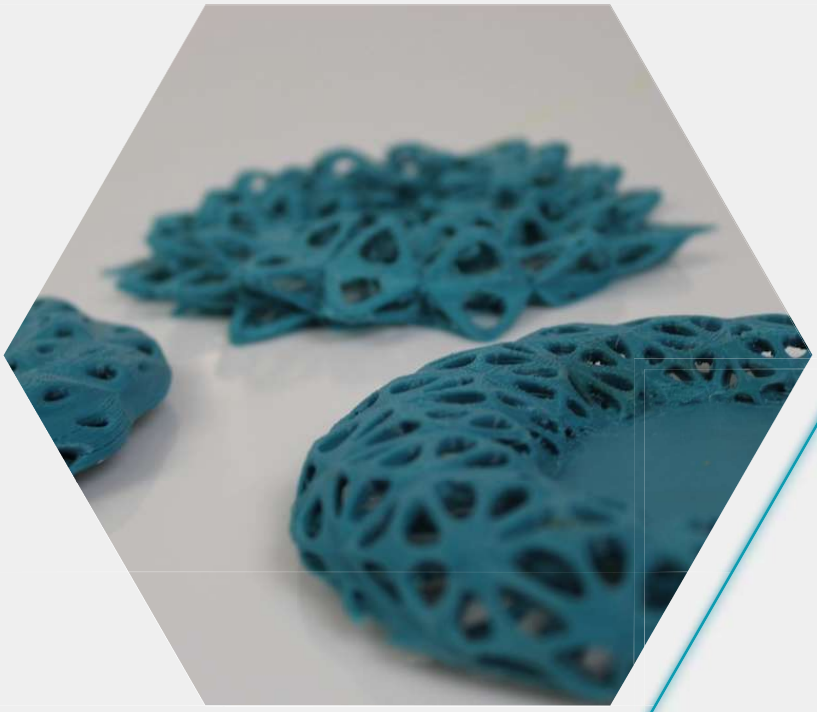
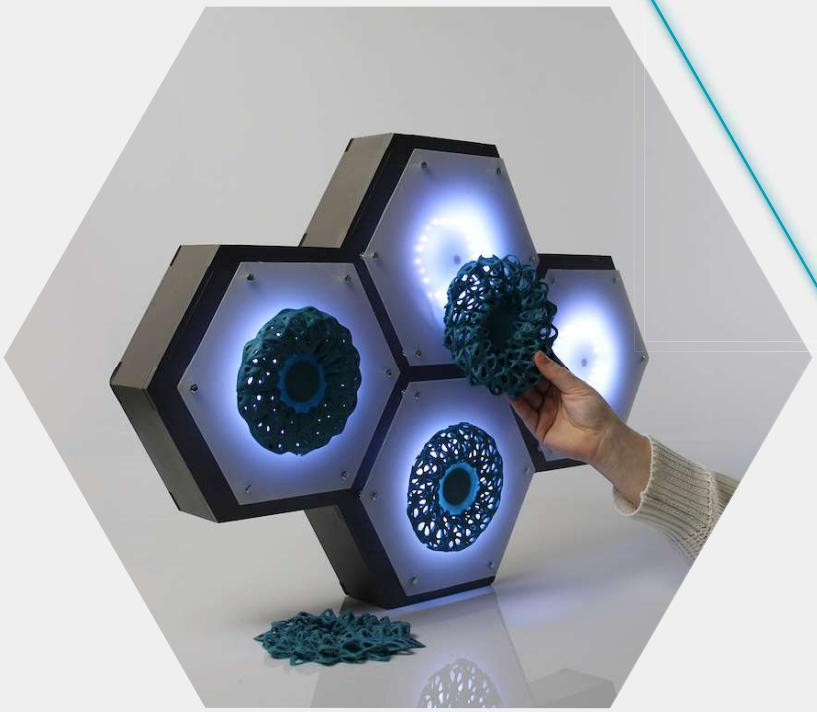
TU/e – M11 Design project

NELO

M11 COLLECTIVE STRESS





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Abstract

This report discusses the development of NELO, a system that transforms employees' physical activity data into tangible 3D-printed artifacts, enabling collective reflection on office behavior and stress. The artifacts' shapes, determined by physical activity levels, encourage deep engagement and aim to foster group discussion. User testing emphasized the need for additional information, as participants found the representation of stress by the physicalizations too abstract. To address this issue, an interface was developed to provide additional insights regarding data translation.

Introduction

Stress can have significant physical consequences, including headaches, fatigue, cardiovascular problems, digestive issues, and even asthma [17]. In severe cases, stress can escalate to burnout, a condition that has become increasingly common in recent years. Factors like heavier workloads, tight deadlines, and mental health challenges have all contributed to this rise [37].

In office settings, stress often becomes a shared experience due to collective goals and the pressure to meet team deadlines [37]. Unfortunately, when employees experience burnout, it's not just their health that suffers, it is also the company's overall well-being that feels the impact as well.

A key aspect of this project is that, according to research, a lack of physical activity is related to an increase in prolonged stress [9, 20, 24]. Therefore, stress levels in the current concept are indicated by physical (in)activity data.

Absenteeism, reduced productivity, and strained team dynamics are just a few of the challenges businesses face when employees are overwhelmed by stress [21]. Therefore, it is important to address these issues.

This leads to the following design challenge: ***"How can a product contribute to collective stress management in office environments by encouraging physical activity through micro-breaks?"***

Related work

Stress in office environments
Stress is a complex phenomenon that involves both brain processes and physical responses. It can be defined as physical or emotional tension triggered by any event, idea, or situation that causes feelings of anxiety, anger, or frustration. The experience of stress is highly individual and can manifest in diverse ways depending on the circumstances and the individual's perception [16].

There are different types of stress, broadly categorized as acute (short-term) stress and cumulative or prolonged stress [4]. Acute stress arises suddenly in response to immediate challenges, often resolving quickly. In contrast, prolonged stress builds up over time, often resulting from prolonged exposure to stressors, and can have significant long-term effects on both physical and mental health [4].

Various factors contribute to stress. Social stress, stemming from interpersonal relationships or societal pressures, is a common cause [4]. Additionally, stress can be influenced by contagion, where stress spreads within groups, and competition, which may exacerbate pressure to perform or succeed [34].

For businesses, unmanaged stress among employees presents serious challenges. These include increased absenteeism, reduced productivity, and strained team dynamics, all of which can undermine organizational success and employee well-being [21]. Addressing stress effectively is therefore critical for both individuals and organizations.

Previous projects on stress in office environments
Several systems have already been designed to address stress relief and promote well-being in the workplace. AromaHub utilizes fragrances to provide synchronized stress relief for individual users [38]. Similarly, PopStress creatively transforms group stress into positive energy by activating a popcorn machine, encouraging office workers to pause and bond over a snack break [4].

The role of visualizations in stress management has also been explored. Smart Cushions for Office Chairs integrates multi-user sensory data into visual outputs, ranging from abstract and grouped representations to metaphorical collective stress visualizations [12]. Meanwhile, Dynamic Painting transforms office stress into a visual artwork that evolves based on the group's intensity and duration of stress [26].

Nature-inspired solutions also play a role in reducing stress. Window to Relief recreates natural scenes in a ceiling light installation, offering a calming, immersive experience for office environments [30]. On a more data-driven level, Reflecting on Organizational Stress presents shared heart rate variability visualizations to raise awareness about group stress patterns [35]. Lastly, Visualizing Health explores a business-oriented strategy to bring stress-monitoring products, such as sensor-equipped chairs, to the market [39].

Together, these works highlight diverse strategies for tackling workplace stress, ranging from sensory stimulation to visual representation. However, there is a lack of exploration in making data related to stress levels in the office tangible.

Measuring collective activity levels in office environments
Measuring collective physical activity in the office is crucial as sedentary behavior in office workers is prevalent, with up to 71% of working hours spent sedentary [10]. Objective measurements using accelerometers and pedometers have been employed to assess both sedentary behavior and physical activity levels during work and non-work hours [5, 10, 13]. Activity levels were categorized into sedentary, light-intensity, and moderate-to-vigorous activity based on count thresholds. Additionally, subjective tools such as self-reports, surveys, and questionnaires are often used as well [7]. Other studies have used cameras as a tool to track employees in office environments [32]. Wojek et al. (2006) uses a network of cameras and microphones to track multiple persons at once. By using video and audio features, a hidden Markov model (HHM) was employed for activity recognition [32]. An HHM is a statistical model used to describe systems that transition between hidden (unobservable) states based on probabilistic rule. Furthermore, Wu et al. have introduced Eaglesense, a system that uses a depth camera to track human activity in interactive spaces. Eaglesense provides accessible and non-intrusive tracking data by only collecting raw depth values [33]. Finally, more advanced techniques are discussed by Chaudhary et al. (2022), were CCTV and machine learning techniques are often combined to monitor crowd behavior [8].

Making physical activity tangible

Making data tangible, especially in the area of physical activity, has been increasingly explored in the human-computer interaction field. Stusak et al. (2014) investigated Activity Sculptures, which transforms running data into physical awards, fostering motivation and ownership and highlighting the potential of tangible feedback [28]. Similarly, Menheere et al. (2021) developed Laina, a shape-changing artifact that visualizes effort-based metrics from running routes using wooden pins [22]. By allowing users to physically interact with and modify the structure, Laina enables engagement and personal connection between users and their data. Another example of shape-changing data objects is demonstrated by Sauvee et al. with LOOP: a physical artifact in the form of multiple rings that dynamically change orientation based on personal activity data [25]. The growing popularity of 3D printing has also become evident in this domain. For instance, SweatAtoms by Kot et al. (2014). introduces 3D-printed artifacts created from bodily data [19]. Specifically, heart rate data is used as input for these physicalizations. Results demonstrated that these material representations increased participant awareness of their physical activity, which in turn encouraged different levels of engagement. The study also emphasized the emotional and reflective connection that material artifacts can evoke with data. SweatAtoms is studied as part of a larger framework named Shelfie by Kot et al.(2020), that aims to transform digital visualizations into interactive artifacts [18]. Other ways of physicalizing data that were explored in the study are using sports drinks and edible chocolate artifacts. These explorations underline the potential of physical representations to provide a multi-sensory and engaging experience, that goes beyond traditional on-screen graphs and information.

Process visualization

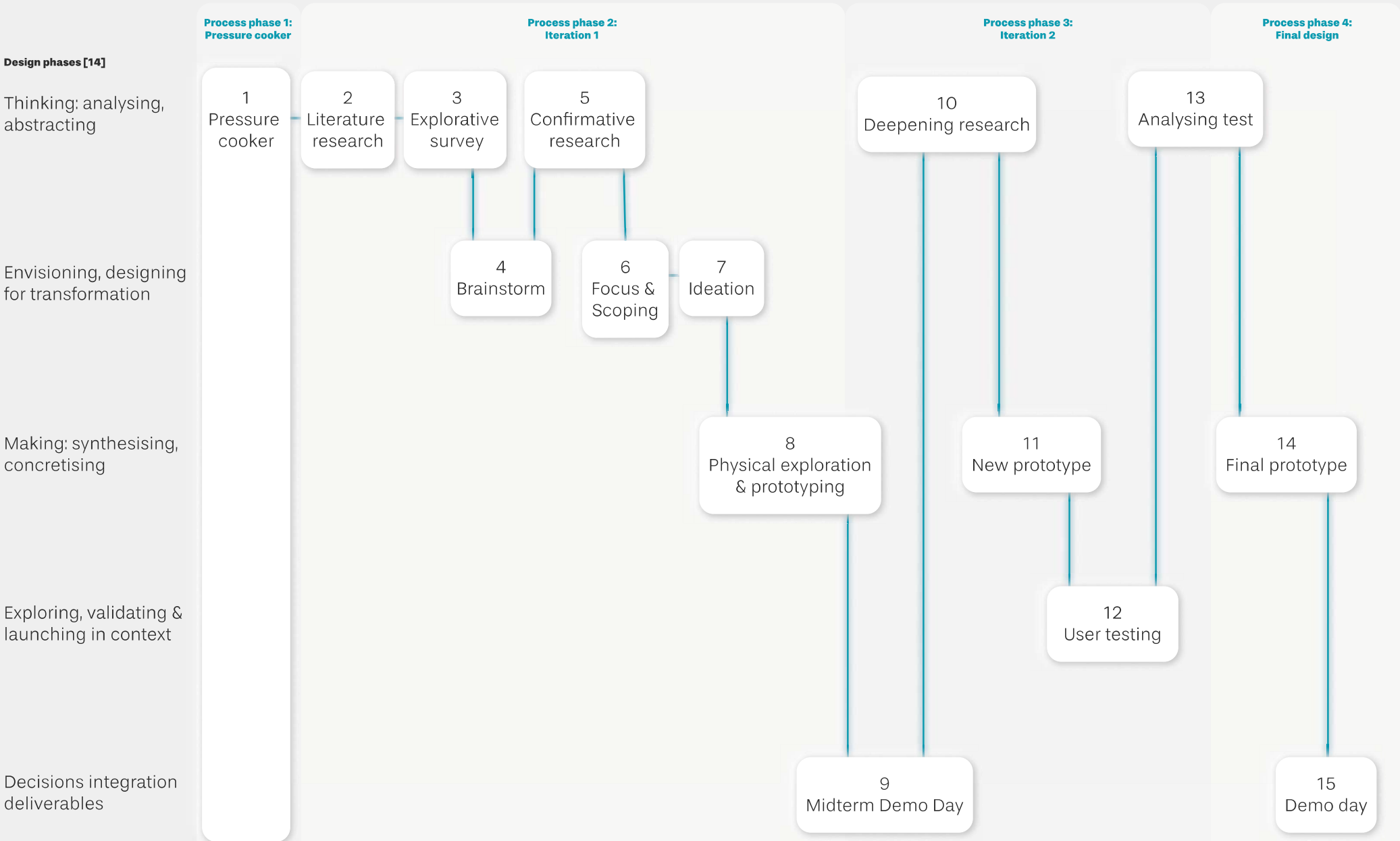


Figure 1. process visualization

Design iterations

Pressure cooker

The project commenced with a pressure cooker exercise during its first week, involving a full-cycle design process. The team explored the concept of collective stress through brainstorming, empathy mapping, and formulating "how might we" questions, which guided ideation. A morphological chart was employed to explore and structure ideas, leading to the concept of a game ceiling for office spaces. This interactive ceiling's default state would have a calming presence but transformed into a game when collective stress levels reach a certain threshold, with game controllers emerging from employees' desks, encouraging engagement.

A low-fidelity prototype was tested (figure 2), revealing the following key insights: (1) the concept was perceived as overly intrusive, (2) participants preferred calming over high-energy interventions, and (3) voluntary participation was deemed critical, as mandatory engagement was unappealing.

These findings clarified directions for future iterations. The team evaluated and concluded that the proposed concept was too disruptive and misaligned with user needs.

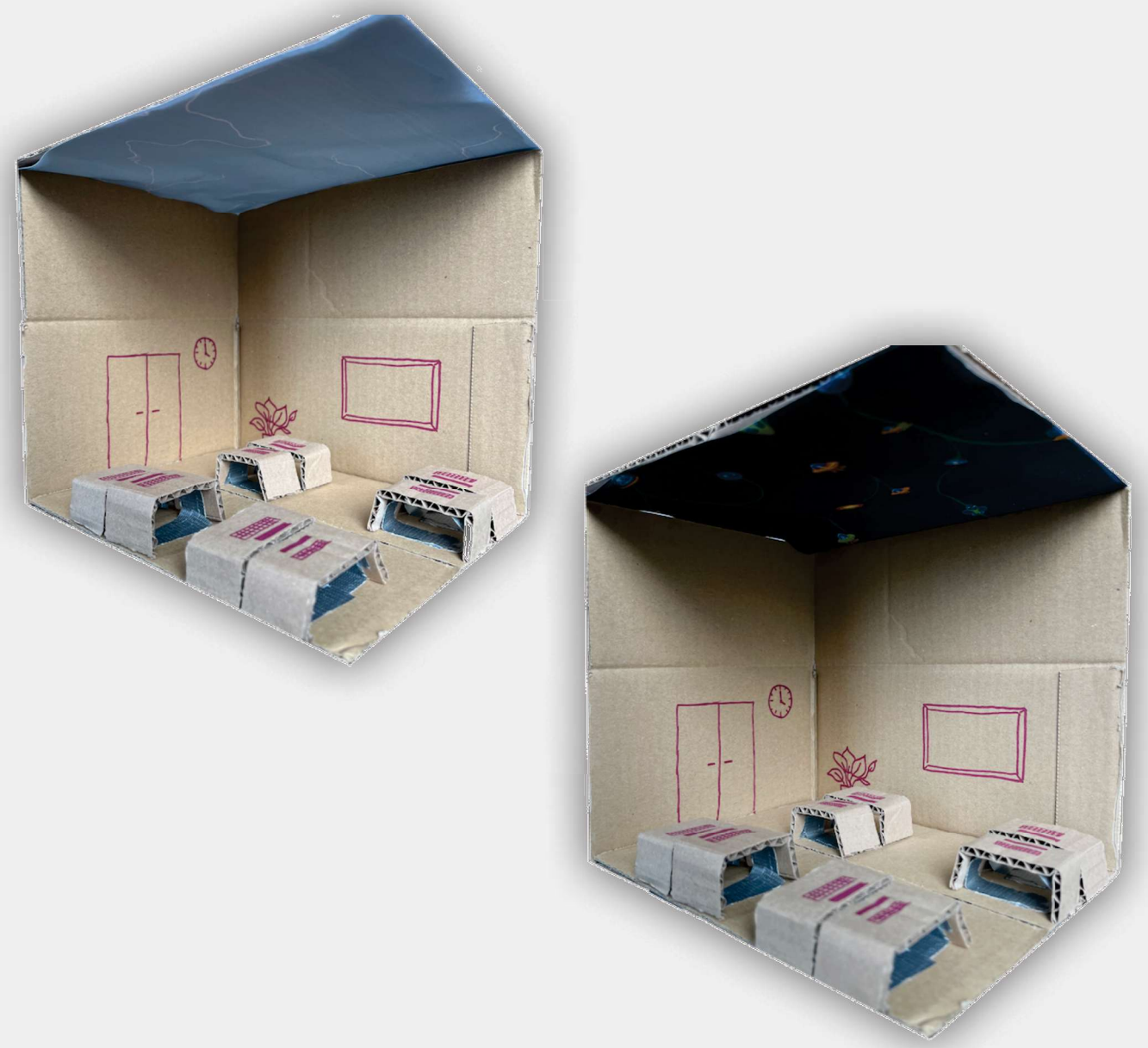


Figure 2. Pictures of the prototype

Iteration 1

Research

Literature research was conducted into aspects, types, and measurement methods for collective stress. While most previous studies monitored stress individually, often through heart rate variability, the team aimed to explore a more abstract and collective approach. Building on these findings, the project was directed toward behavior design, psychological safety, and office culture, leading to the design challenge: ***"How can a product contribute to collective stress management in office environments by fostering psychological safety?"***

An exploratory survey (Appendix 2) was conducted with 12 participants to identify which factors office workers associate with stress. Participants were asked to rank various stress indicators based on relevance to their own experiences. Long working hours was ranked highest, followed by physical inactivity. Since addressing work hours is complex and largely dependent on the employer, the team decided to focus on reducing physical inactivity.

Further literature research revealed a strong link between physical inactivity, specifically sedentary behavior, and workplace stress [9]. As mentioned in the related works, existing solutions provided insights into best practices, emphasizing the need for a trigger that visualizes stress to raise awareness and a motivator that encourages physical activity, helping to alleviate stress. The team brainstormed sensory triggers and ideated potential solutions. Sketches were made to explore different ways to visualize stress and motivate physical activity (figure 3).

Design

A new direction was specified, centering micro-breaks of up to five minutes, and data physicalizations. Instead of real-time stress visualization, the focal point became collecting data over time and transforming it into physical objects. These objects were intended to facilitate collective reflection, fostering a more connected and balanced workplace atmosphere. Additionally, the scope was specified to an office setting of up to ten people, allowing for scalability.

The decision to use physical objects was informed by research suggesting that tactile elements help bridge the gap between intention and action [31]. The benefits of physicalizing data include engaging people with information more effectively, fostering active perception through perception-action loops, addressing multiple senses, and improving accessibility [15].

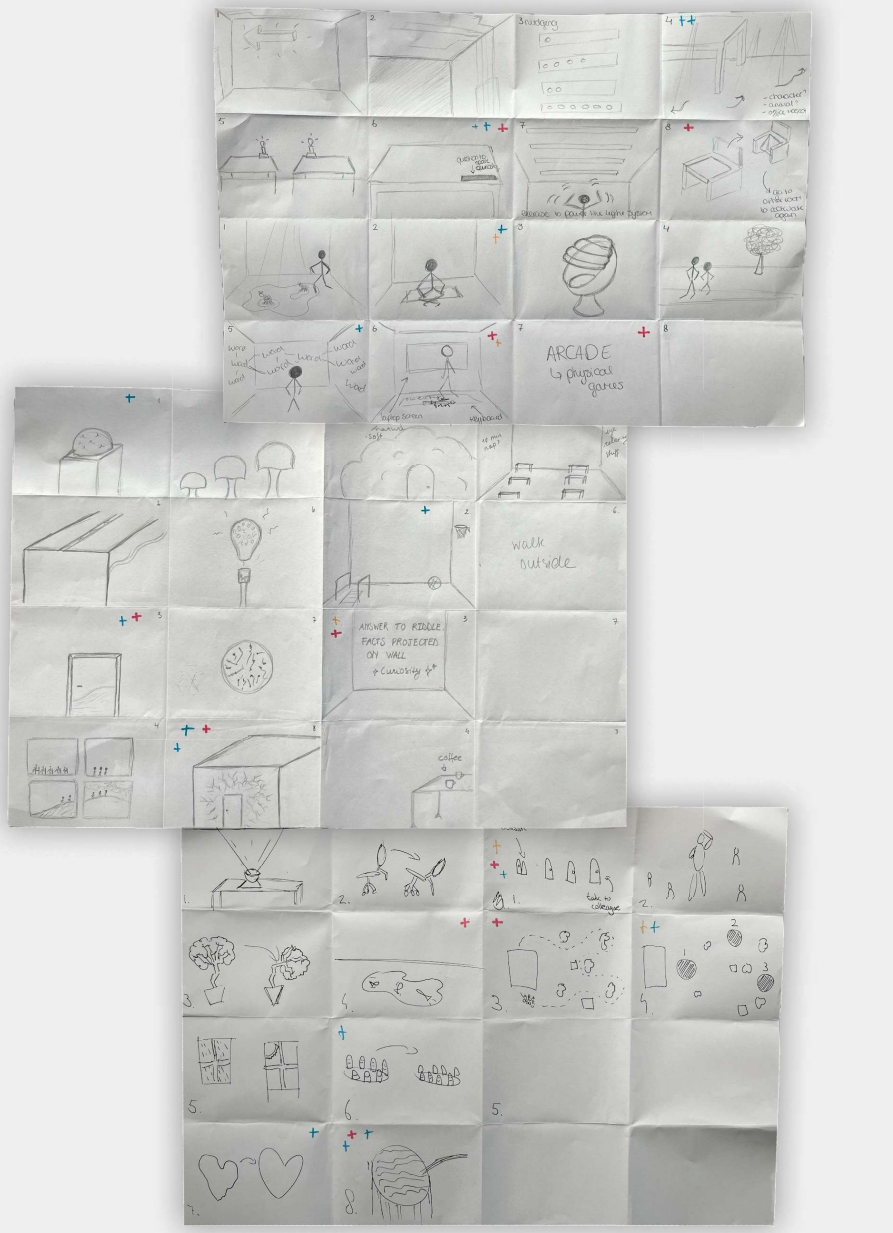


Figure 3. Ideation sketches

For the development of the midterm demo day prototype an acrylic tube, an RGB LED strip [36], an Arduino Uno microcontroller [2], Arduino IDE software [3], Processing software [40], a laptop webcam, and three stackable 3D-printed coral-like disks were used (figure 4). The coral-like shapes were chosen due to the stress-relieving effects of nature-inspired designs, which are known to evoke calmness and reduce tension [23].

The concept involved using a surveillance camera connected to processing software, which was designed to monitor the number of active pixels measured in the office continuously, tracking employee movement within the office space. The gathered data provided input for both the trigger and the data physicalizations.

For the physical part of the prototype, an LED tube was mounted on a stand. During regular conditions, it emitted a calming, orange-tinted light, contributing to a relaxing office atmosphere. When collective physical activity dropped below a predefined threshold over a specific time, the tube acted as a trigger, shifting its light to a stimulating turquoise-blue tint. This subtle but noticeable visual cue was intended to prompt employees to engage in physical activity.

Furthermore, the concept incorporated the idea of a weekly data physicalization feature. Each week, the collected data on office physical (in)activity would be transformed into a tangible object, a 3D-printed disk, representing the team's collective activity levels. This physicalization provided employees with a tactile, visual artifact that encouraged collective reflection on their habits and contributed to a more balanced office culture. The use of physical objects aligns with findings that data physicalizations can effectively communicate abstract data in a tangible, accessible form, fostering engagement and collaboration [15].

For this prototype, the 3D-printed models were sourced from existing designs on Thingiverse.com [29] and did not incorporate real data. Nevertheless, the prototype effectively demonstrated the concept's potential for fostering awareness and encouraging healthier behaviors in the workplace. This iteration laid a strong foundation for the project, with valuable insights regarding the scope of the project and concept refinements, guiding the next stages of development.

Figure 4. Pictures of the prototype

Iteration 2

After receiving feedback during midterm demo day, the second iteration commenced, focusing on refining the concept and addressing key challenges. The final design challenge was defined: ***"How can a product contribute to collective stress management in office environments by encouraging physical activity through micro-breaks?"***

SUE framework

Research into user behavior, product shape, and enabling technologies was conducted. Using the SUE framework [6], people's behaviors and user motivations were analyzed (figure 5).

Pains of current behaviour

What are drawback about the current situation?

- Sore body
- Tired
- Negative emotions

Target audience

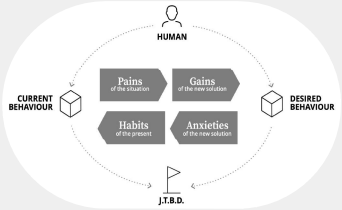
Team of office workers

Gains of desired behaviour

- Believe micro-breaks have independent health benefits
- Taking more micro-breaks make you more productive
- Time to socialize

Current behaviour

Showing a lot of sedentary behaviour while working



Desired behaviour

Collective micro-breaks with physical activity

Habits in current behaviour

What are habits that cause the target audience to become stuck in their behaviour?

- Used to the facts that they work behind a desk
- Lack of awareness of how much they actually sit
- "I'll keep going and have a cup of tea as a reward when I've done it."

Job to be done

What is the main goal of the target audience?

Fulfill their job so they will get paid

Anxieties

What are drawbacks of performing the desired behaviour?

- Job scope: They need to work behind a computer
- Lack of time for activities/microbreaks
- "My activity distracts others"
- "Heavy workload and tight deadlines impel me to sit and work continuously longer than I would like to"

Figure 5. SUE framework

User journey map (Current situation)

A user journey map visualized workplace dynamics, identifying key intervention points for the product.

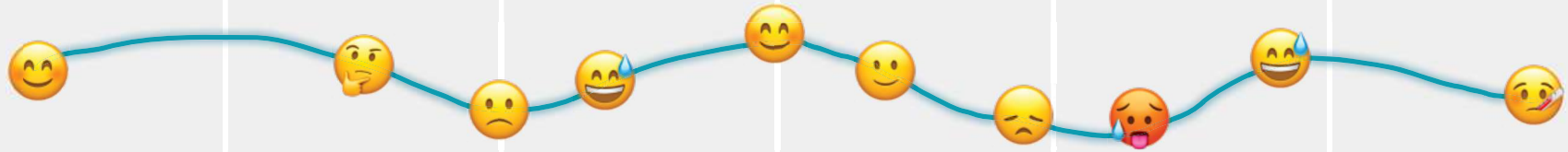
Journey steps	Going to work	Morning	Lunch break	Afternoon	End of work day	Long term
Actions	• Arrives at work • Greets colleagues • Gets ready to start working	• works the whole morning because deadlines need to be finished soon • The only breaks are for the restroom and coffee	• Eat lunch in the canteen • Socialize with colleagues	• Starts to work again • Forgets to take breaks • Back starts to hurt and legs feels stif	• Wraps-up the day • Goes home tired	Prolonged stress
Needs & pains	Need to go to work to do their job	• I want to do as much work as possible to save time in the afternoon • I am unsure about the optimum break interval or scientific rationale behind it	• I want to dettach from work during the break • I want to have time for non-work preoccupations (hobbies/chores/leisure)	• I want to have the time for activities/micro-breaks • "I lose track of time very easily, especially if I'm coding. I know afterwards when I look at the watch and I see that it's been 3 hours and I haven't moved" • I want an adjustable workplace to tackle body complaints	• I want to go home on time • I want to feel content with the work I did during the day • "As I grabbed my keys I hear my boss yell over. He calls me in his office and has me going over multiple projects essentially wanted the low down on my week." [X]	Heightened chance at health risks like heart-disease etc.
Customer feeling						
Opportunities for interventions		Increase a awareness of optimum break interval		Motivate to move more to reduce bodily complaints	Create a 'closing the day'-routine to get in to a relaxing state	

Figure 6. User journey map

Benchmarking

Another benchmarking exercise provided insights into existing products and concepts, helping to clarify what should be implemented and what should be avoided. Findings were categorized into "do's" and "don'ts".

Do's

1. Encourage social breaks;
2. Add gamification elements;
3. Integrate the product seamlessly into the environment.

Don'ts

1. Focus exclusively on individuals;
2. Make the product easy to ignore;
3. Personalization of the product;
4. Distracting users excessively;
5. Rely heavily on user self-discipline.

	Products that promote social breaks	Office objects with Break reminders	Gamified break systems	Smart Office furniture	Time Out Apps & Software
Good practices	• Promotes team-building • If more people are involved, they will take each other accountable • Getting more acquainted with colleagues improve the overall atmosphere in the office	• Subtle reminders • Promoting healthy habits • These products contribute to a positive work environment	• Gamification motivates • Promotes team-building • Easy to install of several devices (desktop, mobile)	• Integrated in the work environment • Supports ergonomics and movement • One time investment for the company	• Easy to install of several devices (desktop, mobile) • Apps are often cheaper than physical objects • Paired for introduction meetings, giving them the chance to connect and build meaningful relationships.
Bad practices	• Might feel forced to the employees	1	• Dependent on each person if they like it • Can be too much of a distraction • Focused on individuals	• (might be) High investment • Usability is very dependent on the office space • Needs a lot of self-discipline • Focused on individuals	• Easy to ignore • Click away and go on with the work • Needs a lot of self-discipline • Screen related • Focused on individuals • Might feel like they are tracked

Figure 7. Benchmarking overview

Privacy research

Since the system's technology relied on a surveillance camera, the research explored employee perceptions of privacy in workplace monitoring technologies. Key findings indicated that employees do not reject these technologies per se and are more accepting when these technologies are transparent, provide controlled access to data, and offer clear productivity benefits. Conversely, negative attitudes arise when privacy safeguards are lacking or when the technologies appear to enable strict managerial control [1].

Material, mechanics, and shape studies

Material, mechanics, and shape studies informed the product's development. Lights remained to be used for the primary trigger mechanism for the product. The data physicalizations retained their coral-like, nature-inspired shape, as these forms evoke calming effects associated with nature [23]. Material explorations were done as an inspiration for the aesthetic of the 3D prints (figure 8). The physicalizations were 3D-printed using PET-G filament [11], chosen for its partially transparent properties when printed in thin layers, enhancing its aesthetic and functional appeal.

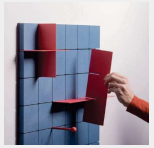
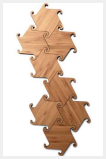
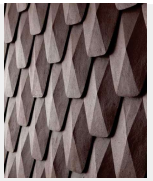
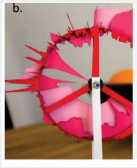
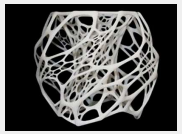
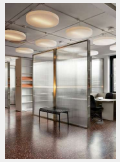
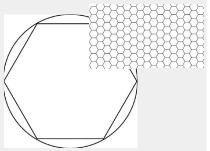
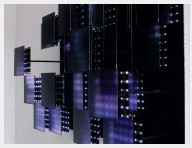
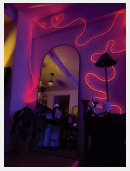
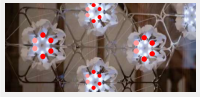
Figure 8. Moodboard of form research

Program of requirements

Based on the new insights from our research, a program of requirements was developed, providing a structured foundation for the design and prototyping process. These requirements were divided into two categories (figure 9):

General requirement	Functionality requirements
The product must be a physical object	The product should signal when it is time to take a micro-break
The product must be modular	The product (or breaks) should not be easy to ignore
The product must be shaped or physicalized by data input	The product should promote collective breaks
The product must trigger users to take micro-breaks	The product should indicate when the break is over
The product should facilitate collective reflection over time	The product should be modular to allow for weekly servicing
The product must be usable by diverse users	The product must collect data via a surveillance camera
The product must be visible to all employees in the office	

Figure 9. Program of requirements

Morphological chart	OPTION 1	OPTION 2	OPTION 3	OPTION 4	OPTION 5
The product needs to be modular					
Product should allow (Longterm) collective reflection					
Product needs to be visible to all in the office					
The product should indicate it is time to take a micro break					
The product(/ the breaks) should not be easy to ignore		Intensify trigger over time when ignored	Pop ups on individual laptop screen (when ignored)	Things coming out of side of frame	Might be nice to have some indication of how they are doing?
The product should promote collective breaks					
The product should indicate when the break is over					

Ideating

To explore implementation of the requirements, a morphological chart was created by outlining various ways the product could fulfill its objectives. By combining different options, concepts were generated. Sketching the final concept led to the initial steps of the prototyping process (figure 10).

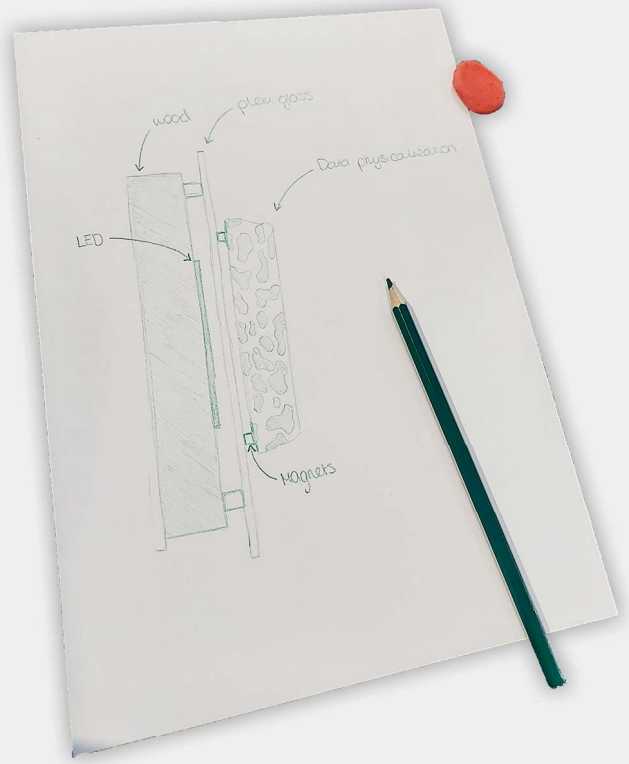


Figure 10. sketch of idea

Prototyping

A low-fidelity prototype was realized using foamboard and an Arduino Uno microcontroller [2] to realize the LEDS of the trigger (figure 11). The 3D-printed objects of the midterm demo day prototype were reused.

The product aimed to make activity data tangible and interactive, bridging the gap between intention and action. By fostering long-lasting behavior change, it aimed to indirectly reduce or potentially even prevent collective stress.

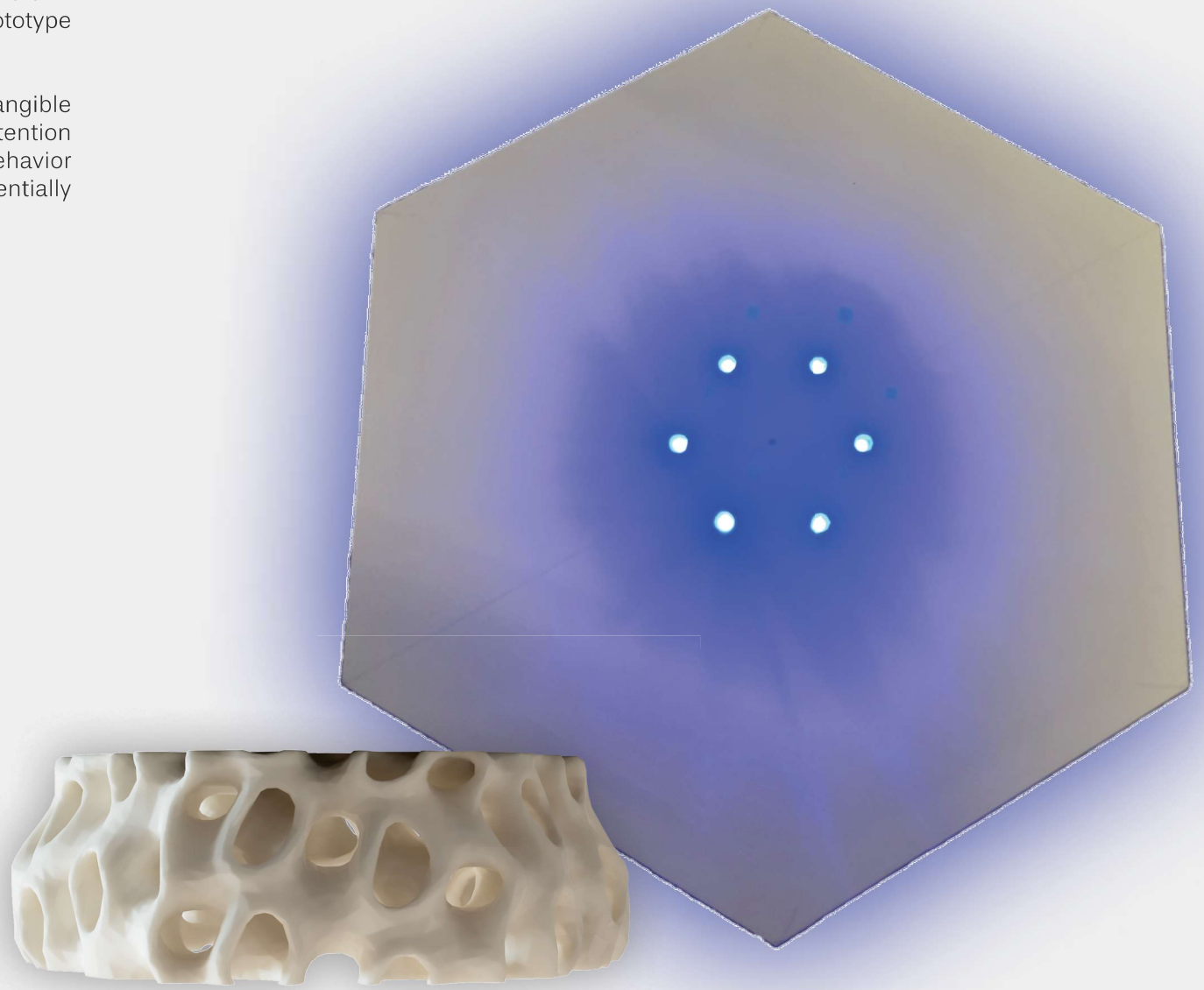


Figure 11. Picture of the prototype

Final design

NELO is an informative art installation designed for small office environments to spark reflection about employees' physical activity during work hours and, therefore, aims to reduce stress over time. The final design consists of multiple components that collect and display activity data, allowing employees to gain a rich understanding of their movement behavior, encouraging microbreaks and collective reflection (figure 12).

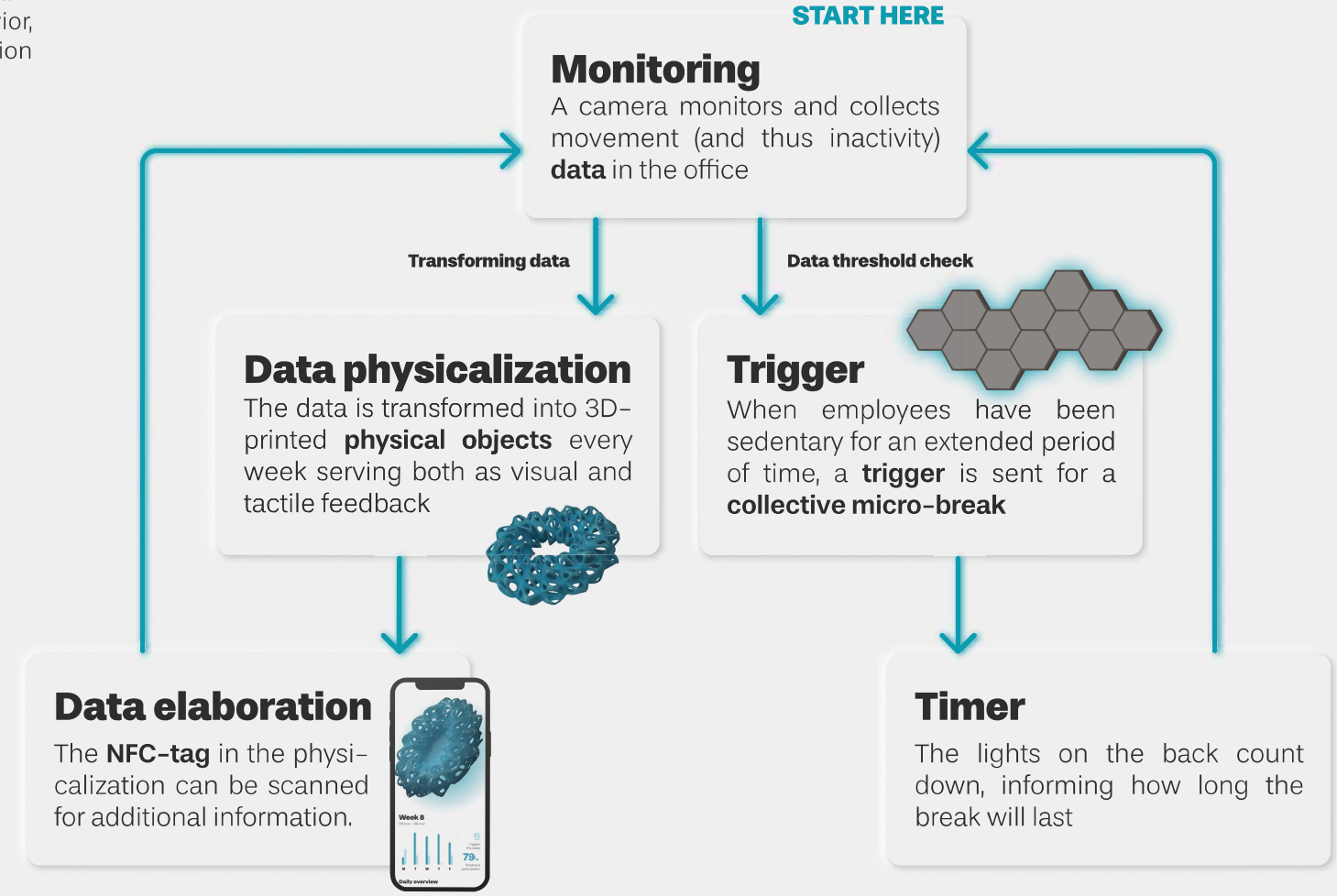


Figure 12. Concept flowchart

Components

Camera with computer vision algorithms

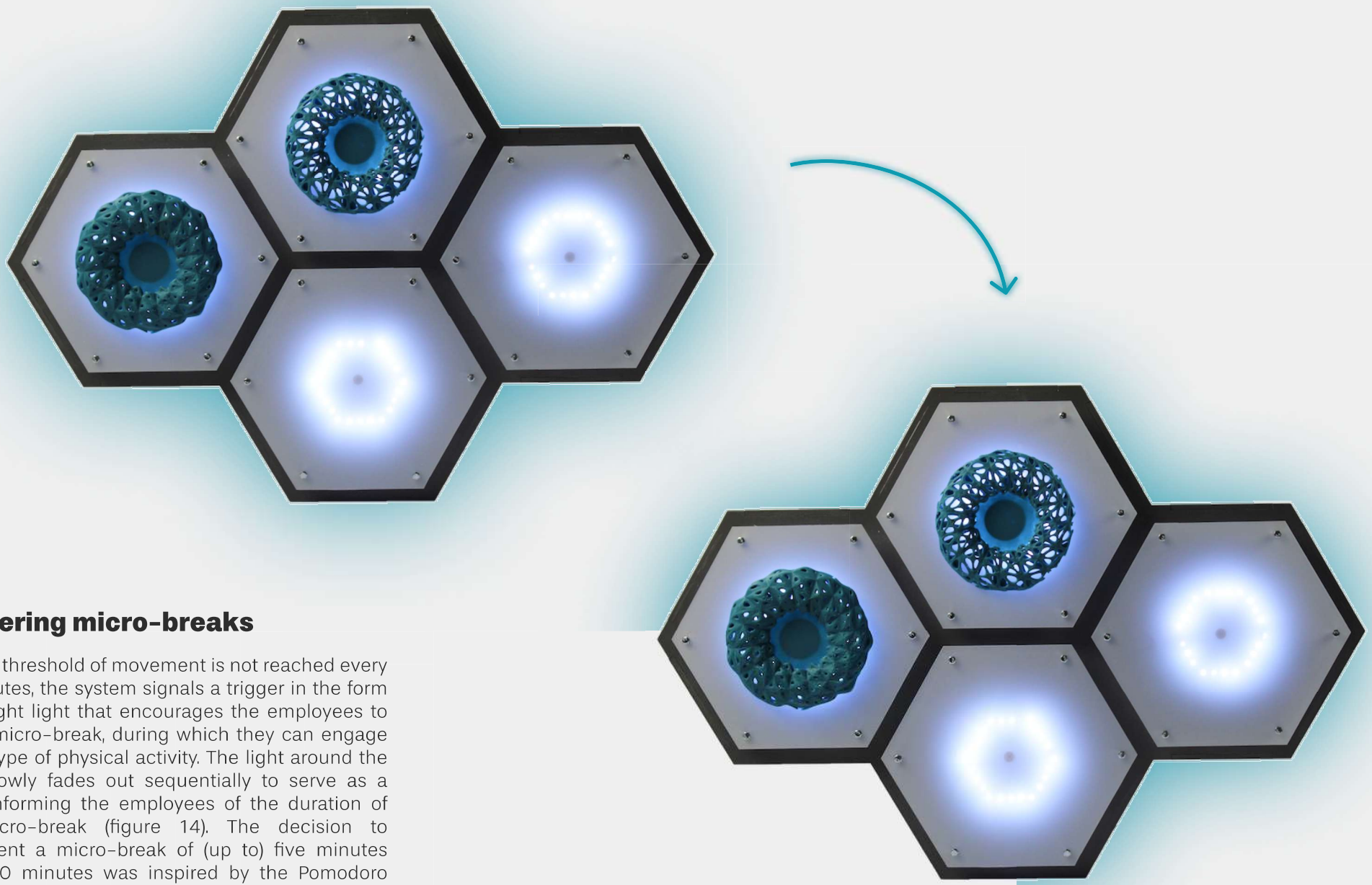
To collect data regarding the movement in office environments, the background subtraction algorithm from the OpenCV Processing library is used to recognize changing pixels on the camera display [41]. This algorithm isolates moving objects by comparing the differences between current and background images, allowing for the detection of activity in the frame (figure 13).

The code is further developed to:

1. **Display the total movement over time**: The code provides a numerical value of the accumulated total displacement of tracked objects over time.
2. **Track individual moving objects**: Each object is tracked individually but anonymously. This makes the algorithm able to recognize how many employees are being active in the office environment. A threshold for object detection is created to filter out small contours that are likely to be noise or non-human objects.

These two data values were then used as parameters to transform the data into a 3D object.

Figure 13. Screenshot of technique demonstration



Triggering micro-breaks

When a threshold of movement is not reached every 30 minutes, the system signals a trigger in the form of a bright light that encourages the employees to take a micro-break, during which they can engage in any type of physical activity. The light around the base slowly fades out sequentially to serve as a timer, informing the employees of the duration of the micro-break (figure 14). The decision to implement a micro-break of (up to) five minutes every 30 minutes was inspired by the Pomodoro Technique, which suggests working for 25 minutes followed by a five-minute break for maximum work efficiency [42].

Figure 14. Pictures of the prototype

Data physicalizations

To transform the data into a physical object, the HE_Mesh Processing library was used [43]. HE_Mesh is a Java library for creating and manipulating polygonal meshes, developed primarily for Processing. The library enables users to modify meshes through parametric design, making it possible to create shapes based on our collected data points.

The following steps outline the shape-creation process that made the collected data come to life:

1. Torus
A toroidal shape, one of the shapes that is available in the HE_Mesh library, was used as the base for the physicalization.

2. Planar slice
To connect the shape to the flat, vertical body of the prototype, it was sliced in half along the x-axis, resulting in a disk that is flat on one side and rounded on the other.

3. Extrude faces – Parameter 1
Each face of the torus was extruded to create an abstract angular shape. This step was the first instance where data is used as a parameter, allowing the amount of extrusion to be adjusted based on the level of movement in the office.

4. Lattice – Parameter 2
The lattice modifier was used to create openings in the faces of the shape. Here, the number of people that were moving determines the size of the openings. Larger openings allow for more LED light to shine through, highlighting active weeks more.

5. Subdivide and smooth
The subdivision and smooth modifiers were applied to make the physicalization appear more organic. This removes hard edges, making the shape feel less aggressive, and making it look more coral-like, aligning with the intended aesthetic.

6. Scale Z-axis
Finally, the shape was scaled down on the Z-axis, simplifying engineering aspects by reducing manufacturing time and lowering the weight of each object. This had little to no impact on the aesthetic, as the physical models are typically viewed from the front.

This process transforms office activity data into tactile, 3D-printed objects (figure 15), providing feedback that fosters team reflection, reinforces positive habits, and symbolizes progress toward collective well-being and stress reduction.

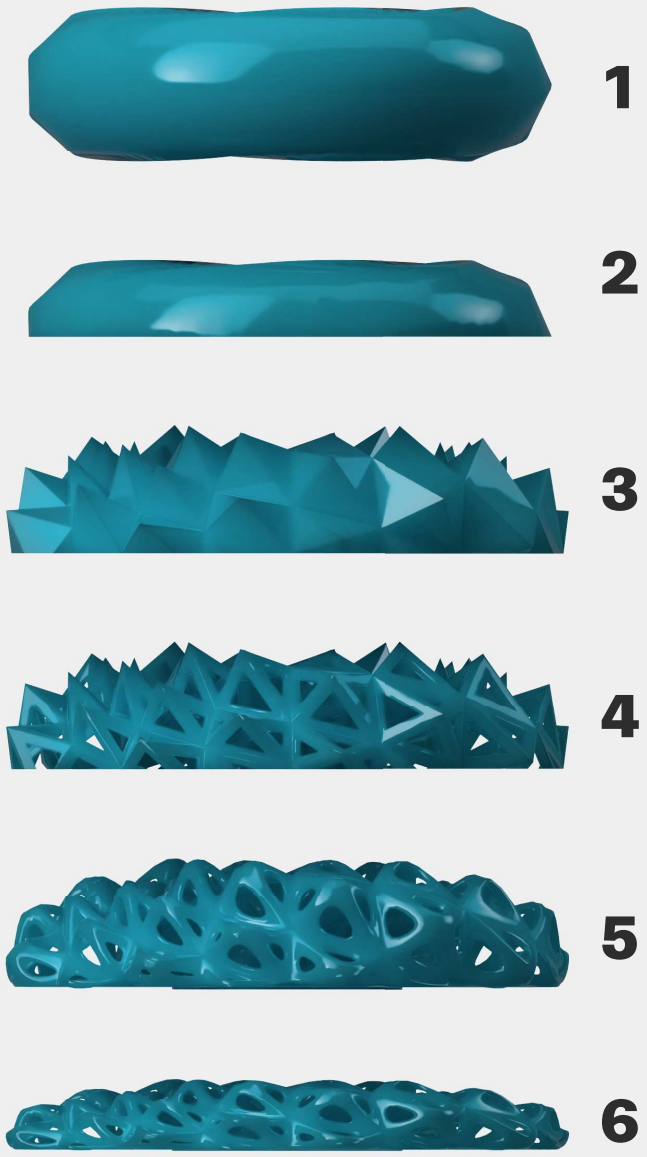


Figure 15. Step by by step process of data physicalization

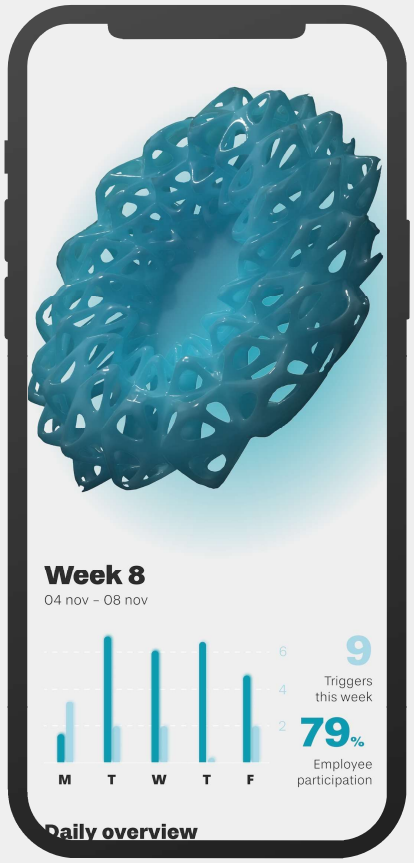
Base of the installation

The physicalizations are placed on hexagonal bases (figure 16). The decision to use hexagonal shapes was made to enhance the product's modularity, as hexagons can be arranged in multiple ways while maintaining an aesthetically pleasing and natural appearance. The base was made from MDF board, into which LEDs were integrated to highlight the physicalizations. A thin layer of translucent acrylic rests on top of the MDF board base and LEDs, diffusing the sharp LED light into a soft glow. Additionally, the trigger indicating low movement is generated by integrating LEDs on the back of the base. Finally, magnets are placed on both the acrylic and physicalizations to allow for smooth (dis)attachment, enabling employees to interact with the artifacts. In total, the base consists of a total of twelve hexagons, each fitting one physicalization. This decision is motivated by the research of Keller et al. (2021), highlighting that it took participants an average of 60 days (12 work weeks) to form a habit.

Figure 16. Screenshot of system demonstration

NFC tag & app

Given the abstract nature of the physicalizations, the decision was made to give the user additional augmented feedback. An NFC tag was included in each data physicalization which, by scanning with a smartphone, provides additional information regarding that week's activity data (figure 17). This gives employees a more complete understanding of their data and allows for deeper reflection and group discussion.



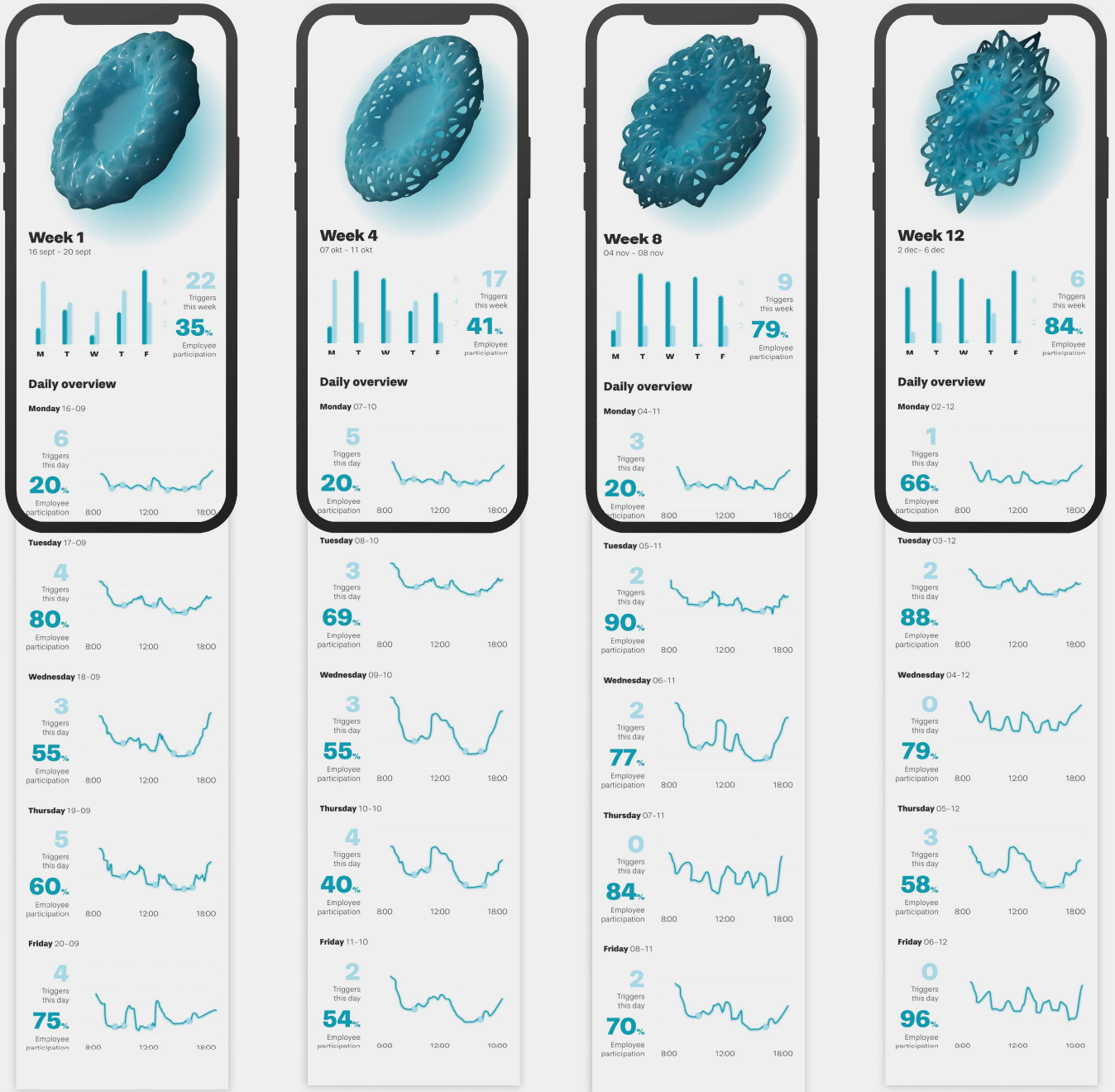


Figure 17. The app with details about the data

Underlying design principles

NELO collects real-time motion and activity data using a camera, transforming the captured information into numerical values to create **data-driven insights**. This data is then physicalized and allows employees to become aware of their day-to-day office behavior related to physical (in)activity. By bridging the digital and physical worlds, NELO creates a **tangible interaction** between employees and numerical data. This fosters a deeper emotional and cognitive connection to the data, making insights and patterns more memorable [27]. The physical artifacts serve as tools that encourage engagement, reflection, and group discussion. Furthermore, new artifacts are added each week, providing **cumulative feedback** through an evolving art installation that highlights the progress toward a healthier, more balanced workplace. By making the data aesthetically pleasing and showing progress over time, NELO creates a sense of **motivation and ownership**. This progress, along with the additional information provided by the NFC, aims to create a **long-term behavioral change** that increases physical activity within the office and possibly reduces stress.

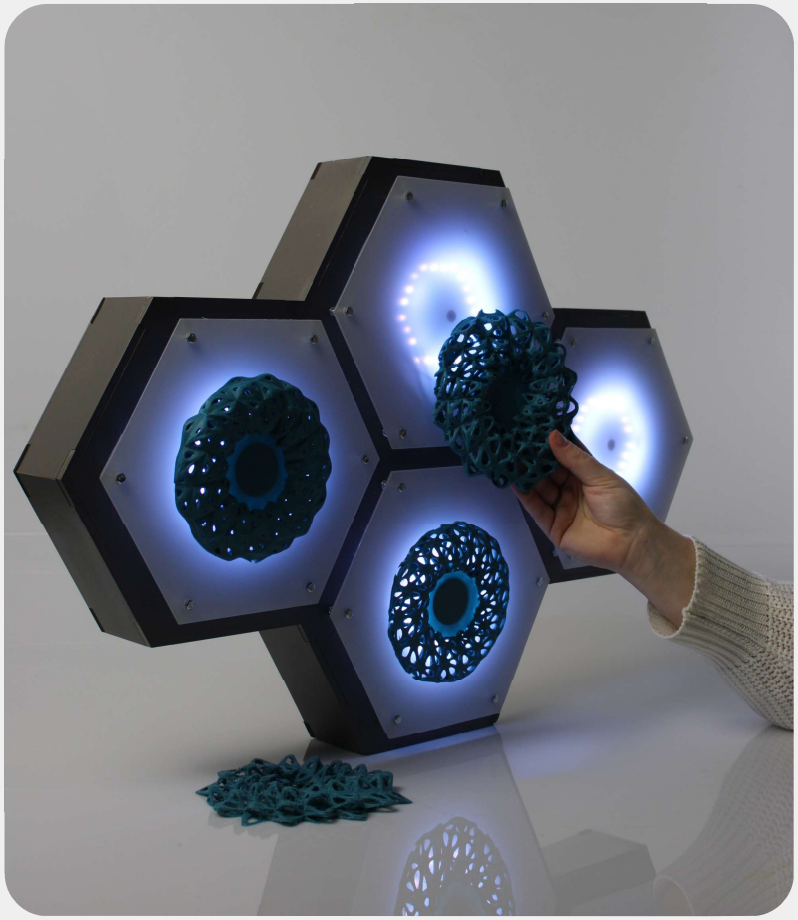


Figure 18. Final prototype

Value proposition

NELO emerges as a valuable concept for lowering collective stress in office environments. This section explores the transformative impact NELO could have on stakeholders such as employees and employers.

Tangible feedback for deep engagement
Unlike traditional data, often provided textually on a screen, NELO uses physical artifacts to enable tangible feedback. This allows employees to get a deeper emotional and cognitive connection with their data, encouraging reflection and behavioral change. This approach makes the data more memorable and actionable for employees.

Collective well-being and team reflection
Many prior projects that have explored office stress management focused on individual stress levels. In contrast, NELO measures the total activity levels of the office to emphasize collective well-being. By adding data physicalizations weekly, NELO fosters team discussion and a shared sense of progress. This way of transforming data is relatively unexplored and provides a novel perspective for creating healthier behaviors.

Physical and Digital insights through serviced-based model
NELO measures activity data through a camera, after which the data gets sent to a 3D-printing facility every Friday afternoon. On Monday morning, a new physicalization is delivered to the office, complete with the NFC tag for additional data exploration. For employers, this method offers significant advantages. It provides a consistent, tangible reminder of workplace activity patterns, encouraging employees to reflect on their physical (in)activity continuously.

Business model canvas

KeyPartnerships
- 3D-printing facilities for physicalization production.
- Wellness consultants and workplace improvement firms.
- Researchers in human-computer interaction (HCI) and behavioral science.
- Data privacy and cybersecurity firms to ensure secure handling of collected data.

KeyActivities
- Designing and maintaining the motion detection system and software.
- Data collection, processing, and analysis.
- Production and delivery of weekly physicalizations.

KeyResources
- Camera systems and sensors for data collection.
- Software for motion detection, data analysis, and NFC insights.
- 3D-printing partnerships for physicalizations.

Value Propositions
- Tangible feedback for deep engagement
- Collective well-being and team reflection
- Digital and physical insights
- Service based model

CustomerRelationships
- Ongoing support for system integration and physicalization delivery
- Tailored insights and analytics for employers.
- Regular feedback mechanisms for continuous system improvement.
- Transparent data privacy practices to build trust.

Channels
- Direct sales to companies through B2B marketing.
- Partnerships with workplace consultants and wellness providers.
- Online platforms for marketing and customer support.

Customer Segments
- Offices that used spaces of maximum 10 people
- Co-working spaces promoting modern workplace culture.
- Technology-forward companies aiming to enhance workplace engagement.

Cost Structure
- Hardware costs: cameras and setup materials.
- Software development and maintenance.
- 3D-printing and delivery logistics for weekly physicalizations.
- Salaries for developers, designers, and support staff.
- Marketing and sales efforts.
- Data security and privacy compliance measures.

Revenue Streams
- Subscription-based model for ongoing data collection, analysis, and physicalization delivery.
- One-time setup fees for initial hardware installation.
- Custom analytics and reporting packages for organizations.
- Licensing NELO technology for integration into other workplace solutions.

Figure 19. Business model canvas

Customer journey map (NELO)

A customer journey map was created to depict a typical working day for an employee in an office utilizing NELO (figure 20).

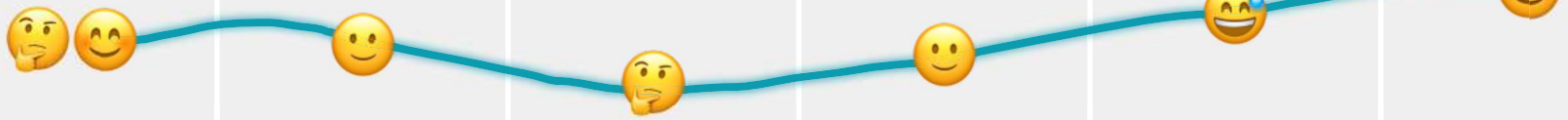
Journey steps	Purchasing the installation/service	Placing the base	First week of NELO	Receiving the first data physiclization	11x weekly progress	After 12 weeks
Actions	• The employer will inform the office about the intent of NELO • The employer buys the installation	The office receives the base existing of 12 hexagons which will be mounted for them on the wall	• The employees will receive information about how NELO works • The first week of data will be collected as a starting point for the data physicalizations	• The data will be physi-calized and sent to the office • The employees will re-ceive the first print and hang it on the wall • The employees will reflect on their week	• Each week, the data will be physicalized and sent to the office • When the threshold is not reached, the instal-lation triggers the em-ployees to take a micro-break	The habit is created and the employees will take enough collective micro-break
Needs & pains	The employer wants that the employees are healthy	It is a large installation, so help with mounting it on the wall is desired	• Employees need transpa-rency on the purpose of NELO • Employees need information on what is expected from them • Employees might have their doubt about NELO	The team will need a more detailed explanation the first week as they have never seen this way of data physicalizations before	• The employees need real-time feedback of how they are doing (Trigger) • The employees need weekly feedback to understand if they are making progress or not (Data physicalization)	The employees might still need real-time feedback of how they are doing (Trigger)
Customer feeling						
Future opportunities	Extra service: Customization of the installation to match the interior of the office	• 1	Extra service: Extra informing session about how the installation is to be used	• 1	Extra service: Providing weekly reflection tools	Extra service: Option to extend the service if want to proceed with receiving data physicalizations after 12 weeks

Figure 20. Customer journey map

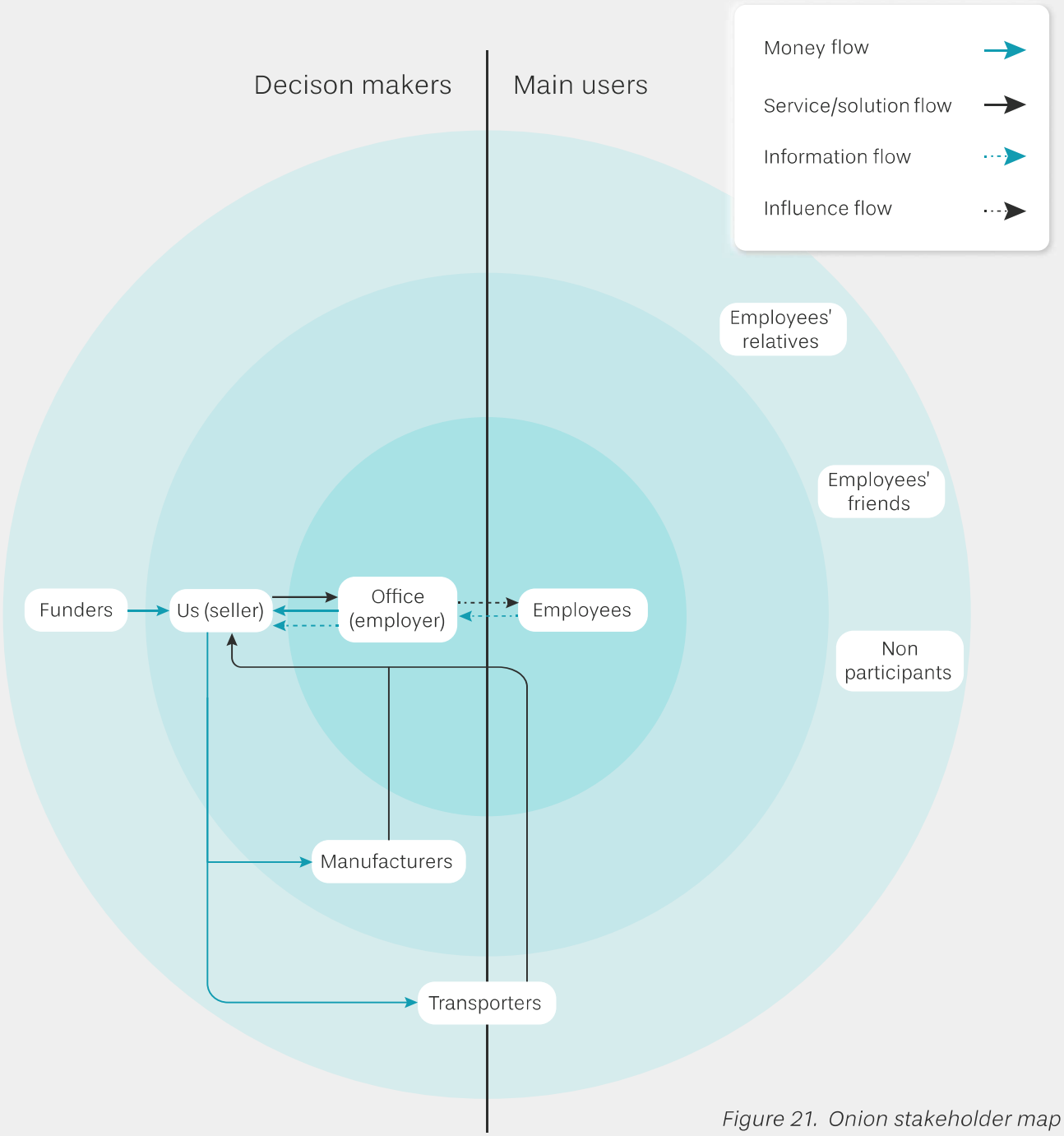


Figure 21. Onion stakeholder map

Onion stakeholder map

To provide an overview of each stakeholder involved with NELO, a business onion map was created (figure 21).

Cost analysis

A cost analysis was conducted to create an estimate of total fixed and variable expenses (figure 22).

Setup cost			Monthly costs	
Hardware	*Camera* *Hardware base* *NFC tag system*	*Installation*	Artifact production and delivery	*3D printed artifact* *NFC tags* *Shipping and delivery*
Software	*Initial configuration* *Cloud access for data storage*		Maintenance and support	*Hardware* *Software* *Customer support*
Customer training			**Annual costs**	
			Hardware maintenance/replacement	*Camera recalibration* *LEDs acrylic and/or magnets*
			Ensuring data privacy	*Legal and technical measures to protect employee data*
			Estimated total costs	
			First year	*setup €1380 -€2110* *monthly €400 -€650* *yearly €5300 -€7900* *yearly total €7080 -€10660*
			Subsequent years	*yearly total €5700 - €8550*

Figure 22. Cost analysis

Ethical considerations

Designer's intention
The design's intention is to reduce the stress of employees in office settings by introducing a system that physicalizes activity data in a tangible and engaging way. This concept exists to create awareness of daily activity patterns and sedentary behavior, and, in turn, encourages behavioral changes through reflection. Therefore, the goal is not to predetermine right or wrong behaviors. The design aligns with moral norms of promoting transparency, inclusivity, and empowerment in workplace interventions.

Potential unethical situations
The main potential risk of using NELO includes misuse or over-surveillance of employee activity, leading to feelings of distrust. Stakeholders may use the data in ways that could have negative consequences for the employees or the company the system is used at. Prolonged use might normalize excessive monitoring, which could cause privacy concerns. To mitigate these risks, safeguards such as anonymity, voluntary participation, and transparency should be ensured.

Methodology

Testing set-up

To evaluate the effectiveness and usability of the data physicalizations, eight individual user tests were conducted. Each participant was introduced to a hypothetical workplace scenario and was asked to imagine how they might interact with the objects within that context.

The testing process included semi-structured interviews to gather insights into participants' perceptions and preferences regarding the data physicalizations. The interviews were flexible, allowing for an in-depth exploration of user impressions and expectations. Key questions addressed during the sessions included the participants' first impressions about the physicalizations, what they believed the objects represented, whether they felt the need for additional information about the objects, what types of information they would find useful, what aspects of the physicalizations they would like to see refined or added, and what their thoughts were on the visual and tactile aspects of the objects. Notes taken during the interviews can be found in Appendix 9.

Results

Key insights of the interviews included that abstract data physicalizations alone may be insufficient for conveying meaningful information to participants. All participants addressed the need for additional information regarding the data and its relationship to the physical objects. They emphasized the importance of understanding how the data was collected, processed, and translated into physical forms.

These findings highlighted the need to integrate supplementary information of the physical (in)activity data serving as the input of the objects' shapes to enhance the interpretability and utility of the data physicalizations. This feedback was taken into consideration for refining the design and ensuring it met the needs of its intended users. Therefore, a user-friendly mockup app with elaborations on the data was developed using Figma [44].

Another key finding was controversial interpretability of the data physicalizations. Greater physical activity corresponded to lower stress levels, a relation that was not immediately clear from the shape of the data physicalizations. The objects were shaped by movement parameters: the more movement and people engaged in physical activity detected, the more holes and extrusion the object featured. However, the ultimate variable being represented was stress. Several participants expressed confusion, assuming an increase in holes and extrusions represented higher stress levels due to its sharp-edged, latticed shape. This misalignment between the measured parameter (physical activity) and the represented variable (stress) created ambiguity.

Figure 23. User testing

Evaluation

Discussion

The system has several key strengths that make it an appealing solution. Offering tangible and visual feedback makes actions more engaging while also encouraging abstract reflection. Furthermore, focusing on the collective rather than individuals, it encourages teamwork and reduces competition in the workplace, creating a more supportive and collaborative work environment. Its use of camera vision to detect movement is a feature that allows for accurate monitoring. Another major strength is the weekly progress updates, keeping participants motivated and engaged throughout the twelve-week program.

There are a few challenges of the concept to address. One main question is how to ensure the system remains engaging after the twelve weeks have passed. Although it takes an average of 60 days to create a habit, there might be offices that take longer. Without new physicalizations coming in, users might lose engagement over time. This could impact the program's long-term effectiveness. Finally, the system's physicalizations might not work for everyone. Since the feedback relies on subjective interpretations, not everyone may find it logical or intuitive.

Finally, there are some risks to consider. Since stress is a subjective, broad parameter influenced by various factors, proving effectiveness of the product in reducing stress is difficult. Providing concrete evidence for prevented stress can thus be challenging. Adresssing these issues will be key to ensuring its long-term success.

Reflection on the process

A key limitation of the process is that the installation was not tested in a real-world context due to time restraints. It was hoped that the installation would be observed in action, particularly to assess whether the trigger would function as intended and if users would engage with the micro-breaks. Observing this in context would have provided valuable insights. Since other tasks were prioritized this testing was not conducted. In the future, placing more emphasis on testing in context would ensure such evaluations are carried out.

The physicalizations were tested with students, whose feedback was useful. Since many of them had worked in office environments before, they could realistically imagine how they would feel in such a setting. However, this does not fully replicate testing with individuals in a live office environment, where situational factors would influence responses. This missed opportunity is acknowledged as a limitation.

Future works

While the project has made significant progress in addressing collective stress through data physicalization and micro-breaks, several areas remain for further exploration and improvement. Future work should focus on further testing and refinement of the product in real-life office settings, incorporating user feedback to add new features and exploring its potential in broader contexts.

A crucial aspect of future development is evaluating the product's long-term impact on behavior and stress reduction. Longitudinal studies should be conducted to assess changes in physical activity, stress levels, and workplace dynamics over extended periods, providing valuable insights into the product's effectiveness in fostering lasting change.

The current design focuses on a small office environment with up to ten employees. Scaling it for larger workplaces could be an interesting opportunity. Also, advancements in camera vision technology means the system's data may get more accurate and useful over time.

Additionally, future iterations could focus on developing customizable features to better align the product with various office settings, cultures, and company preferences, allowing organizations to tailor the system to meet their unique needs.

Conclusion

In modern office environments, collective stress is a rising phenomenon due to tight deadlines and goals, which can have a negative impact on the overall health and well-being of employees. Since physical inactivity has been linked to prolonged stress, NELO addresses this issue by collecting motion and activity data through cameras and transforms it into 3D-printed physical artifacts, aiming to encourage micro-breaks, foster reflection, and create a long-term behavioral change.

By bridging digital and physical worlds, NELO provides tangible feedback on collective office activity, creating a deeper emotional connection between user and data. Testing results show that while the physicalizations can be effective visual and tactile tools for engagement, some participants found them abstract, which resulted in the additional information provided through an NFC tag. The physical artifacts not only became tools for reflection and discussion but also an evolving art installation, highlighting collective progress towards a healthier workplace.

NELO shows potential in reducing and even preventing stress in office environments and opens doors for further research. Future work should focus on conducting longitudinal studies to test the viability of the concept. This project highlights the connection between sedentary behavior and collective stress, emphasizing the need for systems that allow users to reflect on these markers. It provides a steppingstone for ongoing innovation in integrating tangible feedback within office environments.

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