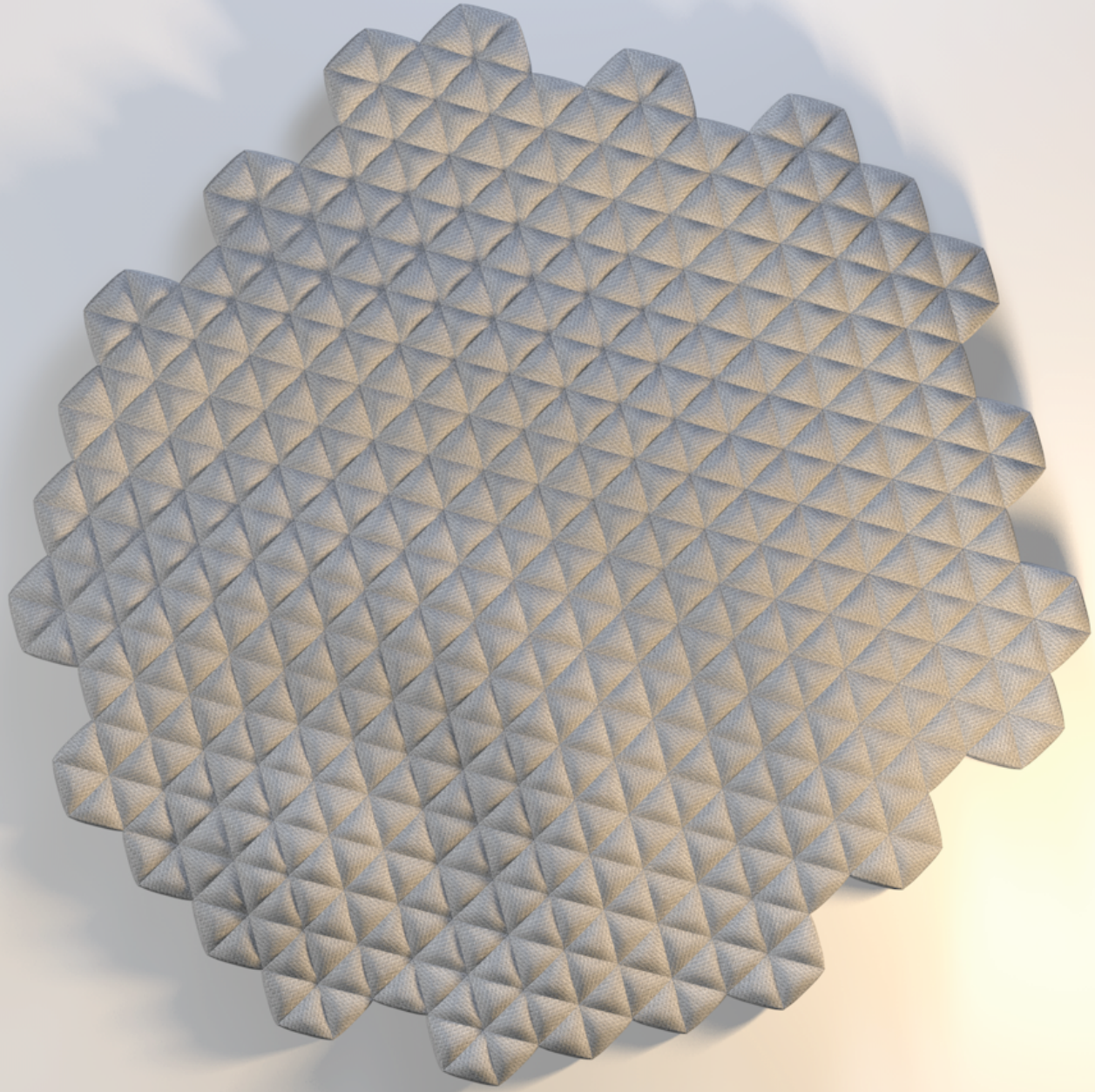
Morphing Matter

Soft Robotics for Health & Wellbeing



TUDelft MSc. Graduation Thesis 2022

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INTRODUCTION

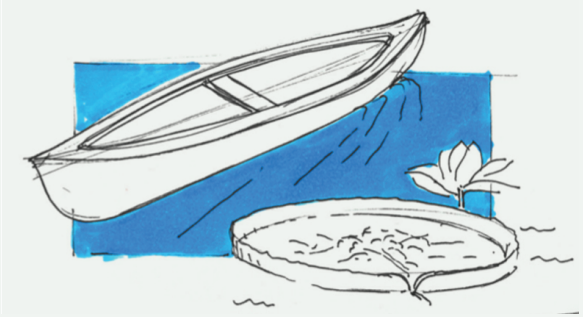
Morphing Matter is a soft-robotic material with a bit of a personality. When applied to the seated context, it can sense posture and simply nudge the user in the right direction by providing support through the contact surface. This project focuses on developing a scalable soft robotic material with programmable behaviour. The project is aimed at creating a tool for the exploration of how dynamic seating can be designed to trigger behavioural change for health and wellbeing. This highlights a quality that we can expect most materials of the future to demand: the ability to be dynamic!

With the digital revolution over the past few decades, printing on paper is now a thing of the past. How much sense then, does printing a thesis report make? This is an experiment supported by my incredible surpervisory team to introduce augmented reporting in the academic context. One of the greatest advantages of this is the embedding of animations and videos that breathe life into the text!

Still, for submission sake, we agreed to create a file for print in the form of an executive summary. 10 pages to print can be the lesser evil in comparison to printing 150-200. The end of this summary contains a link to the final report published on my website, along with a password for access. I hope you enjoy reading it as much as I enjoyed writing it!

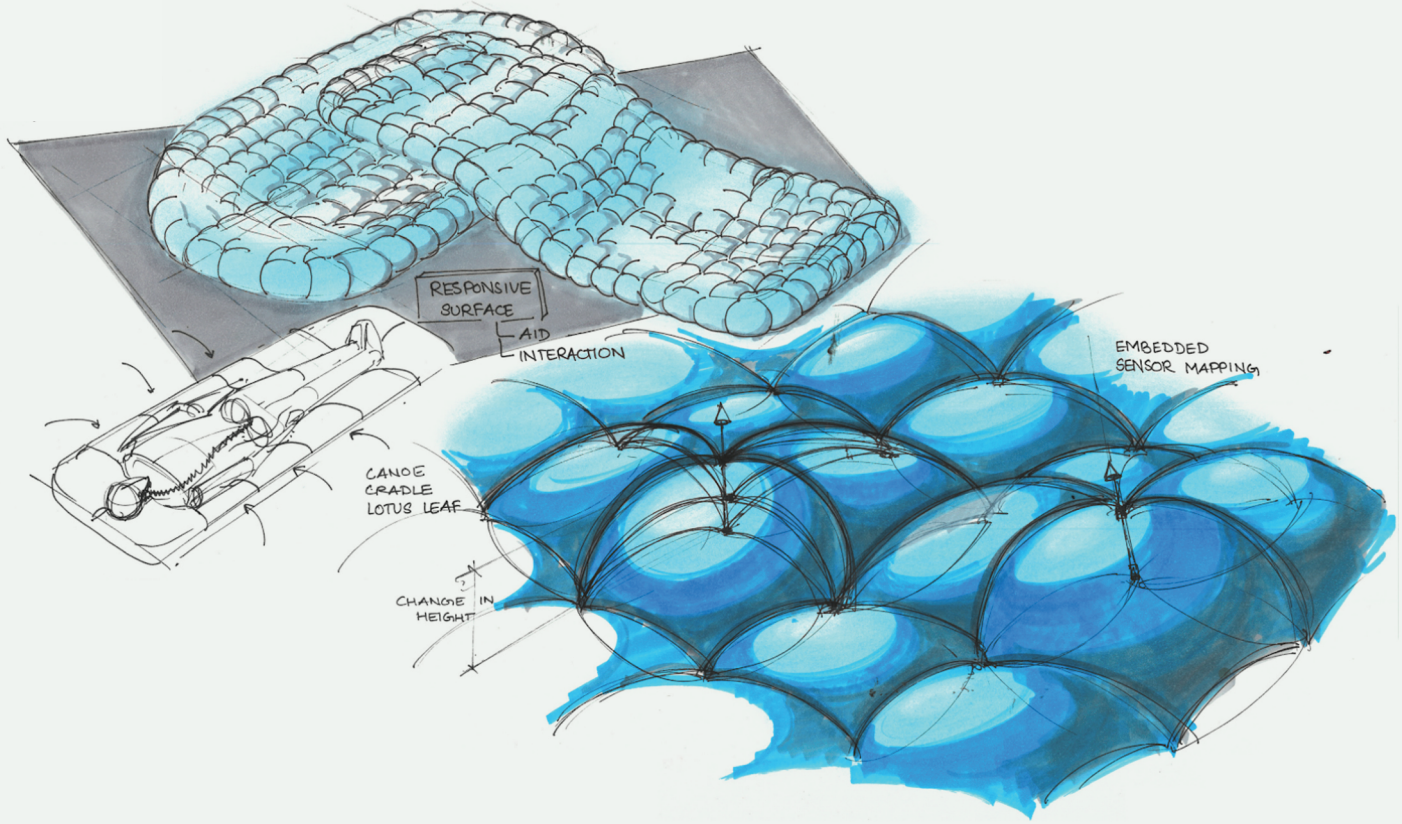
I. A STARTING POINT

The Lily Pad: A Precursor



The Morphing Matter Project (MMP) had a precursor born in the ACD course at the faculty of Industrial Design Engineering,TUDelft. The Lily Pad is a shape-morphing soft robotic object designed to support and empower the elderly. Besides providing a foundation, the project's reflection was coloured with possibilities for further development. The main drivers were from the sedentary context: A wider & varied user group, Multiple contexts and approaches, An issue of urgency and magnitude.

The idea of a shape morphing surface, in essence, is not new; so why do it again? MMP uses a principle different from the 'traditional' pneumatically actuated air chambers. It creates a new affordance of expressive haptic communication through more control over the degree and rate of actuation. Aspects of safety and scalable manufacturing showed potential in its development when applied as a material to the sedentary context.



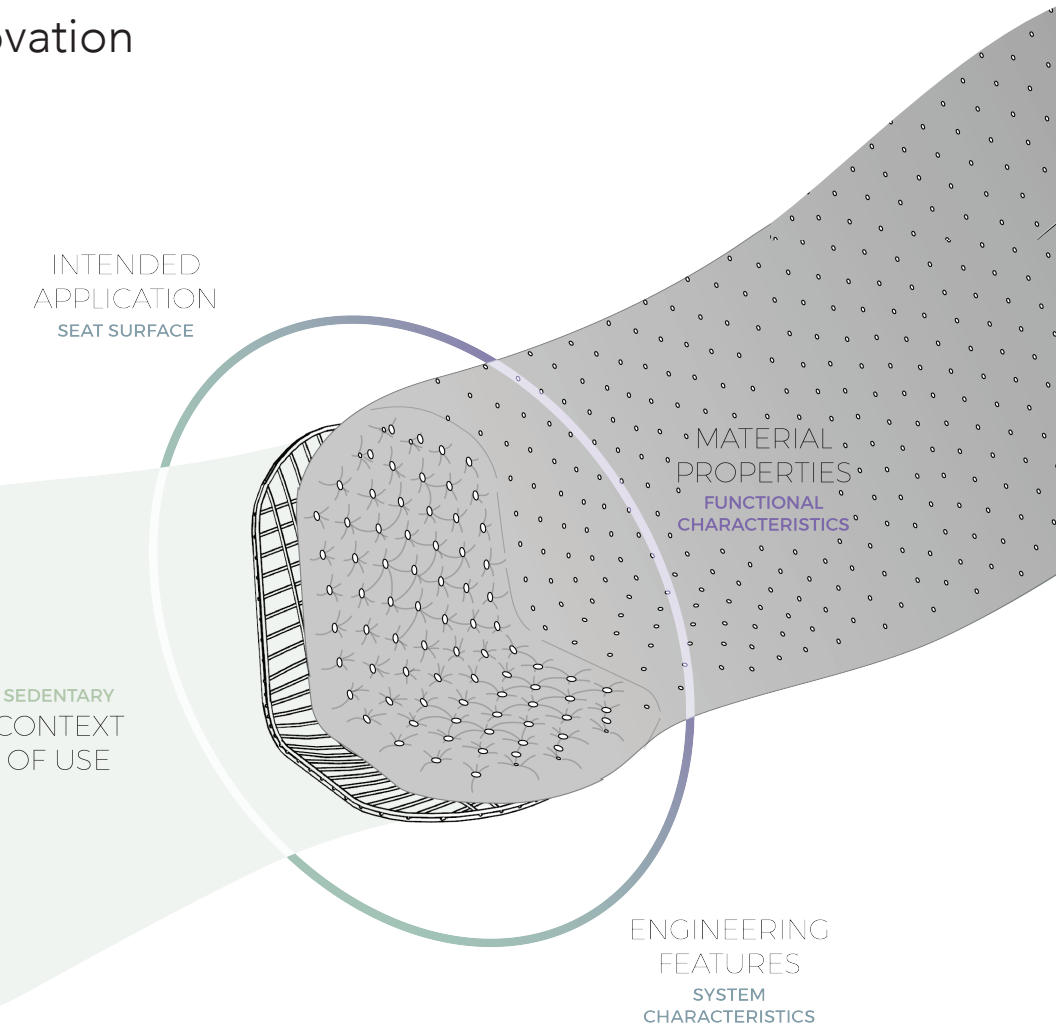
II. CONTEXT AND APPROACH

The Seat Surface for Design Driven Material Innovation

Sedentary behaviours and the common seat surface provide the main direction for contextual research. The ultimate goal this technology sets out to achieve is the user's health & wellbeing and the sedentary context provides posture as a window for design intervention.

This project follows the DDMI approach for an iteration cycle. The contextual research informs the material properties of the object based on which, the engineering features are designed for testing in the sedentary context. This provides direction for fabrication research and development. The cycle continues to refine the (design driven) material innovation with every iteration.

The project's interest lies in behaviour change in the seated environment. Theoretically, this can be achieved through active behaviour/expression of the environment or the objects/technologies of which it is composed. The intervention to affect behavioural change on the individual and population levels necessitates a tailored approach to achieve a quality we require from most future materials: the ability to be dynamic. More specifically, the brief is to build this technology as a tool to design dynamic seating that triggers positive behaviour change

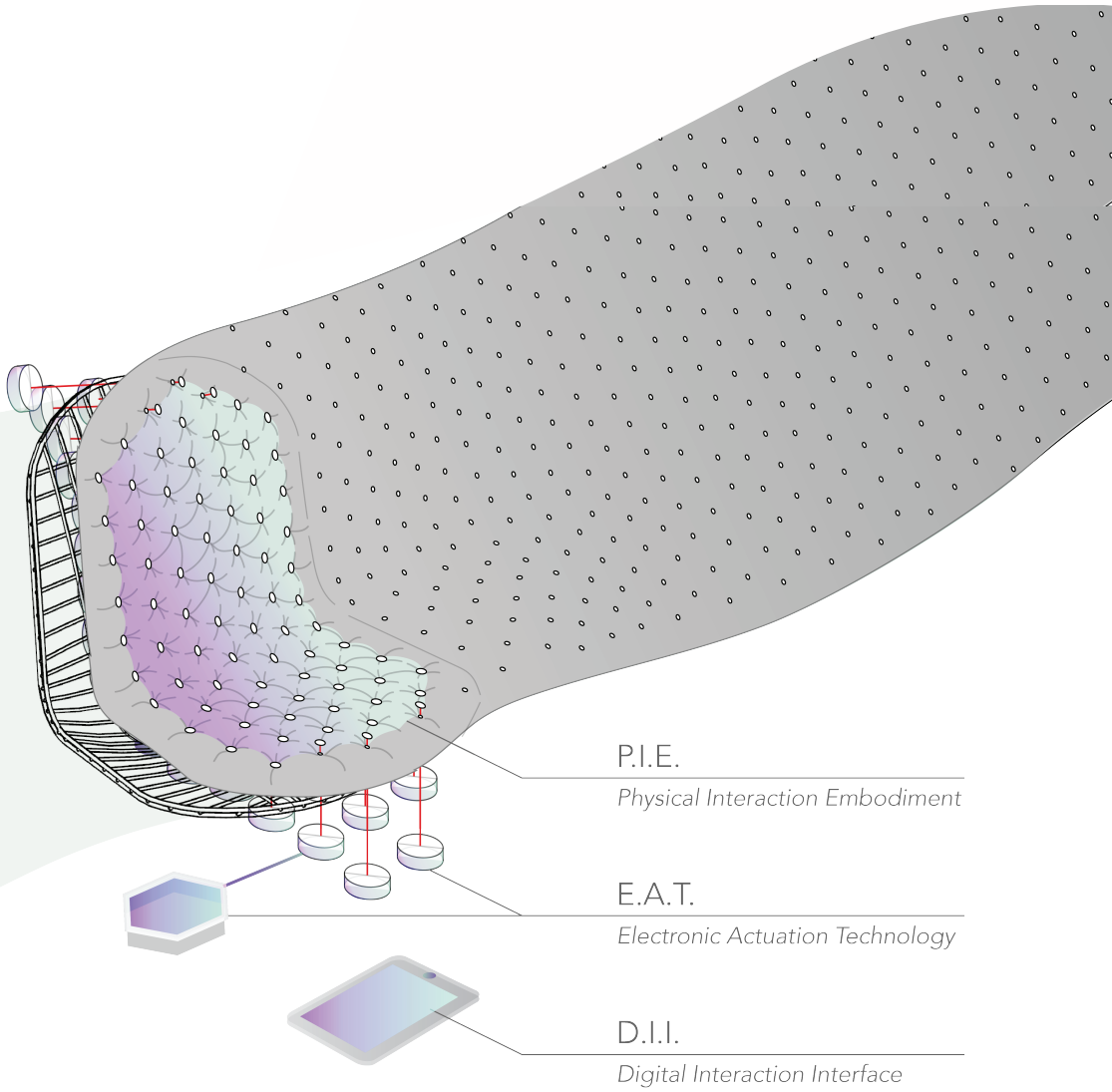


III. MORPHING MATTER

Discovery & Design

Morphing Matter (MM) is a shape morphing soft robotic material, with a programmable personality. Equipped with the ability to be dynamic, the object is no longer just a seat; it blurs the boundaries between the different roles it plays or the identities it can acquire as part of a larger positioning system. More than an object; it is an entity with autonomy and expression! For example, when applied to the seat surface of a chair (where we display sedentary behaviours), it can sense posture and simply nudge the user in the right direction by providing support through the contact surfaces. This plurality is not just acquired at the contextual level, but also at the object, component and material levels, where tangible and digital materials and processes overlap to make a whole. The aim is to design a safe, physical and haptic interaction between a user and their environment through the seat surface.

MM, borrows the rigidity of the furniture's frame to create interactions with its environment through its contact surface. The architecture is composed of three layers: The Physical Interaction Embodiment (PIE) is the soft body of the robot that provides the contact surface and the affordances for interaction with the user. The Electronic Actuation Technology (EAT) is the brain of the robot that creates interactions through the PIE. The Digital Interaction Interface (DII) provides a channel of communication to further control the interaction digitally.

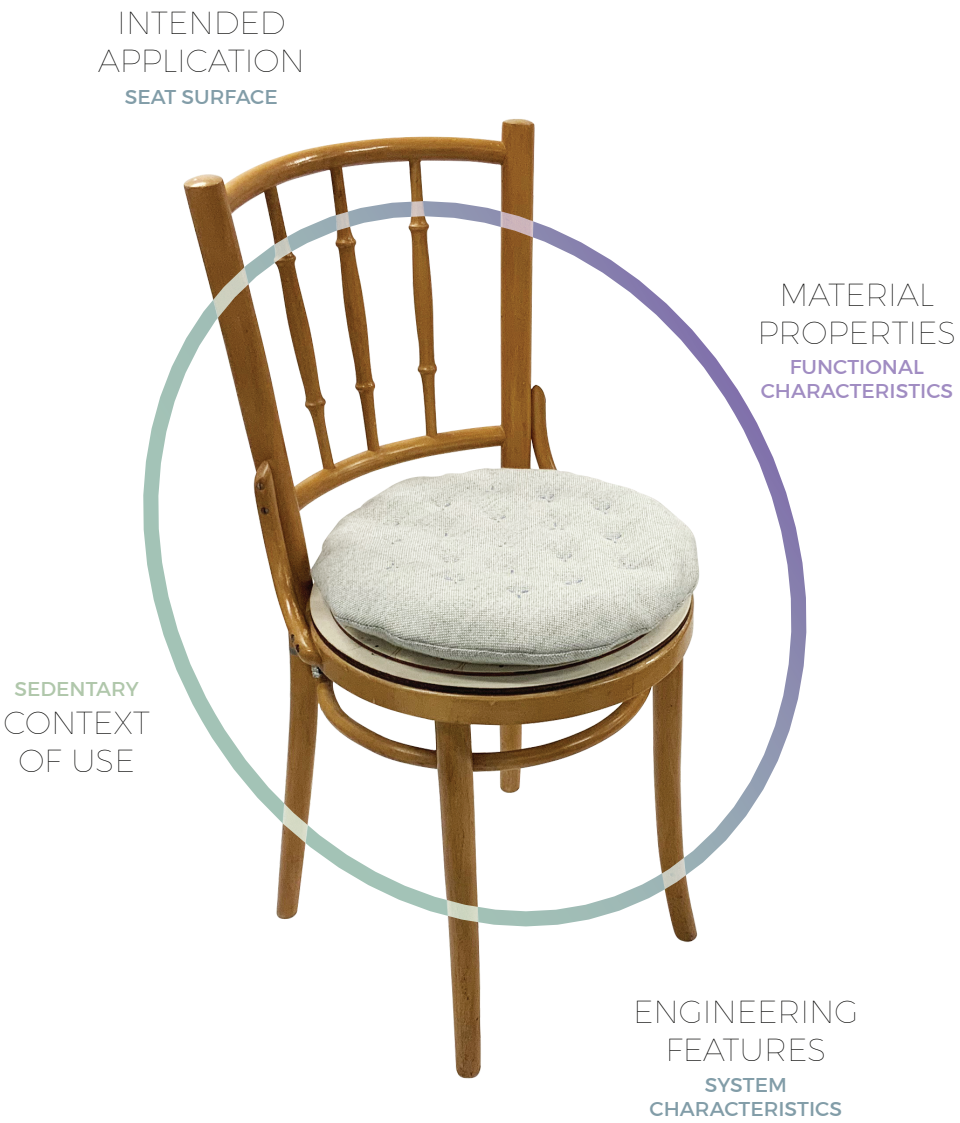


IV. APPLICATION

The Common Cafe Chair

A prototyping exercise to explore the material properties and engineering features proved to be valuable not only in providing a proof of concept for further development but also a direction for the next iteration cycle. Hence the reimagined application could be focused on the seamless integration of the technology, on one hand with the environment and the other with the user. One of the most apt analogies that I have found describing an intuitive and collaborative interaction wherein 'the product is the interface' is that of a horse and its rider (Poelman et al., 2014). This application informs the behavioural properties of the material, based on which the engineering features can be refined/redesigned.

In the current iteration cycle, experiments with (traditional and advanced) fabrication techniques help to combine different materials that create affordances like variable flexibility to guide the deformation of surfaces. Using this affordance, bellow based actuators were designed for the PIE, which was powered by a motor based EAT. Correlations between measurable data and parameters for control were made along with explorations to visualise the DII for testing. MM found definitions on 4 out of 5 operational levels of this project: Material, Component, Functional and Object. Considerations of scalability, manufacturing and assembly were applied in its design whilst highlighting the ample room for improvement in each of these aspects.



V. REFLECTION

A Short Retrospection

Morphing Matter and its development through this project has been an incredible experience of exploration, discovery and design. The DDMI approach fit the project's aims like a glove to create insights over 5 operational levels through the overlap of two opposing streams of thought: the inside-out approach of the material scientist's lens and the outside-in approach of the designer's lens. What I found particularly interesting within this overlap is how the material took shape based on an understanding of our sensing modalities in the sedentary context and appealing to those. This shifted the focus from redesigning the object (the chair) to examining the activity (sitting). It is fascinating how the chair is an artefact that has been redesigned over the centuries, yet the activity of sitting and how we sit largely remains the same. This is because the object's redesign has been spearheaded by our evolving aesthetic along with the development of new materials and manufacturing technologies. Though it is important and has its place in the 'redesign context', I can't shake the feeling that we're missing something: an examination or re-examination of how we sit to accompany how we currently design chairs. Through this project, I have come to believe that it is this shift in perspective that holds the key to helping us sit better. This is, however, not to say that no one's thinking about this. We have a considerably large scientific community studying sedentary behaviour. But the lack of tools to build robust and compelling arguments for change has created what I call accessibility issues in the context. The human posture, being one of the most sophisticated and economical anti-gravity mechanisms designed by nature, is essentially dynamic, and hence, so is the activity of sitting. This highlights the need for the design intervention to be dynamic too, not to mention adaptable from various perspectives. The DDMI approach brought immense value to achieving exactly that! Scalability was also an important aspect of consideration for the concept to be treated as material. Morphing Matter was an attempt to designing for different economies of scale, for example it is adaptable to be built by a person in their garage with a 3D printer and solder kit as well as for mass production on the industrial scale. Another key insight gained through this project was finding affordances that created parametric or measurable material properties and their correlations. This helped design the translation of the material's tangibility into the digital realm for control. As a consequence, we were able to create meaningful measurements from raw data for various stakeholders connected to the context. The project's outcome sufficiently showcases how the material could look like, function and the experience it can create. The project managed to pull the interest of various collaborators while opening possibilities for further study that I am excited to pursue!

VI. ACCESS

Report Link: https://atulajadhav.wixsite.com/atulajadhav/masterthesis

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