

Cybermodeling into the Computational Unknown

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ABSTRACT: This Explorative Practice conducts digital architectural modeling through analogue means, a process known as 'cybermodeling.' This innovative practice was thoroughly examined in a recently completed Design Driven Doctoral Research (DDDR) and continues to be developed through workshops, lectures, demonstrations, and publications aimed at promoting its adoption in academia.

Cybermodeling, née hybrid analogue-digital modeling, utilizes simple microsensor technology to detect manual manipulations (bending, folding, etc.) and contextual information (gravity, light, distance, etc.). These sensors are embedded in the analogue model and connected to parametric code. This 'smart' analogue model serves as an interface for digital modeling, replacing traditional input devices like the mouse and keyboard.

The aim of cybermodeling is to find and support the material nature of computational objects. The importance of achieving or reaching a material quality in digital making is related to the ability of materials to respond and interact to their manipulations and to spatial forces. These reactions in media provide feedback in design making that influences design outcome. By directly linking digital models to real-time sensor data, cybermodeling creates 'live' digital design objects animated by the reactions of their digital material properties to spatial forces. Further, this approach teaches architectural design as an interaction with live media connected to dynamic systems (material, spatial, and environmental). Additionally, cybermodeling prioritizes our uniquely embodied intelligence by formatting digital design through physical making, thus accessible to sensory and intuitive understanding.

Cybermodeling is taught through three progressive tasks: building partial analogue and digital (parametric) models, calibrating sensor data, and then linking and adjusting analogue-digital modeling components to achieve an integrated cybermodeling experience. This Explorative Practice presentation offers an overview and live demonstration of the cybermodeling methodology, allowing participants to observe the setup and interact with the process firsthand.

KEYWORDS: cyber, hybrid, architectural modeling, microsensors, Firefly, Arduino

INTRODUCTION

This explorative practice, cybermodeling, seeks to find and support the material nature of computational objects. To this end, cybermodeling employs simple electronics and microsensor technology to connect computational architectural modeling directly to real-world spatial contexts of vector forces and atmospheric conditions. Following the modeling methods of Frei Otto and Antoni Gaudí—cybermodeling substitutes computational materials (Meshes, Surfaces, BREPs, etc.) for soap bubble solutions and weighted cables. By evoking behavioral responses inherent in computational materials as they react to site conditions (while also factoring geometry and spatial orientation), this methodology finds and emphasizes the material quality of the computational.

Currently in an initial stage of development, cybermodeling is carried out by embedding microsensors into the physical architectural modeling component then electronically linking this to a parametric component. Together analogue and digital components transfer sensor readings of manual manipulations and contextual data to inform a digital object (Figure 1 and 3). As a methodology, cybermodeling, a.k.a. hybrid analogue-digital modeling, seeks to integrate physical and digital making into one unified interface.

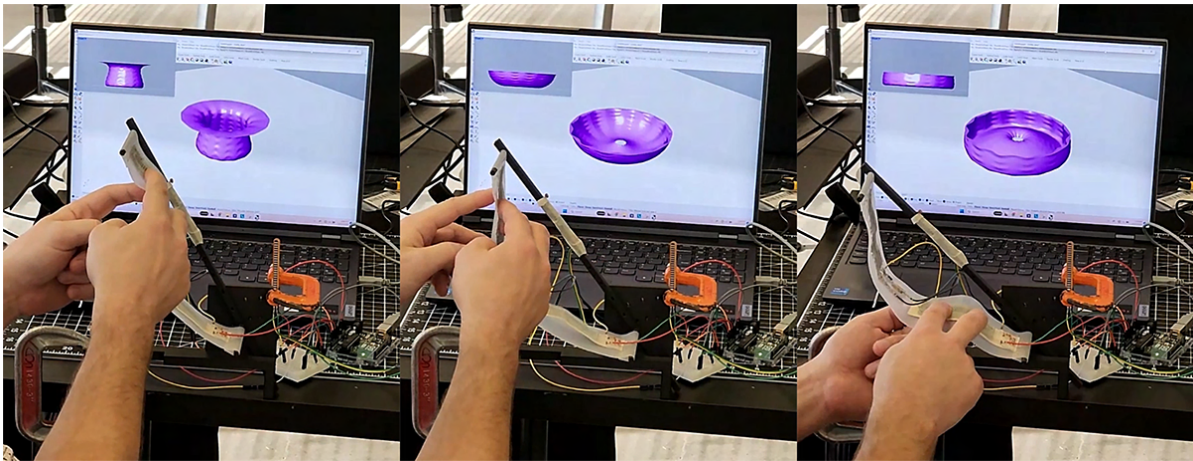


Figure 1: Analogue and digital components transfer manual manipulations and contextual data to digital object. Source: (Author 2023)

1.0 AIMS

1.1 Animated Computational Matter

The aim of this explorative practice is to emphasize the importance of materiality in architectural design process; a challenging task considering today's increasingly immaterial digital design culture. Cybermodeling, née hybrid analogue-digital modeling, stresses materiality in computational making by linking it to analogue making. Binding digital to analogue achieves two things: it reveals the existence of 'computational material properties'¹ and (re)connects digital modeling to context.

This explorative practice is authored by an architect whose 25-year career corresponds to the digitization of design practice. Such first-hand experience in both making modalities imparts awareness and appreciation of their difference. Specifically, in traditional, physical making, what is made is inherently and inescapably determined by material properties reacting in a spatial context *during* making.

In physical materials, the natural interaction between material and spatial properties is defined as *spatiomateriality*¹. The spatio-material connection means that space and matter are connected at a molecular level. This connection and ensuing reactions animates media, giving it agency to respond. This is exhibited in the models of Otto and Gaudí which transfer spatial forces through material properties which in turn respond and react in form-finding.

This exploratory practice identifies the lack of spatiomateriality as a key problematic in contemporary computational design. Due in-part to the isolation of the design object separated from its spatial context. Isolating the design from context also renders computational materials neutral, unable to respond to context. Therefore one of the priorities of cybermodeling is to attach computational materials to context, making their neutrality impossible and redefining digital modeling as wrestling with a 'live' subject.

1.2 Cyber

In its development subsequent to doctoral research, hybrid analogue-digital modeling has been reframed as cybermodeling. The term flirts with notions of 'cyberspace' as coined by the sci-fi writer William Gibson, whereby ...cyber...(was) generically and universally adopted...to evoke almost anything related to electronics and computers...a moniker for any technologically mediated alternative to physical space. (Carpo 2023, 25)

As electronically enhanced (micro- sensors and controllers) analogue models linked as interface to parametric making, cybermodeling connects and engages composite analogue and digital worlds.

Additionally and as unintended outcome, cybermodeling reveals a stark similarity between physical (biological) and computational (algorithmic) material behaviors. Thus 'cybermodeling' raises aspects of cybernetics emphasizing ...the similarity between the binary operations of electronic computers and...living cells (which suggest) a deeper correspondence...warranting the parallel study of computation and (biological systems) (Carpo 2023, 25)

Contained here is the idea, carried over from the doctoral research, that both algorithmic and biological materials are ruled by their internal structures, or properties, which cybermodeling seeks to bridge. Already as a practice, cybermodeling delivers more than an artificial linking of analogue-digital modeling methodologies. The practice finds and connects the bonded spatiomaterial interactions underlying both worlds, their material agency determining what is and can be made.

1.3 Reverse-engineering digital fabrication

Making digital objects through analogue means. The novelty of cybermodeling is to reverse the flow of information from digital to physical that dominates contemporary digital making. The impetus for this radical action stems from first-hand experience. Engaging the media and modalities of both environments imparts an impression of a richness in sophistication in analogue over computational. Thus a main driver of this explorative practice has been to enrich computational with analogue making. But—the surprise found through linking the two modalities is the presence of

a rich 'materiality' lurking within computational media. This computational materiality, or computational material properties², is understood as internal structures of digital materials that direct their behavior and formal capacities. By activating computational material properties cybermodeling seeks to prioritize their direct engagement in digital making. Recognizing that microsensors smart technology and kinetic design modeling can access and attach computational objects to our haptic understanding and to context, this methodology reappropriates these technologies to create computational objects.

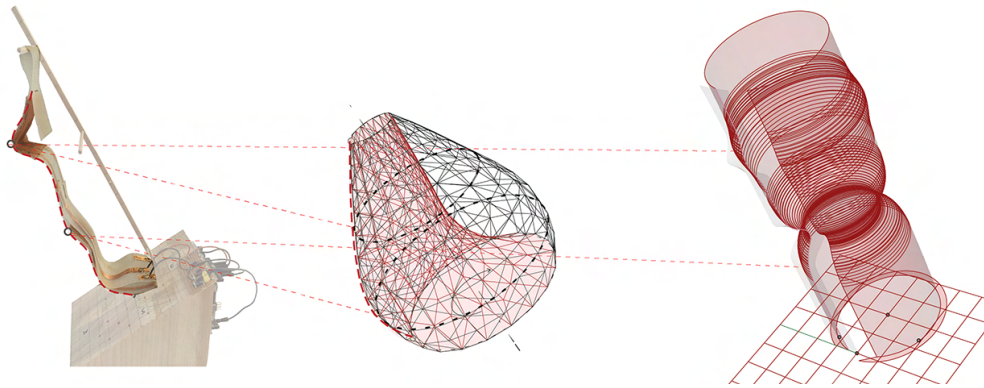


Figure 2: Workshop design problem, design a rubber vase sited on an incline. Source: (Author 2022)

2.0 METHODS

2.1 Workshop as methodology

Cybermodeling, originally a Design Driven Doctoral Research (DDDR) examining the impact of the analogue to digital shift in architectural modeling, is currently being further developed through workshops so that

Findings (are) made accessible to others...communicated and contribut(ing) to the overarching discourse.'
(Ludwig and Voight 2021, 228)

Workshops have been conducted with advanced digital design practitioners in conferences and universities. Thus, workshops act to both develop the methodology through the shared expertise of participants while encouraging adoption within the design community. The workshop discussed here took place at the ACADIA 2023 conference. Workshops cultivate accessibility through the availability of hobby micro-controllers and sensors (Arduinos) and freeware (Firefly), which translates sensor data into parametric modeling. The workshop design problem is simplified, the design of an inclined 'rubber' vase. The analogue model component is a rubber strip embedded with sensors to detect manual shaping. This rubber strip represents a section of the vase that is rotated in parametric modeling. Thus the cybermodel is a composite of a non-structural membrane (analogue rubber with computational B-Spline) subject to spatial forces like gravity (Figure 2). The vase serves as a simplified building envelope incorporating openings, patterns, and shapes influenced by contextual factors such as sound, humidity, and light. For instance, when sound is detected, a hole is created in the vase based on the sound intensity (Figure 3).

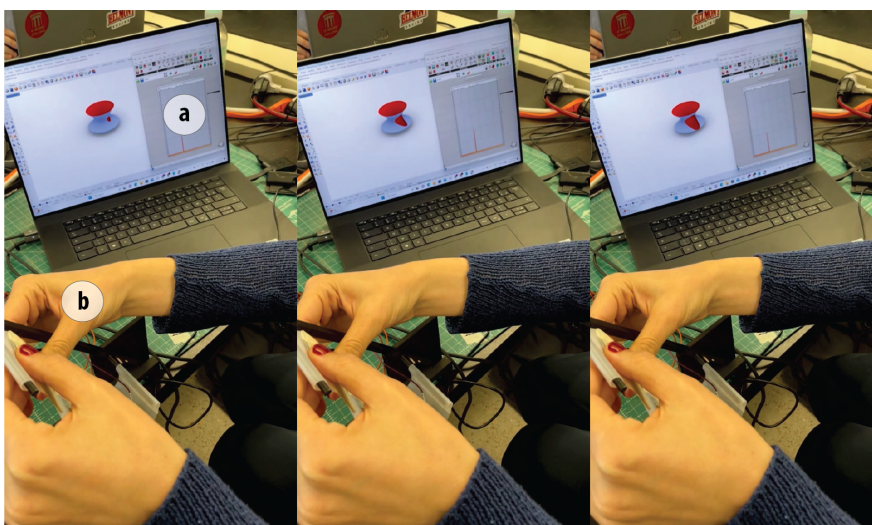


Figure 3: Vase designed through a. sound detection (levels depicted in graph) and b. manual shaping. Source: (Author 2023)

Cybermodeling as burgeoning methodology, lends a quality of improvisation to these workshops that encourages participants to share expertise. Workshops deliver an experience of digital making informed

...through risk in the material, tools and techniques, (until this) workmanship is pushed to its limit and new knowledge can be generated. (Loh 2016,189)

The various platforms connected in the methodology (electronics, coding, physical and digital making) attract participants from diverse backgrounds and interdisciplinary expertise. Including a fine-grained differentiation among designers familiar with programmatic scripting, construction and fabrication, parametric modelling, or electronics. In-person workshops solicits group experts as temporal docents assisting and influencing the tasks and realisations. The ensuing workshop milieu has greatly aided the methodologies technological development (Figure 4).

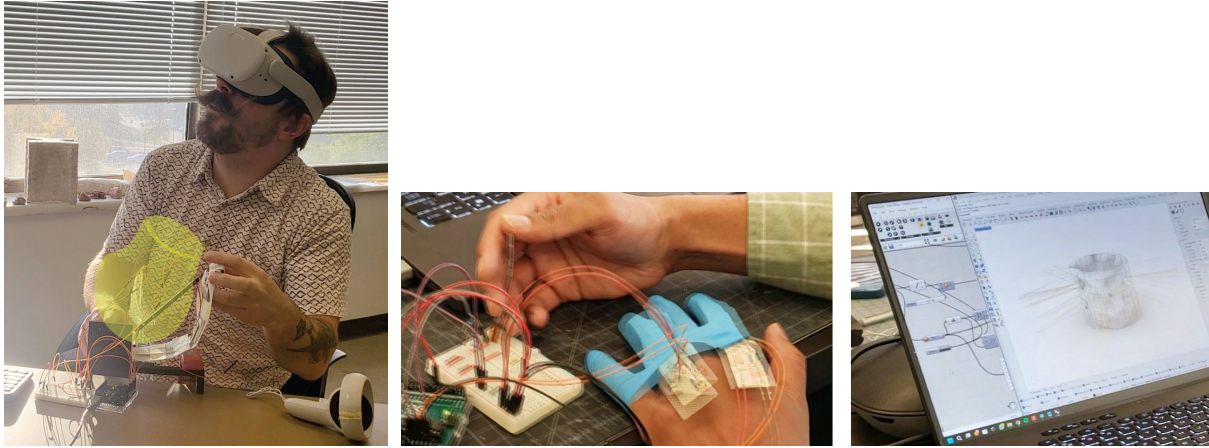


Figure 4: (left) participants added AR equipment and (right) D.I.Y. glove to the cybermodeling interface. Source: (Author 2023)

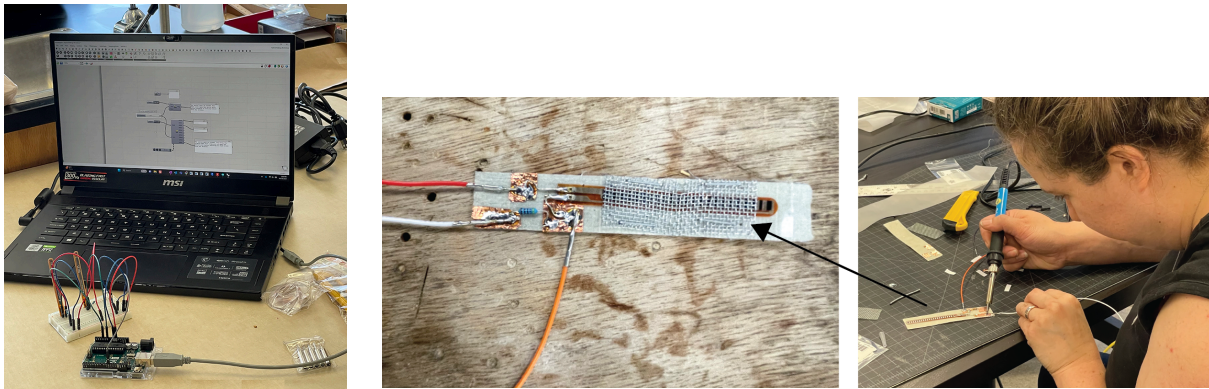


Figure 5: (left) microprocessors interface to parametric modeling (center, right) building sensors into materials. Source: (Author 2023)

2.2 Practice as research

Focus on technological development and adoption in academic and professional practice directs the nature of this exploration from practice to research. Workshops are designed and deployed to test the methodology using the same design problem across multiples of events and participants. The workshops strive for regular and controlled learning through incremental lessons of building the cybermodeling interface: connecting and reading sensors in parametric modeling (Figure 5, left); building sensors into analogue model components (Figure 5, center and right); building parametric model components; and finally connecting analogue-digital components. A fourth 'step' runs continually and in parallel: tweaking and troubleshooting along each of these steps towards an integrated analogue-digital modeling engagement.

Thus workshops aim for:

... universal application...enabling others to learn from the process of finding a solution in a specific case in order to be able to transfer and further develop this approach to other similar, but not identical, questions. (Ludwig and Voight 2021, 227)

Importantly, the workshop format is chosen to convey the tacit and heuristic knowledge found in modeling practice. Through this regular and measured method, individual projects find 'magical, artsy, intuitive' methods stemming from the background and character of the participant (Figure 4). While currently focused on technological development and adoption, the intention is to test the methodology with increasing levels of project parameters thus applicable to architectural design process and projects.

3.0 MODES OF OPERATION AND HUEUISTIC LEARNING

3.1 Learning workmanship

As heir to craftsmanship origins architectural practice conducts analogue modeling in what David Pye describes as the 'domain of quality'. Making in physical modeling requires care and attention to ensure stability of construction. However, there is a level beyond adequate, this is the domain of quality. In this domain, workmanship in making derives from contemplating a material enabled by the sheer amount of time it takes to tool and shape it.

By intentionally binding digital to analogue making, cybermodeling seeks to induce this kind of retrospection-in-making that aligns the designers' actions to the material's logic. Simultaneously accessing the facility of computational making to translate data or input into formal design articulations such as sound detection used to create holes in the vases corresponding to intensity and proximity (Figure 3). Additionally, introducing electronics into these constructions adds to the level of care due to the low tolerance for error in creating and maintaining the flow of electrical current, (Figure 5, center and right).

The importance of attunement through workmanship of materials and tools, requiring skill and precision, is to attain a "...craft practice (wherein) the feedback (from the design object) is not just recursive but also generative...", i.e., the design object is not neutral but actively influences what is made. Further, as a design and modeling methodology, workmanship in cybermodeling is cultivated so that as "the practice evolves, the aesthetics and design co-evolve with this knowledge...over time (and)...over projects." (Loh 2016,199)

3.2 Learning risk

The design project examined in cybermodeling workshops initiates by instigating peril: sited on an incline with an assigned floppy and non-structural materiality. As a cybermodel the analogue-digital materiality is rubber and computational mesh respectively. These risk factors ensure that the resulting design must negotiate stability, thereby become a product of its spatial orientation and material nature. Material and spatial interplay is an essential trope of architectural design. Since the model calibrates its material and spatial condition, the architecture resulting fits site in a manner integral to its integrity.

In terms of design process making, cybermodeling seeks a level of craftsmanship defined by Pye as 'the workmanship of risk' in which "The essential idea is that the quality of the result is continually at risk during the process of making." (Pye 1968, 20) The strategy used in cybermodeling is to burden digital with analogue methods. Thereby adding risk in terms of sustaining electrical circuitry and aligning analogue-digital material behaviours. This delivers a slowed computational design process through preoccupation with spatio-material reactions across design media modalities.

3.3 Learning computational material properties through alignment

Computational materials routinely exhibit alien behaviors (such as infinite elasticity) that hinder our intuitive understanding. Cybermodeling requires bringing analogue-digital behaviors in alignment to create a unified modeling engagement. The alignment of computational to analogue material behaviors serves to bring computational matter into our shared experience of lived reality, allowing access to our intuitive reasoning and embodied channels of understanding³. The use of sensors to connect analogue to digital making is deliberately trying to open the channel of sensing in computational space. By running computational process through physical making, cybermodeling prioritizes our uniquely embodied intelligence. The methodology seeks to leverage the capacity of analogue modeling to include a greater percentage of human embodied intelligence, paired with brute force computing's ability to capture and model real-time dynamic variables of project site and material conditions. The experience of cybermodeling creates space for our 'superordinate programs' (Tooby, 2008) of experiential and intuitive intelligence; teaching digital designers to trust these instincts just as they would objective data.

4.0 INTENDED OUTCOMES

4.1 New materiality

Intended outcomes are to activate materiality as a partner in digital architectural design modeling. This is done by de-isolating the computational design object using sensor technology to attach it directly to site conditions. This has the effect of animating computational material natures responding to sensor data based on internal structures. Designers working with animated, 'live' models capable of factoring their spatial condition through material properties are faced with a dialogue, partnership, and negotiation with the subject of their investigations (Figure 6). The instant awareness and eventual respect of computational material natures connect digital making to a craftsmanship attitude. This entire enterprise directs digital architectural design away from hylomorphic neutrality toward the concept of New Materiality, that conceptualizes all making as engaging

...an active matter endowed with its own tendencies and capacities, engaged in its own divergent, open-ended evolution, animated from within by immanent patterns of being and becoming. (Delanda 2015, 16)

4.2 Unintended outcomes: spatiomateriality

Cybermodeling, initially an effort to increase the material nature of digital making, has, through

...the techniques, tools and materials...developed within the workflow itself...an autopoietic system where tools are modified, adapted and invented. (Loh 2016,195)

unintentionally revealed the existence of computational material properties. Moreover, attaching computational materials to real-time environmental data and manual manipulation, reveals their quasi-sentient or 'live' capacity to respond. These findings led to the concept of spatiomateriality, identifying the true nature of physical materials as inescapably bonded to spatial contexts. The bonded spatio-material quality, necessary to animate design process media, us being pursued in this research as a quality inherent to computational making.

4.3 Other disciplines

Historically, architectural design has been driven by factors of site and material conditions as well as coeval technological advancements. The potential of cybermodeling is to develop digital design practice as formal computation factoring on-site orientation (cantilevered, suspended, etc.) relative to geometric configuration and material composition (analogue and digital). Such a practice could potentially optimize formal solutions (material

distribution, adding or subtracting mass, creating rigidity or flexibility etc.) based on specific site conditions. To the extent that these 'architectural' factors are relevant to other design processes, such as prosthetics or a novel form of telepresence making for remote collaborative working—remains to be seen.

5.0 EXPLORATIVE PRACTICE DESCRIPTION

5.1 Cybermodeling as conference tool

The goal of applying to this conference is to introduce cybermodeling to the EAAE/ARCC community, offering an experience of "Architecture into the Unknown" through novel computational making. This presentation aims to broaden the understanding of cybermodeling within the digital design community, particularly in academia, to influence the next generation of design practitioners. The cybermodeling presentation will provide an overview of its methodologies, development, goals, and challenges, inviting educators and students to engage and contribute to its evolution. A live demonstration will allow participants to try out the methodology, gaining familiarity with this new approach to computational making, which emphasizes the material nature of digital design. The presentation will also cover electronics, micro-sensor/processor data collection, and data mapping as tools for developing architectural design strategies by first animating digital design objects. Cybermodeling is an open platform that encourages participants to bring their unique expertise to the process. The workshop welcomes students, practitioners, and professors, aiming to integrate cybermodeling methodology into mainstream digital design practice.

CONCLUSION

Cybermodeling is explorative practice operating between theoretical concepts of the computational. The first is Kwinter's description of complexity as

implying the presence— within a given system—of a surplus of variables whose interactions cannot be correlated or predicated ahead of time with any degree of certainty. (Kwinter 2001, 21)

This statement seems to describe natural systems such as weather or biological processes, systems containing vast multitudes of interconnected and codependent variables which defy predictability.

On the other side of this conceptual spectrum is Frei Otto, who said of computerized making that

The computer can only calculate what is already conceptually inside of it; you can only find what you look for in computers. (Songel, 2010, 38)

Therefore Otto describes the computational environment as extremely predictable. The goal of Cybermodeling research is to bring some of the (analogue) natural physical environment complexity, described by Kwinter, into the organized, predictable world of the computational, described by Otto.

Cybermodeling is an amalgamation of computational algorithmic matter, dynamic spatial contexts of vector forces and atmospheric conditions. Cybermodeling intentionally activates and accesses a computational material intelligence that, like analogue materials, contains agency based in its own divergent laws and capable of swaying design outcome. We invite the intrepid explorers of the 'Architecture into the Unknown' conference to join us in interfacing and querying the potentials of live, spatiomaterial computational media. We invite you to cyber-model, to make the electronic world work for us to reimpart the rich indeterminacy and magic of matter out of arid, cruel, and numericized world of the reductionist mechanical and the disciplinary electronic... (Kwinter 2003, 91)

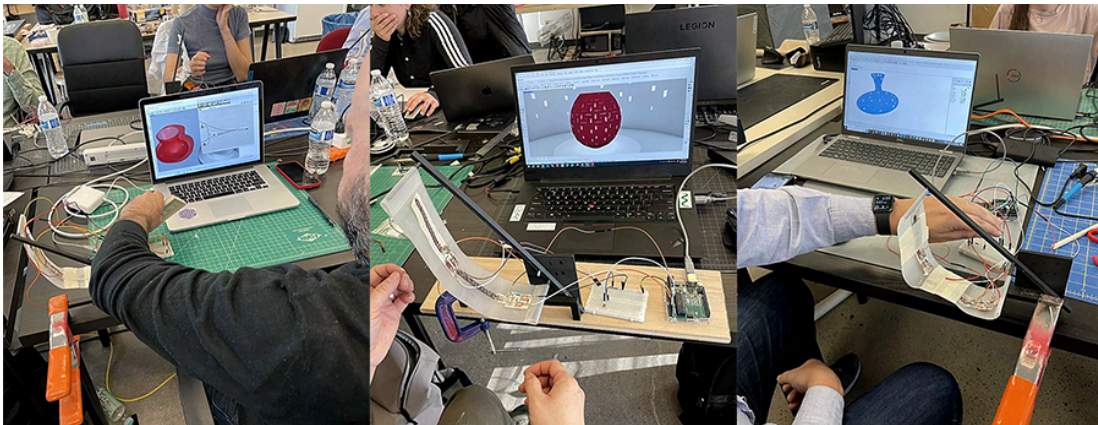


Figure 6: Variation in vase designed through cybermodeling readings of context. Source: (Author 2023)

ACKNOWLEDGEMENTS

My heartfelt gratitude to Prof. Claus Peder Pedersen and Hanne F. Gjelstrup, the EAAE/ARCC2024 organizers, and to the Aarhus School of Architecture, for hosting this wonderful event. Equal thanks go to the peer review committee for valuing this research and granting its participation, as well as for their editorial comments. The enthusiasm of the participants during the conference was inspiring and has already fostered new friendships and collaborations. Such events offer community as a platform for exchange, and I am grateful for the new insights gained from my colleagues. Special thanks to Dr. Axel Kilian and Dr. Augusto Gandia for their valuable suggestions on the research presentation and to Andy Van Mater and Dr. Andrew Payne for technical advice regarding the demonstration model.

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ENDNOTES

¹The existence of computational material properties has been documented in other research, notably in Jahn, Morgan, and Roudavski. (2014).

²The concept of spatiomateriality was formulated in the author's doctoral research. (Iverson-Radtke 2022).

³"Real reason is: mostly unconscious (98%); requires emotion; uses the 'logic' of frames, metaphors, and narratives; is physical (in brain circuitry); and varies considerably, as frames vary." (Lakoff 2014, 72).

