    - Physical → object
    - Digital → interface / app / online coach / reminders through laptop / laptop freezes after 50 minutes of sitting for 10 minutes
- AR / VR
- Integrate into environment
- Wearables
    - Bracelet that gathers points / vibrates as a reminder to take a break
    - Bracelet that allows access to coffee machine / fridge / snack drawer. After 50 minutes of sitting the bracelet will vibrate and pulse letting the user know to have a short break. The user then has 10 minutes to walk to the shed/other room in the house where a previously installed device has to be scanned with the bracelet. If the user does not scan their bracelet within the 10 minutes, then the bracelet will not allow them to access the fridge / drawer / coffee machine (any other motivational place/object the technology is installed on)
- Light/auditory feedback through homey/alexa – like device
- Alarms placed in different locations in the house, a different one goes on every 50 minutes, forcing the user to get up, find where in the house the alarm is and turn it off.

There are certain factors that must be kept in mind when finding an idea for this graduation project.

1. Is it reasonable for a full graduation project?
2. Is it attainable within the given time?
3. Is the solution unique and feasible?

After dividing the ideas and concepts into categories, they were reviewed and the ones that were most applicable to this specific project and could answer “yes” to the above three questions were separated into Table 1. During the following ideation stage, these ideas and concepts should be used as a source of inspiration and be taken into account when creating different possible designs.

Table 1 Brainstorm ideas applicable to project

Category	**Idea/concept**
Physical Health	- Health - Balance work vs exercise - Sedentary behaviour
Values	- All except object vs human
Environment	- Comfortable - Calm - In background - Bring nature to workplace - Forceful vs calm approach
Social	- Sharing behaviour with friends/family
Entertainment	- Motivator to move - Creativity
Technology	- Calm - Persuasive - Ambient - Physical object - Integrate into environment - Wearables - Feedback through a design similar to homey/alexa device - Alarms in different rooms that have to be turned off by walking to them

4.2 PACT Analysis

A PACT analysis evaluates the system from the perspective from the user by looking at the people, activities, context, and technologies.

People

The target group for this project is fairly broad, it includes people working their jobs part time or full time from home as well as students who are studying from home. This means the group is large and contains a diverse range of cultures. This target group was chosen because sedentary behaviour is an extensive problem that affects almost the entire global population. The target group has already been narrowed down to students and workers working from home. This working from home subcategory

of sedentary behaviour was chosen due to the current COVID-19 situation causing more people to have to work from home. There will likely be an increase in people working from home in the future, therefore this project will also be useful in the long-term when there are more possibilities to work from home and more products, including the one created for this project, that will help optimize working time. Many people who have jobs or studies that allow them to work from home also, in most cases, have a laptop and smartphone in order to be able to do their work and stay in contact with colleagues and students. This means that they are familiar with using technology and will be able to understand the technological application and use of the product created in this project.

Activities

The product would be one that can be used daily, meaning it needs to be designed in such a way that it is easy to l how the buttons and interface work in order to optimize its use. Additionally, everyone has a different home situation that can range from quiet and calm to busy and chaotic, thus the product should make use of a variety of senses when providing feedback. If it is quiet then the user can easily hear auditory feedback, which is not the case if the surroundings are busy.

Context

People working from home do so from around 9-5, thus the product should be able to blend into the background of the environment and only come forward when necessary so as not to disturb the working process and because it is present all day so it should not be distracting. Also, not everyone working from home has the strongest WiFi, therefore the product should be able to function without the use of WiFi. Furthermore, as mentioned under “Activities” the environment is also applicable to the context, working from home is calmer than working in an office thus different forms of feedback can be considered.

Technologies

Due to people working from home likely working from a laptop and having a mobile phone, they are familiar with technology and will be better able to understand the functions of a new technology. The new technology will be a calm technological product that is present in the background and only provides feedback at certain times when necessary. A mobile phone uses a similar technique; it is present somewhere in a person’s environment whilst they are working, and they do not focus on it

until it vibrates and/or makes a sound to signal a notification. Thus, like the device being created for this project, it is calm and in the background until some type of feedback causes the user to pay attention to it. The user being familiar with this technique because of their mobile phones will likely make it easier for them to understand and familiarize themselves with the device created for this project.

4.3 Conceptual Mood board

Figure 16 Conceptual mood board

Looking at the mood board in Figure 16, the aim was to combine calm images and shapes that could provide inspiration for an object that can provide feedback to an at-home working user. The images all have products simple shapes with few details, so as not to disrupt the environment of the user, and most of them use a form of light as feedback. They are also all aesthetically pleasing, which is important to consider, the final product should be decorative and aesthetically pleasing in order to blend into the environment of the user and make it more appealing to use.

4.4 Lo-Fi Prototype Sketches

Using the inspiration from the mood board, several product sketches and use-case scenarios were created. These sketches can be separated into two categories: functional and visual. The difference between the two categories is that the first is focused on the functionality of a product, a way of providing feedback that makes the user be physically active in some way. The visualisation category concentrates solely on the visual aspect, displaying the user's sedentary behaviour in a physical, visual way but without pushing them to be physically active.

4.4.1 Functional Designs

Figure 17 shows several shape designs for a functional object that is inspired by the physical design of an Alexa or Google home type of product. The function is different than Alexa, but the overall shape is familiar to users, which might encourage them to be more open to using it.

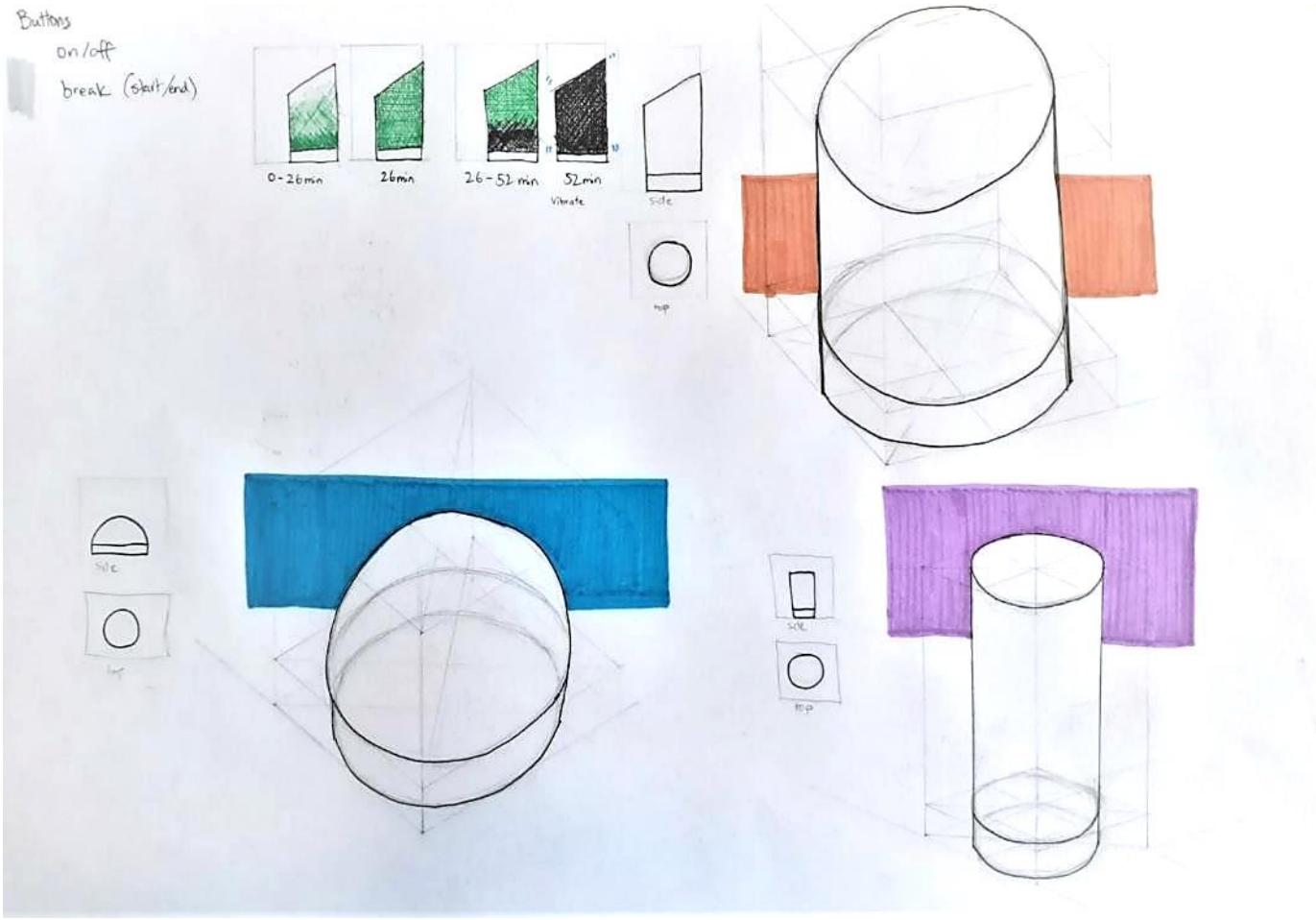


Figure 17 Functional product shapes

Following these design options, a use-case scenario was created for a functional design that concentrates on creating a routine for the user. Students and people with jobs who study and work from home may struggle with following an effective routine (i.e. 1 hour work, then a 15 minute break). Instead, some do not take any breaks at all or at random moments without any structure. However, following a set routine allows users to work more efficiently, combining intensive moments of work with relaxing breaks to re-charge. Figure 19 shows the use-case scenario for such a design. At step one the user presses the start buttons to start the device, giving off a light green light that slowly gets darker the longer the user is sitting. After "X" amount of time (i.e. 60 minutes) the device will be fully dark green and the light will pulse whilst also vibrating to notify the user of being sedentary for "X" amount of time and reminding them to take a break. If they choose to take a break, then they press a 'stop' button on the device to start the "break" phase, where during "X" amount of break time (i.e. 10-15 minutes) the light of the device returns to its initial light colour. When the break time is over, the device will pulse and vibrate once more to notify the user, who will press the start button and start the cycle again (see Figure 18 for a sequence diagram of the steps). This design concept could be useful for those working from home with their own independent schedule and who wish to follow a routine. However, students working from home have online lectures to attend, meaning they lecture schedule is not aligned with the work/break routine from the device, making it irrelevant. The same is true for people working their jobs from home who have calls and online meetings that do not follow the specific schedule of the device. Thus, considering the complications, urging people working from home to use a device that urges them to follow a specific routine may not be the most efficient way of decreasing their sedentary behaviour.

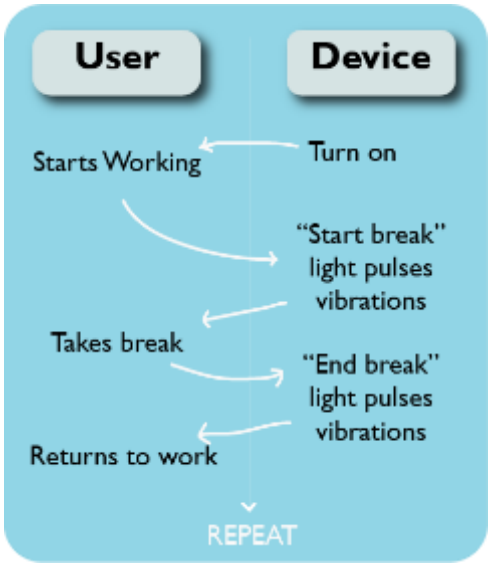


Figure 18 Sequence diagram of green lamp concept

Figure 19 Use-case scenario functional design

Next, a design was created for a device that requires physical action (see Figure 20). It has a dumbbell-like shape with a light weight that is encapsulated by a light-emitting casing. The user taps the top of the device to start it up when they sit down to start working. The longer they sit, the darker the light becomes. To make the light from the device a lighter shade again, the user must shake it. The goal is to have the colour of the light be as light as possible and to prevent it from reaching its darkest colour. This is a very physical approach to the concept, the only thing the user can do is shake the object. This design concept is more focused on increasing physical activity rather than reflecting on their sedentary behaviour. They can also shake it whilst sitting, thus remaining sedentary.

In order to put the focus on reflecting on sedentary behaviour, it may be more useful to focus on visualizing the user's sedentary behaviour, purely making them aware of their behaviour with no consequences attached (like having to shake an object or being urged to move through light pulses and vibrations)

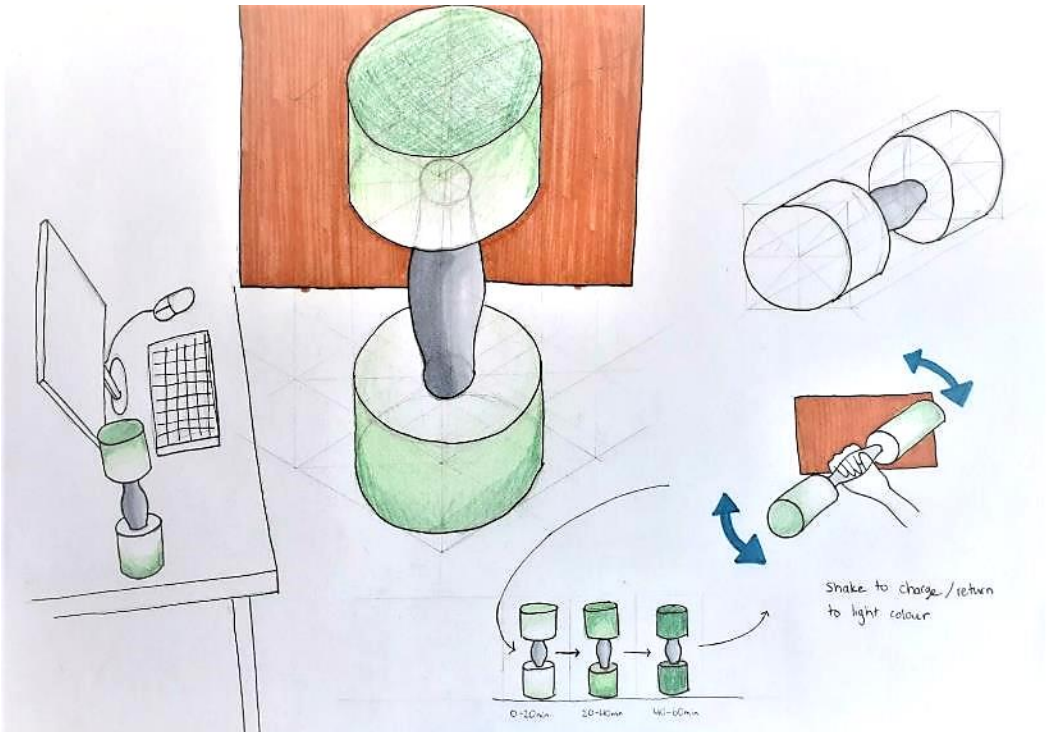


Figure 20 Dumbbell light functional design

4.4.2 Visual Designs

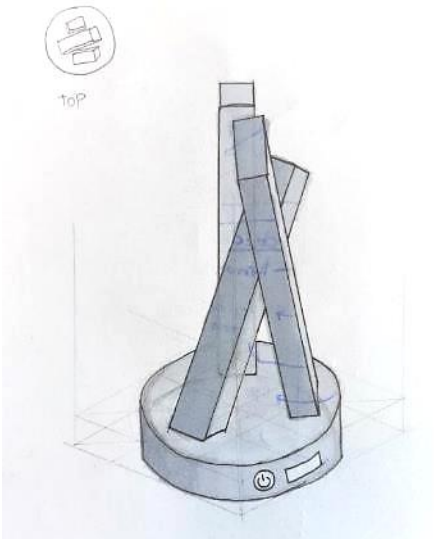


Figure 21 Visual concept: Decorative bars

Succeeding the functional designs, multiple design concepts focusing on the visualisation of sedentary behaviour were created. By solely visualising a user's sedentary time they can reflect on their behaviour without being urged to "do" something, they can choose how they react to the given data.

Figure 21 shows the design concept of a decorative object with three bars. Each bar can emit light, and they each represent 20 minutes. The user turns the device on when they start working and the bars will gradually turn from a light to dark colour on by one the longer the user sits. After the first 20 minutes of work, the first bar will be dark, after 40 minutes the second one as well, and after 60 minutes all three bars will have a dark colour. The user sees the change in lighting and can choose whether they want to react to it or not. There are no consequences if they do not take a break or choose to ignore the object. They can press the button once more to reset.

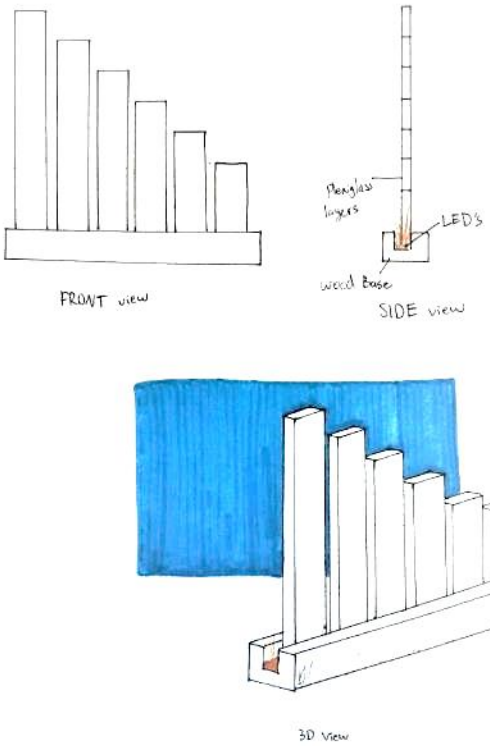


Figure 22 Visual concept: Plexiglass lighting

Figure 22 shows a second decorative design concept inspired by an image from the mood board. It is a wooden base with an LED strip and plexiglass bars on top of the LEDs that allow the light to shine through. Again, same as in Figure 21, each bar represents a certain amount of time and the light will change colour or turn on/off over time to visualize the sedentary time of the user. I am, however, unsure whether the light will be clearly visible through the plexiglass during the day, it may only be effective when the surroundings are darker.

The next design is also a decorative object inspired by landscape hills that has a wooden frame and uses plexiglass and LEDs to display light (see Figure 23Figure 23). The "hills" start off as green and the longer the user sits, the more the colour changes until they eventually reach shades of red. This concept has the same problem as the previous plexiglass lighting design of not being sure whether the light will be clear enough during the day to function effectively. However, it is an interesting concept that does visualize sedentary behaviour in a different way.

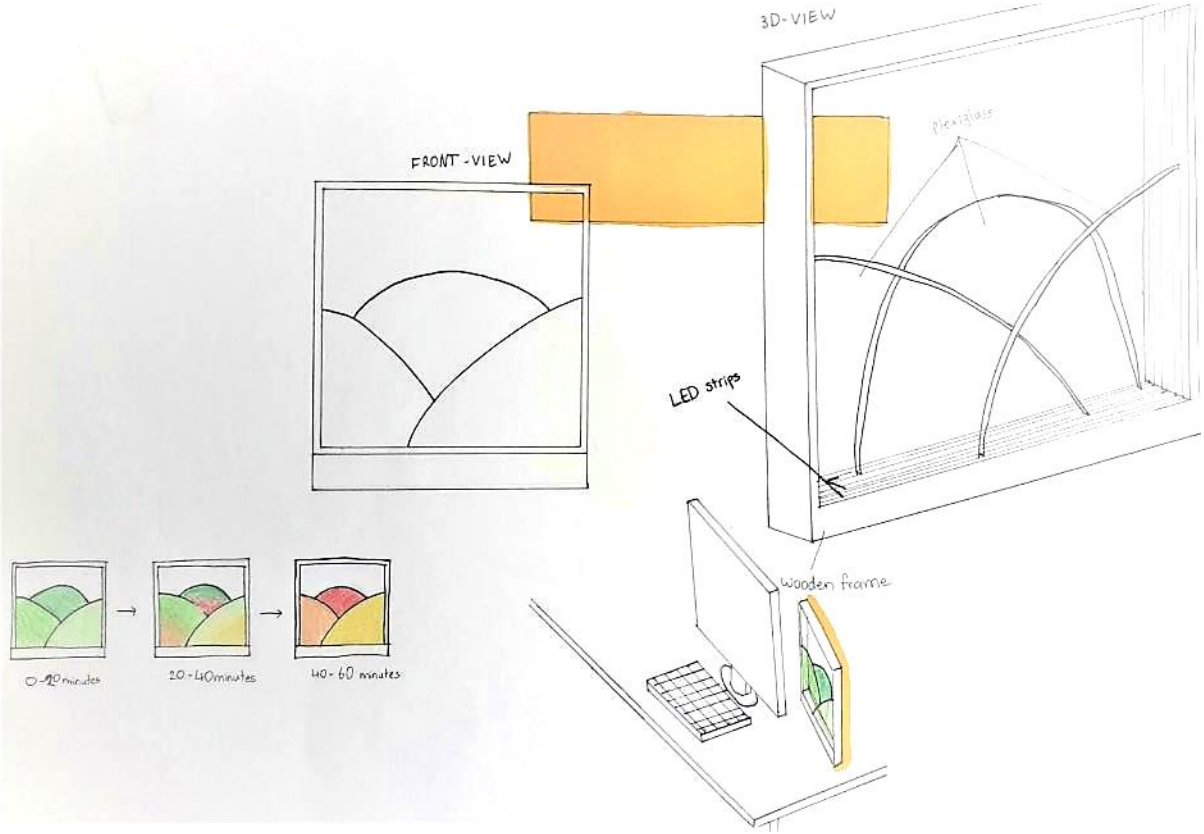


Figure 23 Visual concept: Plexiglass hills

A fourth visual design concept concentrates on using budding flowers as inspiration. Figure 24 shows a wooden base with six flowers. Each flower represents 10 minutes. When the user starts working, they press a start button which results in all six flowers opening and remaining open. After 10 minutes of working the first flower will close, after another 10 minutes the second flower will close. This continues until 60 minutes have passed and all the flowers are closed, representing an hour of sedentary behaviour. It is a very natural decorative design that plays to people's connections to nature; they want to see blooming flowers, not closed ones, which is a motivator for them to reflect on taking a break. They can choose to take a break and press the reset button when they return, or they do not take a break and still press the reset button. Even if they do not take a break, they get urged to reflecting on their behaviour because they become more conscious of the how much time has passed.

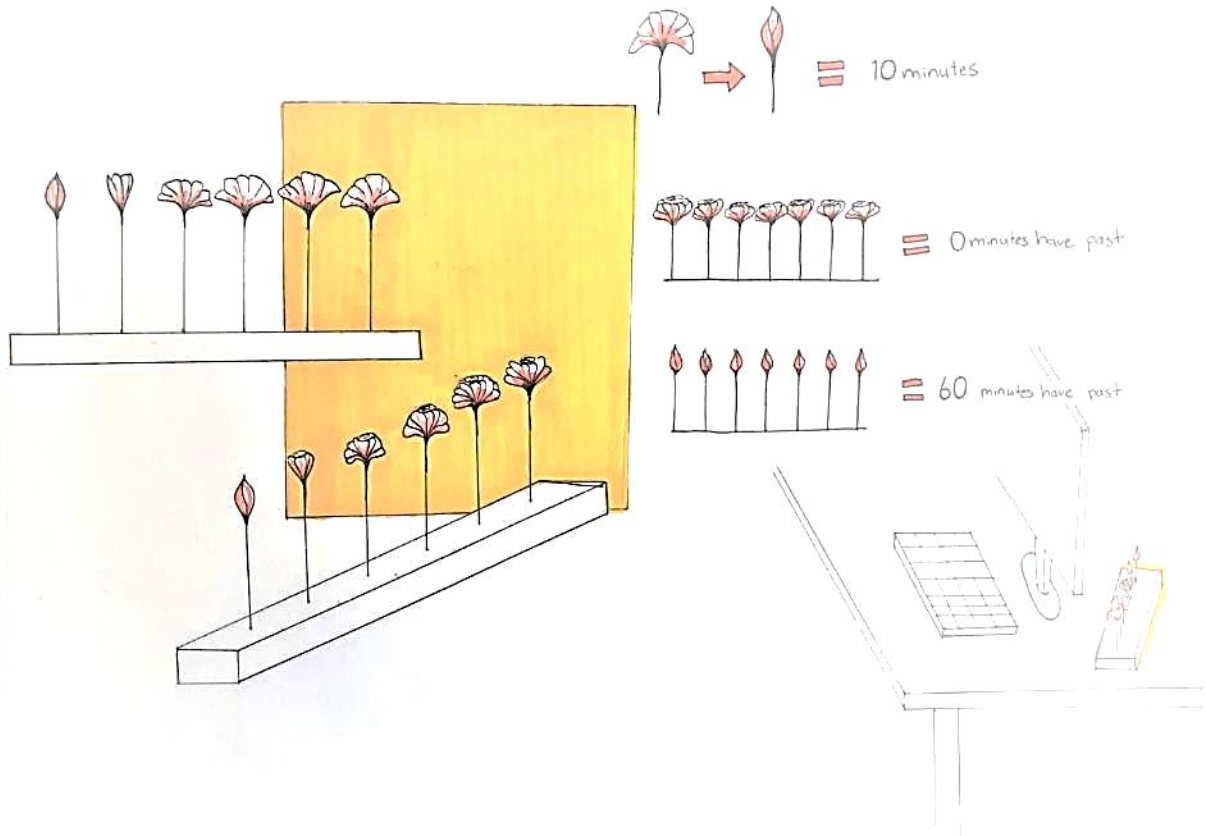


Figure 24 Visual concept: Flower visualisation

4.5 Interview

An online interview was done with Maarten Smith, an industrial design teacher at the University of Eindhoven. I wanted to show him my designs and see if he had any feedback and ideas on how I could improve my project. He came up with several interesting points that I had not previously thought of. One of the things he made me become aware of is that the things we do, our behaviours, are formed by our habits and there are three views of how these habits can be changed. The first is by changing them from the outside, the second by changing them from the inside, or the third is the view that anything can always be changed, which is the least realistic one. He advised me to consider in which way I want to influence the sedentary habits of at-home working people. Additionally, he recommended that I consider the difference between the short-term versus the long-term effects of a product. Often, a product may work for a short amount of time because it is new and exciting. However, after a longer amount of time the user gets used to the product and becomes bored of it. An example he gave was a project done in an office building to increase the use of stairs instead of the elevator by converting the stairs into an interactive piano installation. The only reason this installation worked in the long-term was because the sounds of the piano changed regularly so that the users would not get bored of the same sound. It motivated them to continue using the stairs out of curiosity for what the new sound could be. I could consider incorporating a changing component to my product to increase the likelihood of it being used in the long-term. The talk also made me realize that I must think about what exactly I want the user to reflect on when using the product. Do I want them to reflect on how long they have been sitting or on how their environment is influencing their sedentary behaviour, that they should perhaps consider re-inventing their surroundings?

4.6 Online Survey

An online survey was done to gain insight into the behaviour of the user group and to discover their opinions on two of the design ideas (Figure 19 and Figure 24). The former being based on an object that uses light changes to urge the user to follow a routine, working for ‘x’ amount of time before signalling that they should take a break. This is an approach that is slightly more forceful, the object is calm and in the background, however it gives a clear signal when the user should take a break and should start working again. The latter is a purely based on visualising how long the user has been sedentary, the flowers close every ‘X’ amount of time and when they are all closed the aim is for the user to think about and reflect on how long they have sitting. Out of all the design options, these two were chosen because it allows the participants to compare a functional device with a visual one. This particular functional design concept was chosen because its design was inspired by the design of a

homey/Alexa product (only the design, not the function of it), which the users are familiar and comfortable with. Also, the tweet in Figure 4 gives a representation of what many people are feeling because of working from home, it shows that work is everywhere and that there is a lack of a clear routine. Figure 3 shows that having a set routine is an important aspect when working from home. Therefore, the design in Figure 19 is useful because it creates a set routine. The flower concept was chosen out of all of the visual design concepts because it was the only one that did not use light as a feedback type, instead it is the movement of the flowers closing that provide the information to the user. The functional design already uses light as feedback type and a choice was made to give the participants two different types of products with different types of feedback. Also, adding more plants and natural elements to a workplace is becoming increasingly popular as it connects workers to nature and provides a calm atmosphere. Besides the flower concept persuading the user to reflect, it is also an aesthetically pleasing, nature-inspired device.

Survey Results

In total, the survey received 92 responses. The ages of the respondents ranged from 19-53 out of which 58 (63%) were female and 34 (36.96%) were male. Students made up 53 of the responses, there were 9 with jobs, and 30 were students who also had a job.

After asking whether the respondents were working from home because of the covid-19 regulations several respondents discontinued the survey. 86 were working from home because of the regulations, 2 were already working from home and 4 were not working from home, removing them from the survey seen as they did not meet the requirements for participating in the rest of the survey. All questions preceding this one received 60 responses.

The number of hours that users spend sitting down to work on a weekday are shown in Figure 25. The majority spend 3-8 hours working.

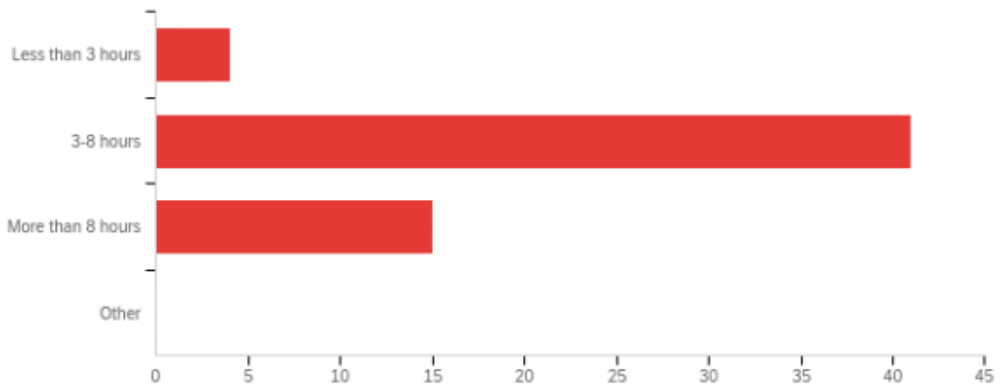


Figure 25 Hours spent sitting to work/study

After discovering how many hours the respondents it was of interest to see how they organize their working time, whether they follow a routine of working and taking breaks or not. Figure 27 shows that the majority take breaks only when they feel the need to. 5 follow a specific routine and 5 others only take a break for lunch.

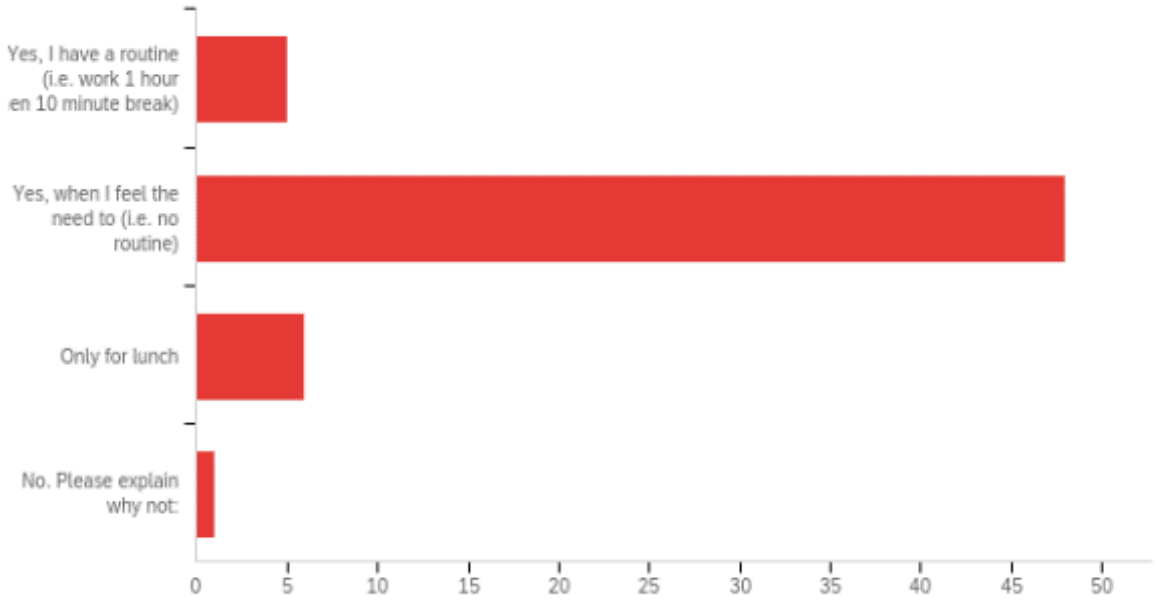


Figure 26 How many breaks respondents take

Furthermore, it was of interest to discover whether the respondents are aware of that sedentary behaviour increases the risk of all-cause mortality, cardiovascular diseases, and diabetes, even for a person who meets the daily activity requirements. 33 were aware, 23 somewhat aware and 4 were unaware (see Figure 26).

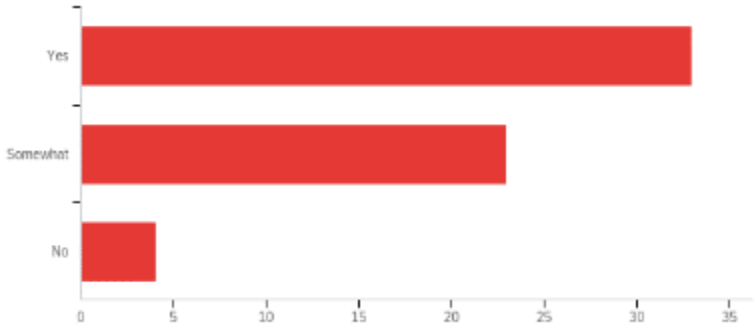


Figure 27 Awareness of the negative health impacts of sedentary behaviour

Additionally, the respondents were asked what types of feedback they would prefer from an object present in the background of the working environment whilst working (see Figure 28). The majority are positive about light that changes colour. The next favourites are audio sound and vibrations. Quite a few also like pulsing light and movement of components. However, it must also be considered that the type of feedback very much depends on the device and users do not always know what they want, sometimes the designer has to show them.

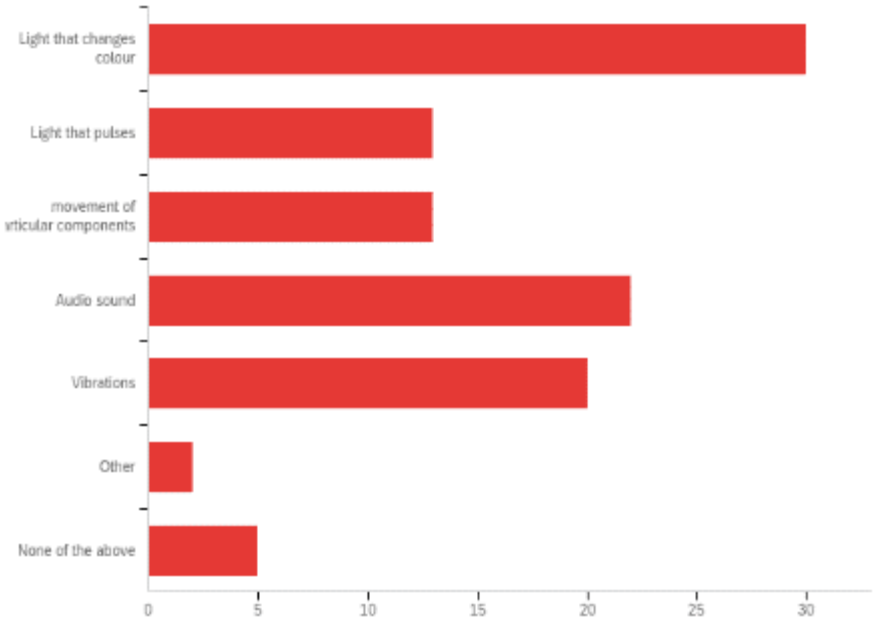


Figure 28 What type of feedback would the respondents prefer for an in-the-background device

Next, a video was shown of a 3D model of the green lamp prototype (see Figure 29). This concept was focused on using green light to create a routine for the user. The light is light green when the user first sits down to start working. The longer the user sits, the darker the colour of the light becomes. After 'X' amount of time (e.g. 50 minutes) the light will pulse twice to urge the user to take a break. After another 'X' amount of time (e.g. 15 minutes) the light will pulse again to signal the end of the break. This cycle continues throughout the day.

Figure 29 Functional, routine-creating green lamp prototype

The initial reactions to the green lamp can be seen in Figure 30. The respondents were asked to give their response through a Likert scale that ranged from 1-7 (1 being very negative and 7 being very positive). They were overall positive about the aesthetics and use of the device.

Figure 30 Initial reaction to the green lamp prototype

The aspects of the first prototype that respondents liked are visualised in word cloud (see Figure 31). The larger and darker the word is, the more often it was used in the responses. This shows that they found the product to have a simple, nice, and easy design. They find it to be a practical, calm, non-invasive product that does not distract. The colour change reminds the user when to work and when to take a break.

Figure 31 Word cloud of what respondents liked about the green lamp prototype

Besides liking the product, the respondents were also asked what they felt could be changed or improved. From the 60 responses the following 13 comments were mentioned. The table shows the comment as wells as the number of times a comment in the same genre was mentioned (see Table 2). Some people mentioned multiple comments in their response, which explains why there is a total of 65 mentioned comments and 60 responses. The most comments mentioned making the device customizable, thus allowing the user to choose what colour they want the light to be and what they want the interval times of the working/break routine to be. There were also some conflicting views on the pulsing of the lamp when it indicates the start or end of a break. 6 people found the pulsing light indicator to be too fast and intrusive whilst 3 others felt it should be more noticeable and pulse for a longer amount of time. Everyone seems to have their own preference regarding this matter. The size of the device was also mentioned 6 times, those respondents were unclear as to the actual size of the device and indicated they did not want it to be too large.

# of times mentioned	Comment
25	Customizable (colour and timing)
7	Nothing
6	Size of the product (not too large)
6	Pulsing is too fast/intrusive (option of ignoring/working through it)
5	Dislike for overall physical design
4	Looks too 'normal', might not pay attention to it, easy to ignore
3	Make the pulses more noticeable / continue pulsing for longer
3	Add features: music/USB charging/temperature indicator
2	Dislike for overall concept of light changing
1	Include audio
1	Automatic sitting detection
1	Use an app instead
1	Light might not work well during the daytime

Table 2 Improvements for the green lamp prototype

Next, a video of the working 3D model of the flower concept was shown to the respondents (see Figure 32 Visual 6 flowers prototype. 6 flowers that are open when the user sits down to start working. Every 10 minutes a flower will close (in order from left to right). When all the flowers are closed 1 hour will have passed, which should then cause the user to reflect on how long they have been sitting since they can visually see all the closed flowers.

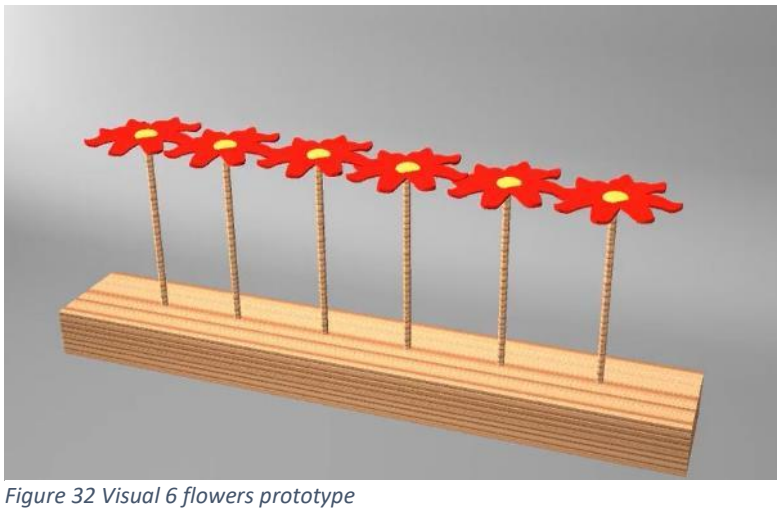


Figure 32 Visual 6 flowers prototype

Figure 33 shows the initial reaction to the device (1 is very negative and 7 is very positive). The reaction is very similar to that of the green lamp prototype, quite positive.

Figure 33 Initial reaction to the flower prototype

Another word cloud was created to form an overview of the features the respondents liked about the flower prototype (see Figure 34). It seems they like the creative, simple aesthetic of the design. They find it an original idea that is decorative and original, as well as suitable for blending into a working environment.

Figure 34 Word cloud of what respondents liked about the flowers prototype

The respondents were then asked what they feel could be changed or improved. Table 3 contains the main points of feedback that were given as well as the number of times they were mentioned by different respondents. 10 out of the 60 respondents had some comments about the overall design of the flowers, they did not find the flowers to look natural enough or they may be bothered by the sound created by the closing of the flowers. 8 respondents mentioned seeing the flowers close every 10 minutes could be too stressful because it would happen too often. Furthermore, it seems they find the size to be important, making sure it is not too large. Also, they feel it might be useful to add a sound when the last flower closes so that it becomes clearer that the hour is over.

Comment #	**Comment**
10	Dislike for design aspects (fragile, sound of moving flowers, more natural, flowers should not be in a straight line)
8	Nothing
8	Watching the flowers close could be stressful /10 minutes too quick / closing is quick
7	Size (not too large)
5	Add a sound at the end to grab the user's attention
4	Not for me
3	Customizable (time intervals)
2	Add features: time/temperature/humidity
2	Preference for digital product (app)
2	Easy to ignore
1	Add more space between the flowers
1	Allow the flowers to grow
1	More variation, different types of flowers
1	Do not use red, it is a panicking colour
1	Do not close one by one

Table 3 Aspects of the flower prototype that can be improved

Lastly, the respondents were asked which if the two prototype concepts they preferred (see Figure 35). The visualization concept refers to the flower and the functional refers to the green lamp. There seems to be a slightly higher preference for the flower prototype.

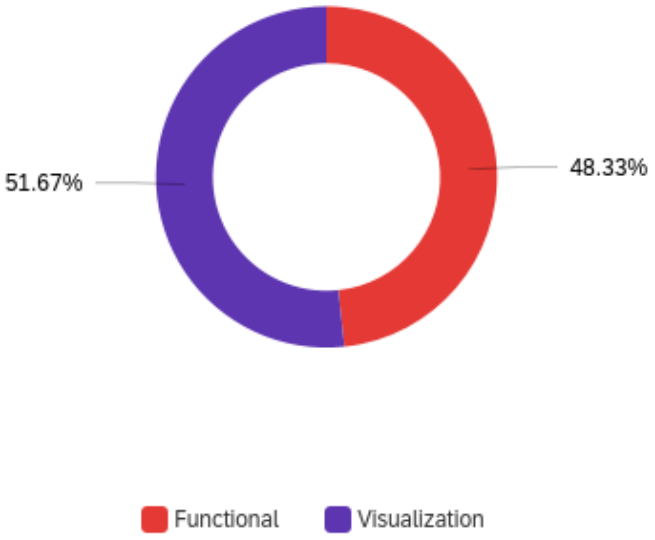


Figure 35 Visualization of which prototype the respondents liked most

Survey Conclusion

The survey allowed an increased understanding of the user group and their behaviour. They study on average 3-8 hours, take breaks whenever they feel the need, and are aware or at least somewhat aware of the effects of sedentary behaviour. It is important to note that the target audience is anyone 18+ who is working from home, however the majority of the respondents were students, meaning there was not a lot of information received on the behaviour of people with fulltime jobs. Additionally, the majority was female which may have had an impact on the results.

The respondents were overall positive about both of the prototype designs. They found both designs to be nice, simple, and as if they would not be distractive. The flower prototype turned out to be slightly more liked than the green lamp prototype. From the comments, this seems to be the case because it is more decorative and creative, it is clear when and how much time has passed and the user would not be forced or urged to make a choice but are urged to reflect and have a more clear realization of time. With the flower prototype the user can also more easily choose to not physically respond to the device and continue working, however the aim is to make them at least reflect on their behaviour and allow them to take a second to realize how long they have been working.

Some of the main feedback points are that the size should not be too large and that it should be customizable, that users should be able to choose what the time intervals are. However, this could impact the whole point of the device, if users can choose the interval then they can make sure that they work for two hours followed by a ten-minute break. However, 2 hours is too long of an interval to be working in one go, they would still experience the negative impacts of being sedentary. Therefore, providing them with one interval that is proven to be efficient is important because it shows them the most efficient and healthy time intervals. Another factor to consider is the type of feedback that the user wants to receive. The respondents were most positive about feedback in the form of light; however, sound, vibrations, movements, and light pulses were not unpopular either. Also, the majority preferred the flower prototype, which did not have light incorporated in its feedback. Thus, being able to incorporate a form of light would be nice, however using any other form of feedback depending on the function of the device would also be sufficient.

Due to the fact that a small majority preferred the flower prototype, that is the one that will be developed further for the final prototype. Another reason for choosing to go with the flower prototype is because I feel it better suits this project and its intentions. The goal is for the device to be calm, aesthetically pleasing, and effective in motivating reflection on behaviour. The green lamp is slightly more forceful in creating a work/break routine, whereas the flowers are more decorative and allow the user to reflect on their behaviour, purely through seeing the flowers close. Also, the green lamp changes colour slowly over a period of time, meaning the user has to decide for themselves when to look at the device. With the flowers, the closing a single flower every ‘x’ amount of time catches the users’ attention, so they do not only get a signal when the full time (i.e. hour) is up, but also moments in between to see their progress.

4.7 Preliminary Requirements

Given the research, PACT analysis, interview, and different ideas that have been formed, the main idea for the coming prototypes is creating a decorative, aesthetically pleasing, persuasive object that can be placed in the workplace of a user. The following is a list of pre-liminary requirements that will be further investigated and developed in the next chapter.

1. The object should be calm and in the background of the users’ working environment
2. The object should provide sensory feedback when necessary (i.e. colour change, sound, movement, vibrations)
3. The feedback should be able to persuade the user to reflect on their sedentary behaviour

4. The object should be large enough to notice visual changes, but not take up too much space on a desk
5. The object should be easily portable
6. The object should be decorative and aesthetically pleasing

4.8 Implementation of Persuasive Technology

Throughout the iteration process for the design of the device, Fogg's [21] 8-step process should be kept in mind to ensure that persuasive technology is implemented in an efficient way. The following list shows how the eight steps have been implemented into the project and design of the device.

1. Choose small behaviour to change → This project focuses on sedentary behaviour, specifically by inciting reflection on the behaviour and making the user more aware of time (see Introduction).
2. Choose a receptive audience → The target audience is people working from home, including students and those with jobs. They are receptive because of their familiarity with technology (see PACT Analysis).
3. Find what prevents the target behaviour → Many people are unaware of the negative effects of sedentary behaviour, the problem is described in the introduction chapter (see Introduction).
4. Choosing familiar technology → The audience is used to working with technology and will therefore be likely to understand this simple device. A number of designs were created and iterated in the ideation chapter (see Ideation).
5. Find relevant examples → A number of similar projects were found and analysed (see Related Works).
6. Imitating successful examples → This was done by iterating conceptual designs (see Ideation).
7. Testing and iterating → This was done multiple times throughout the whole process of the project. Testing was done in three forms: through an online survey for the target audience (see Online Survey), a lo-fi user testing (see Lo-fi prototype), and a high-fi user testing (see Evaluation / Results).
8. Expanding on success →A description of how the success of the project can be expanded is explained near the end of this report (see **Error! Reference source not found.**).

5. Specification

In this chapter, the preliminary requirements will be further investigated through creating a use-case scenario and a lo-fi prototype, which will lead to a final set of requirements for the product.

5.1 Use-case scenario/storyboard

A storyboard was created to clearly show the process of using the device (see Figure 36). First, the device is turned on by plugging it in to any wall socket. Then, an LED turns on, the three flowers open and the user will start their work. After 20 minutes one flower will close, which will catch the user's attention and cause them to briefly look at the flower and realize 20 minutes have passed. The user will return their focus back to their work. After another 20 minutes the second flower will close, again, catching the attention of the user who will briefly look before returning to their work. Another 20 minutes pass, after which the last flower closes and the LED turns off. The user will notice the movement, look at the device and realize that an hour has already passed. This will make the user reflect on how much time has passed and could cause them to consider getting up to take a break before moving on to another hour. After a few minutes, the three flowers will open again, and the process will be repeated.

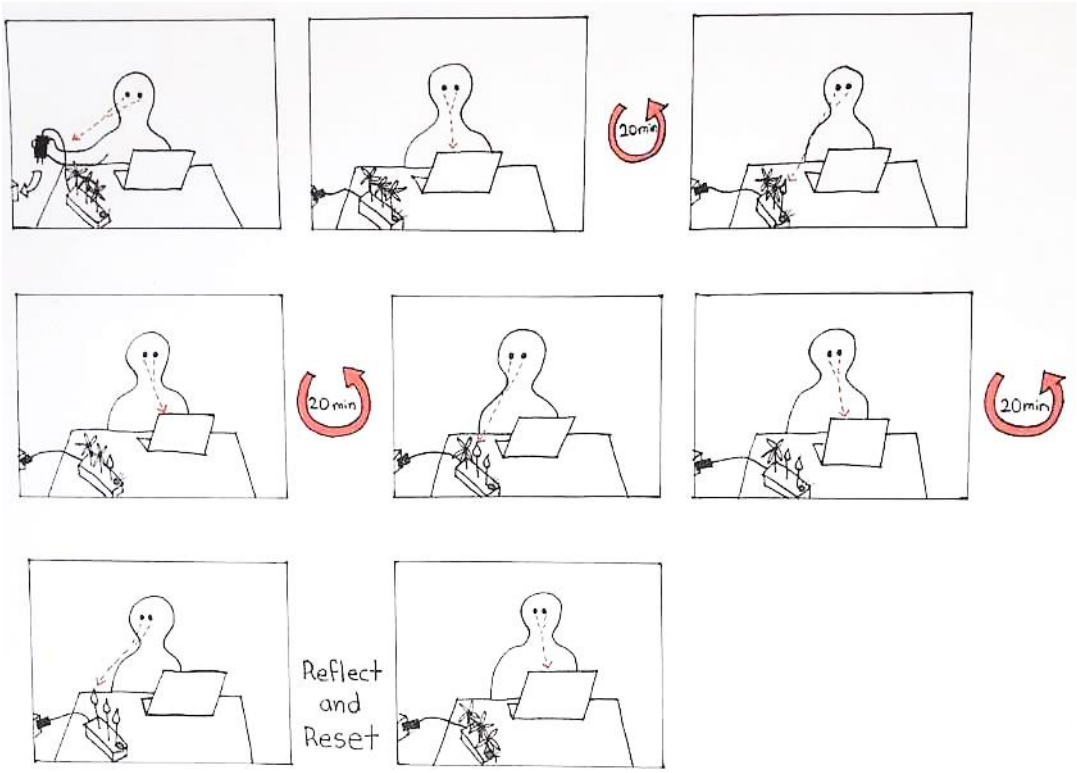


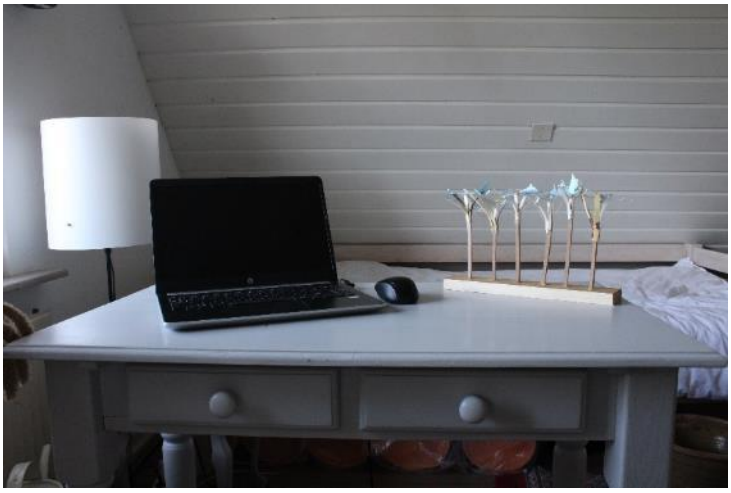
Figure 36 Storyboard showing the use of the flower device

5.2 Lo-fi prototype

5.2.1 Design of lo-fi prototype

Two lo-fi prototypes were created, one consists of 6 flowers and the other of 3. Through the results of the online survey it became clear that the respondents do not want the product to be too large, and some comments mentioned that having six flowers with one flower closing every 10 minutes would be too often and stressful. Therefore, a prototype with 3 flowers was created to test whether the participants notice a difference between the two and what their preference would be. The prototypes were created with simple materials, combining paper and wood to create interactive flowers that can be opened and closed manually.

Lo-fi prototype 1 (6 flowers):



Lo-fi prototype 2 (3 flowers):





5.2.2 user-testing of lo-fi prototype

A lo-fi user test was done with two users to see how they interacted with the product and how it impacted them and their behaviour. First, protype 1 was placed in the working environment of the user. The moderator was quietly present in the room and closed a flower every 10 minutes. The moderator aimed to be as unnoticeable as possible, not communicating with the participant. After 1 hour had passed and all six flowers were closed, the participant was asked to answer a few questions on a questionnaire (see Appendix A: Lo-fi user test questions). Protype 1 was then replaced with prototype 2. The moderator was again quietly present and closed a flower every 20 minutes. After the hour had passed, all three flowers were closed and a timer went off, giving a sound signal that 1 hour had passed. The alarm was not present in the first prototype so as to test whether users would prefer only visual cues or also auditory cues. The participant then answered the remaining questions on the questionnaire.

User 1 was a fulltime Master student, studying from home, and user 2 had a fulltime job and was working from home. The results of the user test and questionnaire are as follows.

User test results prototype 1 (6 flowers):

- Both users understood the function of the six flowers, explaining that each flower represented 10 minutes with a total of one hour.
- They both looked at the flowers briefly when one closed but not whilst they were working. Neither of the users found the device to be distracting, user 2 mention that it made him more aware of time passing.
- Every time a flower closed both users mentioned reflecting on how much time has passed and how long they were sitting. User 1 was in a meeting when the last flower closed and felt the urge to get up to move for a few minutes but was not able to because of being in a meeting, making her aware of how her sedentary is influenced by her study schedule. User 2 described how he normally gets up to get a drink or walk around a bit and now he felt the need to be more productive and wait with getting up until the hour was over.
- User 1 liked that the device made her reflect more and created a visual reminder of how much time had passed. User 2 liked the organic look of the paper and wood.
- User 1 would add an additional type of feedback (audio or light) to make it more obvious that the flowers closed. User 2 did not find it clear what exactly he needed to reflect. He mentions providing a set of questions.

User test results prototype 2 (3 flowers and sound notification):

- Both users understood that each flower represented 20 minutes.
- They both did not pay a lot of attention to the device and would only notice it when a flower closed.
- Neither of the users found the device to be distracting because the device was in the background and did not require constant attention.
- User 1 liked that it made her reflect and be more conscious of time, but she felt this happened more with prototype 1. User 2 again liked the organic feel and the purple color.
- User 1 liked the sound at the end when all flowers were closed because it made it more noticeable that one hour had passed. She felt that it could be helpful to add a light signal when the first two flowers closed so that it would be more noticeable. User 2 again was not sure what to reflect on.
- User 1 preferred prototype 1 with 6 flowers because it gave a more constant reminder. However, she also liked the sound feedback at the end of prototype 2.

- User 2 preferred prototype 2 with three flowers. He felt that prototype made him constantly think about being sedentary and needing to be productive. The sound at the end of prototype 2 did catch his attention more, however, he was used to looking at his laptop clock and would already know if an hour had passed.

5.2.3 Lo-fi user testing conclusion

There are several conclusions that can be drawn from the user testing. One user preferred having six flowers whilst the other preferred three, however, due to the fact that there were also several comments on the online questionnaire about 6 flowers being too stressful, the design will be continued with the three flowers. Additionally, more types of feedback will be added to make it more noticeable when a flower closes and when all flowers have closed (through light or audio). Also, the final prototype will be designed to have a calm, organic feel with soft colors that do not draw extra attention.

5.3 Functional vs non-functional requirements

Next, a set of functional and non-functional requirements can be created, which will be used for the following MoSCoW analysis. Both have been explained in chapter 3.5. See Table 4 for the requirements

Table 4 Functional and non-functional requirements for the device

Functional	**Non-functional**
A flower closes every 20 minutes	Colour/aesthetic of flowers
Device can turn on/off	Feedback cues
Clear when the full hour is over	size
portable	Easy to use
Flowers automatically open again after 1 hour has passed	

5.4 MoSCoW analysis

A MoSCoW analysis is used to determine which of the functional and non-functional requirements the device must, should, could, or will not include. An explanation of each component was given in chapter 3.5. See **Error! Reference source not found.** for the MoSCoW analysis that will be used to create the high-fi prototype. The requirements were divided in the following way based on feedback from the online survey and lo-fi prototype after analysing what seemed most important to the users. Also, the available time for creating the high-fi prototype was taken into consideration during the analysis.

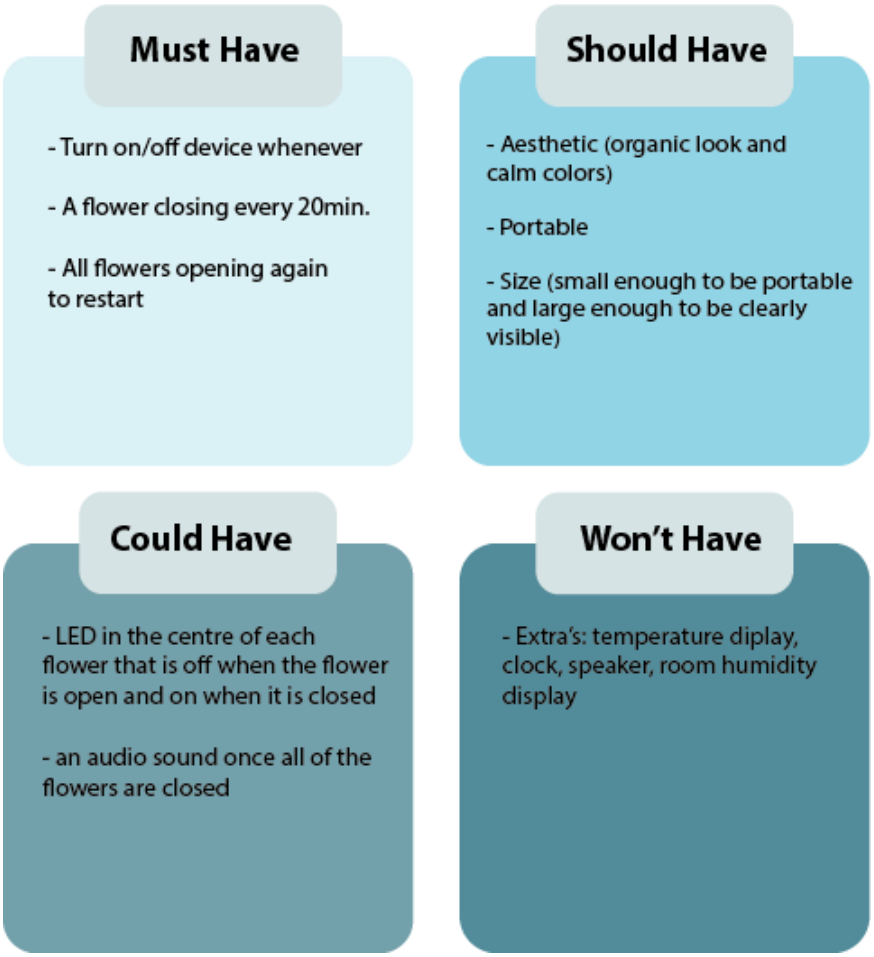


Figure 37 MoSCoW analysis

6 Realisation

In the realisation stage, all the feedback and comments from the previous interviews and questionnaires will be used to create a high-fi prototype. This prototype will be a device with three flowers that represents a visualization of time. This will make the user more conscious of how much time has passed and aims to persuade them to reflect on how long they have been sedentary and consider getting up to take a short break.

6.1 Sequence diagram

A sequence diagram was created to show the steps that occur with the interaction between the user and the device.

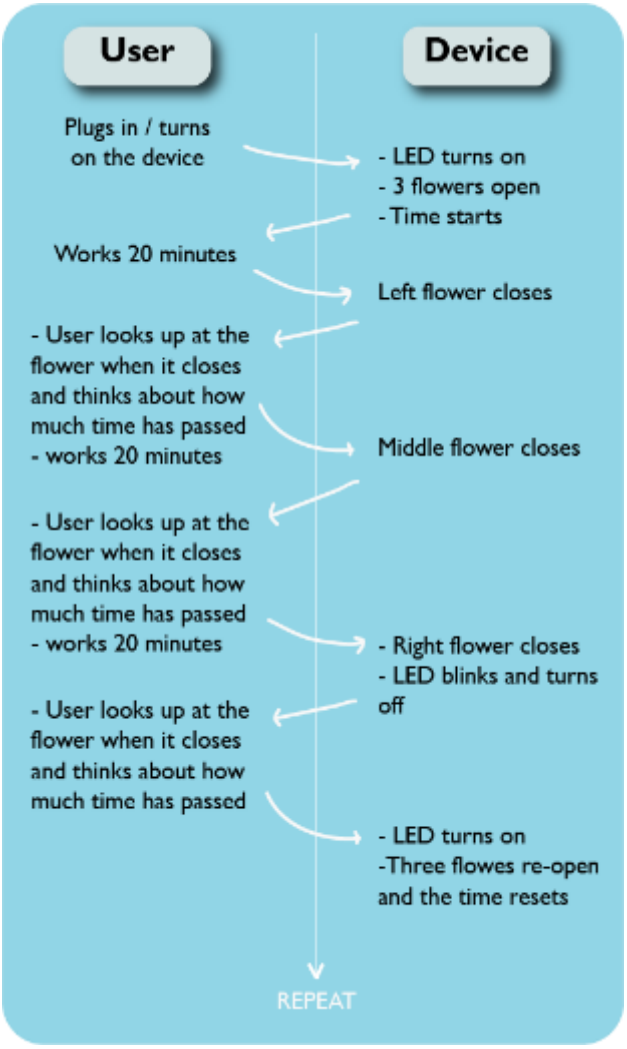


Figure 38 Sequence diagram for the high-fi prototype

6.2 Creation Process

The actual creation process of the device will be shown through pictures and explained in short pieces of text. The most important parts were the 3D printed flowers and the programming of the servos to control the opening and closing of the flowers.

Making the flowers

Seen as there was limited time to create, test, and evaluate the high-fi prototype, an online source was used for the model of the flowers. A team at circuito.io [53] had previously created a 3D printed sunflower that opened and closed following the amount of sunlight through the use of an LDR. For this project, only the flower model was used from this source. At first, the 3D printed flower model from circuito.io [53] seemed too large, therefore it was made smaller so that the device would not take up too much space. However, after printing them, the smaller particles turned out to be too small, which was difficult for the 3D printer to handle. The holes in the model were too small for the printer to create accurately, making it impossible to put together (see Figure 39).

Figure 39 Too small 3D printed parts (three images above)

To solve this issue, the original size of the model was 3D printed, knowing with certainty that it would be large enough to print the holes and be able to put the flower together. Thus, the components were successfully 3D printed (see Figure 40). All the separate components were then put together using thin wire and the holes that were too small for the wire were made bigger by heating a needle and poking it through the hole (see Figure 41). Once all the components were connected with wires, the flower could be opened and closed (see Figure 42).



Figure 40 3D printed flower components (three images above)



Figure 41 Putting the 3D printed components together using wire and a needle to enlarge the holes


Figure 42 3D printed flower open and closed

Programming the servos

The flower is able to open and closes by moving the sepal up and down. This had to be automated, which was done by programming servos (see Figure 43 and Appendix C: programming code servos). The sepal of each flower is connected to a servo that is programmed to rotate, causing the sepal to move up and down. Arduino was used to programme the servos so that the flowers would start with being open. Then, one by one, rotate upwards 90 degrees, pushing the sepal up and closing the flower. Additionally, an LED was used to indicate when the device was on. It would turn on when all three flowers opened in their initial position. The LED would turn off once all the flowers were closed at the end of the hour.

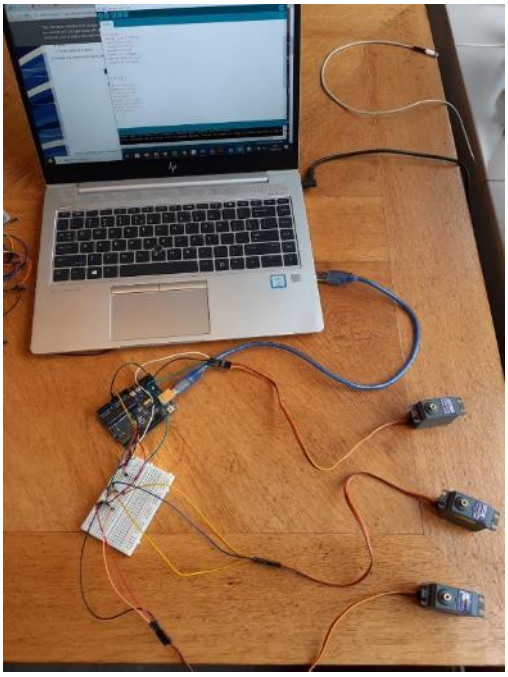


Figure 43 Programming the three servos

Putting it all together

After having put together the separate components, everything was put together to create the final prototype. First, small wooden plates were attached to the servos (see Figure 45). Perpendicularly attached to these wooden plates were sticks and a wire that led from a hole in the wooden plate, to a hole on the side of the sepal to be able to push it up and down (see Figure 44).

Figure 45 Connecting wooden plates to the servos

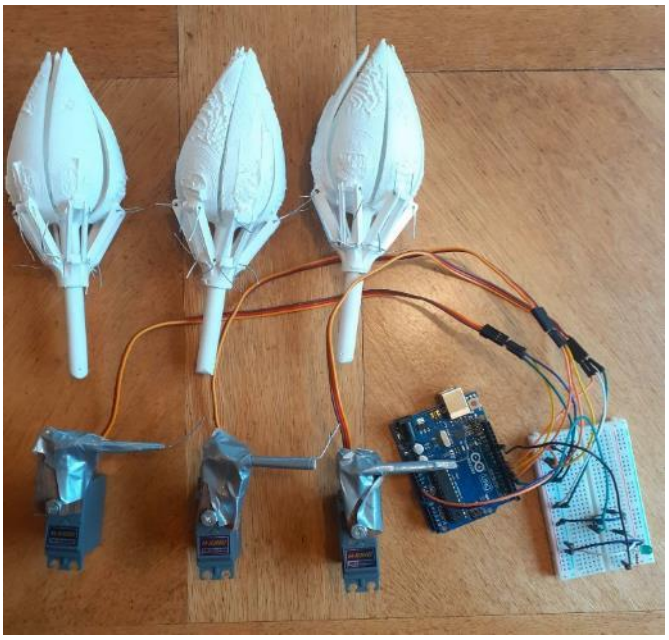


Figure 44 Servos with sticks and wire attached to the wooden plates

Next, a wooden holder was made to attach the servos to the wooden box (see Figure 40 for the wooden box and see Figure 47 for the servo holders). The servos and Arduino needed to be placed inside the box to make the device portable. Also, the flowers were painted so that they look nicer and more organic than the 3D printed white material colour (see Figure 46). Figure 49 shows a layout of all the components: wooden box, flowers, Arduino, servos, and servo holders. The tape turned out not to be strong enough to keep the sticks attached the flowers and servos and the sticks were too short. The sticks were replaced with longer ones and were wrapped in wires, which were also superglued to the sticks (see Figure 48). All components were labelled with a number 1-3 so that each servo would match the right LED, flower, and servo holder when attaching everything (see Figure 50). Next, holes were drilled into the box for the flowers, sticks to control the flowers, and LEDs as well as gluing the servo holders to a wooden plate to keep them in place and create a base (see Figure 51 and Figure 52). The wooden box holding the flowers was attached to the base using a hinge, making it possible to hide the Arduino and wiring under, as well as allowing any necessary changes to the components to be made (see Figure 54). The final high-fi prototype, with all the components combined, can be seen in Figure 56 and Figure 55.

Figure 47 Wooden servo holders

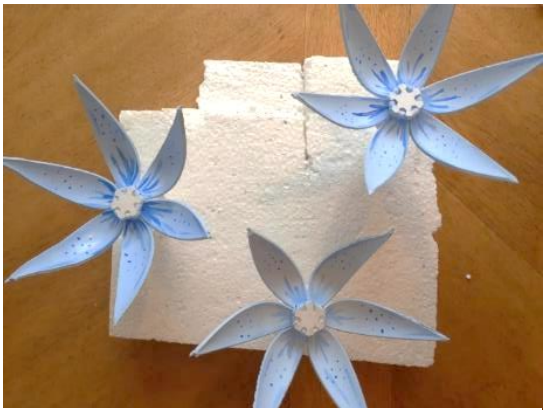


Figure 46 Painted flowers

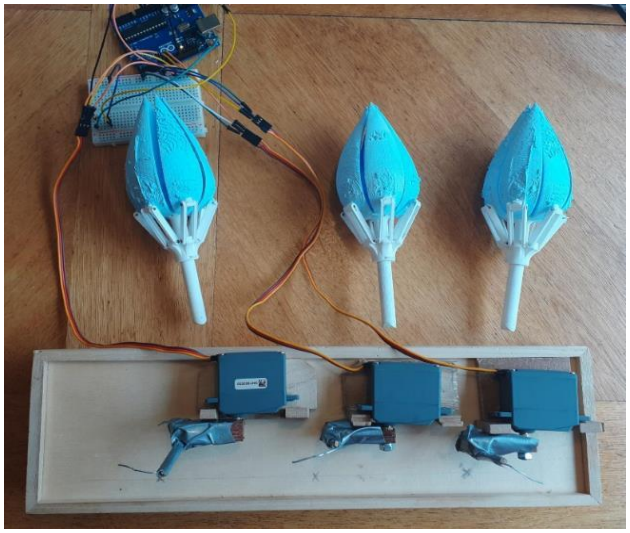


Figure 49 Layout of components

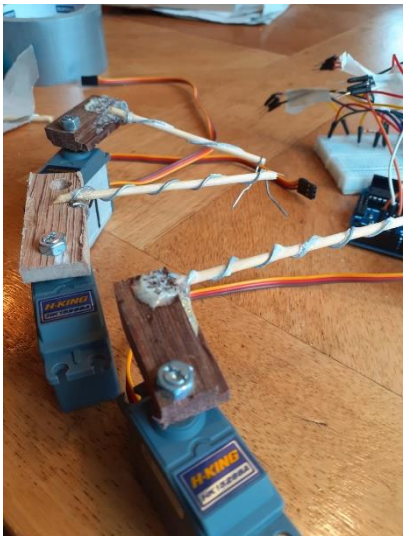


Figure 48 Tape replaced with wire-wrapped sticks

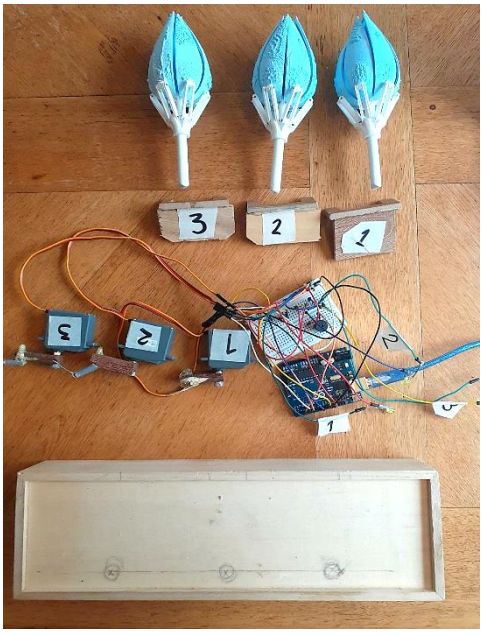


Figure 50 Numbered components

Figure 51 Drilling holes for the flowers, LED's, and servo sticks

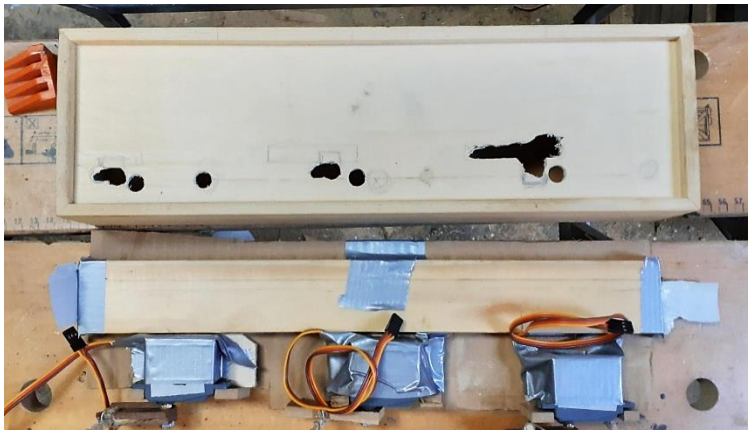


Figure 52 Attaching servo holders to a base

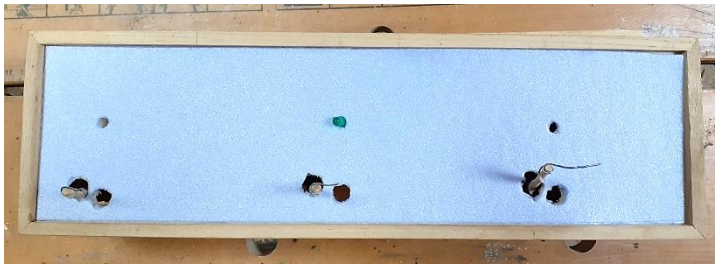


Figure 53 Foam layer to cover the extra holes

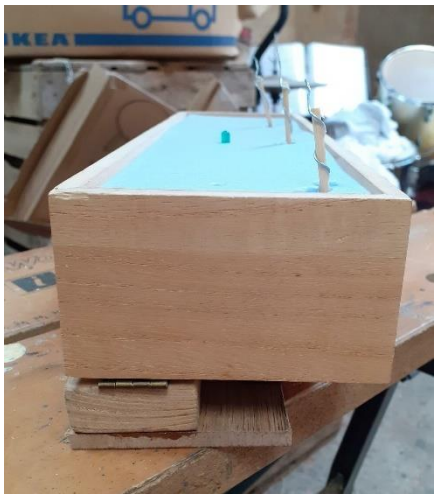


Figure 54 Attaching a hinge to allow access to the components inside the device

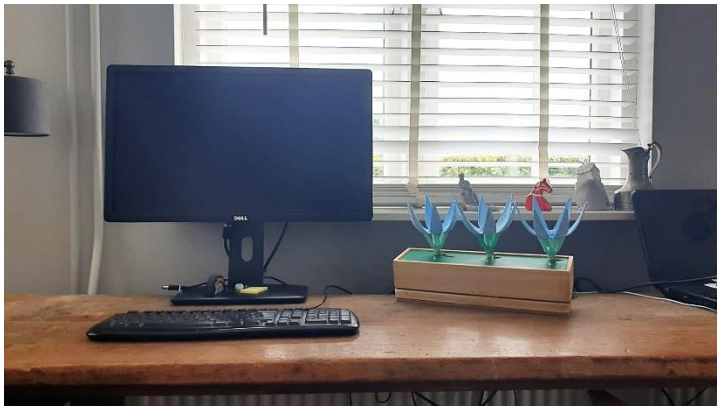


Figure 56 Final high-fi prototype

Figure 55 High-fi prototype open flowers

7 Evaluation / Results

7.2 Method

In order to evaluate the high-fi prototype, a user-test was performed. The user-testing was done with four users; user 1 was a 25 year-old female Master student, user 2 a 25 year-old male with a fulltime job, user 3 a 52 year-old male with a fulltime job, and user 4 a 19 year-old female Bachelor student. Each user was given 3 hours to test the device. They plugged the device in when they started working and made sure it was placed somewhere where it was in their periphery, but not too close to be a constant distraction. After the three hours, they filled in a number of open questions in a questionnaire about their experience with the device (see Appendix B: High-fi user test questions). The objectives of the user testing were to evaluate how the flower device impacted the behaviour of the user, whether the user found the device useful with regard to increasing their reflection, and whether the device met the specifications.

In order to analyse the qualitative data collected through the questionnaires, a thematic analysis was done to organize the data and identify patterns of themes (see Appendix D: Thematic analysis of high-fi prototype results). A thematic analysis involves familiarizing oneself with the data, highlighting important words and phrases that best describe the content, searching for patterns or themes in highlights across interviews, naming the themes, and finally analysing these results. Thus, the analysis was done by looking at each user's questionnaire answers individually and highlighting the words and phrases that were most important to their answer and best described the content of their answers such as "flowers caused a bit of a fright" or "aware of how focused I was on work". Next, themes were created, based on reviewing the lists of words and phrases and looking for patterns and similarities between them. The themes represent the concepts that are important for the evaluation of the device. Additionally, organizing the results in such a way helps provide a clear overview of the outcome of the user-testing, making it more accessible to evaluate. The themes are distraction, reflection, feedback types, physical design, and improvements.

7.3 Results

Distraction

Whilst the participants were working, none of them found the device to be distracting. User 4 answered that they "barely noticed it was there" and use 3 said that the "device was quiet and not disruptive". They were aware of its presence because it was placed in their periphery, however it did

not disturb them from their work. Although it was not distracting in general, users 1 and 2 would be shocked every time a flower closed. They found that they closed very quickly and suddenly, disrupting them, for a brief moment, from their work.

Feedback Types

The feedback type that was most dominant in catching the attention of the users was the movement of the flowers closing and the sound that was caused by this movement. The results of the reaction to the closing of the flowers was slightly conflicting. Users 1 and 2 would be shocked when a flower closed, whilst users 2 and 3 would sometimes not even notice that a flower had closed and would only recognize this had happened when they chose to consciously look at the device. Regarding the other types of feedback, none of the users particularly noticed the sound that was played at the end of the hour when all three flowers closed. It was soft and did not catch their attention. Also, users 1, 2, and 3 mentioned the lights being irrelevant and not adding value to the device. User 4 mentioned they “didn’t notice when the flowers closed, and the LED’s went on”, they would only notice when choosing to look at the device.

Physical Design

Regarding the physical design aspect of the device, user 1 found that although the lights had no added value, they were aesthetically pleasing. Furthermore, users 1, 2, and 3 were positive about the aesthetics and design of the device. They mentioned that it is “clean and easy to place on a desk”, another said, “a very nice design, I like the colours and the shape of the petals”. The users liked the size of device, the colours, and the fact that it was portable and able to fit on any desk. User 4 found the device to be clear and natural but disagreed with the petal design and size, feeling that the flowers were “rather big and sharp/rough”.

Reflection

All users reported that the flower device made them more aware and conscious of how much time had passed. User 1 mentioned being more “aware of how focused I was on work” and said the device reminded her to take more breaks. User 2 became more focused on the work they were doing and would think about being sedentary but was not sure whether he thought about it more than he already did before using the device. User 3 found it a good reminder of the need to take breaks and would walk around the room whilst on a call, which they would already do without the

device but now did more consciously. Besides user 3 taking walks, the others did not actually change their sedentary or physical behaviour. All of the users became more aware of how long they had been working but did not specifically link it to being sedentary and having to make a change. For user 4, the reflection became a distraction because they were busy calculating how many times a flower had closed, and thus how much time had passed in total.

Improvements

To improve the device, the users provided a number of possible future changes. Users 1, 2, and 3 mentioned removing the lights and the sound because they had no added value. User 2 who had mentioned being shocked every time a flower closed, also commented that it might be calmer for them if the flowers closed gradually over time instead of suddenly at once. Also, providing the user with a question was pointed out as an additional idea, because it would give the user a clear goal to reflect on. Additionally, user 2 introduced the idea of making the device even more decorative by placing it inside an aquarium with fish, to make it even more calm and in the background. Another possible improvement from user 3 was to add a sound every time a flower closed, to make it more obvious to the user that a flower had closed. Also, a USB cable or power bank could be incorporated to make the device even more portable and independent of an electricity outlet. Additionally, user 4 said they would user the device in the future to keep track of their break/work time if they had a lot of self-study work (no meetings or calls) and if the device were customizable so that they could choose their own time intervals.

8 Discussion

8.1 Research Questions

In order to fully answer the research question “how can calm, persuasive technology be used to create an object that motivates reflection on sedentary behaviour in an at-home work situation?” the sub-questions had to be investigated and answered. SQ1, “how can persuasive technology be used as a tool?” was answered by investigating literature and through testing its application with prototype user testing. The literature that was used to apply persuasive technology in this project include Fogg’s [21] 8-step process, Cialdini’s [23] tendency of consistency, and Verbeek’s [25] concepts of transparent persuasion and human-technology relations. How these concepts were applied are described in section 8.2 Discussion of Results and Literature. SQ2 was “what impact does calm technology have on a user?” which was also answered through analysing literature and by looking at the results of the user-testing. Weiser and Brown’s [35] three signs of calm technology were used to evaluate the device in 8.2 Discussion of Results and Literature, which is also where a discussion of the effectiveness of calm technology takes place based on the results of the user testing. “How can an environment influence user behaviour?” was asked in SQ3 and answered by looking at literature. Wall and Berry [37] described the importance of workplace personalization for workers to feel more comfortable and allow them to express their identities, which is why this idea was taken into account during the design process of the flower device concept. The flower device not only represents time, it also has a natural aesthetic and can be placed in a workspace as a decorative object that personalizes a user’s working space. Lastly, SQ4 asked “How can a combination of calm and persuasive technology influence reflection on behaviour?”. This question was answered by looking at the results of the user testing, which generally showed that the users reflected on how much time had passed, but not specifically on their sedentary behaviour and changing. A discussion of this possibly being due to the device being too calm and not persuasive enough can be found in 8.2 Discussion of Results and Literature. Overall, all the questions were answered through the literature and user testing, and it has become clearer how calm and persuasive technology can be used to motivate reflection.

8.2 Discussion of Results and Literature

The goal of this project was to use calm, persuasive technology to create an object that motivates reflection on sedentary behaviour in an at-home working situation. Concepts and ideas explained in the literature review were used as a basis to design and create a device that would fulfil this goal.

Besides using Fogg's [21] eight-step process as inspiration to create the final device (as described in 4.8 Implementation of Persuasive Technology), there are also tendencies of human behaviour mentioned by Cialdini [23] that can be applied. Specifically, the tendency of *consistency* is involved in persuading the user to reflect on their sedentary behaviour. Consistency refers to the user making a commitment to the product and setting goals for themselves. This is done by the user of the device; they use it with the goal of being more aware of time passing and their sedentary behaviour, therefore by using the device they are committing to achieving this goal. However, as the results have shown through phrases such as "I did not directly link the passing of time with how long I've been sitting" (user 4) and "helped me reflect on another 20 min having past" (user 1), even with this goal of reflecting on sedentary behaviour in mind, the users ended up being mostly aware of how much time had passed, and not necessarily focused on connecting this to their sedentary behaviour and feeling the need to change it, seen through the phrases "It made me reflect on my sedentary behaviour, but I'm not sure if it was more than I normally do" (user 2) and "not specifically motivating me to reflect on how long I have been sitting" (user 4).

Furthermore, the concept of intentionality, making connections between humans and the world more visible, by Verbeek [27] was used in this project. The device creates a connection between the users and time. Specifically, the hermeneutic relation seemed to be the most applicable; the device represents 'reality' by measuring the amount of time that has passed, which is then 'interpreted' by the user seeing the flowers close (with the knowledge that each flower represents 20 minutes), and then 'perceived' by the user reflecting on how much time has passed and on their sedentary behaviour. Nonetheless, the focus of the users was too much on time and not enough on their sedentary behaviour. It turned out to be more related to the *background* relation instead of the hermeneutic one, because the device was so much in the background that some users did not even notice the flowers had closed, as user 4 mentioned "I didn't notice when the flowers closed and the LEDs went on" and user 3 also "did not always notice flower closing", therefore they did not directly interact with the device and it blended into their environment. Thus, the device was physically present, but absent because it was a part of the immediate environment but in the user's periphery and not always interacted with [54]. Perhaps the physical design of the device should have been more related to being sedentary instead of using flowers. For example the breakaway sculpture whereby a

human-like sculpture would transform from a straight-back sitting position to a slouched position over time, which made it clear what the product was representing and what the problem was that they wanted to portray and solve [5]. The flower design was interesting because of its association with nature, seen as many offices are including nature-connected elements in their environments, and its decorative use. Also, flowers can open and close, providing a necessary movement element to visualize the feedback to the users. The flower concept seems to have more of an abstract relation to sedentary behaviour, visualizing it using flowers which are unrelated to being sedentary, whilst the breakaway sculpture is an exact physicalization of the behaviour it is trying to improve.

Additionally, ambient feedback was incorporated into the design of the device. Environmental changes in the form of movement, light, and sound were used to catch the attention of the user, motivating them to reflect. This can be related back to the hermeneutic and background relations mentioned earlier. The device should not constitute too much of a hermeneutic relation as it will be too distracting, however it should also not correlate too much with a background relation because it will remain unnoticed in the background. This creates a problematic trade-off between ambient and calm technology. A balance could be found, which is difficult because every individual has their own preference for how much ambient and calm technology is used, as was shown by two users being shocked every time a flower closed whilst the other two did not even notice every time a flower closed. Or, one of the two approaches must be chosen and applied.

Rensink, et al. [31] mentioned the need to explicitly focus on an object to perceive a stimulus in the visual field. For that reason, the three forms of feedback (flower movement, Led lights, and sound) were embedded in the device to catch the user's attention and allow them the chance to explicitly focus on the closing flowers, even if it is only for brief moment. One of the users mentioned improving the device by making the flowers close slowly over a longer period of time (i.e. the whole 20 minutes) instead of suddenly in one go, which shocked him. The flowers were specifically chosen to close in a short moment because this sudden movement is what catches the user's attention and makes them explicitly focus on the flowers and perceive the stimulus. If the flowers were to close slowly, then the user would not notice when they are fully closed because the slow movement would be in their periphery, not explicitly focused and easy to ignore. However, this could be solved by adding a sound every time a flower closes, making the sound the main factor that catches the user's intention instead of the movement of the flower suddenly closing. But slow closing flowers over a long period of time could be more distracting, seen as there is constant movement as well as the servos making noise when moving, thus creating a constant sound whilst the device is on.

Also, the device was designed in such a way that it resembled a decorative object, as advised by Heiner, et al. [34]. According to them, ambient displays are created to function in the periphery of the user's awareness and only comes to the user's attention when appropriate and desirable This is also the case for the flower device that was created; it is quiet and in the periphery of the user's at-home working environment, and only calls attention to it when 20 minutes have passed. Users 1, 2, and 3 did like the design of the device and did not find it distracting whilst they were working, it would only catch their attention when a flower closed.

This leads to the concept of calm technology that was also introduced in the literature review. The aim is for technology to be present without requiring constant attention. Technology should be able to inform the user without constantly disturbing them. The flower device is an example of a calm technology; it is present in the background of the user's environment and informs the user of passing time when necessary. Weiser and Brown [35] had mentioned three signs of recognizing a calm technology; it can easily move from the centre to the periphery and back, it enhances "periphery reach" by bringing more details into the periphery, and it is a good information visualization. These three signs are almost all applicable to the flower device. It uses different types of ambient feedback to move from the centre of the user's attention when a flower closes to the periphery and back, however this did not work for all users because two users would not always notice a flower closing and thus the device was not always part of the centre of their attention. It did enhance periphery reach by making the information of how long they have been sitting more clearly and visually available, and the physical closing of the flowers makes it a good information visualization.

Seen as a person's environment can influence working behaviour, it has proven to be of importance to personalize ones working environment as an expression of identity and creating a more comfortable working environment [37]. The flower device has the function of visualising time and motivating reflection; however, it can also be used to personalize a working environment. It is likely that not everyone in the target audience likes the design of the flowers, but those who do can use it as a decorative workplace object that aesthetically enhances their work environment. As mentioned by a user during the user-testing, it could be useful to make it possible for the user to customize the interval timing of the closing flowers so that they have more control and can create their own routine that they may be more likely to follow than the current one.

The flower device also uses a feedback loop to make the users more aware of their behaviour, which could then lead to a behaviour change. The three phases of a feedback loop, as described by Damian, et al. [39], consisted of perception, reflection, and action. Looking at the flower device, *perception* occurs when the flowers close and open to display the sedentary behaviour of the user. Then,

reflection happens as the user processes and evaluates the information provided about their sedentary behaviour. Lastly, during the *action* phase the user has the option of staying seated or getting up to move and break their sedentary behaviour. The feedback increases the user's awareness of their behaviour and allows to reflect on and change it. The results have shown that the users did process and evaluate how much time had passed, however, in the action phase they chose not to make a change and would remain sitting. Only one user would get up to walk around the room. Therefore, it can be concluded that the feedback loop was effective in displaying the information in the form of time and allowed the user to reflect on this behaviour, but it did not make them physically act on this reflection. Perhaps the device should "do" something instead of purely visualizing information for the user to receive, reflect, and possible act upon. On the other hand, it could be that the target audience is somewhat aware of the negative impact of sedentary behaviour, but not enough. Maybe if they knew more about the negative effects and their consequences and were reminded of them, then they would be more likely to reflect on their sedentary behaviour and change it.

8.3 Analysing Specifications

In chapter 5 Specification, a number of requirements were created that the device should meet. A MoSCoW analysis was done to categorize the requirements by importance. The following Table 5 shows whether the device has met the set requirements.

Table 5 Analysis of requirements

MoSCoW component:	Requirement	Requirement met?
Must have		
	- Turn on/off device whenever	Yes, there is an AC/DC adapter that causes the device to turn on when plugged in and turn off when plugged out. It would have been even better if the device would turn on/off with the push of a button instead of plugging and unplugging the adapter.
	- Flower closing every 20 minutes	Yes, the flowers are attached to servos that are programmed to close every 20 minutes.
	- All flowers opening to restart	Yes, after 60 minutes all the flower re-open
Should have		

	- Aesthetic (organic look and calm colours)	Yes, the flowers give off a natural look and the colours used are light and calm.
	- Portable	Yes, the device is light and stable enough to be portable, as well as being attached to an adapter that allows to be powered through any socket.
	- Size (large enough to clearly perceive feedback but small enough to be portable)	Yes, the device is small enough to be portable and fit on any desk or working environment, but large enough to see the components clearly.
Could have		
	- Feedback cues	Yes, besides the movement of the closing flowers, the device also has LEDs that turn on when a flower closes and a sound at the end of the cycle when all the flowers have closed to signify one hour having passed.
Won't have		
	- Extra features	No, there was a lack of time and equipment to add any additional features. For future improvements additional features can be added, such as a speaker, and displaying humidity and temperature.

8.4 Limitations

There were a number of limitations that may have had an effect on the final results of this project. Primarily, the COVID-19 situation. Due to the intelligent lockdown all research and testing had to be done from home. The interview with the Industrial Design teacher Maarten Smith was done online instead of in person, which is not necessarily uncommon but interviews in real life allow for more interaction with the interviewee and a smoother conversation without audio and video lagging. Additionally, due to the corona measures it was difficult to test the device with a large sample size and a variety of users from the target audience, it was limited to four users. Also, due to the time constraints of the project, the high-fi user testing lasted three hours, however having the users test the device for a longer period of time may have provided some differences in the results.

9 Conclusion

9.1 Conclusion

To conclude, the goal of this project was to use calm and persuasive technology to create a device that motivates reflection on sedentary behaviour in an at-home working situation. This was done by creating and testing a device that applies calm and persuasive technology concepts and techniques that were studied through literature reviews. The process was iterative, consisting of brainstorming, sketches of design concepts, lo-fi prototype testing, and ending with high-fi prototype testing. The device was affective in inciting reflection on the amount of time that had passed, however it did not necessarily make the users reflect on their sedentary behaviour and the possibility of changing it. Perhaps a better balance between ambient and calm technology should be found, however further testing is needed to determine how this device can most effectively motivate reflection on sedentary behaviour.

9.1 Future Work

If this device were to be further developed, there are a number of aspects that could be changed to make it more successful and perhaps more desirable for the target audience. The possible future implementations are based on feedback received through the online survey, lo-fi, and high-fi user testing. There were comments that mentioned it would be beneficial if the users could customize the time intervals of the flowers closing. This will provide them with more freedom over the user of the device. Also, it could be helpful if there were a display that showed the total number of cycles the device has gone through since turning it on. This would solve the problem of trying to remember how many times the flowers have closed and opened. Moreover, as has been mentioned in the discussion, perhaps the device is too calm and should be adapted to use a more direct or forceful approach to make them reflect on sedentary behaviour. Related to this, it could be a possibility to change the design of the device so that it is more physically related to the concept of sedentary behaviour, so that when they look at the device they are instantly visually reminded of their sedentary behaviour.

Furthermore, additional features could be added to the device to give it multiple functions and make it more desirable. The device could include a speaker that allows the user to play and control music as well as a small screen that displays temperature and humidity. Also, it might be useful if the timing of the device were more customizable, allowing the user the freedom to choose at what time intervals each flower closes. Besides giving feedback related to time, the device could also provide feedback to

remind the user to drink more water, making them more aware of how much water they should be drinking and improving their drinking habits.

Additionally, the device could be adapted in such a way that it is able to display information about the sedentary behaviour of other people working from home. Perhaps others using such a device who are in a similar location or specific friends who users can connect with. The device would then allow the user to indicate when they are sitting to work and when they are taking break. This information would then be visible to friends, motivating them to take more or less breaks. Displaying collective information can sometimes be more motivational, however this idea would need to be tested and iterated further.

Appendices

Appendix A: Lo-fi user test questions

Prototype 1 (6 flowers):

1. Do you understand what the prototype does? Please explain.
2. Did you pay attention to the object when a flower closed?
3. Was the object distracting whilst you were working?
4. Once all the flowers were closed, did it make you reflect on / think about how long you have been sitting?
5. Are there any features you think are missing, if so which ones?
6. What did you like about the device?

Prototype 2 (3 flowers):

1. Do you understand what the prototype does? Please explain.
2. Did you pay attention to the object when a flower closed?
3. Was the object distracting whilst you were working?
4. Once all the flowers were closed, did it make you reflect on / think about how long you have been sitting?
5. Are there any features you think are missing, if so which ones?
6. What did you like about the device?

Final questions:

1. Which of the three did you prefer and why?

Appendix B: High-fi user test questions

Purpose = making the user more aware of how much time has passed and motivating them to reflect on how long they have been sitting still to work.

1. Do you think the product design matches the above-mentioned purpose? If so, how?
2. In your own words, how would you describe the device?
3. Was the device distracting whilst you were working or was it calm and in the background?
4. Did you look at the device when a flower closed?
5. What did you think of the multiple types of feedback (movement of flowers opening and closing, the lights turning on/off, and the sound after all of the flowers were closed)?
6. Were there any features you ignored or feel should be removed? Please explain.
7. Did the device make you reflect / think about how much time had passed and your sitting behaviour more than you usually do without the device?
8. What, if anything, would make you want to use this device frequently?
9. What is your opinion on the aesthetic of the design?
10. Do you have any other comments, opinions, or ideas about the device?

Appendix C: programming code servos

```
//3 servos, on turns every 20 minutes, after 60 minutes they all turn back to initial position
//3 LEDs, turn on when their corresponding servo turns, all turn off after 60 minutes
// code inspired by https://learn.adafruit.com/multi-tasking-the-arduino-part-1/now-for-two-at-once

#include <Servo.h>

int ledPin1 =  12;      // the number of the LED pin
int ledState1 = LOW;            // ledState used to set the LED
unsigned long previousMillis1 = 0;       // will store last time LED was updated
long OnTime1 = 2460000;          // milliseconds of on-time 2400000
long OffTime1 = 1200000;         // milliseconds of off-time 1200000

int ledPin2 =  13;      // the number of the LED pin
int ledState2 = LOW;            // ledState used to set the LED
unsigned long previousMillis2 = 0;       // will store last time LED was updated
long OnTime2 = 1260000;          // milliseconds of on-time 1200000
long OffTime2 = 2400000;         // milliseconds of off-time 2400000

int ledPin3 = 11;   //3rd led pin
int ledState3 = LOW; //starts off
unsigned long previousMillis3 = 0;
long OnTime3 = 800;         //  1000
long OffTime3 = 3600000;       // 3600000

Servo servo1;
Servo servo2;
Servo servo3;
int buzzerPin = 3;
```

```
void setup()
{
  // set the digital pin as output:
  pinMode(ledPin1, OUTPUT);
  pinMode(ledPin2, OUTPUT);
  pinMode(ledPin3, OUTPUT);
  pinMode (buzzerPin, OUTPUT);
  servo1.attach(9);
  servo2.attach (6);
  servo3.attach (5);
  servo1.write(100);
  servo2.write(100);
  servo3.write(105);
}

void loop()
{
  // check to see if it's time to change the state of the LED
  unsigned long currentMillis = millis();

  if ((ledState1 == HIGH) && (currentMillis - previousMillis1 >= OnTime1))
  {
    ledState1 = LOW;  // Turn it off
    servo1.write(95);
    previousMillis1 = currentMillis;  // Remember the time
    digitalWrite(ledPin1, ledState1);  // Update the actual LED
  }
  else if ((ledState1 == LOW) && (currentMillis - previousMillis1 >= OffTime1))
  {
    ledState1 = HIGH;  // turn it on
    servo1.write(75);
    previousMillis1 = currentMillis;   // Remember the time
```

```
  digitalWrite(ledPin1, ledState1);    // Update the actual LED
}

if ((ledState2 == HIGH) && (currentMillis - previousMillis2 >= OnTime2))
{
  ledState2 = LOW;  // Turn it off
  servo2.write(100);
  previousMillis2 = currentMillis;  // Remember the time
  digitalWrite(ledPin2, ledState2);  // Update the actual LED
}
else if ((ledState2 == LOW) && (currentMillis - previousMillis2 >= OffTime2))
{
  ledState2 = HIGH;  // turn it on
  servo2.write(73);
  previousMillis2 = currentMillis;   // Remember the time
  digitalWrite(ledPin2, ledState2);   // Update the actual LED
}

if ((ledState3 == HIGH) && (currentMillis - previousMillis3 >= OnTime3))
{
  ledState3 = LOW;  // Turn it off
  servo3.write(105);
  previousMillis3 = currentMillis;  // Remember the time
  digitalWrite(ledPin3, ledState3);  // Update the actual LED
}
else if ((ledState3 == LOW) && (currentMillis - previousMillis3 >= OffTime3)) {
  ledState3 = HIGH;  // turn it on
  servo3.write(73);
  tone(buzzerPin, 1200, 1500); // makes buzzing sound at the end
  previousMillis3 = currentMillis;   // Remember the time
  digitalWrite(ledPin3, ledState3);   // Update the actual LED
}
```

Appendix D: Thematic analysis of high-fi prototype results

User	Reflection	Distraction	Feedback Type	Physical Design	Improvements
User 1	Reflection is up to users themselves	No movement/sound was not distracting	Flowers closed caused a bit of a fright	Really like the look	Not sure how much the lights added
	Aware of how focused I was on work	Flowers closed caused a bit of a fright	Small sound/buzzer made me aware of its presence	Lights were aesthetically pleasing	
	Helped me reflect on another 20 min having past		Not sure how much the lights added	I really like it	
	To take enough breaks			It is clean and easy to place on desk	
	Reminds me how much time has passed				
User 2	more focused on whether I was being productive with the time	Most of the time the device was not distracting	I mostly noticed the flowers closing	a very nice design, I like the colours and shapes of the petals.	would have been really cool if the flowers closed gradually, might have made it calmer and more in the background.
	Sometimes I wondered whether I should take a walk or not, but then I did not want to miss the flowers closing.	speed at which the flowers closed made me jump each time	did not really notice the lights or hear the sound		I think the light and sound are not necessary

	It made me reflect on my sedentary behaviour, but I'm not sure if it was more than I normally do.	definitely was conscious of the device being near me.			It would be cool if it were placed in a real aquarium with fish swimming round it. Or even if the flowers were underwater
					some sort of interesting question or trigger to think about, would help me reflect more concretely about what I could change about my sedentary lifestyle.
User 3	I was reminded multiple times of not having left my workplace	Device was quiet and not disruptive	Only caught my attention when flower closed	Portable	Add a sound when a flower closes to make more obvious
	Helpful tool to remind you of sedentary behaviour		Did not always notice flower closing	Can be placed in any workplace	Could make more portable through USB connection not laptop or power bank
	Realizing it is good to move more, like walking around the room		Lights do not seem to have an added value	Takes up little space on the desk	
	Good reminder for sitting long			Nice, large flowers that are nicely decorated with pretty colours	

User 4	matches the purpose of making the user aware of how much time has passed	I barely noticed it was there	Looked at the flower close if I happened to be looking that way	clear what it represents and natural	Glitches that made the servo make noise
	not specifically motivating me to reflect on how long I have been sitting.	I did not really notice them	When I looked at it I saw the lights	rather big and sharp/rough	very full work day with a lot of self study, then I could maybe use the device to keep track of my work and break time and be able to change the time interval
	I did think quite a lot about how much time had passed		Could see movement from the side of my viewing angle		
	I did not directly link the passing of time with how long I've been sitting		I didn't notice when the flowers closed and the LEDs went on		

	made me conscious of how much time had passed				
	I kept calculating how long I had been sitting here based on how many times the flowers had opened and closed				

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