Designing Tangible Interactive Technologies for Promoting Physical Activity at the Office

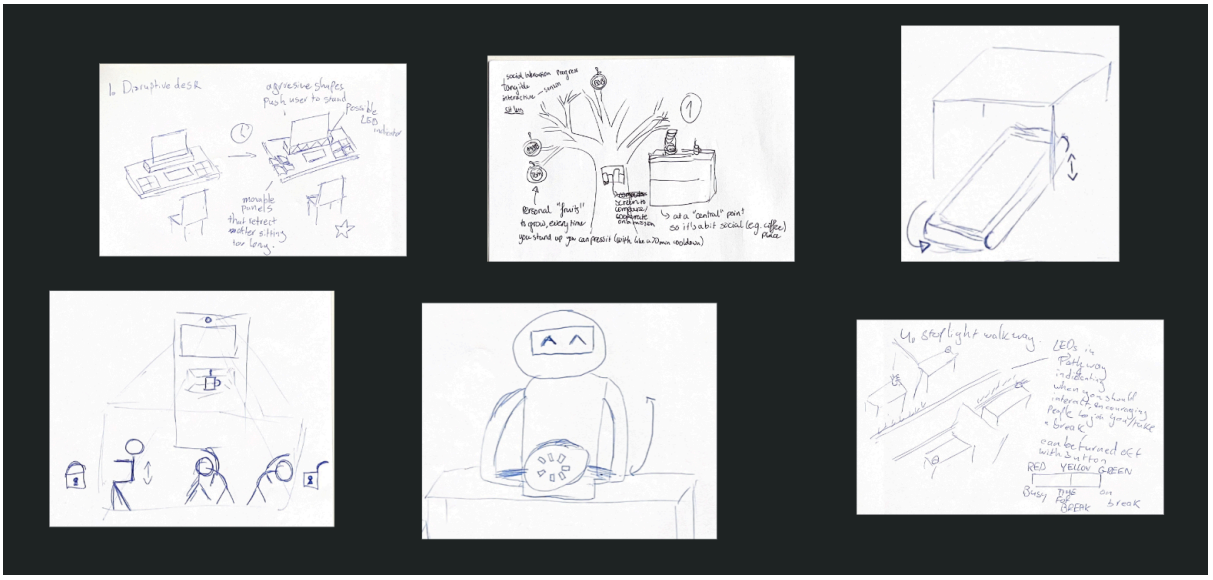
Author: Reinier Algra

BSc. Creative Technology, University of Twente

Supervisor: dr. Champika Ranasinghe

Critical observer: Nacir Bouali MSc

July 5, 2024



Abstract

While interventions promoting physical activity have become increasingly popular, they have still not been widely adopted and are often disregarded. This project presents a focus group and collaborative design session that explores the feasibility and potential of using the everyday office as an interface to promote physical activity through tangible interactive technologies. A focus group was held with potential users to gain insights into their physical activity levels, motivations, and impressions of existing interventions. A result of the focus group was the formulation of design considerations. Key findings revealed that social interaction and subtle, non-intrusive interventions were highly valued. Following this, a collaborative sketching session was held, where participants were invited to design and draw sketches of tangible interactive technological interventions aimed at stimulating physical activity in offices based on the design considerations. The session revealed many innovative design ideas, including interactive desks and chairs, office companions, and an interactive office tree. The design ideas, analysis, and classification demonstrate the potential and feasibility of these interventions.

Acknowledgement

First, I would like to thank my supervisor, Champika Ranasinghe, for her guidance and support in this graduation project. She has been crucial in the direction of this project through our weekly meetings and discussions, allowing me to grow a lot as a researcher. I also extend my gratitude to all the participants of the focus group and collaborative sketching session. Thank you so much for providing insights and creative ideas that formed the base of this research. Lastly, I want to thank Dóra Csiszár for helping me with brainstorming and discussions on the project, and GAF for allowing and supporting me to hold a focus group at their office with willing employees.

Table of Contents

List of Figures

Chapter 1 – Introduction

The leading cause of death in Western society is Non-Communicable Diseases (NCDs) [2,3]. NCDs encompass health conditions that are neither infectious nor transmissible, such as cancers or diabetes [1]. According to the World Health Organization, NCDs are the primary cause of death and disability worldwide, resulting in 41 million fatalities annually [2,3], which represents 74% of all global deaths [3] and 90% of all deaths in the EU [32]. These illnesses are predominantly linked to an individual's lifestyle choices or behaviours. Physical inactivity is one of the main factors that can influence the risk of contracting NCDs [1-6]. Dutch office employees are the best in sitting for long hours, as seen in a report from the research institute TNO [7]. The World Health Organization's regional office for Europe recognizes the necessity of promoting physical activity in the workplace for its health benefits through a publication providing initiatives for this [21]. Per Sustainable Development Goal 3: ensuring healthy lives and promoting well-being [17], successfully promoting physical activity to office employees will significantly improve overall well-being by reducing the risk of NCDs.

Having observed the increase and unhealthy amount of sitting in current society's knowledge workers, many design interventions aim to reduce prolonged sitting or inactive behaviour. These are most often in digital form [12,13] and through regular PC or similar reminders [11]. However, current app-based approaches have clear disadvantages, such as display blindness, attention overload, and low recall [8]. Overcoming these shortcomings, the field of tangible, technological interventions is suggested to be very promising [13] and has received much traction in recent research. A tangible user interface (TUI) is a physical artefact that allows users to interact with digital information. These tangible user interfaces have the potential to increase engagement, social collaboration, and interaction [14,15]. The present project aims to explore the feasibility and potential of using the everyday office as an interface to promote physical activity at work using tangible interactive technologies. The research question is thus formulated as: *How can tangible interactive technologies be used to promote physical activity in an office?*

To explore this question, a user-centred approach was taken, and the project conducted a literature review, focus group, and collaborative sketching session. This paper presents the design considerations from the focus group, the design ideas from the collaborative sketching workshop, and an analysis of key takeaways, concepts, and classification of the designs. The designs capitalise on the creative implementation of interactive technologies.

Chapter 2 presents the current interventions promoting physical activity, tangible user interfaces, and the opportunity for natural interaction. Chapter 3 elaborates on the methods and techniques used in the project, and Chapter 4 describes the detailed method and findings of the focus group, whereas Chapter 5 does so for the collaborative sketching session. Afterwards, the discussion takes place with future work and a conclusion.

Chapter 2 – Background Research

An overview of current strategies and what could be improved in them is needed to best design an intervention targeting physical activity in an office environment. The first part of the literature review will focus on understanding current interventions targeting physical activity and overall well-being for employees at the workplace. Here, the effectiveness of digital and tangible solutions will be explored. The second part will seek an opportunity in the research within the specific solution type found for design considerations for this current project.

2.1 Current interventions promoting physical activity in the office

Having observed the increase and unhealthy amount of sitting in current society's knowledge workers, many proposed design interventions aim to reduce prolonged sitting or inactive behaviour. These are most often in digital form [12,13] and through regular PC reminders [11]. Nudges work effectively when an effort is made to follow them through other motivational factors, as they do little to motivate the user. Digital solutions are also found to have clear disadvantages over their tangible counterparts through display blindness, attention overload, and low recall [8]. Overcoming these shortcomings, the field of tangible, technological interventions is suggested to be very promising [13] and has received much traction in recent research. A tangible user interface (TUI) is a physical artefact that allows users to interact with digital information. These tangible user interfaces reportedly increase engagement, social collaboration, and interaction [14,16]. Some examples include Zenscape [17], a small zen garden giving sound and visual signals that remind the user to take frequent breaks; or i-Candies [18], where putting unique candy-like objects in a smart bowl changes the display information at a company coffee corner. Another project [19] created a network of signpost-looking stands with note-taking abilities around the office environment to facilitate walking meetings.

While tangible user interfaces (TUIs) are great for increasing engagement and interaction, much improvement is still possible here. In a research landscape analysis on tangible user interfaces, [8] presented design considerations for future interventions targeting well-being in an office environment. To enrich the user experience and provide more control to the user, one such design consideration is to add direct, user-controlled interaction to the artefact. The users can then, for example, give personal input on their preferred ways and times of working or taking breaks. The artefact could use this data to

personalize the output experience, providing a more effective and engaging intervention. One study [15] for instance, used individual input data to give automated, personalized, and actionable suggestions for a healthier lifestyle. [16] States the effectiveness of natural actuation in TUIs. The research highlights the lack of tangible user interfaces integrating this and direct future research for its promise. Specifically, creating artefacts for physical manipulation like touching, pointing, and performing publicly visible actions. The tangibles allow for bodily engagement to control a digital system.

2.2 Natural interaction in tangible interventions

Having established the opportunity to physically manipulate tangible interventions for promoting physical activity, few existing artefacts utilize it. Crucial attributes for the success of these interventions are intuitiveness, unobtrusiveness, ability to entice passers-by, and robustness, among others [14]. On top of that, making it easy to learn what happens and how to engage with it by watching is a significant contributor to performance when combined with general visibility [14]. An example of a tangible user interaction designed for direct, user-controlled interaction is a microwave door holding a rotational knob that is also slideable to the side for controlling both the power and time [16]. This artefact makes use of the simple physical motions of rotating the hand and pulling it to the side. Designing around basic body movements allows for a natural engagement with the object. Other studies have created a tangible technology in the shape of already existing, non-technological environments. The i-Candies [18] described earlier took this approach to their design. Putting candy in a bowl is an action readily taken in people's lives. That project took notice of the action in a social environment like a coffee corner and attempted to design an intelligent application integrated with an everyday object. Many current interventions have made use of a break or created a break from work, while [20] chose to transform an existing digital act into a tangible physical one. They created a physical 'letter' artefact on which the participants could load an email, which had to be moved to a mailbox somewhere in the workplace to be sent digitally.

Natural interaction thus sets the tone for different engagement categories to stimulate physical interaction. They could try to motivate the user through different types of data physicalizations [15], require large physical movements to operate [19,20], and/or facilitate a different way of doing existing actions [20].

2.3 Conclusion

The goal of this literature review was to gain an overview of current interventions addressing physical inactivity among office workers and to find a promising design direction. Current interventions predominantly focus on digital solutions, often making use of reminders, while tangible user interfaces (TUIs) are emerging as a promising alternative through their ability to increase engagement and interaction. Within the field of TUIs, natural interaction elements like physical manipulation can even further improve their effectiveness. There are many ways to implement them for stimulating physical activity, for example, physicalizing existing work tasks, facilitating physically active meetings, stimulating (micro-) breaks, and inciting active postures.

A limitation of the research is the small amount of literature that currently exists, to the best of my knowledge, on natural interaction in TUIs. As it is a new field, there is very little research on it yet. On top of that, each intervention that incorporates such interaction involves a lot of technical complexity. As such, long-term studies are rarely found due to the needed resources, cost, and time passed since the creation of the field. This decreases the reliability of the results in the studies referenced, but the opportunity that this field presents for future interventions is very relevant nonetheless.

Future research could compare different ways of implementing natural interaction with tangible interventions, such as basic movements and existing complex actions. Another interesting direction would be to transfer digital actions into physical ones. An example of this could be physically opening a small box to open a desktop folder. These cases are not often found currently but could integrate more physical activity into daily life through the artefact being placed at a distance from the user or requiring large bodily movements to operate.

Chapter 3 - Method

To explore the feasibility and potential of using the everyday office environment as an interface for tangible interactive technologies for promoting physical activity at work, the users' needs and preferences have to be gathered. This was ensured by conducting a focus group with potential users. During this session, the participants were asked to share their current physical activity levels, motivations for physical activity, and impressions on existing tangible office interventions meant to promote physical activity.

Findings from the focus group were then used to formulate design considerations to guide a creative process of designing interventions that meet the users' needs and preferences. To do this, a collaborative sketching session was held, employing a merger of different existing proven methods to best suit this subject. In this method, participants created sketches of their intervention ideas with collaborative iteration. These end design ideas were then analysed and categorised in a classification system.

Chapter 4 - Focus Group

4.1 Method Focus Group

4.1.1 Participants

The participants were five employees from an architecture office in Rotterdam. These participants were chosen based on their experience working in an open office layout in The Netherlands to ensure relevance to the study's focus on such environments. No compensation was offered for taking part in the session. The focus group had approval from the university's ethical committee. All the participants read the participant information letter and signed the consent form before the session (See appendix A and B). A limitation of this study could be that the participants voluntarily participated and could have a bias towards becoming more active already, thus possibly not receiving a true representation of the office. Another limitation could be the influence of this office's work culture on their perception and awareness of decreasing sedentary behaviour at the workplace (collectively).

4.1.2 Procedure

The focus group was conducted in the participants' office meeting room, within their work environment. This allowed the participants to visualize the artefacts and their use more easily. It lasted 55 minutes and was formatted as a semi-structured group discussion with a visual PowerPoint presentation. The session was divided into three main phases. The focus group started with a welcome and introduction of the present project and its relevance, followed by an overview of the session's procedure. Afterward, phase I commenced.

4.1.2.1 Phase I

In the first phase, participants were asked about their current level of physical activity, their attitudes toward sedentary behaviour, whether they have a physically active working style and how they sustain it, whether they desire to be more physically active at work, and the significance of social interaction in this context.

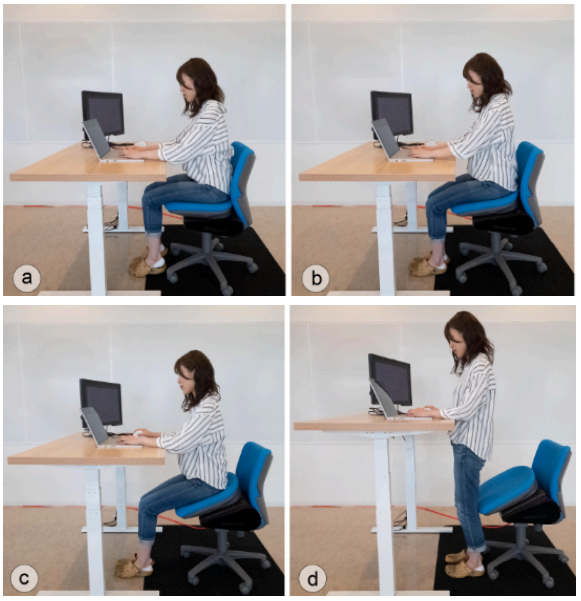
4.1.2.2 Phase II

The second phase introduced the three main categories found in current interventions that aim to reduce sedentary behaviour, and showed an example of an existing intervention in literature for each category, asking multiple questions. For each example, the intervention was explained with images shown (see Figure 1) and the participants were asked for their

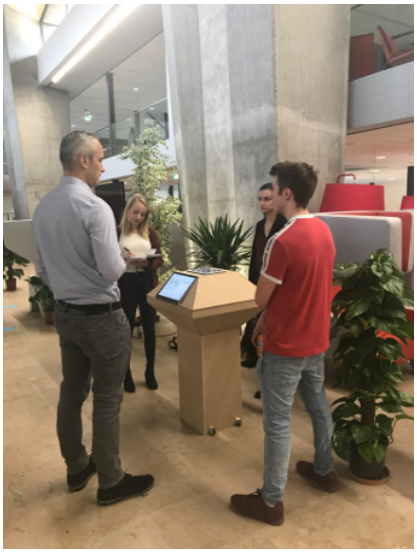
impressions, what they (dis-) liked about them, whether they could see themselves using it, what their perceived significance of interaction is, and whether they could name any possible improvements or have any other comments. These questions were guiding, and the participants were encouraged to discuss amongst themselves during this phase.

The observed categories in literature are tangible interventions that incite a change in posture, stimulate the taking of (micro-) breaks, or introduce physically active ways of working, which can be divided between physically active meetings or work tasks. See Figure 1 for the examples shown in the session.

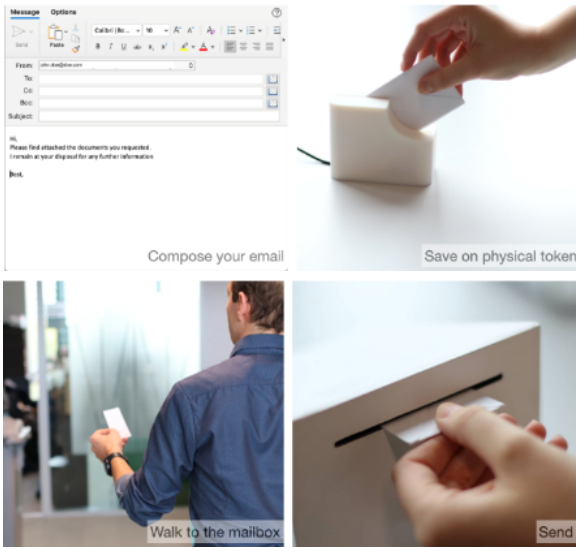
(a) Taking (micro-) breaks: LightSit [23]



(b) Change in posture: TiltChair [24]



(c) Physically active meetings: The Hub [19]



(d) Physically active work tasks: A2I2 [20]

Figure 1: The intervention examples

At the end of phase II, the participants were asked which of the interventions they preferred the most and why. This gave valuable insight into user preferences and requirements.

4.1.2.3 Phase III

In the last phase, the same questions as in phase II were asked, but on an intervention developed by the author of the project. The concept was described without sketches or designs being displayed.

The intervention concept was created by the student based on the background research done earlier. It was the result of iterations of individual brainstorming of designs. The artefact is a small and discreet indication object on the user's desk that uses light as an unobtrusive data conveyor, a timer to regularly incite breaking seating behaviour, and social interaction as a secondary motivator. It displays a progression of the timer through the light's color gradient that changes color from white to red slowly over time as the user continues sitting. This light is visible to colleagues sitting next to the user and is intended to encourage taking standing or walking breaks with a colleague whose light is also red. The artefact's light color slowly resets within a couple of minutes as the user is not seated. One variation was to include another light, in sync with the original, on top of the desk. This would be visible to the whole office. Another variation would have all the indication lights of people centrally connected. Once in a while, four employees' lights that have been seated for a while would be encouraged to take a break together.

After all phases were finished, the participants were asked to share any ideas they had or any other remarks they might have. Lastly, they were debriefed on the future of the project and thanked once more.

4.1.3 Analysis

Open coding was utilized on the transcribed focus group data. This resulted in the identification of important user requirements and preferences as well as improvements on the phase III concept. These requirements and preferences were used to guide the participants of the collaborative sketching session. This sketching session will be elaborated on below.

4.2 Findings Focus Group

4.2.1 Current physical activity levels and attitude toward sedentary behaviour

The participants shared a variance of daily activity levels, with one participant noting very high amounts of activity. Regardless of their individual physical exercise in their free time, all participants acknowledged the potential damage of prolonged sitting at work. They also highlight feeling the need to change their current sitting behaviour at the office to tackle that. One participant shared, “I was always sitting, sitting, sitting behind a computer or in meetings.” And another “I always would like to move more [at the office].” with the other participants quickly sharing that moving more is never the main motivator for getting up at work.

The whole office is equipped with standing desks, but they are rarely used in their standing mode. A participant states, “I have a sit-stand desk, but I often forget to use it. When I'm really busy, it's just easier to stay seated.” Related to this, another participant mentions that "When deadlines are tight, it's hard to remember to move. I get so focused on the task at hand that I can sit for hours without realizing it. By the time I remember to stand up, I'm already stiff and uncomfortable." In those situations, designing an intervention that allows for an active working posture could accommodate the harsh deadlines.

The majority of the employees participate in a daily walk at the office at noon for about half an hour. Another participant also mentions appreciating the fact that he smokes as it makes him walk more.

4.2.2 Motivations for physical activity

Social interaction emerged as a key motivator for participants to remain active. One participant highlighted the success of the office's daily lunch walks, "I always go out for lunch walks, preferably with others. If no one is available, I do it alone. It’s important for me to take these breaks and move around. Sometimes, just having someone to talk to makes a huge difference in sticking to this habit." This indicates that social aspects can significantly enhance the effectiveness of physical activity interventions, "Having a buddy who also wants to be active really helps. We remind each other to stand up, take breaks, or go for a quick walk. It's a great way to stay accountable and make it a fun part of the day." Some activities the office participates in, such as running the marathon and a football tournament for architects, were only attended and trained for every week by a participant because one colleague enthusiastically persuaded them, the participant states happily.

Participants also suggested using rewards as additional motivation, "Rewards could be a great motivator. Even small incentives can make a big difference in encouraging regular movement." One participant mentioned a reward like collecting stickers in a book.

4.2.3 Impressions on existing interventions

4.2.3.1 LightSit (Figure 2)

This intervention received mixed reviews. While it could create beneficial peer pressure and social interaction, it might also increase stress under high workloads, "If the office layout lets you see the light of others, it creates some peer pressure in a good way. It encourages social interaction and stimulates moving together if the lights are both indicating to move more. However, in high workload or stress situations, it could just add to the stress."

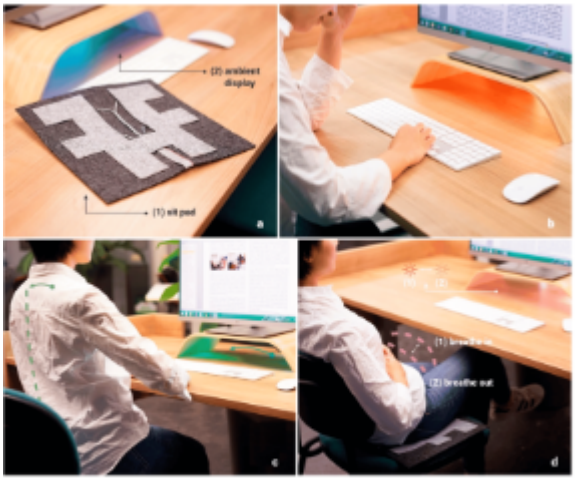


Figure 2: LightSit [23]

Participants suggested adding an indicator showing how long one should move to reset the light, and emphasized the importance of research-based timing settings, "There should be an indicator for how long you need to move to reset the light. I wouldn't want to customize the timing; it should be research-based for optimal effectiveness. Direct feedback on progress through a gradient or maybe even a reward would be helpful." However, not all participants found it useful as one participant would "probably have moved already in the meantime. Many people have the motivation to stand while working, but never do."

4.2.3.2 TiltChair (Figure 3)

Participants generally disliked the idea of forceful posture changes, finding it potentially annoying and restrictive, "I would not like it, it would be annoying. It would only work if all the chairs in the office were like this, otherwise, I'd just get another chair. Personalization wouldn't help; when busy, you don't want the fussing around. It

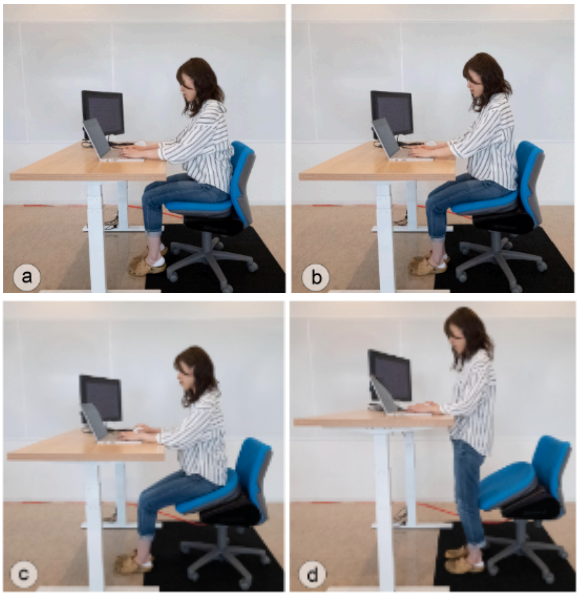


Figure 3: TiltChair [24]

would be very inconvenient during team meetings."

Some recognized that it might help certain people, but emphasized the importance of user autonomy, "Some people might need this, but I want to decide for myself when to stand or sit."

4.2.3.3 The Hub (Figure 4)

Walking and standing meetings received mixed reactions. While participants appreciated the concept for informal meetings, it was found impractical for technical tasks, "I like walking meetings, but the screens and moving around would be a bit much. Standing meetings would be great for brief, informal meetings. However, for technical drawings and detailed work, it wouldn't really work. Confidentiality in some meetings is also a concern."

Figure 4: The Hub [19]

The idea of a bar-height table for informal meetings was well-received, "A bar-height table for informal meetings would be great. It creates urgency for brief meetings and encourages moving around. It would be a good addition to existing meeting rooms."

4.2.3.4 A2I2 (Figure 5)

Participants were unsure about this intervention's practicality, expressing concerns in workflow obstruction and the irregularity of its effectiveness based on urgency, "I like the idea, but practically, if the email isn't urgent, would they pile up until the end of the day? The amount it makes you move really depends on the user's motivation. If it's busy, you wouldn't move there."

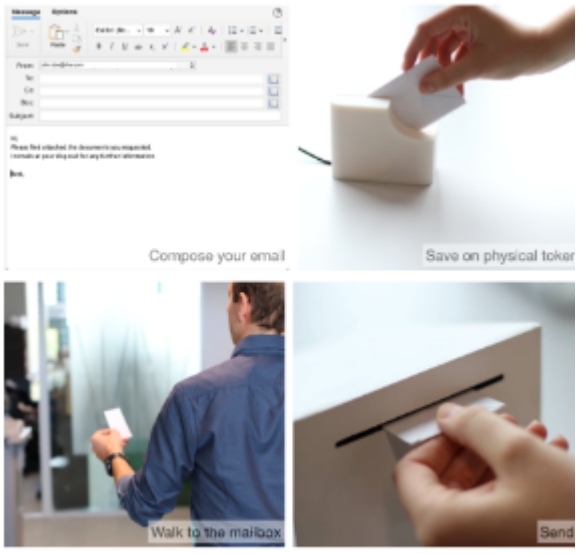


Figure 5: A2I2 [20]

Participants suggested alternatives like planning meetings on a physical board to encourage movement without disrupting workflow, as they are perceived as side tasks, "Planning meetings on a physical board where you have to walk to reserve a time slot could work better. Physically pinning the meeting on the board would not obstruct the workflow as much."

4.2.3.5 Other remarks

One participant mentions a reward system for tracking progress in a game-like manner. A reply quickly came elaborating how games would not be effective in a professional environment.

4.2.3.6 Preferred intervention

Three of the five participants preferred the LightSit [23] the most as it “seems like it would work well for creating social motivation. Seeing others' lights would remind me to move more often.” The other two participants indicated their favourite was The Hub [19], “I would prefer the Hub for its potential to encourage standing meetings and brief interactions. It seems practical for informal gatherings.”

4.2.4 Impressions on concept intervention

The intervention concept described in 3.1.2.3 received enthusiastic feedback for its incorporation of social interaction, “I think the visibility to others could motivate to get the sitting done with for a minute together.” Its effectiveness shines especially when it's busy and “you forget to take your break — It's good if somebody else tips ‘hey come on, your colour’s changing’.”

In the variations where the indicator light is hanging from the ceiling in the open above the desk or sitting on the desk only visible to neighbours, the participants collectively preferred the latter. One participant also mentioned that “The ones you were sitting next to more often are the ones you're in a project with or you're collaborating with at that moment”, arguing that a person “three rows down saying ‘hey you’, wouldn’t work as well”.

The collectively controlled variation was appreciated, “I like the one which is collective control; the other ones are also nice.” However, an important feature should then be included to allow some time to react to the break invitation, “I think for me it should be more or less voluntary. So that I have several minutes or maybe a quarter of an hour to decide whether I go walking or not, instead of just moving now.”

4.2.5 Design considerations and requirements

Based on the focus group insights, the following design considerations and requirements have been formulated.

- *Break prolonged sitting.* Design interventions that focus on breaking prolonged sitting periods rather than increasing overall physical activity.
- *Subtle interventions*. Develop interventions that are subtle without being intrusive or disruptive (e.g. forced posture changes).

- *Respect workflow*. Design interventions that integrate into the work environment without obstructing workflow.
- *Incorporate social interaction*. Use social elements to increase motivation. Group activities, social reminders, and team-based incentives can be highly effective.
- P*rovide direct feedback*. Ensure that the intervention provides clear and direct feedback on progress. Users want to see how long they've been sitting and when it's time to move.
- *Avoid customization*. Implement scientifically set parameters for interventions rather than allowing users to customize settings.
- *Use rewards*. Consider incorporating a reward system to additionally motivate users to engage in regular physical activity.
- *Stay professional*. Maintain a professional environment through the intervention.
- *Change in posture.* Consider interventions that allow for different working and meeting postures.

Chapter 5 - Collaborative Sketching

5.1 Method Collaborative Sketching

5.1.1 Participants

The collaborative sketching workshop was held with six participants, whom are PCs for the rest of this report. Five of the participants were in their thesis module, the last module, of the Bachelor Creative Technology. The “goal of Creative Technology is to design products and applications that improve the quality of daily life in its manifold aspects, building on Information and Communication Technology (ICT)”, “A paradigm of Creative Technology is to make use of existing technology in novel combinations –in contrast to developing new technology” [22]. For this end, these students are taught to be experts in sensing and actuation technologies and how to use those in creative applications. This skillset is, to the authors knowledge, the most relevant for designing tangible interactive technological interventions to promote physical activity at the office. The last participant had already graduated from this programme and is currently enrolled in MSc Data Science at the same university.

The participants were recruited through the authors network via direct messages. They received no compensation, but were given snacks during the session. The collaborative sketching session had approval of the university’s ethical committee, and all

participants read the relevant participant information letter and signed the consent form before the session (See appendix C and D). A limitation of the study is that study consisted only of students with no experience working full-time in an open office.

5.1.2 Procedure

The collaborative sketching session was held inside a meeting room of the university for the accessibility of the participants. It lasted one hour and was structured in five phases. The materials used were post-it notes, pens and A3 papers for the participants to sketch on.

After an introduction to the research, the participants were explained the structure of the session and given the set of design considerations and requirements found in the previously held focus group (see Chapter 4.2.5). Afterwards, a round of sketching was held, followed by the participants briefly presenting their designs and discussing them. Following that, another round of sketching was held where the participants were asked to improve or expand existing sketches from the previous round and prompted to create new designs if inspiration strikes. The session ended with a final round of presenting the new designs and a discussion of them, including their perceived important notions and concepts in these designs.

The structure of the collaborative sketching session is based on [25] and [26]. The C-Sketch [25] was found to be a very effective idea-generation technique for engineering design, to be used after the problem definition and clarification stage in the design process. In this method, the engineers independently sketch their solutions, then pass their design to the next person and try to improve it. The last step repeats, creating a cycle. This method places value on iteration and the use of sketching for idea generation, also stated by [30]. In between these steps, this project added a round of discussion. The aim of this was to allow for other participants as a group to verbally propose new features [26], pick out valuable concepts to develop further, as well as find any immediate faults in the created designs. This structure of individual sketching followed by discussion was also done in [31]. Aligning with the goal of bringing out novelty and creativity, [29] suggested keeping the briefing session brief. The briefing was thus limited in additional information given on background research. Lastly, before the open discussion, all participants were asked to shortly present their designs. This was added to avoid the very original ideas not being improved upon because of difficulty in understanding them [30].

5.1.2.1 Phases

The first phase, of ten minutes, started with an explanation of the goal of the session, an introduction to the project and its relevance, a run-through of the structure, and a description

of the previously found user preferences and requirements. The user preferences, requirements, and insights explained can be read in section 4.2.5.
After the introduction phase, the participants were asked to take the following fifteen minutes to sketch at least two designs individually.

Immediately after, ten minutes were devoted towards an open discussion of the sketches. The participants briefly presented all their sketches to the group and were prompted to discuss the designs and key takeaways they could think of.

Afterwards, another round of sketching was held, during which the participants were asked to try to improve or adapt the concepts of others. Each participant took the A3 paper from another that they had been inspired by and proceeded to expand it. They were also allowed to create new sketches if inspiration struck.

Following the last sketching round, in the final phase, another open discussion was held. The participants once again quickly presented their new designs or additions and were prompted to discuss key takeaways and favourites and come up with any final ideas, new or merger.

After all phases, the participants were asked to leave their sketches and sticky notes behind on the table. These were collected to be analysed later.

5.1.3 Analysis

All sketches are digitised and analysed by open coding. Key takeaways are identified, and a classification system is made based on this. Notes were taken during the last round of discussion, with (new) favourites and a discussion. These will be presented in the findings below.

Figure 6: Mindmap of classification of design ideas

5.2 Findings Collaborative sketching

5.2.1 Analysis

The analysis of the sketches followed a systematic approach for accurate classification of the intervention designs. The process followed several steps, starting with the creation of a PowerPoint containing all the sketches cropped individually, constructing a description and title for each sketch, documenting key takeaways and remarks, consulting with relevant participants on ambiguous details, gathering all data into a Miro whiteboard for a comprehensive brainstorming to reach an accurate classification.

Firstly, each sketch was digitised, individually cropped, and placed on a separate slide in a PowerPoint presentation. This provided a structured format to capture all relevant information per design. For each sketch, a detailed description was written. Key takeaways were identified and documented, expanding continuously through every sketch, leading to the previous sketches' takeaways to update as well. In cases where sketches were ambiguous or lacked sufficient detail, direct communication with the respective participants was had for more clarification. All sketches, along with their key takeaways and remarks, were transferred to a Miro whiteboard. This platform facilitated the visualisation and organisation of data, making it easier to identify patterns and relationships among the sketches. Lastly, Multiple brainstorming sessions were held using the organised sketches on the Miro whiteboard to identify logical groupings and classification methods. This led to the identification of main themes and subclassifications, ensuring that each intervention design was categorised based on its characteristics and intended outcomes. The design ideas were also vectorized for future researchers (see Appendix F).

5.2.2 Classification

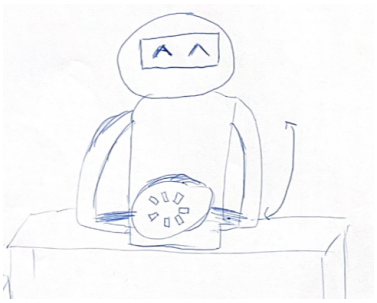
The findings can be divided into two subthemes that emerged from the central theme of using tangible interactive technology to promote physical activity at the office: (1) inciting (micro-) breaks for physical activity, and (2) adding more movement to current work events. See Figure 6 for a visual overview.

5.2.2.1 Taking (micro-) breaks

Most of the concepts sketched by the participants try to break up long sitting sessions by encouraging the user to take breaks. One example, the Massage Chair (see appendix [E.1] and Figure 7a), uses a chair that detects the amount of time the user has sat and makes it

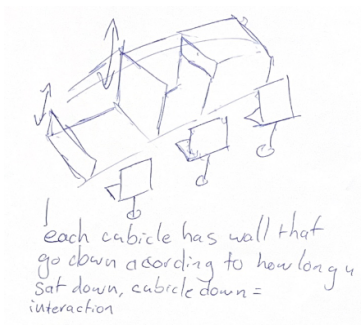
continuously more uncomfortable over time through massage balls in the back. With the chair creating discomfort, users are meant to become motivated to take a (small) break.

(a) Massage Chair [E.1]

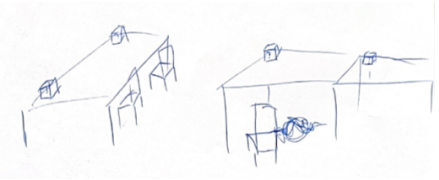


(b) CoCo the Robot [E.3]

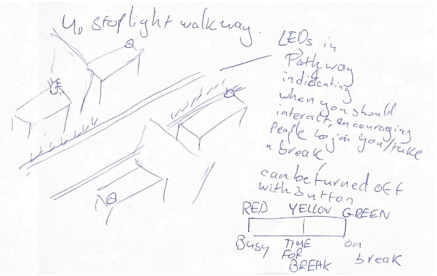
(c) Growing Desk [E.8]



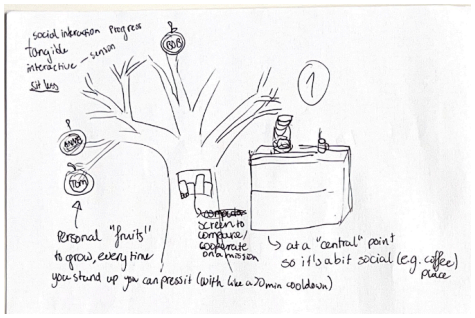
(d) Cubicle Lowering [E.7]



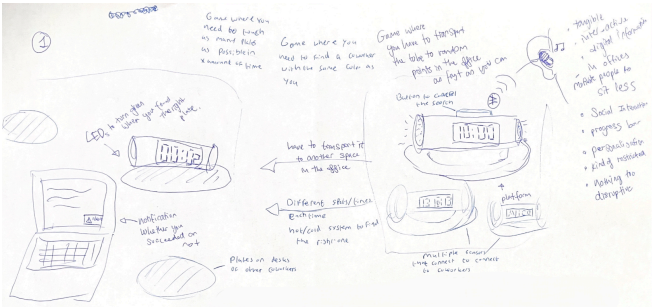
(e) WalkMate [E.12]



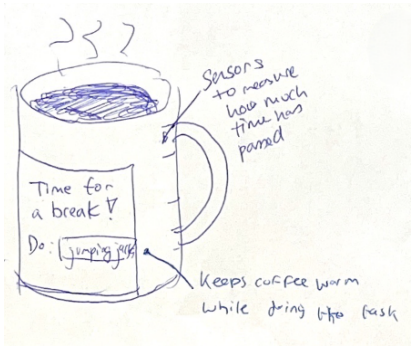
(f) Stoplight Walkway [E.13]



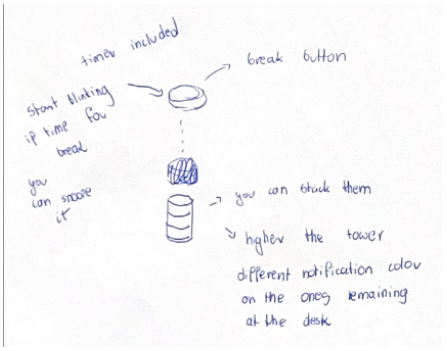
(g) Movement Tree [E.17]



(h) Cylinder Scavenger Hunt [E.20]



(i) Smart Mug [E.18]



(j) Stacked Timer Blocks [E.21]

Figure 7: Design idea sketches by collaborative sketching participants

Another variation of using discomfort presented in the session was the Spinning Chair [E.2], which starts spinning after a set time.

Some participants leveraged the persuading power of a companion. The Office Pet Roomba [E.6] is a Roomba that drives around in the office and audibly asks people to take a walk (with them). It allows the user to say ‘no’ or ‘later’ through a built-in microphone. Its playful image was also adopted by CoCo the Robot [E.3] (see Figure 7b). CoCo sits still, carrying a ball, which he gives to the user when they have been sitting for too long. The ball is meant to be taken with the user on the walk, counting the steps. This idea created multiple variations in the session.

Inciting (desk shaping) was particularly popular among the participants. Some designs raised the user’s monitor and desk over time, only to come back down after a small break from the desk was taken (Raising Monitor [E.10]; Growing Desk [E.8], see Figure 7c). Another participant sketched a desk with panels on each side that start raising and tilting every item on top when the user has been negligent in their break-taking (Disruptive Desk [E.9]). The Disruptive Desk [E.9] creates consequences for the user’s sedentary behaviour without obstructing their workflow.

Combining Inciting with another element, Cubicle Lowering [E.7] (see Figure 7d) introduces a creative design using social interaction as a motivator. Social interaction was found to be utilised in two manners, encouraging users to take breaks together, and individually taking breaks for a collective goal.

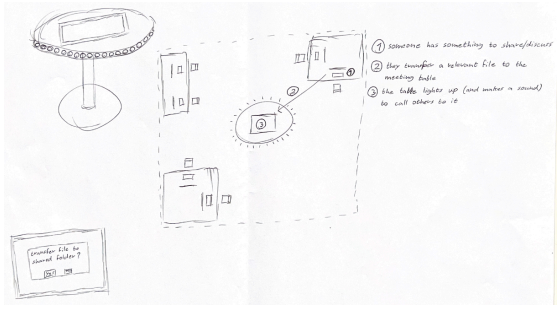
WalkMate [E.12] (see Figure 7e) is an example of a device that stimulates users to let others know they have been seated for a while and are looking forward to a break. The device unintrusively communicates this to other users, prompting them to tag along. While WalkMate [E.12] requires human input to nudge a break time, Stoplight Walkway [E.13] (see Figure 7f) operates on sedentary time. The Stoplight Walkway [E.13] measures how long the user sits and autonomously indicates break times on the desk and walkway, encouraging other employees to take the user for a break. Multiple variations and mergers with both of these original concepts have been created in the second phase of the session.

Promoting active breaks without users actively having to encourage each other, yet still walking for a collective goal was the aim of the Movement Tree [E.17] (see Figure 7g). An artefact that tracks office-wide progress towards milestones of every user taking micro-breaks of walking to the Movement Tree [E.17] and activating their personal fruit.

While the Movement Tree [E.17] ideally makes people walk to the tree every twenty minutes, some of the intervention designs give users many different assignments. This unique assignment giving materialises in the Smart Mug [E.18] (see Figure 7i), instructing users on various exercises to do each break. Another participant sketched the Cylinder Scavenger Hunt [E.20] (see Figure 7h), making the user go to many people’s desks, find

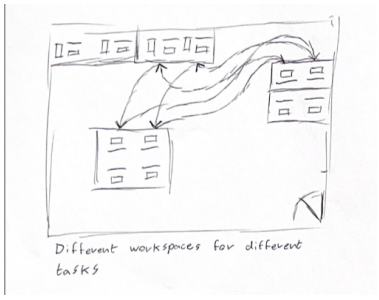
matching co-workers, and even play hot and cold to search for the correct location. Some of the assignment-giving designs integrate a form of playfulness.

Lastly, for the already motivated users requiring only a small interactive reminder system, the Stacked Timer Blocks [E.21] (see Figure 7j) integrated a novel system of letting users set themselves timers for breaks.

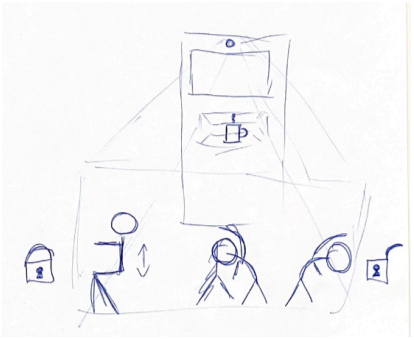


(a) Improved Standing Meeting Table [E.22]

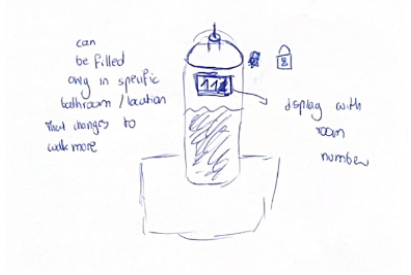
(b) Omni-Directional Treadmill [E.30]



(c) Dynamic Workstation [E.24]



(d) Exercise-for-Coffee Machine [E.25]



(e) Quest Bottle [E.19]

Figure 8: More design idea sketches by collaborative sketching participants

5.2.2.2 Active work

The participants' sketches revealed four methods for increasing employees' physical activity levels through the transformation of standard work processes. These methods targeted meetings, working posture, work tasks, and breaks.

The Improved Standing Meeting Table [E.22] (see Figure 8a) was created in the second phase of the sessions. It calls for relevant employees to have a standing meeting around it. The Office Jungle [E.23] takes active meetings even further, facilitating all kinds of unique postures during the meetings.

Besides active meeting postures, some interventions were aimed at encouraging or facilitating active postures during regular desk work. A common theme found was the implementation of treadmill-like technologies to be used in a standing stance, from the

Omni-Directional Treadmill [E.30] (see Figure 8b) and regular Treadmill [E.32] to the Rotational Panel [E.31]. Aside from those, the Growing Desk [E.8] simply raises the height of the desk after a set time. This way, the user is forced into a standing pose as they continue working.

The Dynamic Workstation [E.24] (see Figure 8c) forces a different kind of activity onto the user. In this intervention, every task has a different desk workstation where they can be done. As a result, the user is regularly walking between the desks throughout the day.

Lastly, some intervention designs utilise existing breaks in employees' days as an opportunity to increase physical activity. This is done, for example, through the Exercise-for-Coffee Machine [E.25] (see Figure 8d), which requires the user to execute three exercise movements to unlock the coffee machine, taking advantage of the frequent coffee drinking in offices. One participant added an element of playfulness to it, making users play Just Dance to get coffee (Just-Dance-for-Coffee Machine [E.26]). Others focused only on playfulness, creating the Interaction Room [E.29]. This device allows users to play a movement-heavy game on the ground of a meeting room while they are taking a break. To encourage more movement during breaks, unique assignment giving was also used. The Quest Bottle [E.19] (see Figure 8e) indicates the specific location where it should be refilled and keeps its cap locked until the user reaches that location. This location is intentionally placed farther away than the usual refill spot to promote more physical activity. Social motivation was the last method identified in the sketches for this target. As a strategy to motivate individuals to take the stairs more often, the Stair Lights [E.28] uses a collective progress bar through growing lights on the wall.

5.2.3 Technologies

Almost all of the intervention designs, as they are interactive technologies with sensing and actuation, require a microcontroller to communicate with these technologies and run the software. The sedentary time based intervention designs likely use a capacitive sensor on the seat to measure the user's sitting behaviour. The Inciting (desk shaping) interventions presumably require a linear actuator, while the designs integrating multiple devices likely require the microcontroller to have WiFi access. Assignment giving interventions might even require GPS or NFC access to oversee location. Two of the Coffee Machine solutions utilize a Kinect sensor to identify movement patterns. Treadmills and robots are required for treadmill and robotic designs, respectively. Additional components include displays, electric locks, and projection or lighting systems for output.

Chapter 6 - Discussion & Future Work

6.1 Interpretation of results and contributions

This study created many preliminary design ideas for tangible interactive technologies to be used in an office setting and formulated a classification system to explore their potential and feasibility. Based on this classification, a reflection on opportunities and challenges is presented, along with design considerations from the user focus group. Researchers benefit from this work by using it as a starting point for their research on creating tangible interactive interventions for promoting physical activity in an office environment.

Participants of the focus group, with varying amounts of daily physical activity, recognised the detrimental effects of their prolonged sitting at work and showed a clear desire to change this behaviour. Although the participants' office is fully equipped with sit-stand desks, they are underutilised, identifying the need for a more effective change method. There was an enthusiastic response to the tangible nature of the example interventions shown, in line with the expected potential increase in engagement from these artefacts [14, 15]. The focus group's results resulted in the formulation of important design considerations for this type of intervention. These design considerations can provide guidance for researchers aiming to design (and evaluate) these tangible interventions for increasing office activity.

To further aid future research, the present project developed classifications for the design ideas created through the collaborative sketching session. The two main branches of inciting (micro-) breaks for physical activity and adding more movement in current work events can be starting points for researchers to specify the goal of their intervention(s). Further on, the subcategories for the (micro-) breaks direct the designer to various methods that can be used, while the subcategories for adding movement for current work events first break it down into the type of work events that can be targeted, to then provide various methods of getting there. Researchers can, after having selected a direction, take a look at the example(s) within the category they selected to gain inspiration for such intervention.

The literature review identified an opportunity for the implementation of natural interaction. The natural interaction of artefacts can be found in a multitude of the design ideas found in the current project. The concepts that used discomfort [E.1; E.2] or inciting [E.7-E.11] physically changed aspects of the user's direct environment, interacting with the user in a physically manipulative way. On the other hand, interventions like the Stacked Timer Blocks [E.21] push the user to pick up and stack items. These basic body movements stimulate a very natural method of interacting with users. CoCo the Robot [E.3] physically

hands a ball over to the user, much like how a human normally would. As there is currently little research on natural interaction and, thus, ways to implement it, this project could serve as a repository for different implementation possibilities.

All of the designs created by the collaborative sketching participants can be considered highly feasible to implement with the technology of today, as none of the interventions would require any technology that currently does not exist or is not widespread to produce. While interventions like the Office Pet Roomba [E.6] require voice recognition and a path-finding ability, it is possible to produce without a large team. On the other hand, many of the intervention ideas are expected to be technologically simple. This means that researchers without an extensive background in sensing and actuation can still take inspiration from these ideas.

The design ideas creatively show many possibilities of artefacts integrating as part of the everyday office used as an interface, allowing users to become more physically active while at the workplace. This project has thus answered the research question of how tangible interactive technologies can be used to promote physical activity in an office by exploring the feasibility and potential of using the everyday office as an interface through design ideas created by experts in sensing and actuation given design considerations based on user requirements and preferences.

Future researchers should be very thorough in using their own creativity while taking inspiration from the presented design ideas, as many of the artefacts' components and methods can be changed for the same end goal. The ball apple in the Movement Tree [E.17] could, for example, be something for the user to take on a walk with, measuring steps taken and adding a personal visualisation or physicalisation of data for extra motivation. Another example could be the Cylinder Scavenger Hunt [E.20] integrating a wearable version instead of the 'clunky' cylinder or integrating the Improved Standing Meeting Table [E.22] into the organisation's internal scheduling calendar for an enhanced user experience. Many of the design ideas can be merged together for different (or still similar) purposes, as has already been done with some by the participants.

It should also be taken into account to what extend some design ideas have the possibility to impact productivity levels and where they can be applied. The Cubicle Lowering [E.7] can only be integrated into a cubicle office setting, while most are (also) suitable for an open or shared office layout.

6.2 Limitations and future research

Three clear limitations can be identified in this project. The structure and method of the collaborative sketching session held were non-standard. This means that, while highly

contextual to the needs of the project, no previous research has been done on the effectiveness of the exact methodology procedure utilised. This creates a fair degree of doubt on the reliability of the results from the session.

There is also some doubt cast on reliability, as the design ideas were created by only six participants. This limited amount of participants allows the possibility of some classification categories not being present within all the designs. The comprehensiveness of the final classification can thus, although very valuable, be lacking completeness.

Lastly, as with any group of artefacts, they can be classified in a near-infinite amount of ways. The author presents, to the best of their ability, the most relevant and applicable classifications, but there are always different groupings that are possible and useful. This means that while the design ideas might be comprehensive, the classification could be lacking in specific use case scenarios.

In the future, researchers could focus on the different classification systems for the designs, focusing on targeted emotions, intentions, technologies, effectiveness, and more. This would form an extensive repertoire of dimensions to consider for a designer for tangible interventions to promote physical activity at the office.

Another possibility for future research would be to apply concepts and methods from the present research into another environment outside of offices. Researchers could also test the generalizability by applying it in multiple environments or using the present methodology to create design ideas and classifications for other well-being interventions within the office environment. Finally, integrating behavioural change theories from psychology into the concept generation and specification phases of creating interventions would significantly increase the reliability in effectiveness.

6.3 Ethical Considerations

As the present project is concerned with designing to influence human behaviour, ethical considerations have to be taken into account. In the following chapter, relevant ethical dilemmas are identified and discussed, a code of ethics is created, and an ethical analysis is done based on the ethical cycle [27].

6.3.1 Ethical dilemmas

An ethical dilemma is a situation in which whichever decision is made, every choice crosses (different) ethical boundaries.

One such ethical dilemma concerning this project is how the interventions resulting from my research will aim to increase physical activity in the workplace but possibly at the cost of productivity. This likely means that the employees might be stimulated to take more

walking breaks. Taking more breaks allows them less time to sit at their desk and work, thus productivity could take a hit. The more, quantitatively, it is being stimulated, the less time there is to work, most likely. At this point, the employers might have to decide to what extent they value the promotion of the well-being of their employees over their productivity.

To find a balance between promoting health and remaining productive, an approach as a designer could be to focus on interventions that do not obstruct an employee's workflow. The interventions could instead focus on periods where less concentration is needed. Another workaround could be an intervention that can consistently be done while working without requiring (much) attention. Besides those, a device that relies on human interaction to prompt movement allows people to make decisions and find the best times to interrupt someone else's workflow.

Another ethical dilemma involved in the project regards the privacy of the employees and the (possible) effectiveness of the solution through personalization. The designs created so far are mostly driven by the employees' personal data. This allows for a very personalized, flexible, and effective solution, much more than most non-data-collecting devices can do. The types of data that are collected in some of these (preliminary) designs are related to the employees' sitting behaviour, movement, breaks taken and when, willingness to socialize, favorite exercises, and what tasks they do in a day and when. The consideration in this case is the amount of monitoring and data collection that is comfortable for each user. Some employees might even feel distrustful of their employer because of this monitoring. It also introduces the possibility of data leakage, which could be used negatively towards an employee or whole business.

It is very difficult to address privacy concerns about a device that uses personal data. Some solutions would be to keep the intervention very simple, data-wise, to not require any storing of data, even if this does not take complex working situations into account. Strong data protection, transparency of what data is being collected for what reason, and anonymizing the data are necessary. Aside from that, it depends on the individual users or whole office in how comfortable they are with different amounts of data collection and how passionate they are to become more physically active at work. That presents the best solution, to have different amounts of data collection and thus personalization possible per device to allow for the users to determine the weight of both values and how it should materialize.

6.3.2 Code of Ethics

Inspired by the Code of Ethics of the Royal Netherlands Society of Engineers [28] and the project's context, a code of ethics has been created tailored to the present project's context.

The code of ethics has been created for this project to ensure that all research activities and outcomes adhere to ethical standards. The code of ethics is important for creating credibility and ensuring the positive impact of the research and its findings.

We shall prioritize the health and safety of users through every design decision and implementation detail. This means making sure that all of the intervention designs are made to be safe for use without any risks. This is relevant as the project's primary purpose is to improve people’s health by reducing the risk of NCDs. The principle influences the design by implementing an analysis of its safety and possible risks in the general evaluation. The designs should not pose any health risks. This also means that health and safety are prioritized over possible productivity gains.

We shall protect the privacy of users, minimize the collection of data, and be transparent in its usage. Even though data collection is necessary for effective personalization, users' privacy concerns have to be addressed and solved first. This will be done by minimizing how much data is actually collected in the designs. On top of that, full transparency must be given about what data will be collected and for what purpose. Besides that, users will be given the option not to use the intervention and have their data collected if they wish for it. Lastly, the designs should, as much as possible, allow for different levels of data collection to accommodate as many people comfortably as possible.

We shall design for people by ensuring that all interventions do not promote harassment or disrespect and prioritize the well-being of its users. Through design, we support people and their future. This is only possible if it promotes well-being and does not encourage any unintended negative social interactions. This means that use cases have to be carefully analyzed and predicted with ‘bad’ people in mind as well as people with different accessibility restrictions.

We shall design interventions that promote physical activity without significantly disrupting productivity at the workplace. Though the primary goal of the project is to create designs that support physical activity in the office, productivity should not be impacted too much. Conforming with this, the designs should not disrupt the user's workflow and should be evaluated on the impact on performance.

We shall minimize the environmental impact of all designs through sustainable materials and lifecycle design. In every phase of the design creation, sustainability will be considered for our ethical responsibility to the world. This will be done in sustainable material selection, minimizing energy usage, extending their lifespan, and minimizing waste creation.

6.3.3 Engaging the Design through Moral Values and Ethical Decision-Making

The Ethical Cycle from van de Poel & Royakkers [27] will be applied to the present project in this section. By utilizing the ethical cycle, the project can systematically address ethical considerations at each stage of the design process. The ethical cycle is a structured approach to ethical decision-making that involves several key steps. The steps include identifying the ethical issue or problem in the project, considering the different perspectives and values of stakeholders involved, generating potential solutions, evaluating the potential consequences of each solution, making a decision based on ethical principles and values, and finally reflecting on the decision and its outcomes to learn and improve for future ethical dilemmas.

6.3.3.1 Moral problem statement

How can designers design interventions that promote physical activity at offices without sacrificing well-being, productivity, privacy, inclusivity, and environmental sustainability?

6.3.3.2 Problem analysis

Relevant values are:

- Health and well-being
- Productivity
- Privacy
- Respect and inclusivity
- Environmental sustainability

These values are also reflected in the problem statement. This way, the moral problem statement accurately emphasizes the relevant ethical values. Because of all these values, there will also not be one clear solution, but many ways to solve the problem.

The stakeholders and their interests are:

- Office Employees: improving health, decreasing the risk for NCDs, high privacy, respect, inclusivity, and a sustainable office.
- Employers: maintaining or improving productivity and employee well-being.
- Designers: creating health-improving interventions ethically.

Some unknown and disputed facts are:

- The effectiveness of the interventions in improving physical activity.
- The impact on productivity the interventions introduce.

- The employees' acceptance and adaptation of the interventions.
- The effect on inclusivity.

6.3.3.3 Options for action

Some options for action possible with the moral problem statement's formulation are:

- Finding a creative middle way solution that incorporates a balance of all values previously identified.
- Contact and collaborate with all stakeholders to find a solution together.
- Contact other design experts in the field for support on the solution.

Two of the three identified options require collaboration with relevant stakeholders or experts to create designs extra carefully and decrease ambiguous facts. The other relies on the understanding of the designer to create a design that balances all values to their best abilities.

6.3.3.4 Ethical evaluation

The intervention may decrease productivity when prioritizing improving physical activity. Applying Kant's universalization test gives the following: If the designer proceeds with the intervention, the relevant maxim might be "prioritize health interventions even if they slightly reduce productivity." If everyone acts this way, health will always be prioritized over productivity. While this is great for employees' health, it would consistently reduce productivity in society. Kantian ethics would thus likely reject this maxim as it is not universally applicable without making productivity meaningless and potentially resulting in an unstable economy. On top of that, it could be argued that it is an employee's duty to be productive for their employer. Thus any acts against them infringe on this duty.

Applying utilitarianism, where utility is taken as happiness in this evaluation, the question becomes what maximizes happiness for the greatest number of people. If the employees or users gain the most happiness from their improving health or from their productivity is difficult to evaluate. The reduced risk for NCDs and its relation to long-term health and healthcare costs could be said to be worth the slight productivity dip. On the other hand, if the decrease in productivity is substantial, then the net happiness might decrease due to the loss in profit. A utilitarian would support the interventions that compromise in both values, where health benefits are maximized while productivity can only slightly be impacted.

6.3.3.5 Reflection

Since the ethical theories applied give multiple different outcomes, more reflection should be done, including moral judgments, moral principles, and background theories. My first intuitive

opinion is that promoting physical activity is of great importance, even if at a slight cost in productivity. This is generally supported by utilitarianism if it significantly reduces the risk for NCDs. However, Kantian ethics could challenge this by universalizing, saying that if everyone thinks this way, societal productivity would take a nose-dive, becoming meaningless. Utilitarianism again might focus on the longer-term benefits too much and lose sight of possible consequences in productivity reduction. On the other hand, Kantian ethics might put a strong emphasis on privacy and duty for productivity while ignoring any consequences of a lack of physical activity. An ecocentrism approach might argue that designs with significant environmental impact are not worth the possible health benefits.

Different ethical frameworks have conflicts of opinion in the present project. To address this, a balanced approach incorporating elements from multiple frameworks has to be created. The project should promote physical activity at offices to reduce the risk of NCDs without significantly sacrificing well-being, productivity, privacy, inclusivity, and environmental sustainability. This allows the intervention design to be ethically robust.

Chapter 7 - Conclusion

While interventions promoting physical activity have become increasingly popular, they still need to be widely adopted and are often disregarded. This project attempted to answer the research question, how can tangible interactive technologies be used to promote physical activity in an office, by exploring the feasibility and potential of using the everyday office as an interface to promote physical activity using tangible interactive technologies. Tangible interactive technologies can be used to promote physical activity in an office by integrating it into the everyday office as an interface for promoting physical activity, where the design ideas function as examples and the classification with its corresponding analysis function as directions for this integration. This answer was found through conducting a focus group and a collaborative sketching session. As a result of the focus group, a list of design considerations was formulated. The collaborative sketching session resulted in many design ideas, and an analysis and classification were defined for all of them. Researchers benefit from this project by receiving design considerations to guide their intervention development process, by obtaining a large classification to specify the directions of such interventions, and by providing design ideas for each of the categories with further insights in the analysis sections and design idea description. Lastly, the project presents the potential of natural interaction in tangible well-being interventions and a method of using experts to ideate with them. Researchers can use this work as a starting point for research into tangible interactive technological interventions for promoting physical activity and designing for a healthier lifestyle at work.

Appendix

A. Information Letter Focus Group

Information letter for Promoting Physical Activity In Office Using Tangible Data Physicalizations

Dear participant,

The purpose of this study is to gather insights from employees, like yourself, who work in open office environments regarding their first impressions of an intervention designed to encourage physical activity during the workday. We are particularly interested in understanding your thoughts on the acceptability and usability of such a device, as well as any design considerations you may have.

Your participation in this study will involve attending a focus group session with 4-8 other participants. During this session, you will be asked to share your thoughts on your sitting practices at work, including when, how long, and how often you take walking breaks during a typical day. You will also engage in discussions with other participants about various ways of promoting and taking breaks together. The session will be audio recorded for research purposes only, and all recordings will be transcribed right after the session and immediately destroyed after that.

Before participating, I kindly ask you to fill in the attached Informed Consent Form carefully. This form outlines the details of the study, including your rights as a participant and how your information will be used. If you agree to participate, please fill out and sign the consent form.

If you have any questions or concerns about the study or your participation, please do not hesitate to contact me, Reinier Algra, at r.a.algra@student.utwente.nl.

Your contribution to this research is highly valued, and your insights will help us better understand how to promote physical activity in office environments effectively.

Kind regards,

Reinier Algra
E: r.a.algra@student.utwente.nl

B. Consent Form Focus Group

Consent Form for Promoting Physical Activity In Office Using Tangible Data Physicalizations

YOU WILL BE GIVEN A COPY OF THIS INFORMED CONSENT FORM

Please tick the appropriate boxes	Yes	No
Taking part in the study		
I have read and understood the study information dated 22-04-2024, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	○	○
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	○	○
I understand that taking part in the study involves a focus group and observations that collect information via audio recording and written notes. The recording will only be used for supplementing the written notes and will be destroyed immediately after transcribing the recording.	○	○
Use of the information in the study		
I understand that information I provide will be used for a graduation project for the study Creative Technology at the University of Twente. The results of this study can be shared to the participants and their workplace.	○	○
I understand that personal information collected about me that can identify me, such as my name, will not be shared beyond the study team.	○	○
I agree that my information can be quoted, anonymously, in research outputs.	○	○
Consent to be Audio Recorded		
I agree to be audio recorded.	○	○

Signatures

_____	_____	_____
Name of participant	Signature	Date

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

__Reinier Algra_____	_____	_____
Researcher name	Signature	Date

Study contact details for further information: Reinier Algra, *r.a.algra@student.utwente.nl*

Contact Information for Questions about Your Rights as a Research Participant

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee Information & Computer Science: ethicscommittee-CIS@utwente.nl

C. Information Letter Collaborative Sketching

Information letter for *Collaborative Sketching* for Promoting Physical Activity In Office Using Interactive Technology

Dear participant,

The purpose of this study is to gather creative input and preliminary designs from experts in creative technology as you, on the creation of devices designed to encourage physical activity at the office.

Your participation in this study will involve attending a collaborative sketching session with 4-8 other participants. The aim is to generate new ideas quickly, easily, and sketchily and to optimize existing ideas. Achieving great creativity through rapid idea brainstorming with constructive cooperation. At the beginning of the session, the problem/task is defined with the user requirements collected from the previously held focus group. The participants are asked to write/draw their ideas on large sheets of paper afterward. Then each idea is shortly presented. Another (quick) round of sketching is held. Lastly, a discussion is held on the new ideas after they are once again shortly presented. There will be no recording used. No identifiable data is collected. The participants write and sketch on large sheets of paper, these will be kept by the researcher. Additional notes will be taken by the researcher, to more clearly describe the ideas designed on paper.

Before participating, I kindly ask you to fill in the attached Informed Consent Form carefully. This form outlines the details of the study, including your rights as a participant and how your information will be used. If you agree to participate, please fill out and sign the consent form.

If you have any questions or concerns about the study or your participation, please do not hesitate to contact me, Reinier Algra, at r.a.algra@student.utwente.nl.

Your contribution to this research is highly valued, and your insights will help us better understand how to promote physical activity in office environments effectively.

Kind regards,

Reinier Algra
E: r.a.algra@student.utwente.nl

D. Consent Form Collaborative Sketching

Consent Form for Promoting Physical Activity In Office Using Interactive Technology

YOU WILL BE GIVEN A COPY OF THIS INFORMED CONSENT FORM

Please tick the appropriate boxes	**Yes**	**No**
Taking part in the study		
I have read and understood the study information dated 15-05-2024, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	○	○
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	○	○
I understand that taking part in the study involves collaborative sketching and observations that collect information via created drawings and written notes.	○	○
Use of the information in the study		
I understand that information I provide will be used for a graduation project for the study Creative Technology at the University of Twente. The results of this study can be shared to the participants and their workplace.	○	○
I understand that personal information collected about me that can identify me, such as my name, will not be shared beyond the study team.	○	○
I agree that my information can be quoted, anonymously, in research outputs.	○	○

Signatures

_____	_____	_____
Name of participant	Signature	Date

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

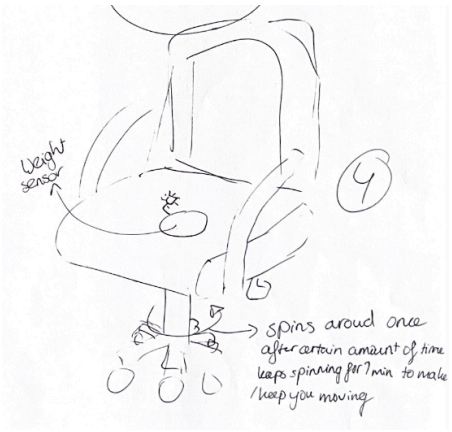
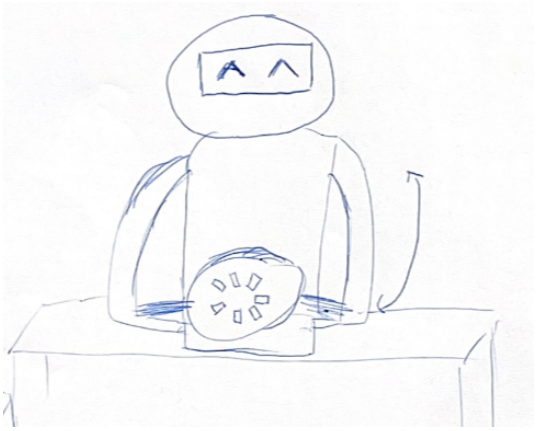
__Reinier Algra_____	_____	_____
Researcher name	Signature	Date

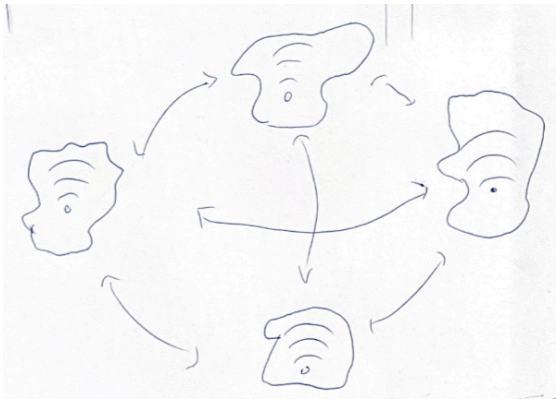
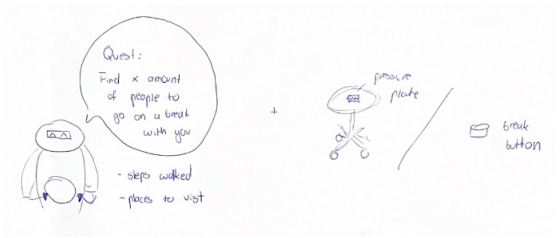
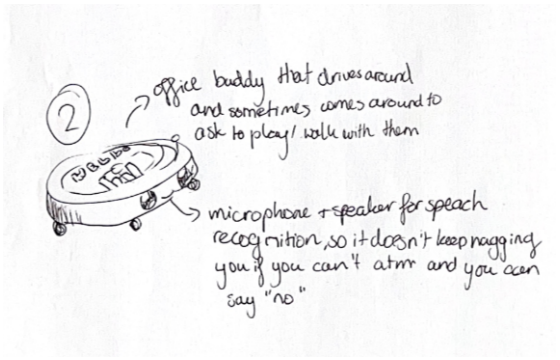
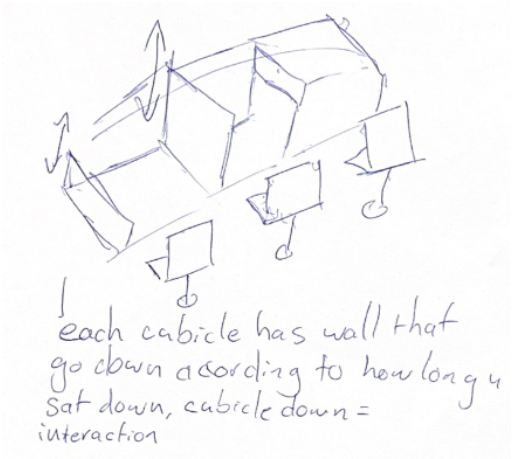
Study contact details for further information: Reinier Algra, *r.a.algra@student.utwente.nl*

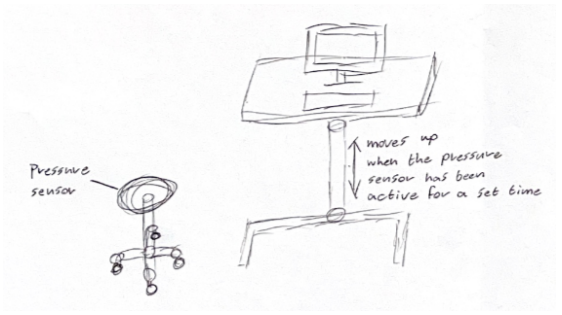
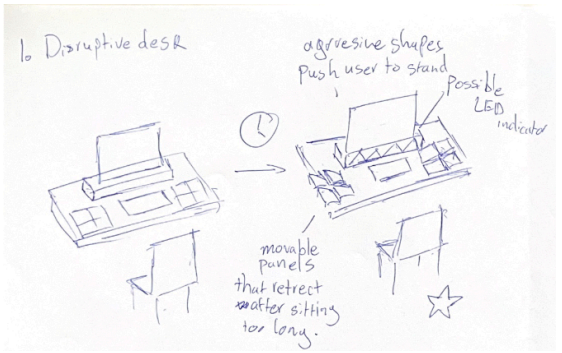
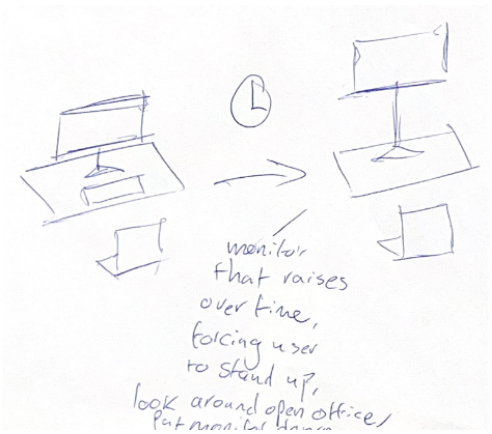
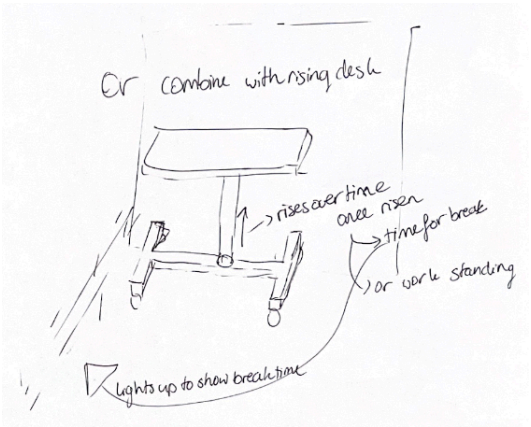
Contact Information for Questions about Your Rights as a Research Participant

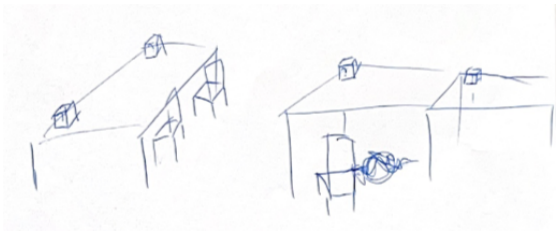
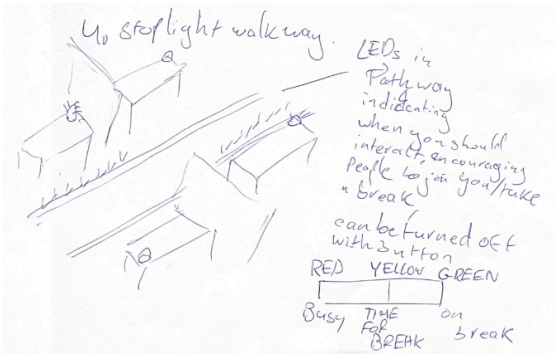
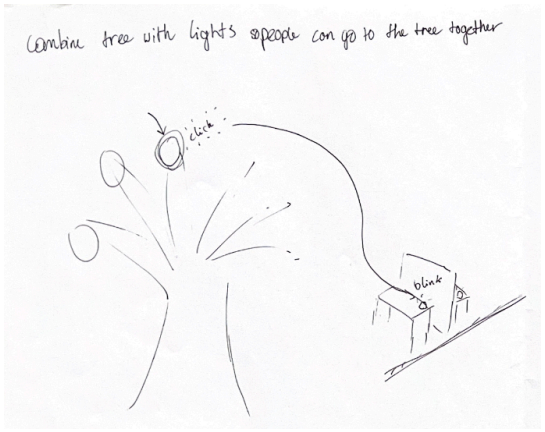
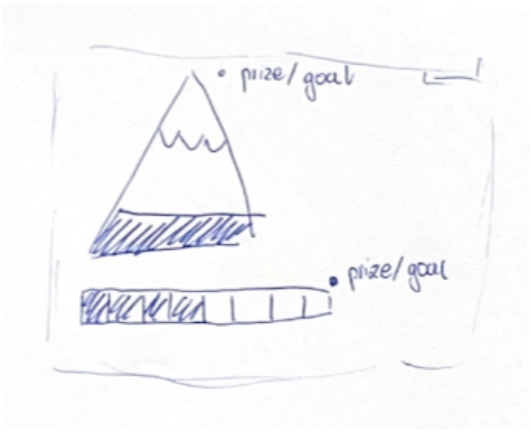
If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee Information & Computer Science: ethicscommittee-CIS@utwente.nl

E. Sketches from Collaborative Sketching Session

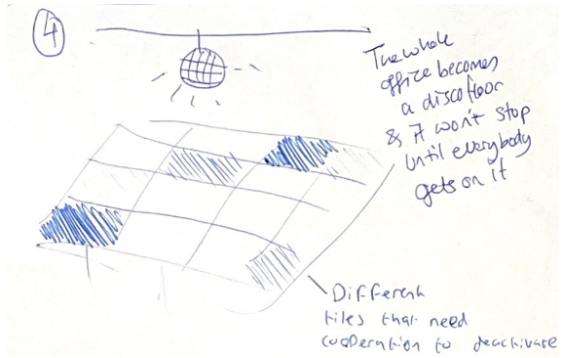
E.1		**Massage Chair** A chair that detects the amount of time the user has sat, and makes it continuously more uncomfortable over time to motivate the user to stand up.
E.2		**Spinning Chair** A chair that spins the user after a set time seated. Aims to force the user to take breaks.
E.3		**CoCo the Robot** A robot with a ball that decides when the user has been sitting for too long. He then gives the user a ball to take with on a walk, counting the steps.

E.4		**Connected CoCoMate** A combination of CoCo the Robot and WalkMate. Connects all CoCos with each other, allowing every user to communicate with the others.
E.5		**CoCo the Adventurer** Combines CoCo the Robot with a centrally controlled hub. CoCo gives the user a quest to find people to go on a break with based on how long the user and other colleagues have been sedentary or are ready for a break.
E.6		**Office Pet Roomba** A roomba in the office that drives around and audibly asks people to take a walk (with them). Allows the user to say 'no' or 'later' through a built-in microphone.
E.7		**Cubicle Lowering** Cubicle walls that go down based on the time a user has been sitting in place. If two neighbours have been sitting for *x* amount of time, the cubicle wall lowers, indicating it is time to take a walking or other movement-related break.

E.8		## Growing Desk Desk frame that moves up based on the time a user has been sitting in place. If the user has been sitting for *x* amount of time, the desk moves up, indicating it is time to take a walking break or a more active posture.
E.9		## Disruptive Desk Desk with desk panels that slant themselves slowly as the user is sedentary over time. Only disrupts objects on the user's desk, still allowing him/her to work through it, at the cost of a messy desk. Aimed at stimulating (micro-) breaks or a standing posture regularly.
E.10		## Raising Monitor Monitor that raises over time, forcing the user to stand up.
E.11		## Stoplight Height Desk Combines the Stoplight Walkway with the Growing Desk.

E.12		**WalkMate** Small blocks on everyone's desk that allow the user to communicate that they wish to or are going to take a walk and if anyone else would like to come along.
E.13		**Stoplight Walkway** LEDs on the side of the walkway next to desks that indicate when the user is recommended to take a break. Encourages (micro-) break taking through social interaction. Can be turned off with a button. The colors of the LEDs are: Red: busy, Yellow: time for a break, and Green: on a break.
E.14		**Stoplight Walkway Tree** The Movement Tree combined with the Stoplight Walkway. Encourages users to walk towards the Movement Tree together.
E.15		**Office Goal** A concept to possibly include as part of another design. A company-wide progress tracker to incentivize movement collectively toward a prize or goal.

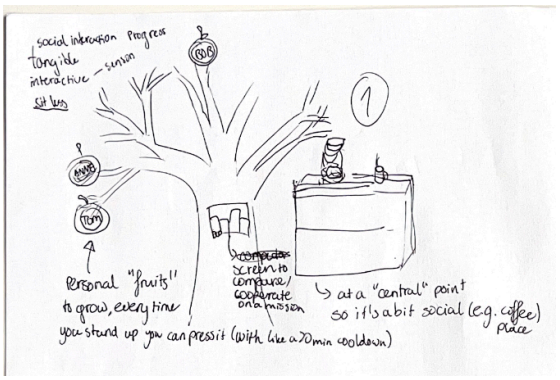
E.16



Office Disco

The office turns into a disco. Requires the cooperation of all employees to step on certain places to deactivate it.

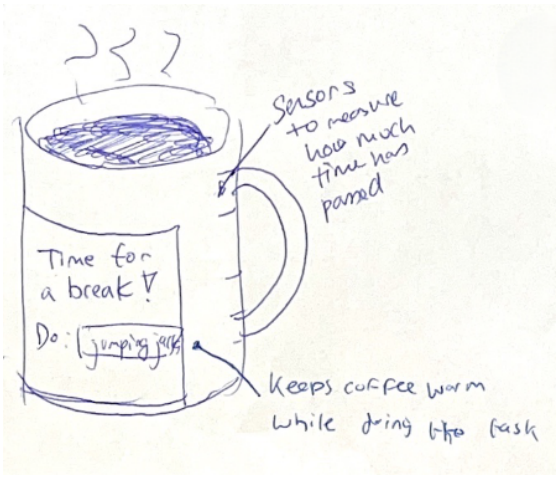
E.17



Movement Tree

An artificial apple tree at a social place in the office. Each employee has a representative apple (with a button) which grows every time it is pressed with at least 20 minutes in-between presses. Also displays a collaborative goal tracker inside the tree.

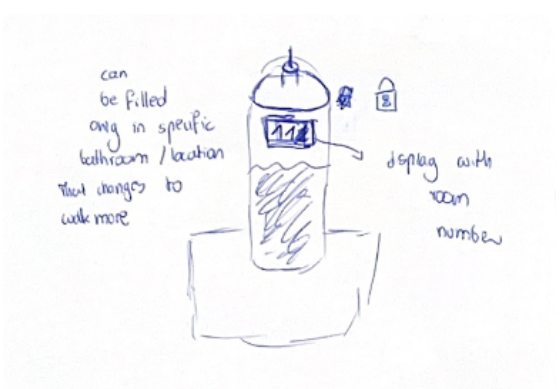
E.18



Smart Mug

A mug with a timer and display. Senses time spent on the table and lets the user know through the display to take a break. The mug also recommends an exercise to do during the break. It also keeps the liquid warm.

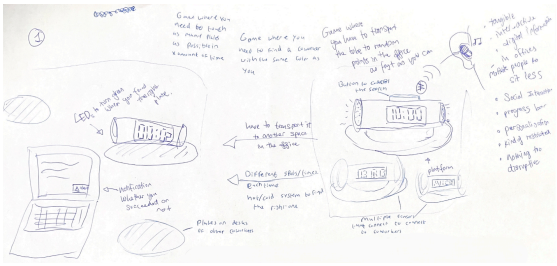
E.19



Quest Bottle

A water bottle that displays a specific location it wants to be filled in. Can only be fully opened in that room.

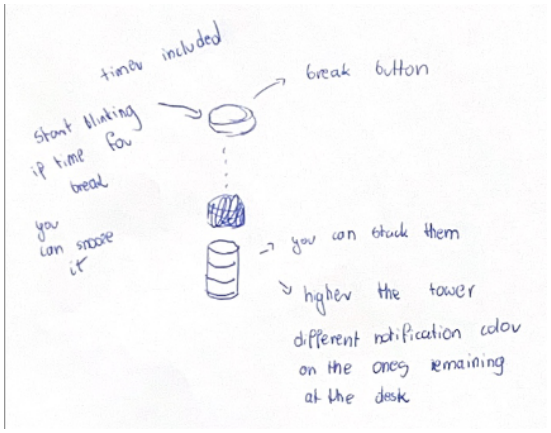
E.20



Cylinder Scavenger Hunt

Cylinder with an display and multiple sensors. Has different modes, such as touching as many base plates within a time limit, finding coworkers devices with matching colors, and transporting the device to random office locations, hot/cold system to find the plates. Makes sound when it is time to play one of the modes. Able to cancel the action. The base plates are located on each employees' desk.

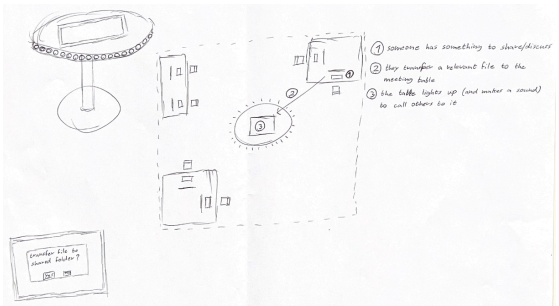
E.21



Stacked Timer Blocks

Cylinder blocks that stack. Each block represents a certain amount of time, stacking them increases the timer duration. The blocks share a colour gradient that represents the time left on the timer and starts blinking once the time is up. The button up top starts the break time.

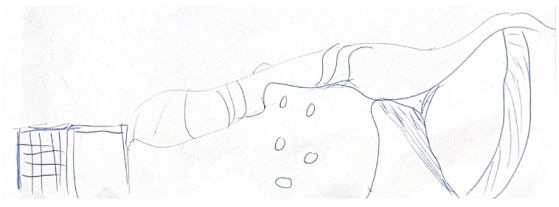
E.22



Improved Standing Meeting Table

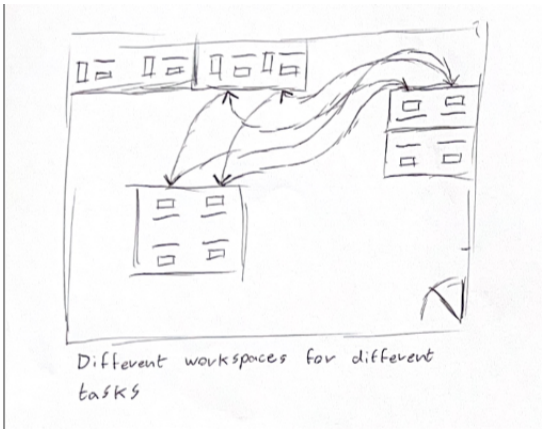
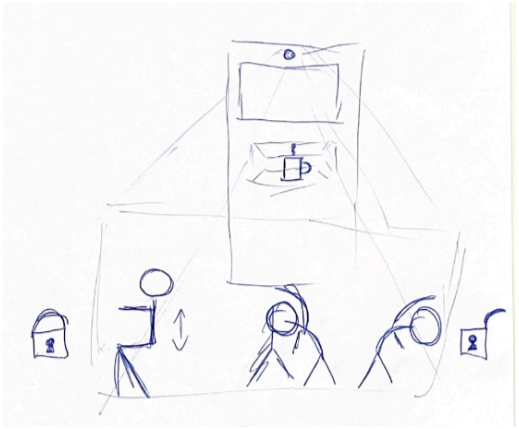
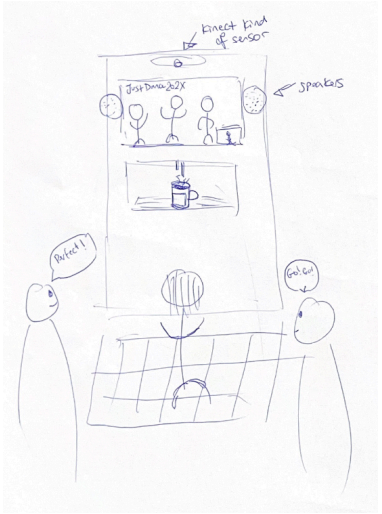
A taller meeting table with a laptop touch screen built in for standing meetings. Allows the meeting agenda/presentation to be opened on it. When someone has something to share or discuss, they transfer the relevant file to the meeting table, it lights up (and makes a sound), and calls others to it.

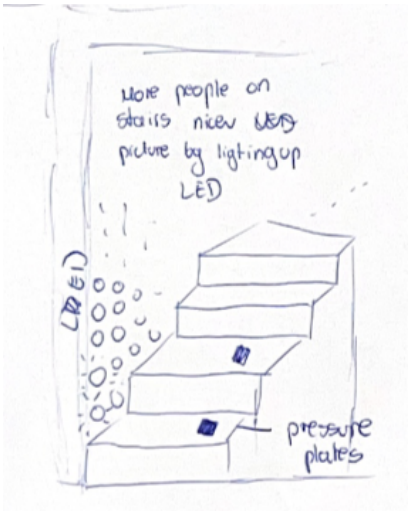
E.23

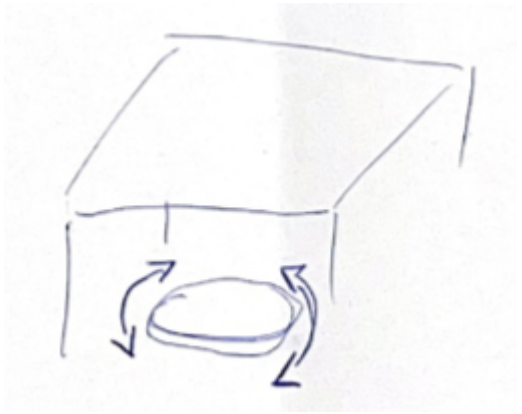


Office Jungle

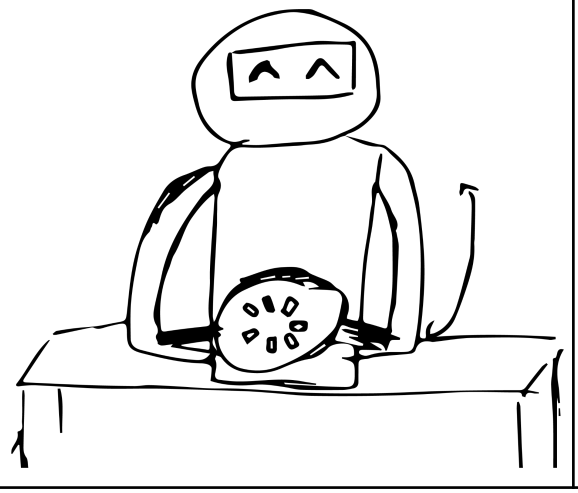
A climbing jungle in the office to facilitate unique meeting and sitting postures.

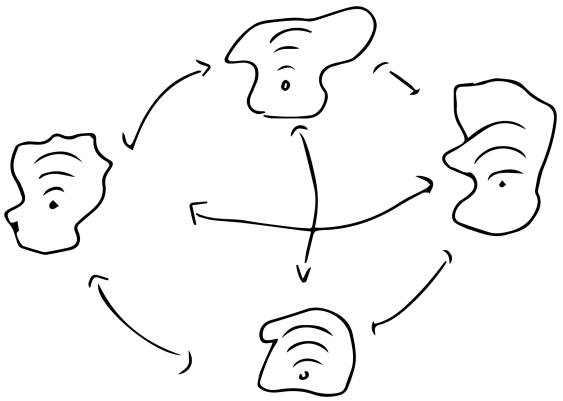
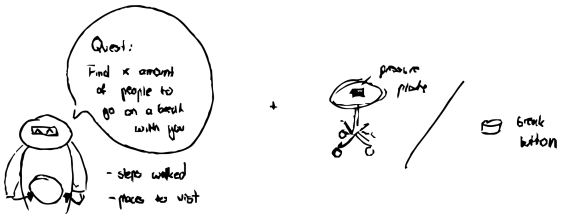
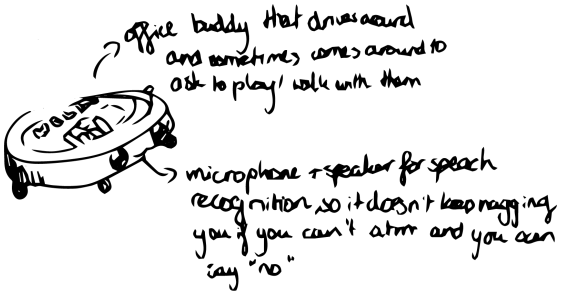
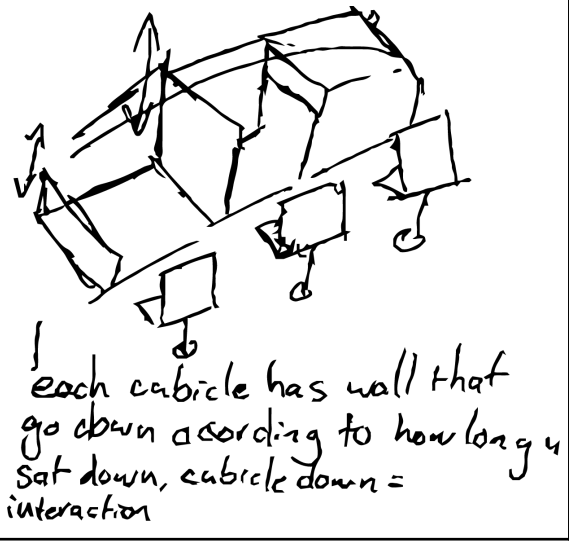
E.24		## Dynamic Workstation A workplace where each task in the day can (only) be done at different desks with workstations. Resulting in each employee often moving from one desk to another throughout the day regularly.
E.25		## Exercise-for-Coffee Machine A coffee machine that requires the user to execute three exercise movements to unlock the machine.
E.26		## Just-Dance-for-Coffee Machine Coffee machine that plays Just Dance as the coffee is being made.

E.27		## Choose-Action-Coffee Machine Coffee machine that requires the user to have a dance off, photo booth picture, or relax and audio book listen to get coffee to be made.
E.28		## Stair Lights The wall next to the staircase increasingly lights up as more employees use the stairs to get to the office, instead of the elevator. Uses pressure plates as data collector.
E.29		## Interaction Room An interactive playground that can be set up in a meeting room. Allows users to play a game on the floor.

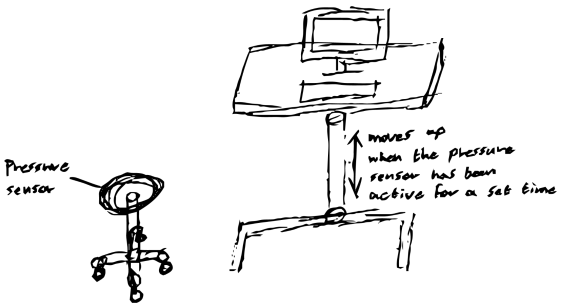
E.30		**Omni-Directional Treadmill** An omni-directional treadmill that can be used while working in a standing posture.
E.31		**Rotational Panel** A rotational panel to stand on behind the desk, allowing for hip rotations in an active posture.
E.32		**Treadmill** A treadmill to be used while working behind a standing desk. Allows the user to walk during work tasks.
E.33		**Collective Scavenger Hunt** Throughout the day, quests to find objects are revealed. Finding them alerts other users, meant to encourage them to look for the item revealed (e.g. an apple). The goal is to collect as many in a day. Daily leaderboard with rewards for the top scorer(s).

F. Vectorized Design Ideas

E.1		**Massage Chair** A chair that detects the amount of time the user has sat, and makes it continuously more uncomfortable over time to motivate the user to stand up.
E.2		**Spinning Chair** A chair that spins the user after a set time seated. Aims to force the user to take breaks.
E.3		**CoCo the Robot** A robot with a ball that decides when the user has been sitting for too long. He then gives the user a ball to take with on a walk, counting the steps.

E.4		## Connected CoCoMate A combination of CoCo the Robot and WalkMate. Connects all CoCos with each other, allowing every user to communicate with the others.
E.5		## CoCo the Adventurer Combines CoCo the Robot with a centrally controlled hub. CoCo gives the user a quest to find people to go on a break with based on how long the user and other colleagues have been sedentary or are ready for a break.
E.6		## Office Pet Roomba A roomba in the office that drives around and audibly asks people to take a walk (with them). Allows the user to say 'no' or 'later' through a built-in microphone.
E.7		## Cubicle Lowering Cubicle walls that go down based on the time a user has been sitting in place. If two neighbours have been sitting for *x* amount of time, the cubicle wall lowers, indicating it is time to take a walking or other movement-related break.

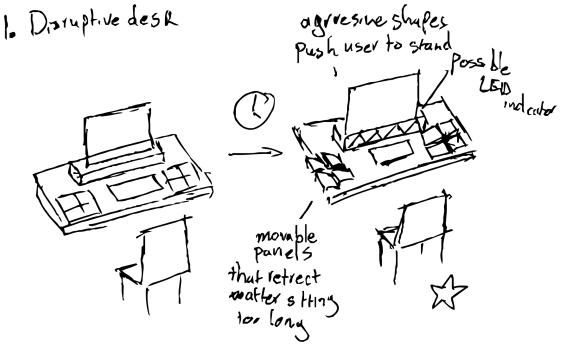
E.8



Growing Desk

Desk frame that moves up based on the time a user has been sitting in place. If the user has been sitting for *x* amount of time, the desk moves up, indicating it is time to take a walking break or a more active posture.

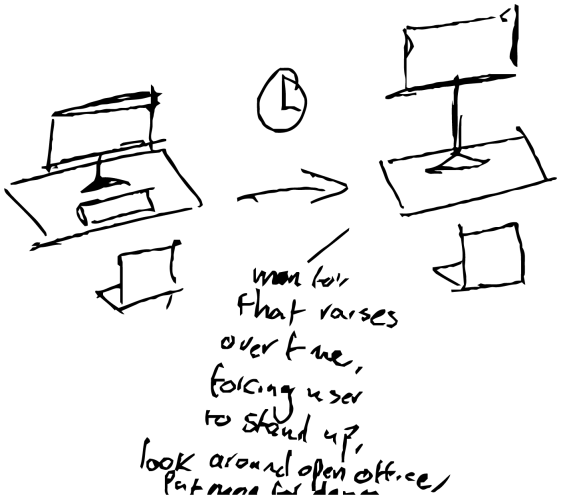
E.9



Disruptive Desk

Desk with desk panels that slant themselves slowly as the user is sedentary over time. Only disrupts objects on the user's desk, still allowing him/her to work through it, at the cost of a messy desk. Aimed at stimulating (micro-) breaks or a standing posture regularly.

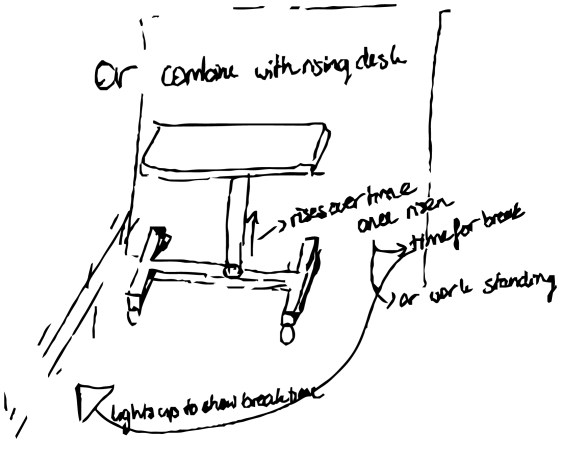
E.10



Raising Monitor

Monitor that raises over time, forcing the user to stand up.

E.11



Stoplight Height Desk

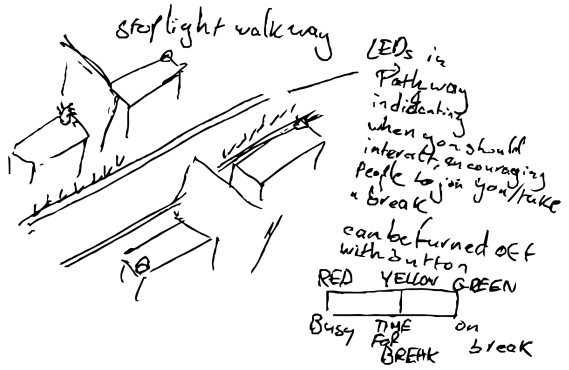
Combines the Stoplight Walkway with the Growing Desk.

E.12

WalkMate

Small blocks on everyone's desk that allow the user to communicate that they wish to or are going to take a walk and if anyone else would like to come along.

E.13



Stoplight Walkway

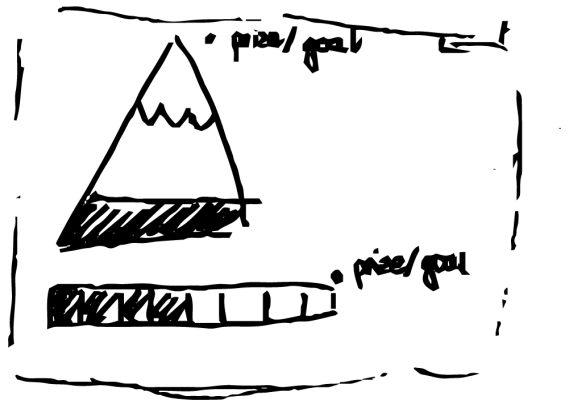
LEDs on the side of the walkway next to desks that indicate when the user is recommended to take a break. Encourages (micro-) break taking through social interaction. Can be turned off with a button. The colors of the LEDs are: Red: busy, Yellow: time for a break, and Green: on a break.

E.14

Stoplight Walkway Tree

The Movement Tree combined with the Stoplight Walkway. Encourages users to walk towards the Movement Tree together.

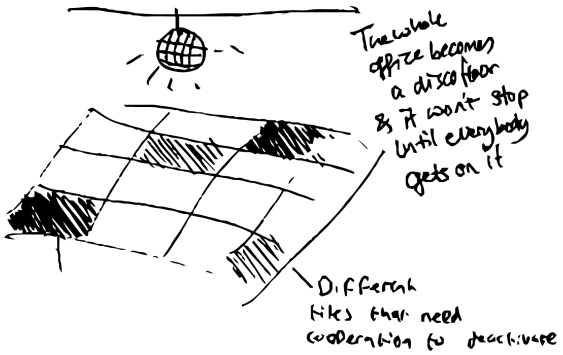
E.15



Office Goal

A concept to possibly include as part of another design. A company-wide progress tracker to incentivize movement collectively toward a prize or goal.

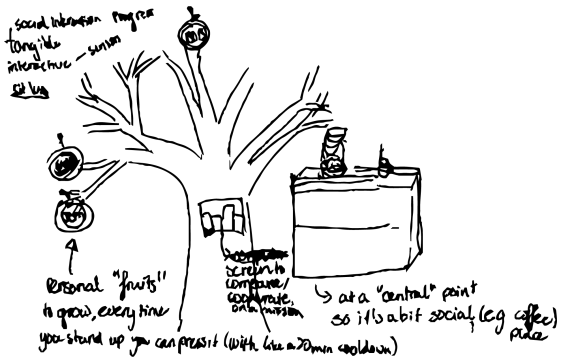
E.16



Office Disco

The office turns into a disco. Requires the cooperation of all employees to step on certain places to deactivate it.

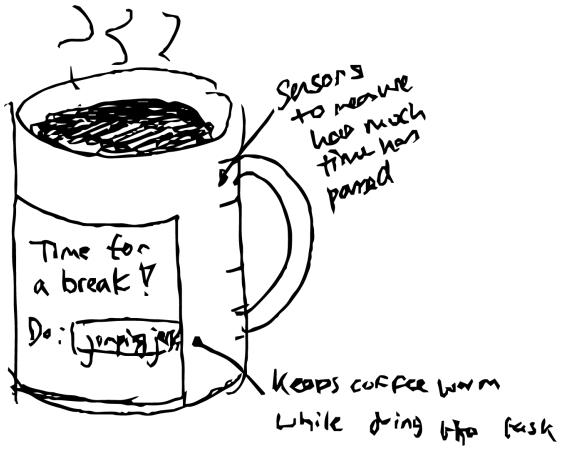
E.17



Movement Tree

An artificial apple tree at a social place in the office. Each employee has a representative apple (with a button) which grows every time it is pressed with at least 20 minutes in-between presses. Also displays a collaborative goal tracker inside the tree.

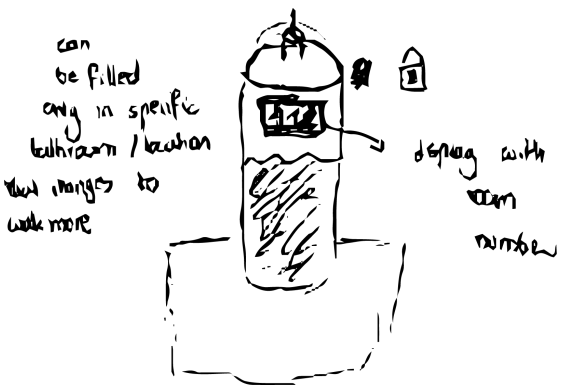
E.18



Smart Mug

A mug with a timer and display. Senses time spent on the table and lets the user know through the display to take a break. The mug also recommends an exercise to do during the break. It also keeps the liquid warm.

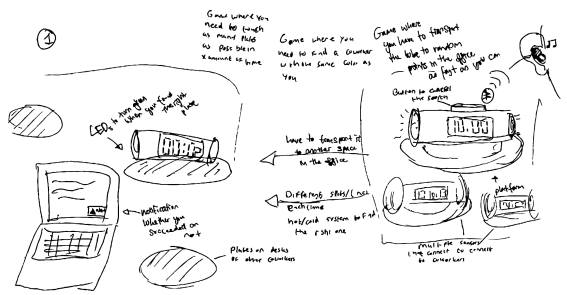
E.19



Quest Bottle

A water bottle that displays a specific location it wants to be filled in. Can only be fully opened in that room.

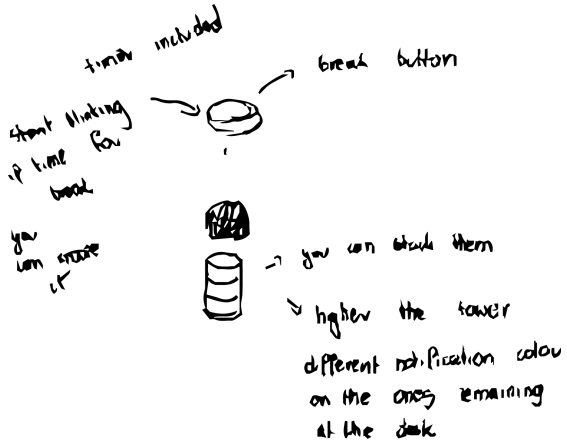
E.20



Cylinder Scavenger Hunt

Cylinder with an display and multiple sensors. Has different modes, such as touching as many base plates within a time limit, finding coworkers devices with matching colors, and transporting the device to random office locations, hot/cold system to find the plates. Makes sound when it is time to play one of the modes. Able to cancel the action. The base plates are located on each employees' desk.

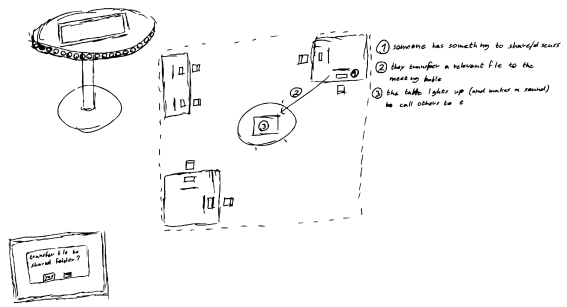
E.21



Stacked Timer Blocks

Cylinder blocks that stack. Each block represents a certain amount of time, stacking them increases the timer duration. The blocks share a colour gradient that represents the time left on the timer and starts blinking once the time is up. The button up top starts the break time.

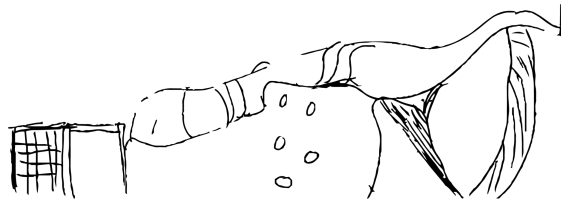
E.22



Improved Standing Meeting Table

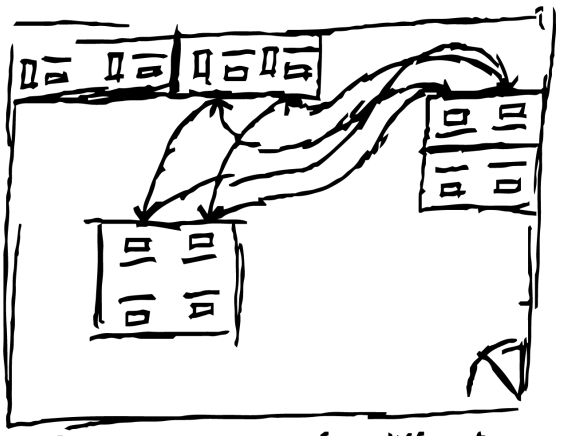
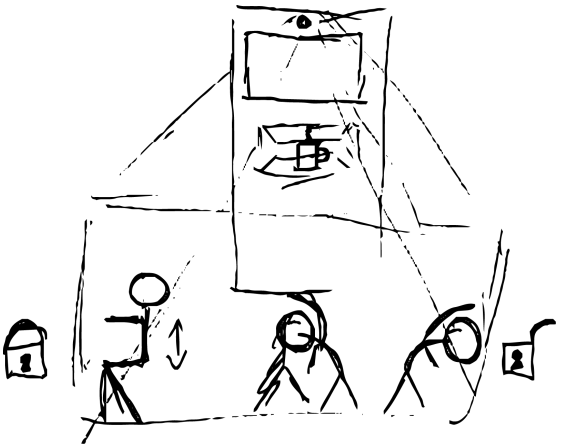
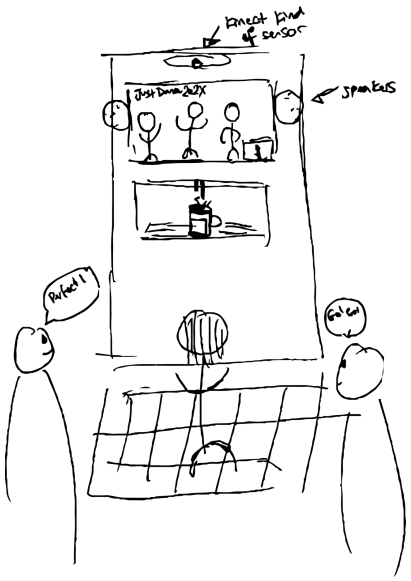
A taller meeting table with a laptop touch screen built in for standing meetings. Allows the meeting agenda/presentation to be opened on it. When someone has something to share or discuss, they transfer the relevant file to the meeting table, it lights up (and makes a sound), and calls others to it.

E.23

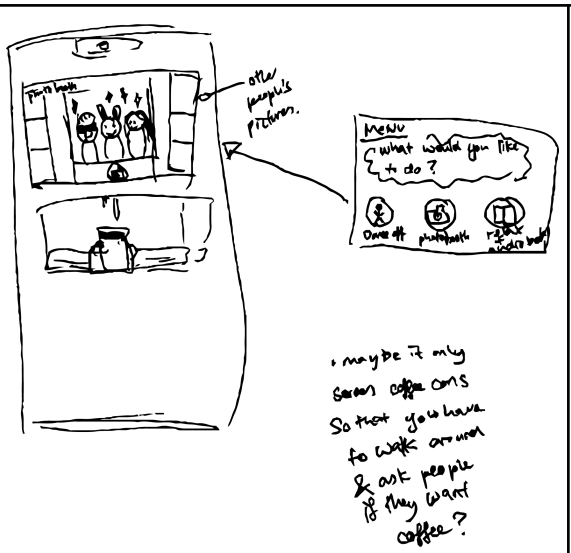


Office Jungle

A climbing jungle in the office to facilitate unique meeting and sitting postures.

E.24		## Dynamic Workstation A workplace where each task in the day can (only) be done at different desks with workstations. Resulting in each employee often moving from one desk to another throughout the day regularly.
E.25		## Exercise-for-Coffee Machine A coffee machine that requires the user to execute three exercise movements to unlock the machine.
E.26		## Just-Dance-for-Coffee Machine Coffee machine that plays Just Dance as the coffee is being made.

E.27



Choose-Action-Coffee Machine

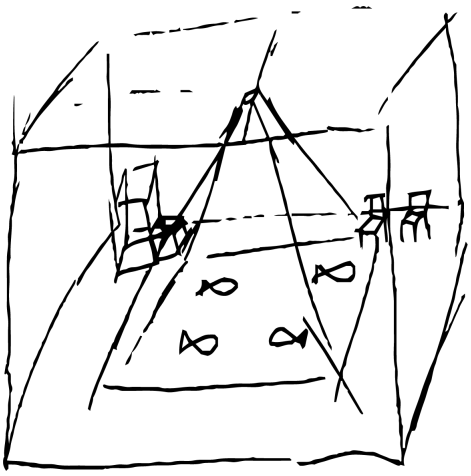
Coffee machine that requires the user to have a dance off, photo booth picture, or relax and audio book listen to get coffee to be made.

E.28

Stair Lights

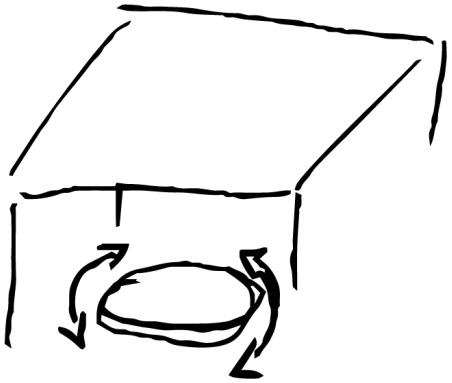
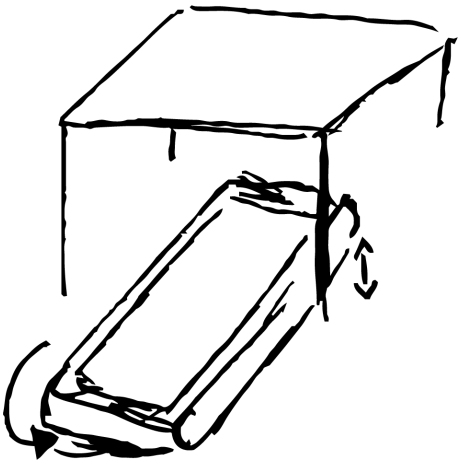
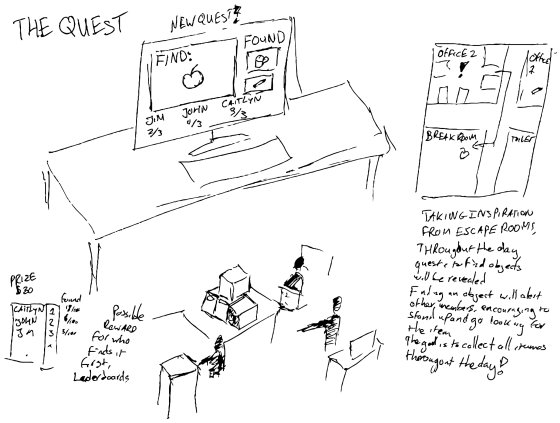
The wall next to the staircase increasingly lights up as more employees use the stairs to get to the office, instead of the elevator. Uses pressure plates as data collector.

E.29



Interaction Room

An interactive playground that can be set up in a meeting room. Allows users to play a game on the floor.

E.30		## Omni-Directional Treadmill An omni-directional treadmill that can be used while working in a standing posture.
E.31		## Rotational Panel A rotational panel to stand on behind the desk, allowing for hip rotations in an active posture.
E.32		## Treadmill A treadmill to be used while working behind a standing desk. Allows the user to walk during work tasks.
E.33		## Collective Scavenger Hunt Throughout the day, quests to find objects are revealed. Finding them alerts other users, meant to encourage them to look for the item revealed (e.g. an apple). The goal is to collect as many in a day. Daily leaderboard with rewards for the top scorer(s).

References

[1] United Nations Children's Fund (UNICEF), (April, 2021). Non-communicable diseases. [Online]. Available at: https://data.unicef.org/topic/child-health/noncommunicable-diseases/, last accessed on 25-11-2023.

[2] Pan American Health Organization, Regional Office for the Americas of the World Health Organization(n.d.). Noncommunicable Diseases. [Online]. Available at: https://www.paho.org/en/topics/noncommunicable-diseases, last accesed on 25-11-2023.

[3] World Health Organization, (Sep, 2023). Noncommunicable Diseases. [Online]. Available at: https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases, last accessed on 25-11-2023.

[4] Al-Maskari, F, United Nations (n.d.). Lifestyle Diseases: An Economic Burden on the Health Services. [Online]. Available at: https://www.un.org/en/chronicle/article/lifestyle-diseases-economic-burden-health services, last accessed on 25-11-2023.

[5] Centers for Disease Control and Prevention, U.S. Department of Health & Human Services (Oct 2020). Lifestyle Risk Factors. [Online]. Available at: https://www.cdc.gov/nceh/tracking/topics/LifestyleRiskFactors.htm#anchor_1606671360465, last accessed on 25-11-2023.

[6] Budreviciute, A., Damiati, S., Sabir, D. K., Onder, K., Schuller-Goetzburg, P., Plakys, G.,, Katileviciute, A., Khoja, S. & Kodzius, R. (2020). Management and prevention strategies for non-communicable diseases (NCDs) and their risk factors. Frontiers in public health, 8, 788.

[7] Unknown. “Nederland Europees kampioen zitten.” TNO. https://www.tno.nl/nl/newsroom/2024/02/nederland-europees-kampioen-zitten/ (accessed 15-03-2024)

[8] Brombacher, H., Houben, S. and Vos, S., 2023. Tangible interventions for office work well-being: approaches, classification, and design considerations. *Behaviour & Information Technology*, pp.1-25.

[9] van der Valk, Steven, Trina Myers, Ian Atkinson, and Karl Mohring. 2015. “Sensor Networks in Workplaces: Correlating Comfort and Productivity.” In 2015 IEEE Tenth International Conference on Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP), 1–6.

[10] “Meer bewegen kan uw bedrijf winst opleveren”. TNO https://publications.tno.nl/publication/34613487/SVOvOG/hildebrandt-2003-winst.pdf

[11] Y. Wang, L. Wu, J.-P. Lange, A. Fadhil, and H. Reiterer, “Persuasive technology in reducing prolonged sedentary behaviour at work: A systematic review,” *Smart Health*, vol. 7–8, pp. 19–30, Jun. 2018, doi: 10.1016/j.smhl.2018.05.002.

[12] I. Damen et al., “A Scoping Review of Digital Tools to Reduce Sedentary behaviour or Increase Physical Activity in Knowledge Workers,” *International Journal of Environmental Research and Public Health*, vol. 17, no. 2, p. 499, Jan. 2020, doi: 10.3390/ijerph17020499.

[13] Y. Huang, S. Benford, and H. Blake, “Digital Interventions to Reduce Sedentary behaviours of Office Workers: Scoping Review,” *Journal of Medical Internet Research*, vol. 21, no. 2, p. e11079, Feb. 2019, doi: 10.2196/11079.

[14] O. Shaer, “Tangible User Interfaces: Past, Present, and Future Directions,” *Foundations and Trends in Human-Computer Interaction,* vol. 3, no. 1–2, pp. 1–137, 2009, doi: 10.1561/1100000026.

[15] M. Rabbi, A. Pfammatter, M. Zhang, B. Spring, and T. Choudhury, “Automated Personalized Feedback for Physical Activity and Dietary behaviour Change With Mobile Phones: A Randomized Controlled Trial on Adults,” *JMIR mHealth and uHealth,* vol. 3, no. 2, p. e42, May 2015, doi: 10.2196/mhealth.4160.

[16] T. Djajadiningrat, B. Matthews, and M. Stienstra, “Easy doesn’t do it: skill and expression in tangible aesthetics,” *Personal and Ubiquitous Computing*, vol. 11, no. 8, pp. 657–676, Mar. 2007, doi: 10.1007/s00779-006-0137-9.

[17] D. Aggarwal, R. A. Khot, and J.-Y. (Lois) Yi, “Zenscape: Encouraging Microbreaks from Screen-based Work through a Tangible System,” *Proceedings of the Eighteenth International Conference on Tangible, Embedded, and Embodied Interaction*, Feb. 2024, doi: 10.1145/3623509.3633368.

[18] K. Fachry, I. Mulder, H. Eertink, and M. Janse, “Enticing Sociability in an Intelligent Coffee Corner,” *Lecture Notes in Computer Science*, vol. 4781, pp. 490–501, 2007.

[19] I. Damen, A. Kok, B. Vink, H. Brombacher, S. Vos, and C. Lallemand, “The Hub,” *Companion Publication of the 2020 ACM Designing Interactive Systems Conference*, Jul. 2020, doi: 10.1145/3393914.3395876.

[20] P. Keller, R. van den Heuvel, and C. Lallemand, “Bringing Movement to Digital Tasks at the Office: Designing an Acceptably Active Interface Interaction for Sending Emails,” *Proceedings of the Seventeenth International Conference on Tangible, Embedded, and Embodied Interaction*, Feb. 2023, doi: 10.1145/3569009.3573113.

[21] World Health Organization, (2023). Promotion of health-enhancing physical activity in small-to-medium-sized enterprises. [Online]. Available at: https://iris.who.int/handle/10665/373629, last accessed on 19-04-2024.

[22] A. H. Mader and W. Eggink, “A Design Process for Creative Technology,” *Proceedings of the 16th International conference on Engineering and Product Design*, E&PDE 2014, Sep. 2014.

[23] X. Ren, B. Yu, Y. Lu, B. Zhang, J. Hu, and A. Brombacher, “LightSit: An Unobtrusive Health-Promoting System for Relaxation and Fitness Microbreaks at Work,” *Sensors*, vol. 19, no. 9, p. 2162, May 2019, doi: 10.3390/s19092162.

[24] K. Fujita, A. Suzuki, K. Takashima, K. Ikematsu, and Y. Kitamura, “TiltChair: Manipulative Posture Guidance by Actively Inclining the Seat of an Office Chair,” Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, May 2021, Published, doi: 10.1145/3411764.3445151.

[25] J. J. Shah, N. Vargas‐hernandez, J. D. Summers, and S. Kulkarni, “Collaborative Sketching (C-Sketch) - An Idea Generation Technique for Engineering Design,” *Journal of Creative behaviour*, vol. 35, no. 3, pp. 168–198, Sep. 2001, doi: 10.1002/j.2162-6057.2001.tb01045.x.

[26] T. Härkki, P. Seitamaa-Hakkarainen, and K. Hakkarainen, “Line by line, part by part:

collaborative sketching for designing," *International Journal of Technology and Design Education*, vol. 28, no. 2, pp. 471–494, Sep. 2016, doi: 10.1007/s10798-016-9379-7.

[27] I. Van De Poel and L. Royakkers, *Ethics, Technology, and Engineering: An Introduction*. Blackwell Publishing, 2011, ch. 5

[28] The Royal Netherlands Society of Engineers, "Code of Ethics," KIVI Engineering Society, Jan. 2018. Accessed: Jun. 07, 2024. [Online]. Available: https://www.kivi.nl/uploads/media/5a587110c2160/2018-01%20Code%20of%20Ethics.pdf

[29] G. Koronis, H. Casakin, and A. Silva, "Crafting briefs to stimulate creativity in the design studio," *Thinking Skills and Creativity*, vol. 40, p. 100810, Jun. 2021, doi: 10.1016/j.tsc.2021.100810.

[30] L. Sun, W. Xiang, S. Chen, and Z. Yang, "Collaborative sketching in crowdsourcing design: a new method for idea generation," *International Journal of Technology and Design Education*, vol. 25, no. 3, pp. 409–427, Sep. 2014, doi: 10.1007/s10798-014-9283-y.

[31] W. Wang, Ding, and I. Hirskyj-Douglas, "Everyday Space as an Interface for Health Data Engagement: Designing Tangible Displays of Stress Data," Jul. 2023, doi: 10.1145/3563657.3596096.

[32] "Monitoring noncommunicable disease commitments in Europe 2021," World Health Organization, Dec. 2021. Accessed: Jun. 25, 2024. [Online]. Available: https://www.who.int/europe/publications/i/item/WHO-EURO-2021-4479-44242-62494