DESIGN x SCIENCE

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DESIGN × SCIENCE

Doctoral design research projects at FAD STU in Bratislava

Michala Lipková

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Spotlight on design research at the intersection of disciplines

Text: Michala Lipková

Buckminster Fuller at the Black Mountain College, summer 1948
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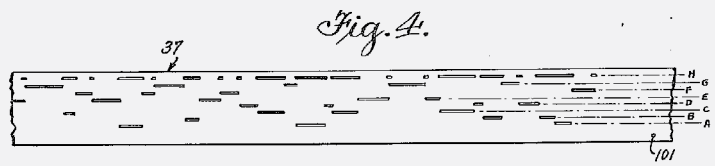
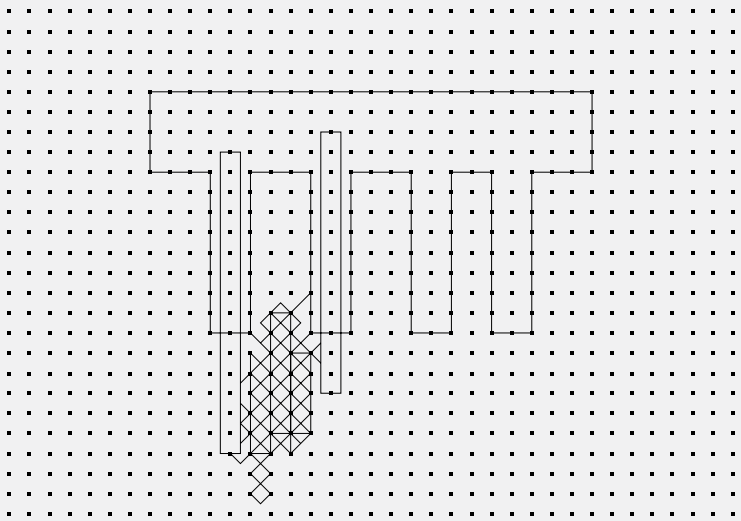




Top: Patent Nr. US2292387A. Sketch of the principle of frequency hopping in the spread spectrum
© Hedy Lamarr, George Antheil, 1942

Bottom: Visualising the concept of Antidisciplinarity
© Joi Ito, MIT Media Lab 2014

CROSSING THE DISCIPLINES

Filed mids the Second World War in 1941, the 'secret communication system' patent Nr. US2292387A has an unusual story of origin. The authors of this concept are two non-scientists: actress Hedy Lamarr and American composer George Antheil.

When the patent was filed, Antheil was an active experimental music composer, and Lamarr was a Hollywood movie star. Inspired by Antheil's experiments with mechanical pianos, Lamarr came up with the idea that a military communications radio signal could randomly jump across the frequency spectrum to avoid eavesdropping.

Originally a military technique born out of a wartime crisis, the frequency hoppping principle (FHSS—Frequency Hopping Spread Spectrum) enabled the coexistence of multiple systems in one location. It has found application in today's massively used wireless technologies, such as WiFi or Bluetooth.

What does this story teach us about? Innovative ideas can spring from the least expected sources. In-depth knowledge of specific phenomena or discipline-specific mindsets very often lead to the “lost in translation” state. Fragile communication between researchers from different fields of science - not to mention the outreach creative disciplines - easily loses momentum. In her Krebs Cycle of Creativity (KCC), Neri Oxman asks whether the approach of a scientist and an artist is really different? In the individual quadrants of the KCC, anyone can move between the fields of science, technology, design and art, in any direction (Oxman, 2016).

Similarly, in his concept of ‘antidisciplinarity’, the former director of the Media Lab, Joi Ito, aptly describes all human knowledge as a blank sheet of paper. The small dots on it represent individual disciplines in which “hyper-specialization” often occurs, and the much bigger space between the dots is described by Ito as “anti-disciplinary”:

“As we engage in tackling harder and harder problems that require many fields and perspectives, the separation of disciplines appears to be causing more and more damage. The complex system that is the human body has become impossibly multi-disciplinary. We should really be working on “One Science,” but instead we are a mosaic of different disciplines sometimes not even recognizing when we are looking at the same problem because our language is so different and microscopes are set so differently (Ito, 2014).”

Design has an extraordinary power to make ideas tangible. It allows us to experience abstract solutions through our senses, make them understandable through models, prototypes, and other visual clues.

In today's world of wicked problems (Buchanan 1992), design as an output, a thinking and work process or as a strategy finds applications in a wide range of fields, far beyond the boundaries of its original professional classification, understood primarily in the context of the art disciplines.

The goal of the DESIGN × SCIENCE exhibition project is to extend our understanding of what design can do for science and the opposite by promoting case studies of interdisciplinary design research.

PROTOTYPING CHANGE

As the team of researchers from Dark Matter Labs state in their recent invitation paper on the new European Bauhaus economy, even our most ambitious pledges (IPCC 2023) lead to climate disaster (Kemp et al, 2022). Authors argue that “apart from design and creativity, our new reality could require new ethics, governance, institutions, accounting regimes, regenerative investments, smart services and systems.”

The collective sees an exploration of “what is emerging at the intersection of the material and immaterial” and “establishing new relationships between tangible assets and intangible assets” as one of the ways ahead to support the shift towards a regenerative future for our built environment. (Johar 2023).

One thought repeatedly comes to the forefront in the global transition design discourse: only a radical worldview and behaviour shift - on the level of both individuals, institutions, and organisations - can lead to the necessary scale of transformation.

“We should really be working on ‘One Science,’ but instead we are a mosaic of different disciplines sometimes not even recognizing when we are looking at the same problem because our language is so different and microscopes are set so differently (Ito, 2014).”

How can doctoral design research become a laboratory for the emerging design practice that does not seek minor adjustments to the existing system but is capable of re-imagining and transforming it? Which research questions are worth asking and what kind of design research can contribute to transition to a future we actually want? How can design enable and accelerate cross-sectoral dialog?

Being both a creative but pragmatic action driven profession, design has the potential to practically contribute to the change in the way manufacturers, entrepreneurs, researchers, scholars (and any other stakeholders) think and work together towards common goals.

To mention a few examples, design research can be useful in providing critical points of view, identifying the one problem to solve a single project at a given point of time and splitting big challenges into smaller, actionable steps. Design naturally brings an iterative mindset, creative curiosity and collaboration.

We do not pretend we have all the answers, but one thing is clear: The scale of the problems we face requires paradigm-oriented design methods, and we need to speed up learning how to use them together.

This need has led us to create a platform that allows not only the accumulation of collective intelligence but one that facilitates collective action. In the situation when we have a lot to lose by not trying, accelerating collaboration offers an actionable way to go.

TRIMTAB MINDSET

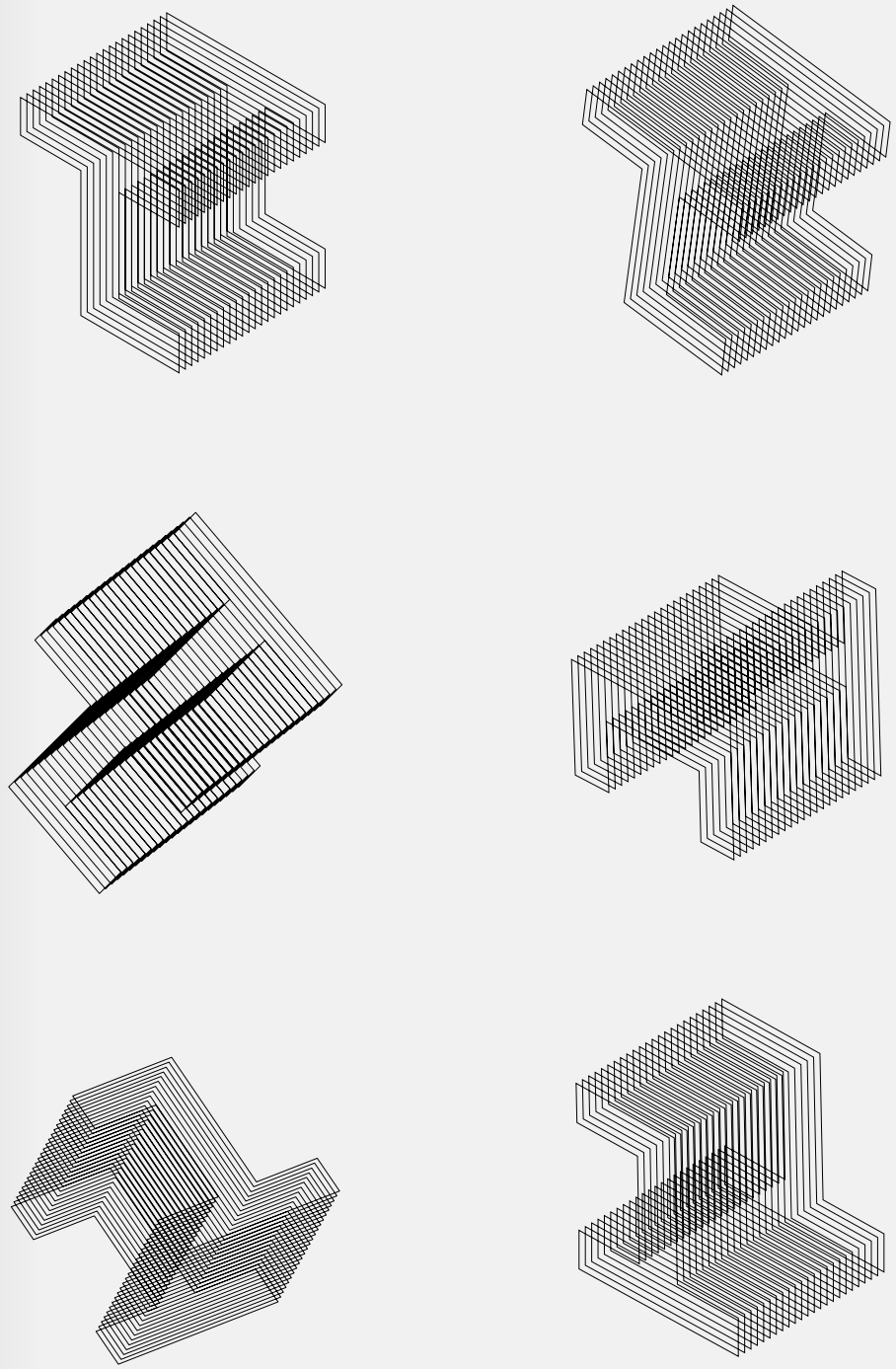
Buckminster Fuller inspires generations of architects and designers despite the fact that he did not receive any formal architectural or design training himself. Scholarly sources refer to Fuller with countless adjectives – architect, system theorist, writer, designer, inventor or futurist.

His concept of being a ‘trim tab’ is a metaphor of a ship's miniature rudder, a small part that can influence a large system (Fuller, 1962). In today's reality, which can easily induce helplessness in us; the idea of being a ‘trim tab’ resonates even more: it invites us to take action to reshape our immediate surroundings.

Fuller’s concept of acting as a ‘trim tab’ inspired the name of the recently founded platform for design research and technology transfer at the STU in Bratislava. Built on the belief that small actions deliver global impact, the platform promotes the idea of design-driven innovation under the motto: ‘Prototyping change.’

The emphasis on ‘prototyping’ within the platform's communication strategy is intentional. By intentionally avoiding using the term ‘design’ at the forefront of the narrative, we shift attention to design as a process - a research activity with the aim to test ideas, a process to learn from, rather than supporting the idea of producing polished artifacts.

The recently founded communication and networking platform aims to actively seek



Spatial transformation of the double meaning symbol T/1, present in the logotype of the Trimtab platform

Installation DESIGN × SCIENCE
at the The Trade Fair Palace
during Designblok 2023 in Prague

"His concept of being a 'trim tab' is a metaphor of a ship's miniature rudder, a small part that can influence a large system (Fuller, 1962). In today's reality, which can easily induce helplessness in us, the idea of being a 'trim tab' resonates even more: it invites us to take action to reshape our immediate surroundings."

new industry partnerships and accelerate collaboration across STU's faculties. 'Prototyping change' refers to design's ability to bridge disciplines and help innovative ideas ascend across the ladder of technology readiness levels by producing tangible outputs of research processes that are otherwise hard to comprehend from the outside and challenging to communicate to potential partners.

The selective group exhibition We Will Design, located at BASE Milano during Milan Design Week 2024, presents its aim to become a "Conviviality Laboratory" where a temporary community explores new forms of interdependent relationships. The exhibition curators invite the visitors to reflect on innovative practices of coexistence and sharing, touching on pressing issues such as migration, gender, abilities, health, and cultural backgrounds. We Will Design emphasizes principles of cooperation, democracy, and ecological responsibility - a context in which we believe the DESIGN × SCIENCE message fits.

In the world of polarized opinions and parallel realities, the motivation for the science outreach through the DESIGN × SCIENCE project is to promote a rational approach to design based on clearly stated problems, informed design decisions, collective intelligence, and the participation of diverse stakeholders.

DESIGN × SCIENCE

The current study program Design at the FAD STU stems from an industrial design agenda originally developed at the Faculty of Mechanical Engineering three decades ago. Early understanding of industrial design at STU saw the discipline as a strictly form-oriented, convergent view of design practice, comparable to the Danish Design Ladder model's first step of "design as styling" (Kretzschmar, 2003).

While the executive profession of industrial design styling is undoubtedly still needed and should not be abandoned, the current strategy of STU's Institute of Design and FAD supports a diversity of approaches to design creation in its full spectrum of formal outputs, understanding design as "first and foremost a thinking process"(Rams, 1995, p. 152).

The exhibition title uses the mathematical sign of multiplication between the words "design" and "science" to represent the metaphorical amplification that design can offer for different fields of science and research. The biggest opportunity we currently recognise is the focus on strategic and systemic positions of design, which represent the opportunity for an 'upgrade' of the design profession towards one capable of driving cross-sectoral facilitation, accelerating technology transfer by design.

The curatorial selection of doctoral researchers from the study program Design at the Faculty of Architecture and Design, Slovak University of Technology in Bratislava in Bratislava (FAD STU) represents three successfully defended and four ongoing projects. However, much more than that - the selection reflects, on the one hand, an undeniable generational shift, and on the other, it illustrates trajectories of the ongoing transition.

Four of the featured projects bring their own view of the new challenges of the design profession - be it the leading role in a multidisciplinary scientific team (Kubušová), the role of a design thinker exploring the territory of philosophy (Hurai), the role of an activator within the creative community (Mjartan) or the role of the ambassador of circular design, advocating for closed loop systems across industries (Sombathy).

Three additional projects represent the work of the research group MX lab, STU's laboratory for multidisciplinary research and experience design. One already defended (Mauš), and two ongoing doctoral projects (Boroň, Suchá) explore the impact of emerging technologies and interdisciplinary collaborations on the design process within industrial design and serial production applications.

The installation DESIGN × SCIENCE, as the first group presentation of doctoral design research projects from FAD STU at the Milan Design Week, is itself a prototype. Let us give the format a chance to open an ongoing conversation and become an invitation to collaborate.

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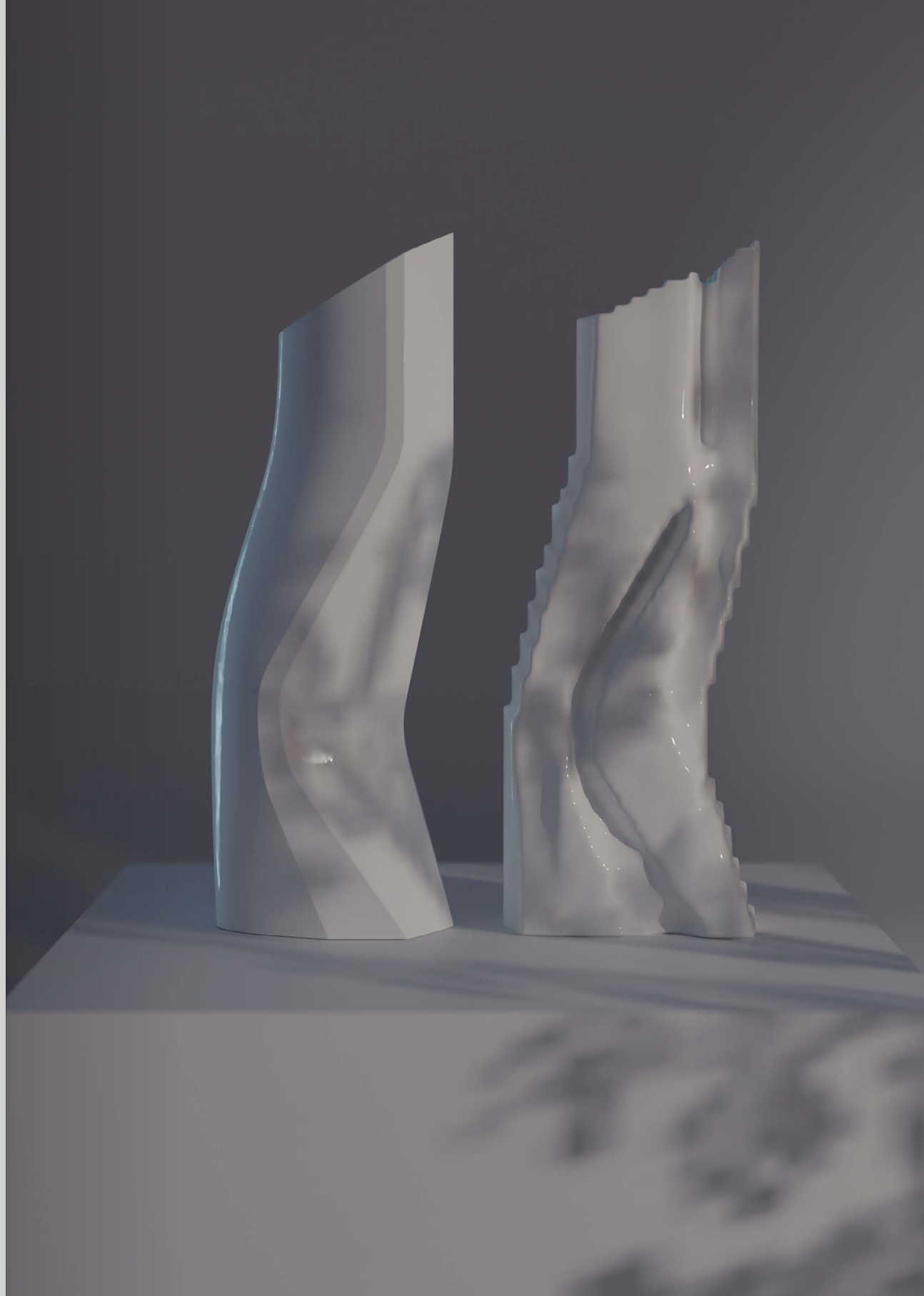
Lipková is head of the Institute of Design at the Faculty of Architecture and Design in Bratislava and founder of Trimtab, science outreach platform for design-driven technology transfer & multidisciplinary collaboration at the STU Bratislava. The platform's main goal is to seek opportunities to prototype innovative solutions with positive impact and bring added value to the production loop.

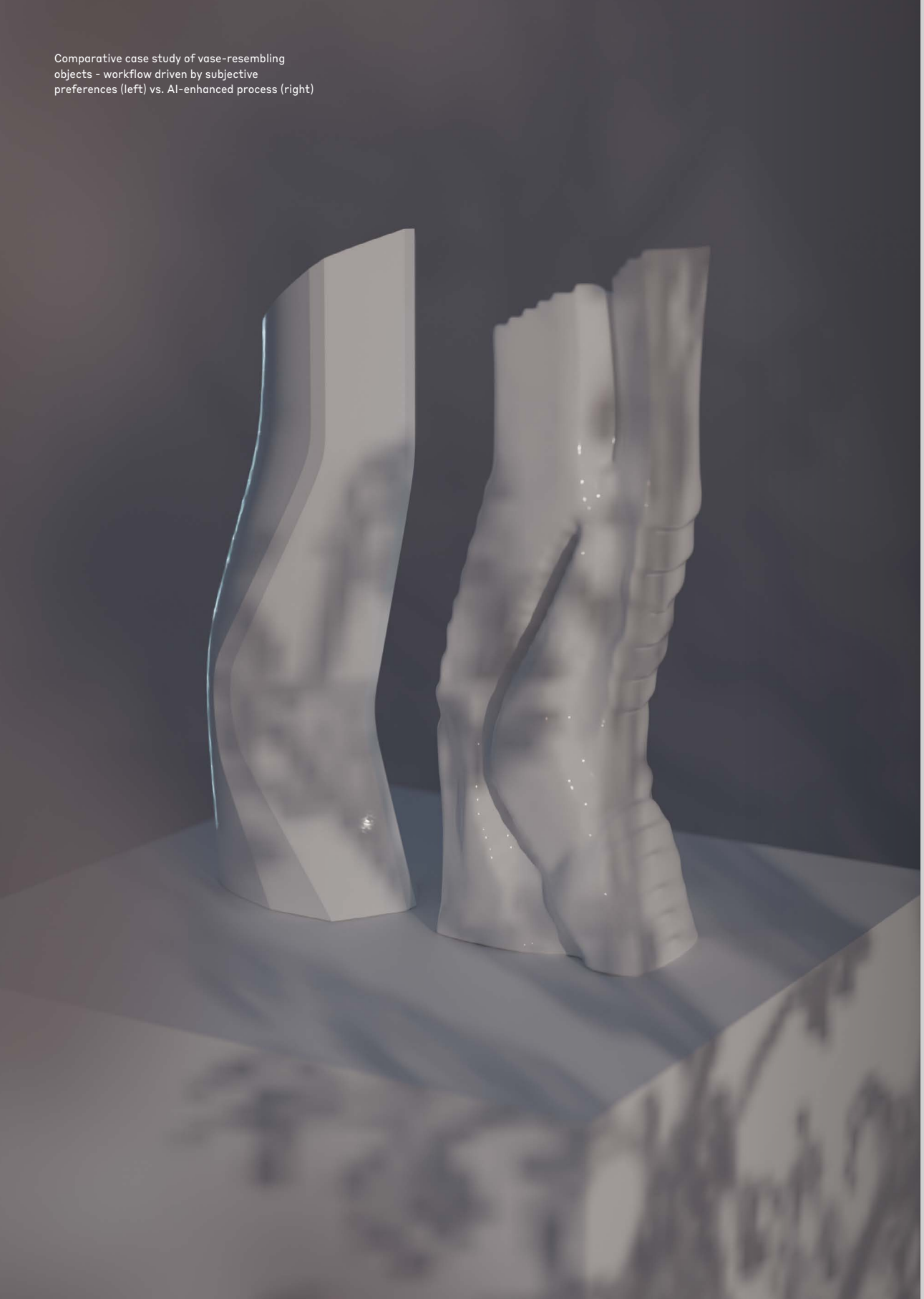
Visual identity of the Trimtab communication platform by Peter Chmela. The number "1" in tr1mtab.com's URL replaces the subject "I," aiming to emphasise the importance of a single step if taken in the right direction.

Informed Creativity

Exploring thresholds of AI-powered authorship by Vladimír Boroň

Doctoral research:	Artificial intelligence in automotive design process
Realization:	2023 — ongoing
Researcher:	Mgr. art. Vladimír Boroň
Research supervisor:	Assoc. Prof. Michala Lipková, ArtD.
Text:	Michala Lipková





Comparative case study of vase-resembling objects - workflow driven by subjective preferences (left) vs. AI-enhanced process (right)

What exactly happens when hand-sketched ideas are interpreted into three-dimensional shapes? How can AI design tools become a source of formal inspiration? Starting with the same initial idea, expressed by a hand sketch, the two 3D-printed vase-resembling objects explore the visuality of different form-finding workflows in the CAD environment.

The first vase is a manually modeled result driven by purely subjective aesthetic preferences. It is created using standard 3D modeling tools in Blender and powered by the author's embodied expression.
The second object results from AI images prompting iterations in Vizcom and their subsequent transformations in a 3D program.

The objects are an early outcome of Vladimír Boroň's dissertation research, which focused on the use of AI-supported tools in the automotive design process.
The research aims to explore practices that could enable the use of emerging AI tools in a way that empowers, rather than exploits, human creativity.

As a graduate of transportation design with a focus on exterior design and automotive styling, Vladimír Boroň approaches his doctoral research from the standpoint of an experienced, creative maker:

“The reason for my insight into fine art practices is a decline and unoriginality of current production design, oversaturation of the market with generic products, and a personal need to experiment and get out of the vicious circle. (...) In the portfolio of many students, there are often generic, even identical projects, the execution of which is at a very high level, but without a special character.” (Boroň, 2021, p.14)

Being aware of the divide between free artistic practice and the industry standards of automotive design, Boroň admits that “design is a field in which we also have to follow the logic and not just personal feeling,” and therefore, he tries to "interpret a feeling and cultivate fragments of free work into a kind of design language." (Boroň, 2021, p.26)

The currently started dissertation research aims to explore two streams of creative exploration within the practical part of the thesis:

- Exploration of the potential of emerging design **tools enabled by generative artificial intelligence (GenAI)**, trained on large, publicly available datasets that include copyrighted works - nowadays, only emerging but widely discussed and problematic areas of design practice.
- Simultaneous **dive into analog, authentic hands-on practice** inspired by psychic automatism or even surrealism (Choucha, 1991, p. 51), which we could compare to the author's own “creative intelligence model,” trained on his embodied hands-on experience of creating and experimenting with different media. The objects presented at the Milan exhibition are the first results of the outlined strategy. By casting the objects in delicate, handmade porcelain, the strategy spotlights the differences between the physical, 3D-printed outputs.

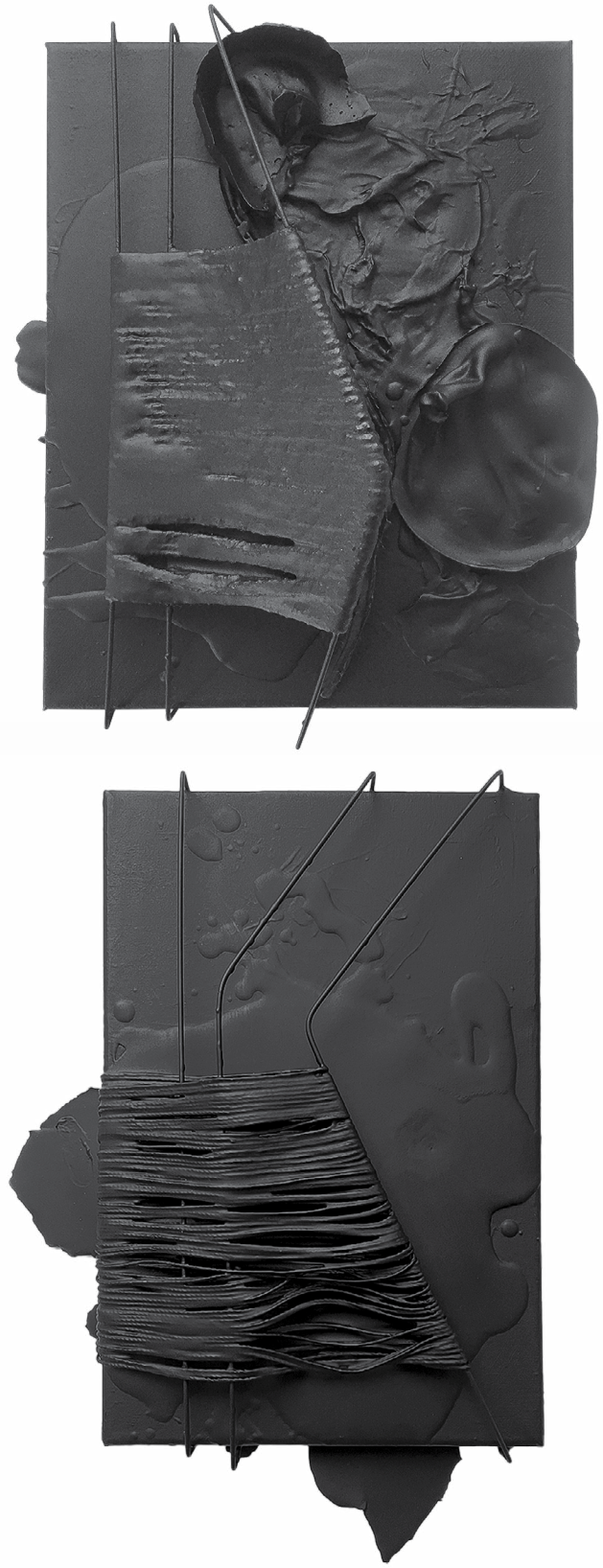
With advancements in AI technologies, the automotive industry is witnessing a paradigm shift where AI is revolutionizing how vehicles are designed and manufactured. The dissertation research aims to explore various applications of artificial intelligence in automotive design and methodically describe the potential of GenAI tools to increase creativity and efficiency in the design process. Over the last year, many AI tools, as well as add-ons to existing programs, have appeared, which can generate digital imagery, textures, or even animations. However, many of these programs draw from internet portals and databases where they select and then apply the characteristic features of the handwriting of established artists. At this point, the question arises about the extent to which artificial intelligence is ethical and whether it can be considered an author's acceptable entry into the design work.

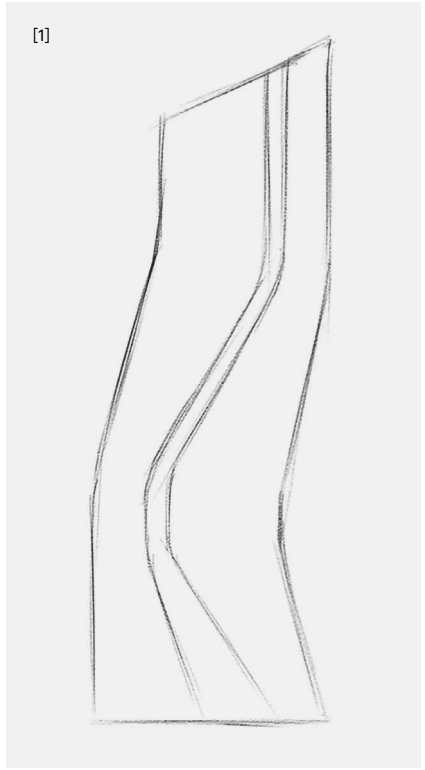
The goals of the dissertation research are:

- **Mapping the use of GenAI tools in automotive design:** This project will examine the historical development of AI and its integration into the field of automotive design to provide an overview of the timeline and key milestones that shaped the current environment.
- **Critically evaluate the impact of GenAI tools on creativity and innovation in design:** Artificial intelligence provides new

Right: Form-finding 'post graffiti' experiments from V. Boroň's diploma project

Next page: 4 steps of AI-supported design process:
[1] Input sketch
[2] Ai Vizcom outcome
[3] Ai Zoe Depth outcome depth map
[4] 3D model from height map

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opportunities to expand the creative capabilities of automotive designers. Through a series of case studies with FAD STU students, we will explore how AI-based tools and algorithms can help designers create innovative concepts, explore different design options, and push the boundaries of conventional aesthetics.

- **Analyze the role of GenAI in increasing the efficiency of the automotive design process:** GenAI has the potential to streamline the design process by automating repetitive tasks, facilitating the rapid creation of design variations. The research will explore the integration of AI-driven design tools, simulation techniques, and virtual reality to increase efficiency, reduce development time, and minimize costs.

- **Discuss the ethical and societal implications of GenAI in automotive design:** The research will explore ethical questions regarding authorship, safety, and bias, which are coded into the publicly available large language models. We aim to identify potential risks, challenges, and opportunities associated with adopting GenAI in the automotive industry, ensuring a comprehensive understanding of the wider implications.

To achieve the objectives of this research, a methodology involving a combination of case studies, interviews with industry experts, and analysis of relevant data will be used. In addition, hands-on experimentation with AI-based design tools and software, analog and digital drafting, and 3D modeling will be conducted to gain practical insights into their capabilities and limitations. Ultimately, this project aims to inspire further innovation and collaboration between AI and automotive design.

Mgr. art. Vladimír Boroň
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Vladimír Boroň graduated in transportation design at the Academy of Fine Arts and Design in Bratislava. He has hands-on experience from both the automotive industry (Superiore Design studio) and startup world (Appara Technologies Ltd.). He is actively engaged in “post-graffiti” creation-abstract and analog painting & modeling) which he perceives as a way of forming an author's expression in design work.

Time Research

Toolkit for experience design and speculation by Petra Hurai

Doctoral research:	Principles of Time Measurement and their Development Using Intelligent Technologies
Realization:	2016 — 2023
Researcher:	Mgr. art. Petra Hurai, ArtD.
Research supervisor:	Prof. Peter Paliatka
Text:	Michala Lipková

Ephemeris wristwatch design
concept by Petra Hurai

Petra Hurai’s dissertation research thesis, Experience of Time, describes the complex concept of time from the perspective of the design process and social development. The perception of time is a phenomenon subjectively felt by a person and can be accurately described thanks to research advancements in physics, biology, cognitive psychology, neuroscience, and the like.

Hurai’s research mainly focused on exploring the notion of ‘subjective time’ described through sensory perceptions. The project considers the subjectivity of time as a characteristic feature that should be included during the design process — ‘designing with time’. The thesis proposes an inspiring tool for designers and the general public; it explores the relational context of subjective time and sensory perceptions through visual clues.

‘Thanks’ to technology, our days are longer, our loved ones are always within reach, and our work never ends. We hear about the imbalance between the biology of our bodies and the pace of modern times in the media every day. In his book In the Bubble, John Thackara begins the chapter on speed by quoting the English writer Bruce Chatwin, retelling a story of a group of white explorers in Africa who forced native porters to rush to their expedition’s destination. At the point when the porters stopped and refused to continue the journey, they argued: “We have to wait until our souls catch up with our bodies” (Thackara, 2006). In an era in which Stewart Brand calls long-term thinking ‘challenging and rare’ (Brand 1999, 2) and Douglas Rushkoff (2013) warns against ‘the twenty-first-century presentism’, designers have the opportunity to provide a counterpoint to the current acceleration culture and contribute to the expansion of the limited understanding of time.

“Objective time is the concept used worldwide daily using numbers and dials. Mathematical and physical principles can accurately describe it. On the contrary, subjective time is a perception of time tied to an individual experience.”

The topic of subjective time already appeared in Hurai's diploma thesis, in which she describes a subconscious perception of time that consists of visual signals placed on a watch dial as a reminder of upcoming events. The diploma thesis resulted in two wristwatch designs, Ephemeris I and II, with mechanical and hybrid movements. The Ephemeris concept operates with anticipation — a psychological phenomenon that influences the subjective passage of time — if we know what awaits us = time passes faster.

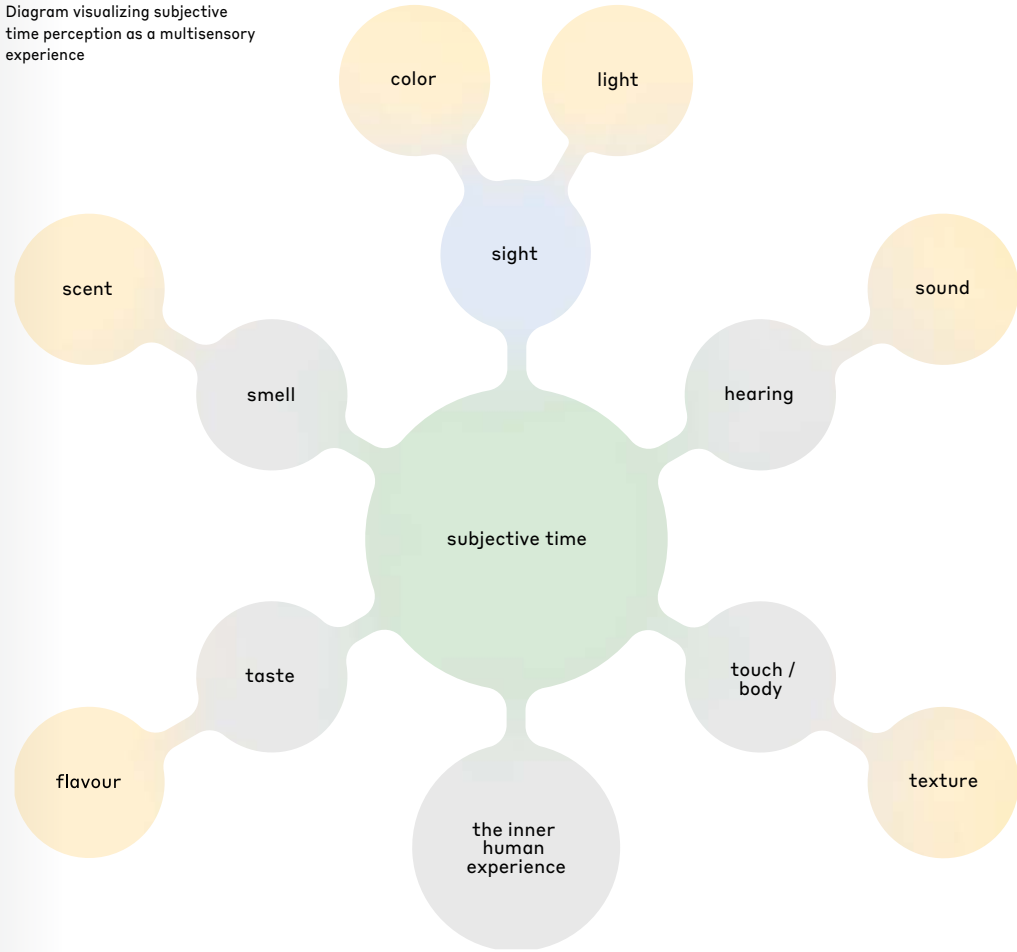
The dissertation project Experience of Time initiates a much-needed conversation about the phenomenon of individual time perception. The core of the research carried out by Petra Hurai is based on changes in society after the period of the COVID-19 pandemic. In her thesis, Hurai draws attention to the still overlooked notion of subjectively experienced perception of time, which can be accurately described thanks to improving scientific research today:

“Objective time is the concept used worldwide daily using numbers and dials. Mathematical and physical principles can accurately describe it. On the contrary, subjective time is a perception of time tied to an individual experience. Subjective time can be perceived as the duration of time, distortion of time, or temporal illusion, such as perceived speed of time or length of time interval, Vierordt’s Law, oddball effect, or chronostasis (Foster, 2022). The basis of the concept of subjective time was created by the French philosopher Henri-Louis Bergson. The concept of time describes the duration of time — ‘durée’ — one of the temporal illusions perceived by a person” (Hurai, 2023). The quantification of subjective time, unlike objective metrics such as spatial dimensions or objective time, eludes direct measurement. However, its manifestation can be discerned through the lens of temporal illusions, specifically the perceived speed of subjective time, which is the main domain of Petra Hurai’s research.

The immediacy of communication technologies largely marks our perception of time, and it radically differs from how our ancestors in pre-industrial times perceived the current passage of time. The research considers the subjectivity of time as one of the important external characteristics of product design that should be included in the design process — rather than as the final touch or as an additional function. The first mention of ‘designing with time’ comes from Robert Hunt’s dissertation thesis, which describes the possibility of using the concept of time as a fourth dimension in the creative design process (Hunt, 2021). Petra Hurai’s research then suggests dividing the concept of time into two main fields: objective and subjective time, with further emphasis on describing subjective time in relation to the design process.

One of the strong aspects of Hurai’s dissertation is visual representations of complex concepts in the form of representative charts and diagrams, similar to ‘images of philosophy’ used to express philosophical thoughts through a rich system of metaphors and other means of imagination (Zapletal, 2022, 246).

Diagram visualizing subjective time perception as a multisensory experience



The dissertation thesis's main ambition is to contribute to describing different aspects of subjective time experience. One of the key charts of the thesis visualizes the concept of subjective time perception as a multisensory experience, assigning specific properties to each of the senses (e.g., 'light' and 'color' in the case of sight).

"The notion of subjective time can be described and further explored through sensory perceptions. Perception of time is defined as the multisensory experience based on an individual interpretation of internal and external stimuli. A set of stimuli then creates a space for the subconscious perception of the passage of time (duration of time). The research consequently deals with one of the temporal illusions — the duration of time that is possible to describe via scientific methods, such as measurement of the duration (and speed) of the perceived time interval. We explore different ways to define and measure this 'unit' of subjective time through a visual form of a conceptual chart containing basic senses, sensory dimensions, and their properties ('zeitgebers'). One example of subjective time perception is the situation when the time interval is perceived as shorter if the color of the perceived object or space is in warm hues (red or yellow hues) (Thönes et al., 2018)." (Hurai, 2023). The speed of perceived intervals of time can be described from the perspective of many different sensory dimensions, such as types of flavours (Baccarani et al., 2021), the height of body temperature (van Maanen et al., 2019) or music tempo (Droit-Volet et al., 2023).

The tangible outcome of Hurai's research project — the Experience of Time toolkit — becomes an inspiring, ready-to-be-explored provocation targeted not only at design experts. As a designer, Hurai successfully applies her creative training and art craft to distill her theories into tangible, open-ended visual clues. The universality of the cards allows interdisciplinary discussion, offering a new perspective on the concept of subjective time measurement through evocative visual guides, focusing specifically on the perceived speed of time interval.

"The toolkit consists of a deck of cards, in which each card displays one property ('zeitgeber') of a sensory dimension and the length (speed) of a perceived unit of subjective time. The project brings a new viewpoint on the concept of time, initiates a conversation on the subjective time phenomenon, and highlights its importance as an essential dimension in the design process" (Hurai, 2023). Understanding the concept of time objectively and subjectively constitutes a crucial aspect of design thinking and the design process. Beyond incorporating time as a parameter in design (design with time), designers can design new principles of time (repetitive intervals) or devise methods for displaying time digitally or analogously.

The main aim of the ongoing research is to describe the concept of time so that designers and the general public can see, use, and benefit from the knowledge about time.

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Petra Hurai is a visual storyteller, creative director, and founder of The Shamrock Green Studio, focusing on bespoke photography and visual communication. She is an experienced product designer passionate about practice-based and theoretical research and the art of watchmaking.

colour

SATURATION

EXPERIENCE OF TIME

colour

BRIGHTNESS

EXPERIENCE OF TIME

colour

HUE

slower

faster

EXPERIENCE OF TIME

light

INTENSITY

slower

faster

EXPERIENCE OF TIME

light

COLOUR

EXPERIENCE OF TIME

light

TEMPERATURE

slower

faster

EXPERIENCE OF TIME

motion

TEMPO

slower

faster

EXPERIENCE OF TIME

motion

RHYTHM

EXPERIENCE OF TIME

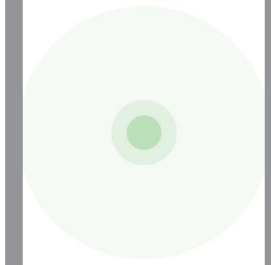
shape

TYPE

EXPERIENCE OF TIME

shape

SIZE



EXPERIENCE OF TIME

pattern

REGULARITY

EXPERIENCE OF TIME

temperature

HEIGHT

slower

faster

EXPERIENCE OF TIME

flavour

TYPE

slower

faster

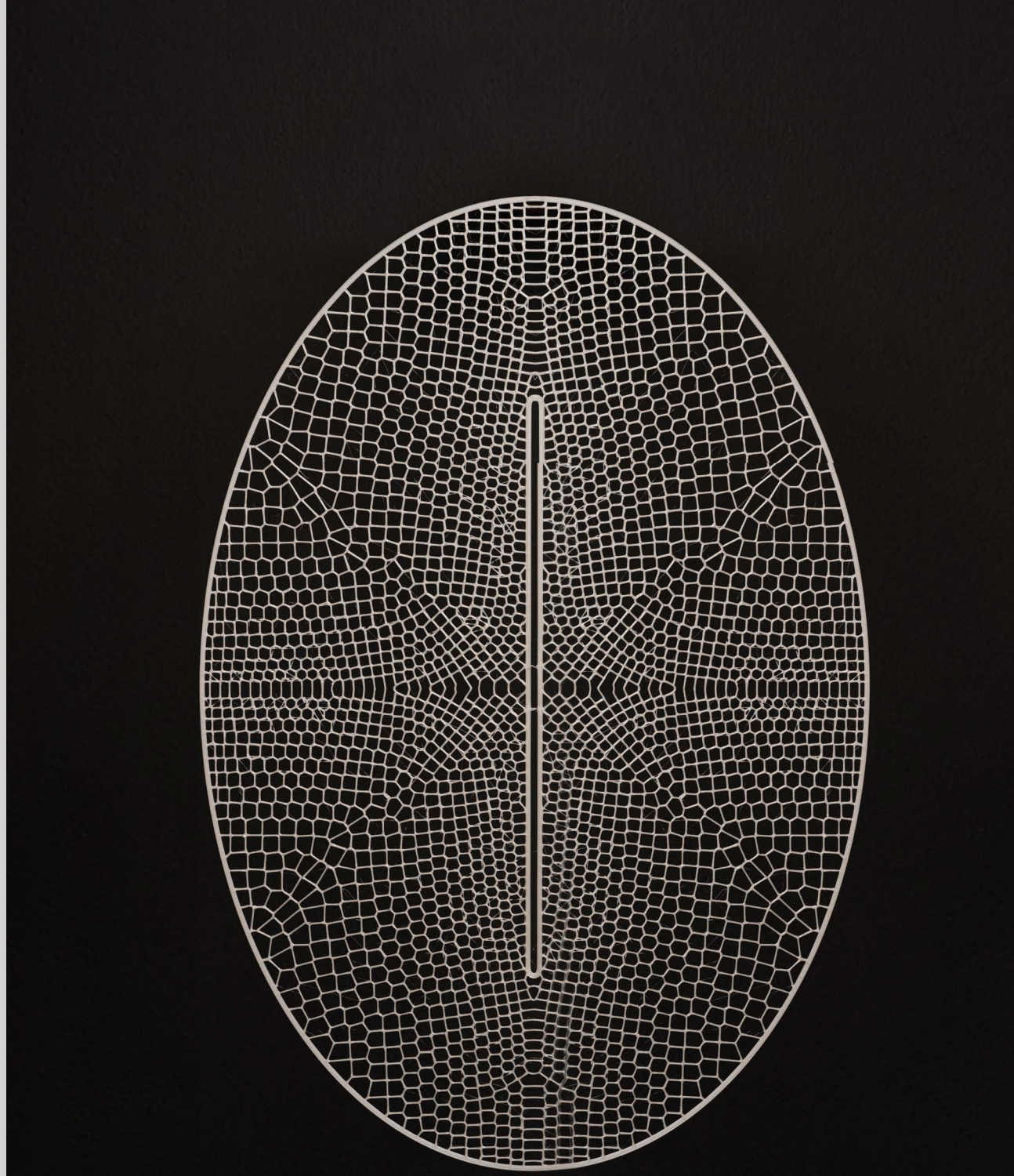
EXPERIENCE OF TIME

Experience of Time toolkit: a set of cards for the illustration of subjective time perception, focusing specifically on the perceived speed of time interval

Senseable Biomaterials

Design-driven innovations in biomaterials by Vlasta Kubušová

Doctoral research:	Design-driven Biomaterials Innovation for Positive Impact
Realization:	2019 — ongoing
Researcher:	Mgr. art. Vlasta Kubušová, MA
Research supervisor:	Assoc. Prof. Michala Lipková
Text:	Michala Lipková



Detail of folded 3D-printed lattices

The project Sensbiom #1 is one of Vlasta Kubušová's Fulbright fellowship results at DumoLab Research for Biodegradable Architecture at Penn's Weitzman School of Design and in collaboration with crafting plastics! studio and Label-Free Research Group at Center For Bits and Atoms, MIT.

The project brings together biomaterial-driven and computer-controlled manufacturing of aroma-active lattices. The research team sets forth the question of materials in the built environment being able to passively identify harmful particles and respond with aroma-active molecule release to help detoxify indoor air.

The 3D printed lattice-like forms are prototypes of self-supporting, scented modules made from two types of bio-based materials: biopolymer blends aiming to replace fossil fuel plastics and water-based biocomposites made from the most abundant biopolymers on Earth such as chitin, cellulose, and silk.

Vlasta Kubušová has approached her doctoral studies from a strong position and is in an already advanced stage of previously carried out independent creative research. Together with Miroslav Král, the founding duo of crafting plastics! studio has explored the vastly unknown field of bioplastics derived from plants for more than a decade:

"Realizing dynamic research and innovation in materials and design, we provide a base for interdisciplinary progress towards enjoyable sustainability and more transparent production. We explore new product development methods, from a basic craft approach to high-tech machinery. Our pursuit is to fully control the product's lifespan, from its origin — in the form of unrefined material — through the final product until its inevitable decay." (Kubušová et al., 2023).

“Our pursuit is to fully control the product’s lifespan, from its origin — in the form of unrefined material — through the final product until its inevitable decay.”

As a visiting doctoral degree candidate and Fullbright scholar at UPenn’s DumoLab Research for Biodegradable Architecture at Penn’s Weitzman School of Design, Vlasta Kubušová has focused on investigating the scaling potential of innovative biologic materials for the use in product design and architecture systems. The project Sensbiom #1 focused on exploring biomaterials’ sensory (especially olfactory) properties.

Kubušová’s research intention has grown from a previously explored idea of distinguishing natural and synthetic materials by the sense of smell. Together with Moritz Maria Karl, crafting plastics! studio investigated the possibilities of olfactory properties of bioplastics during their common research project Breathe In/Breathe Out, presented for the first time at Milan Design Week in 2019 and later at MAK’s Vienna Biennale For Change in 2021:

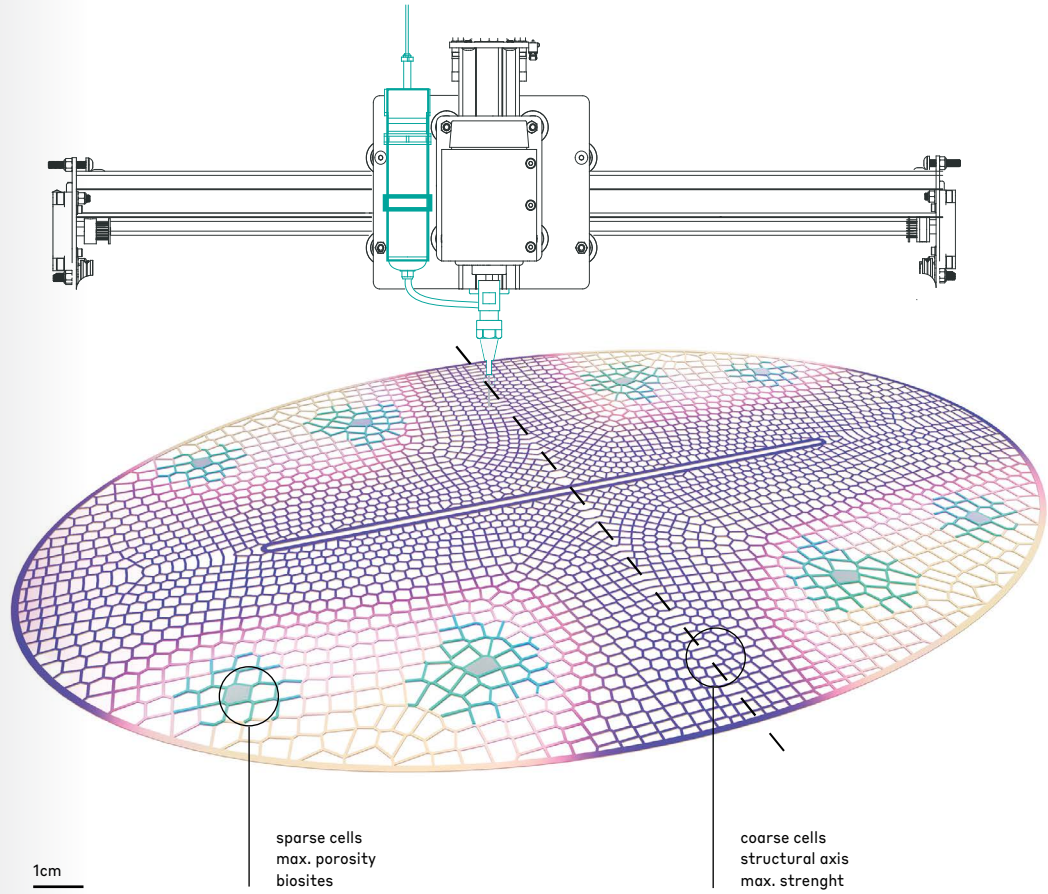
“By discussing the complexity of challenges when integrating bioplastics for longer-lasting products, we discovered that these new materials are missing their own identity. (...) We need to create new acceptance for the natural alternatives and enhance their own features and properties, respecting where they came from and their entire lifecycle. (...) One of the challenges in implementing bioplastics on a larger scale is that it is very difficult for the user to identify whether the product is made from petroleum-based plastics or a biocomposite. The sense of smell can add an additional material property and help to distinguish natural and synthetic materials. (...) Within the design research project Breathe In/Breathe Out, we aimed to develop a unique scents library for the bioplastic material NUATAN. On the one hand, this would help customers distinguish between synthetic and natural plastics and create a new relationship with these new materials that suddenly gets their own identity or story” (Wirth, 2021).

In her initial research proposal for the Fulbright fellowship, Kubušová draws attention to the “interactive and responsive potential of biomaterials towards their environment and consumers” as being a much-underexplored feature:

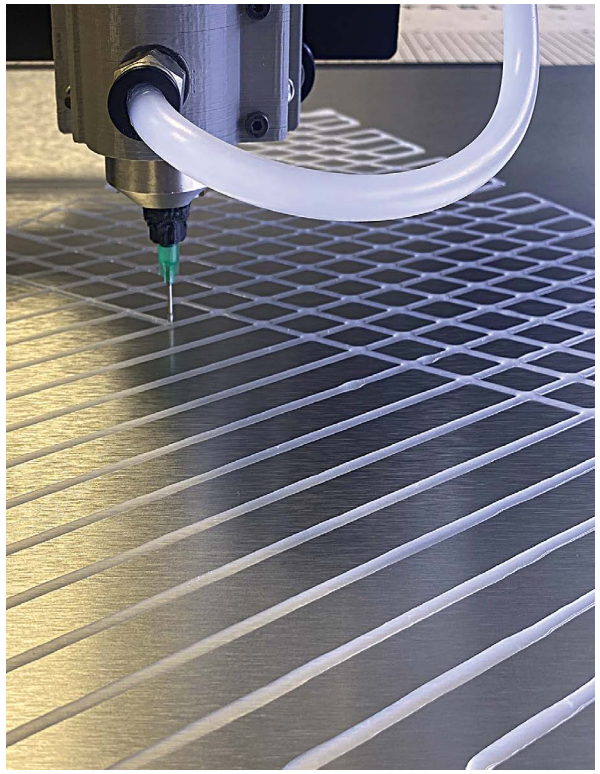
“Biomaterials are also very good candidates to host and enhance interactivity thanks to their programmable properties, i.e., encapsulations of active molecules of responsive substances. In general, visual and haptic properties primarily perceive materials currently used in architecture, interior, and product design, and olfactory properties are much less prominent. However, features such as a scent play a central role in the emotional acceptance of material and decisively determine its distinctive character.”

One of the multiscale questions asked by material scientists, designers, architects, and synthetic biologists (UPENN, 2023) was, “Could future materials help detect and correct the presence of toxic volatile compounds?” Sensbiom #1 became an interdisciplinary cross-country collaboration, proposing new design-driven solutions for integrating interactive biomaterials based on waste resources into functional everyday applications. The technical development and final material fabrication solution of the Sensbiom #1 project is in detail documented in a research paper published by the team in Frontiers magazine:

“Cell-free protein expression systems are combined here with 3D-printed structures to study the challenges and opportunities as bio-fabrication enters the spaces of architecture and design. Harnessing large-scale additive manufacturing of biological materials, we examined the addition of cell-free protein expression systems (‘TXTL,’ i.e., biological transcription-translation machinery without using living cells) to printed structures. It allowed us to consider programmable, living-like,



Mesoscale design methodology. Additive manufacturing is used to functionally distribute fibrous biopolymer blends in 50 cm long lattices with varied cell size and material composition (Figure 3 from Frontiers, 2023, 7).



Cells cloning (top) and additive manufacturing of biological materials (bottom) in DumoLab Research

Next doublepage: Laia Mogas-Soldevila, director DumoLab Research, in the Sensbiom #1 installation at ICA, Philadelphia

responsive systems for product design and indoor architectural applications. (...) We propose a roadmap towards creating healthier, functional, and more durable systems by deploying a multiscale platform containing biologically active components encapsulated within biopolymer lattices operating at three design scales: (i) supporting cell-free protein expression in a biopolymer matrix (microscale), (ii) varying material properties of porosity and strength within two-dimensional lattices to support biological and structural functions (mesoscale), and (iii) obtaining folded indoor surfaces that are structurally sound at the meter scale and biologically active (we label that regime macroscale)" (Frontiers, 2023).

Following a build to understand its philosophy, the installation of Sensbiom #1 became an attractive and tangible outcome of an otherwise difficult-to-explain science research project. Sensbiom #1 was publicly presented during the ACADIA 2022 conference reception at the Institute for Contemporary Art (ICA) in October 2022 in Philadelphia. The temporary installation combined biomaterial-driven and computer-controlled manufacturing of aroma-active, 3D-printed lattices as self-supporting, scented modules.

The modules were made from two types of bio-based materials: biopolymer blends aiming to replace fossil fuel plastics and water-based biocomposites made from the most abundant biopolymers on Earth, such as chitin, cellulose, and silk. The team set forth the question of materials in the built environment being able to passively identify harmful particles and respond with aroma-active molecule release to help detoxify indoor air.

"Zingernone (4-(4-hydroxy-3-methoxyphenyl) butan-2-one) is the aroma infused into the water-based biocomposite modules during fabrication and demonstrates the potential of air-purifying scents released by active materials. In particular, zingerone can help purify the air as it is thought to have known pharmacological and biological activities, including anti-inflammatory, anticancer, antimicrobial, and hepatoprotective activity" (Kubušová et al., 2023).

The installation was a joint effort stemming from ongoing work on the SENSBIOM Project (Senseable biomaterials for healthier habitats) by DumoLab Research for Biodegradable Architecture at Penn's Weitzman School of Design and crafting plastics! studio and the project soon continued further with a second iteration. Sensbiom II — Solar Active Materials was presented by crafting plastics! & DumoLab Research at the Milan Design Week 2023. The follow-up project proposes a future where objects help humans reconnect with the planet using environmentally interactive materials derived from renewable resources — this time by visualizing ultraviolet radiation (UPENN, 2023).

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Vlasta Kubušová is a material designer, researcher, and co-founder of award-winning crafting plastics! studio, an interdisciplinary design studio focusing on circular design and research in innovative, responsible materials. During her doctoral studies at FAD STU, Kubušová received a Fulbright Scholarship for 2021/2022, working on interactive biomaterials at the University of Pennsylvania (DumoLab Research). Recently, Kubušová received MIT-SLOVAKIA MISTI Global Seed Funding for project Senseable Matter — research in interactive biomaterials for design and architecture with Dr. Andreas Mershin at Massachusetts Institute of Technology.

Mixed Reality Workflows

Applications of virtual reality in the design process by Filip Maukš

Doctoral research:	Applications of virtual reality in the design process
Realization:	2017 — 2022
Researcher:	Mgr. art. Filip Maukš, ArtD
Research supervisor:	Assoc. Prof. Peter Olah, ArtD.
Text:	Michala Lipková

Modular construction of variable
motorcycle geometry simulator

The dissertation project explored the use of virtual and mixed reality in transport design within the activities of FAD STU's MX lab, a workplace focused on research in the field of digital design tools and the impact of emerging technologies on the design process.

Through a series of industrial design case studies, the project introduced different mixed reality workflows, including aspects of software development (beta testing features of the then-emerging VR modeling tool Gravity Sketch) and modular hardware infrastructure for physical, ergonomic simulation.

As a part of the exhibition at BASE Milano, Filip Maukš is presenting the final case study of his dissertation project - the hybrid e-bike/dirt bike concept. The project was developed during Filip's internship at Škoda's research department and successfully demonstrated a design workflow with maximum use of VR tools.

The design research at MX lab (Multidisciplinary research and experience design laboratory) oscillates at the intersection of several disciplines, ranging from artificial intelligence, software development, and mechatronics to ergonomics, additive manufacturing, or human-computer interaction.

Filip Maukš's research, carried out from 2017 to 2022, was focused on exploring emerging software and hardware solutions for virtual reality modeling. The thesis provides an interesting snapshot of specific stages within the development of this rapidly accelerating field.

As a part of the initial analysis of the digital tools, Maukš lists the following advantages of the use of virtual reality in transportation design (Maukš, 2022):

- The opportunity to visualize new designs of big objects (e.g., cars or motorbikes) on a real scale can save significant amounts of resources and work hours otherwise used to build a physical model.
- Virtual reality provides a wide range of options for data configuration - e.g., 3D data of a new car exterior can be visualized through VR software in various colors and materials.
- Models can be placed and viewed in a studio's interior and any simulated outdoor environment - an option previously available only for design studios with significantly advanced infrastructure.
- Individual parts of the simulated model can be changed in real-time (e.g., lights or bumpers), allowing faster and more effective review and evaluation of design possibilities (similar to configurators already common on car manufacturers' websites).

Further in the text, Maukš describes the status quo of automotive simulators in the following words:

“The primary feature of the simulator is its synchronization with virtual data. The person sitting inside the simulator is shown the new design visuals in virtual reality, and they can interact with them through the physical simulator. In this mixed reality scenario, the virtual steering wheel lines up with its physical counterpart to provide haptic feedback.”

The field of motorcycle design was chosen as the main subject of the dissertation project. The decision was made firstly because of the author's personal experience with the subject (previously realized projects as well as personal race driving experience) and secondly because of the easier technical feasibility with regard to the scale of the object (in comparison to car design).

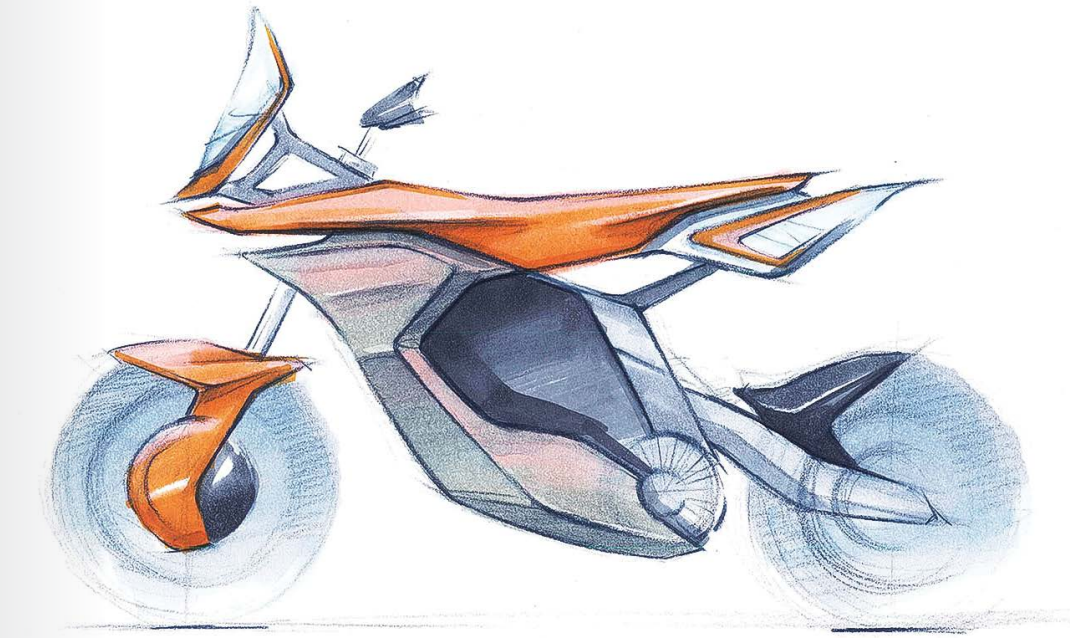
The introductory part of the thesis contains an overview about virtual reality technology. It classifies virtual and mixed reality (MR) in the reality-virtuality continuum (Milgram et al., 1999) and provides examples of different interactions between the real world and virtual data in the design industry. Maukš views MR as the most modern and rapidly developing way of interacting between the real and digital realms. Thanks to the characteristic feature of mixed reality — the ability to synchronize digital and real data — in MR, virtual and real objects can react and influence each other in real-time, which he further explores in all of the case studies featured in the thesis.

Since even during the short duration of the doctoral thesis, MR and VR technologies moved forward rapidly, the possibilities and limits of the specific hardware and software were not the prime focus of the research. The author rather focused on the impact of specific, brand-independent features and principles in relation to the actual steps of the design process - the design process: the process of ideation, concept development, design execution, and final design presentation.

Thanks to the rapid improvements in the field, VR tools are becoming increasingly suited for early creative work, e.g., capturing a first thought or creating multiple variations of an early design idea - extending the possibilities beyond hand sketching using paper and pen or 2D digital sketching using a graphic tablet.

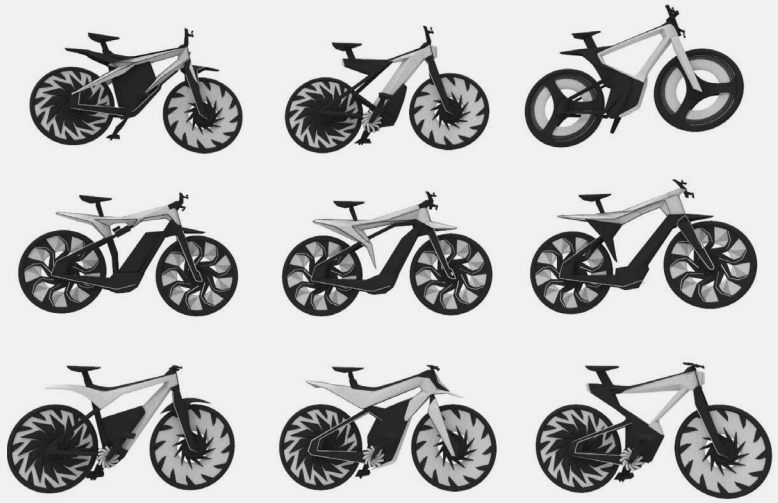
From the hardware and software perspective, Maukš highlights the following points in the MR/VR trends in terms of technology that were relevant to the thesis' case studies:

- At the time of project realization (2017 - 2022), HTC and Oculus were the key players driving the adoption of VR headsets in the mass consumer market. Therefore, the HTC Vive headset, in combination with the HTC Tracker and later Oculus Quest 1 and 2, was first used in the realized case studies.
- Gravity Sketch was used as the main VR modeling software (using Oculus Quest) since it proved to be a promising tool that allows sketching in virtual reality. Using Gravity Sketch, the designer can capture an idea of a design directly in 3D space and share the virtual design directly with others in real time through the so-called “co-creation mode.” At the same time, the company was open to closely cooperating and participating in the research by exclusively disclosing beta features that were not publicly available (Gravity Sketch, 2020).
- An interesting shift has also occurred in the design presentation field: Gaming engines like Unreal Engine and Unity, orig-



Top: Rally motorcycle concept - sketches from the second case study

Next page: Fast doodles from the VR ideation process (Gravity Sketch) and Gravity Sketch output model



“The primary feature of the simulator is its synchronization with virtual data. The person sitting inside the simulator is shown the new design visuals in virtual reality and they are able to interact with it through the physical simulator. In this mixed reality scenario, the virtual steering wheel lines up with its physical counterpart to provide haptic feedback.”

inally developed for creating computer games, are now used in industrial design and the automotive industry. Gaming engines combine quality visualizations with the ability to program a wide range of interactive features, e.g., material configurators, door animations, interior mood light changes, or other featured simulations.

The core practical part of the dissertation project included 3 case studies:

- **Presentation in VR -**
  Sports motorcycle concept
  The first case study followed up on Maukš's diploma project - by taking 3D data (and previously prototype in only 1:4 scale) created using traditional desktop CAD modeling technique and simulating them in real size on a physical motorcycle simulator. The simulator was set to match the ergonomics of an electric motorcycle, and the 3D model of the motorcycle was mapped onto the simulator construction, including the handlebars, whose physical motion corresponded with the motion of the handlebars in VR. The second part of the simulation was a VR configurator programmed to change the color of fairings and wheel discs. The six color swatches in the background represent the color palette. The top colors are for wheel rims, and the bottom is for fairings. The colors can be switched by pointing the controller at one of the samples and pressing the button on the controller. The simulation exposed several ergonomic design issues and attracted attention to the potential of real-size ergonomy testing in MR/VR during the early stages of the design process.

- **Creativity in VR -**
  Rally motorcycle concept
  The second case study focused on experimenting with VR tools during the early stages of the design process. In the modeling environment of Gravity Sketch, a 3D model of the simulator was introduced to reference the ergonomics of a sports rally motorcycle and a 2D scan of a hand drawing as a basis for future design. Modeling in virtual reality combines elements of classic modeling with 2D sketching. In 3D space, it is possible to create lines or volumes using spatial gestures. The case study was focused on capturing the initial idea and proportions of the future design, which acquired a sculptural touch thanks to gestural modeling. Since the design was modeled in real size and can be presented through virtual reality, it proved to serve as a more effective communication tool during expert critiques. The simulator used to visualize the sports bike was transformed into the ergonomics of the rally bike and synchronized with 3D data to test the seat's ergonomics and the

seat's shapes and fairings. During the project, it was possible to establish direct cooperation with the company Gravity Sketch. A trial beta version of the Gravity Sketch software was created to synchronize the 3D data of the rally motorcycle and simulator.

- **Maximizing the use of VR tools - Hybrid e-bike/dirt bike concept**
  The third case study, developed during an internship at the Škoda Auto design studio in Mladá Boleslav, explores the problem of last-mile micro-mobility and its intersection with the possibilities of making the most of the eclectic drive in the cities of the near future. The electric bike project started with an empty scene in the VR modeling program Gravity Sketch. It ended with a presentation of the final design in 1:1 scale VR with a programmed configurator; the case study intended to use every available possibility of working with virtual reality in all stages of the design process (ideation - refinement - presentation).

The motorcycle simulator developed during the research project fulfilled the task of the very first prototype. However, when using it, the real-life experience of interacting with the motorcycle and with the user's own weight is still missing. The motorcycle lowers on the shock absorbers under the rider's weight, which affects the position and reach to the ground. With a motorcycle, the rider moves his body, whether leaning into corners or maneuvering at low speeds.

The perpendicular static frame of the simulator prototype did not yet allow these aspects to be tested. The vision of the next research activities in the MX lab is to continue developing simulation environments for industrial design that provide a more realistic user experience and allow the designer to appropriately replace physical prototyping with technological aids.

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Filip Maukš is an industrial designer passionate about motorbike and bicycle design. He is currently actively participating in FAD STU's research group, MX lab. During his doctoral research, he formed a partnership with Gravity Sketch and interned at ŠKODA DESIGN. Filip has experience designing for hardware startups as a lead designer at Trainshot Ltd.

Hybrid e-bike/dirt bike concept - final presentation sketches from the third case study

Collaborative Craft

Enabling serendipity by community building and craft by Martin Mjartan

Doctoral research:	Design as an Integrating Element of the STU Creative Center in Bratislava
Realization:	2018 — 2021
Researcher:	Mgr. art. Martin Mjartan, ArtD.
Research supervisor:	Prof. Peter Paliatka
Text:	Michala Lipková

Experimental drinking glass designs and
a steel mold for shaping hand-blown glass
by Martin Mjartan

In his dissertation thesis, Design as an Integrating Element of The STU Creative Center in Bratislava, Martin Mjartan focuses on intersections of community building and craft-based design practice in the tertiary design education context. Learning from the theory of creativity and the history of creative industries, the core of Mjartan's research activities involves creating opportunities for unexpected interdisciplinary connections to arise in the academic environment through the discussion platform Pechtle Mechtle.

In the suggested pedagogical approach, Mjartan emphasizes the importance of being active in the local and international creative community by directly collaborating with artisans and producers. Using features of informal education, workshops organized by Martin have allowed students to explore different materials, e.g., leather making, concrete 3D printing, and working with hemp. The most recent collaboration with Herbert Syrups presents experiments with hand-blown glass. The most recent follow up on the research is Mjartan’s collaboration with Czech glass blower Ondřej Novotný from Nový bor.

Martin Majartan's research keywords are communication, creativity, collaboration, community, and execution. The emphasis on prototyping and 'making things happen' was apparent in all his activities during the studies. The doctoral research focuses on direct contribution to the local context of design education at the FAD STU and the development of the Creative Center of STU (CC STU), located in the faculty's building. The goal of the emerging CC STU fulfills the role of a multidisciplinary platform, aiming to support cooperation between various disciplines at the technical university and fields of creative practice beyond the academic environment.

While the concept of the 'creative class' (Florida, 2002) needs no introduction anymore, Mjartan's reflection revolves around the notion of 'creativity,' quoting Csikszentmihalyi (2013): "Creative individuals are exceptional because of their ability to adapt to almost any situation and work with whatever is available to achieve goals. (...) Creativity does not happen in people's heads but in the interaction of a person's thought processes with his socio-cultural context. It is a systemic rather than an individual phenomenon."

In the context of product design education, Mjartan criticizes the concept of the 'sole genius', and he suggests understanding creativity as the "result of relationships and people's interaction with the surrounding facts or context in which creativity is manifested" (Mjartan, 2021, 18), referring to the Sawyer's claim that "creativity is almost 80% learned and acquired" (Sawyer, 2013).

In his thesis, Mjartan proposes a definition of "design as a profession combining various disciplines' discoveries into complex works of aesthetic and ethical qualities" (Mjartan, 2021, 20). The thesis sums up seven in-depth interviews with recognized experts and, at the same time, active connectors from different research centers and knowledge hubs across STU, ranging from scientific fields concerned with basic research, such as photonics or machine vision, to applied research fields such as robotics or civil engineering. All interviews agree that collaboration between different departments and practices is highly desirable and plays a key role in the university's future development in an international sense.

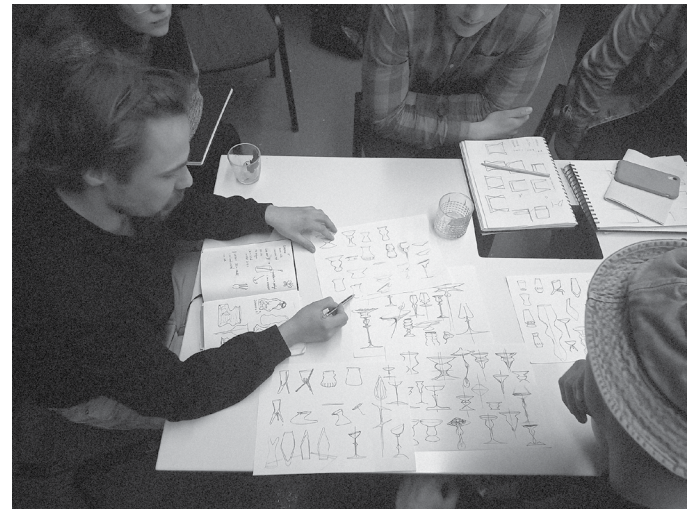
How can we effectively prepare a design student for successful work in contemporary creative practice with the need for multidisciplinarity and with the definition, as mentioned earlier, of creativity in mind? Mjartan tries to answer the question by experimenting with two forms of informal education:

- **Informal discussion in the form of a public event**
  The discussion platform Pechtle Mechtle was founded in 2016 as a grassroots activity of a group of students of FAD STU's master design course (Petra Debnárová, Adriana Bártfayová, Zuzana Wasczuková, Matej Čička, and Martin Mjartan). By the time of thesis publication, 35 public discussions had been organized, hosting 52 speakers. What started as an informal networking activity from pure curiosity later evolved into a popular go-to event with wide recognition. Mjartan's survey confirmed that the participating students consider targeted interactive discussions with creative industry members a relevant part of their design education.

- **One-off voluntary workshops**
  In a four-year timeframe, from 2018 to 2021, Martin Mjartan conducted 7 practical workshops dedicated to different materials and topics of the creative industry. All workshops were promoted through an open call, and participation in them was — as it was in the case of the discussion platform — voluntary, outside the existing curriculum. Workshops have always filled their capacity even though they were not mandatory and came with a cost (in some cases). Partners from the creative industry were extremely helpful in providing all the necessary know-how and tools for the workshop. Three out of seven workshops were organized on request from the local companies: the project Clean or Dirty? (in Slovak 'Čistý či špinavý?'), initiated by Slovak firm Redox s.r.o., a creative marketplace for the City of Žilina, and a Hempcrete workshop in cooperation with Austrian startup Hempstatic. All workshops focused on craft-based design, and small series production brought satisfactory results (the workshops Experience Leather / Zaži kožu, Taste the Clay / Ochutnaj Hlinu, and Blow Glass / Fúkni sklo). The follow-up surveys confirmed that workshop participants considered a practical workshop a "time-efficient form of design education."

Right: Atmosphere of craft-based design workshops organized by Martin Mjartan

Next doublepage: Glass design collection designed for Herbert Syrups. Authors of individual designs: (from the left) Anna Gergelyová, Ondrej Ferianec, Juraj Kotoč, Rebeca Ihringová, Vanessa Píverová, Tomáš Páriš, Martin Sombathy, Barbora Hagarová, Martin Miština, Paulína Varechová, Martin Mjartan, Barbora Pavlikovská




Harbert

Based on the realized and evaluated activities, Mjartan's research contributes to the ongoing discussion on the future of design education, confirming the need for new roles of the lecturer in the contemporary context of higher education, such as content curation and management (Černý, 2019), creation of opportunities for "the act of knowing and as a creative act" to emerge (Freire, 1970, 75—79) or development of an "achievement habit" (Roth, 2015) through iterative and multidisciplinary project-based learning.

The project 'Blow Glass #2' was a continuation of one of the previously mentioned craft-based design workshops focused on familiarising students with unique features of designing for small-series production. Organised for the first time during the pandemic, the 'Blow Glass' workshop focused on experimentation with the traditional hand blown glass technique, using wooden or metallic moulds. Both glass collections were designed by FAD STU students with Martin's support and supervision, and prototyped through partly remote, partly direct cooperation with glass artist and craftsman Ondřej Novotný from renowned Czech glassworks in Nový Bor.

The workshop was organised by Martin already in his new role of assistant professor, after successfully defending his thesis in 2021. The collection resulting from the 'Blow Glass #2' workshop series presents 12 pieces of drinking glass, designed for Slovak producers of local handcrafted syrups - the brand Herbert Syrups from Trnava. The brief identified three types of drinking glass the brand is currently interested in producing:

- "long drink glass" for the brand's new fermented, prosecco-like drink (200 ml);
- "mixed drink glass" with the approx. volume 300 - 400 ml for both alcoholic and non-alcoholic drinks;
- "lemonade glass" (500 ml).

The result of the workshop is 12 unique pieces of glass intended for serial production. The creative part of the Blow Glass project took place in April and May 2023 at the FAD STU in Bratislava as a series of design workshops. An important part of the whole process was the participation of brand representatives at the feedback sessions, commenting on the student designs, sharing insight into the business side of syrup making, and providing an actual tasting of the products. The authors of the 12 designs: Ondrej Ferianec, Anna Gergelyová, Barbora Hagarová, Rebeca Ihringová, Juraj Kotoč, Martin Miština, Tomáš Páriš, Barbora Pavlikovská, Vanessa Píverová, Paulína Varechová, Martin Sombathy and Martin Mjartan.

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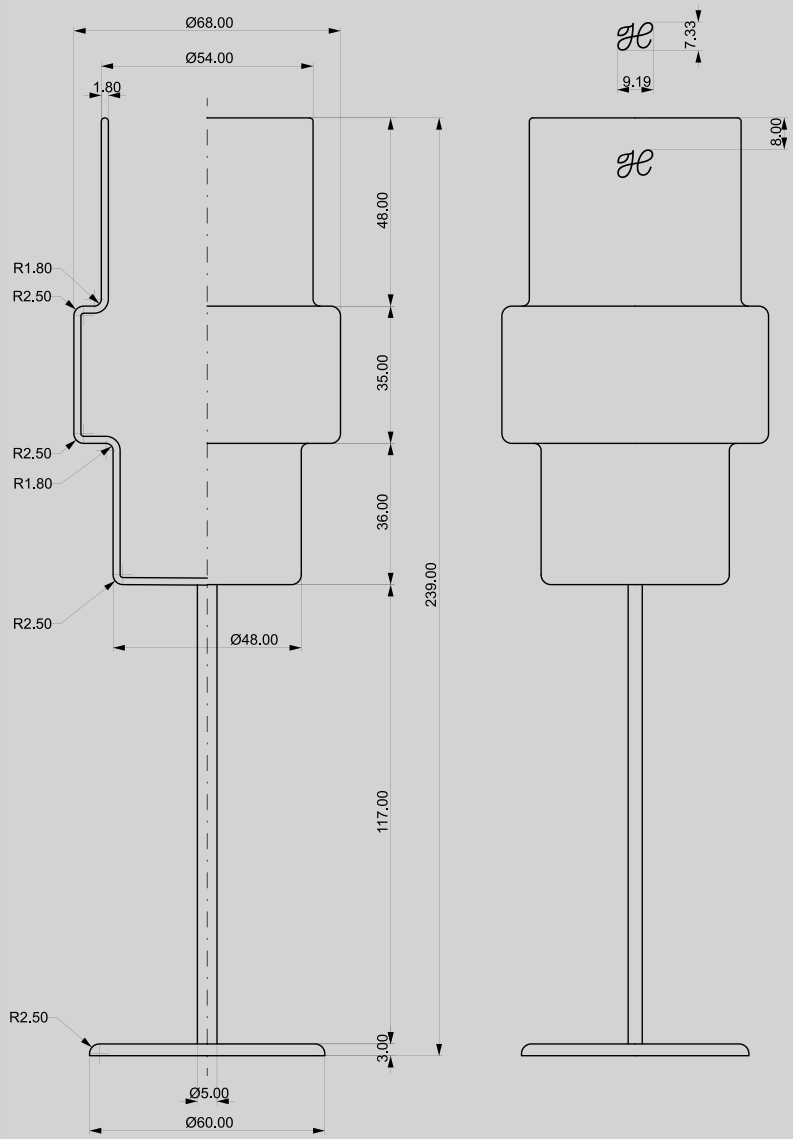
Martin Mjartan's creative work is centered around hands-on experimentation and sculptural work with metal. In 2018, Martin participated in the very first Young Ambassador program at Michelangelo Foundation's Homo Faber exhibition in Venice. Several of his works are permanently placed in public space, including the IMMORTAL TRUTH monument in memory of the murdered journalists Daphne Caruana Galizia and Ján Kuciak and his fiancee Martina Kušnírová.

Technical drawing of a drinking glass design for the Herbert Syrups brand by Martin Sombathy



Designing out Waste

Exploring applications of industrial waste by Martin Sombathy

Doctoral research:	Age- and environmentally friendly design
Realization:	2022 — ongoing
Researcher:	MID Martin Sombathy
Research supervisor:	Prof. Veronika Kotradyová, PhD.
Text:	Michala Lipková

Manual heat bending of SymaLITE® boards

Research by Martin Sombathy focuses on integrating industrial waste from specific local companies within serial production design. The project aims to impact the environment realistically rather than produce art design solitaires. The project explores the possibility of applying the principles of circular economy in local production, using the tools of product life cycle assessment to compare hypothetical design concepts and the existing product portfolio of local producers.

The first step in applying industrial waste in interior design is a case study of a modular display system used in the first DESIGN × SCIENCE exhibition project at Prague's Designblok '23. The system uses heat-bent spare SymaLITE® boards donated by local automotive suppliers as the main display surface, combined with custom 3D-printed PLA components and standard bolts and nuts inspired by joints used in construction scaffolding. Each part of the exhibition system is replaceable and fully demountable, allowing for future adaptation, reuse, or recycling.

In his recent research progress report, Sombathy outlines the current waste policy situation in Slovakia:

“Several laws and decrees legislatively support the Slovak Republic's waste management. Definitions of waste, its types, and disposal methods are dealt with by Act no. 79/2015 Coll. on waste and amendments to certain laws (White Book, p. 6). According to this law, waste is “a movable thing or a substance that its holder gets rid of, wants to get rid of or is obliged to get rid of in accordance with this law or special regulations” (§2, paragraph 1) and waste management is defined as “a set of activities aimed at preventing and limiting the generation of waste and reducing its danger to the environment and managing waste in accordance with this law” (§3, paragraph 1).” (Sombathy, 2024)

The most recent legal activities in Slovakia consider the obligation to ensure the sorted collection of textiles - a new category of sorted waste collection, which will bring new challenges and responsibilities for municipalities, as well as local manufacturers (Potočár, 2022). Only two companies are currently operating in the Slovak market in terms of recycling textile waste. One is the company SK-TEX, which was successfully approached as one of the partners in Sombathy's research project.

Sombathy considers the dissertation research to be the starting point of a long-term R&D project that combines elements of education with new approaches to designing and manufacturing products.

As Sombathy states in his progress report, the theoretical part and primary research carried out within the dissertation project are divided into two streams with related research questions:

- **Researching the influence of the input material choice on the product's environmental friendliness.**
  RESEARCH QUESTION #1: To what extent can a designer influence the effect of a product on the environment through creative selection and work with materials?
  RESEARCH QUESTION #2: To what extent can the choice of materials used in the product design process reduce its burden on the environment?
- **Surveying the level of knowledge about the environmental impact of products among design students and professionals involved in product development and production.**
  RESEARCH QUESTION #3: How knowledgeable are design students and design professionals about the impact of the products they design on the environment?

Sombathy defined the first steps and conditions of the practice-based research as follows:

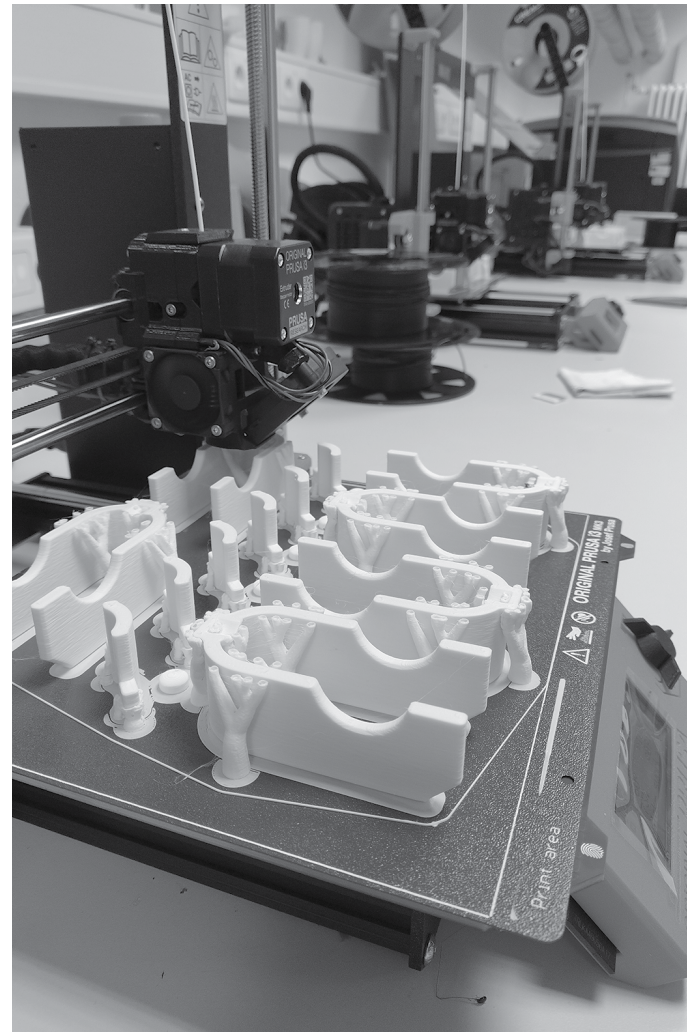
- **Establishing contacts with industrial producers in Slovakia,** looking for companies that generate large quantities of waste when creating their products. Focusing on materials that are no longer suitable for internal processing or recycling but still usable in another production method.
- **Obtaining samples of waste materials,** looking for possibilities of their use in a design case study, focused on testing different material processing possibilities and potential combinations with different materials.
- **Creating the first proposals for a specific use** involves designing a product made from waste material, prototyped in real size, and then subjecting it to a comparative LCA study.

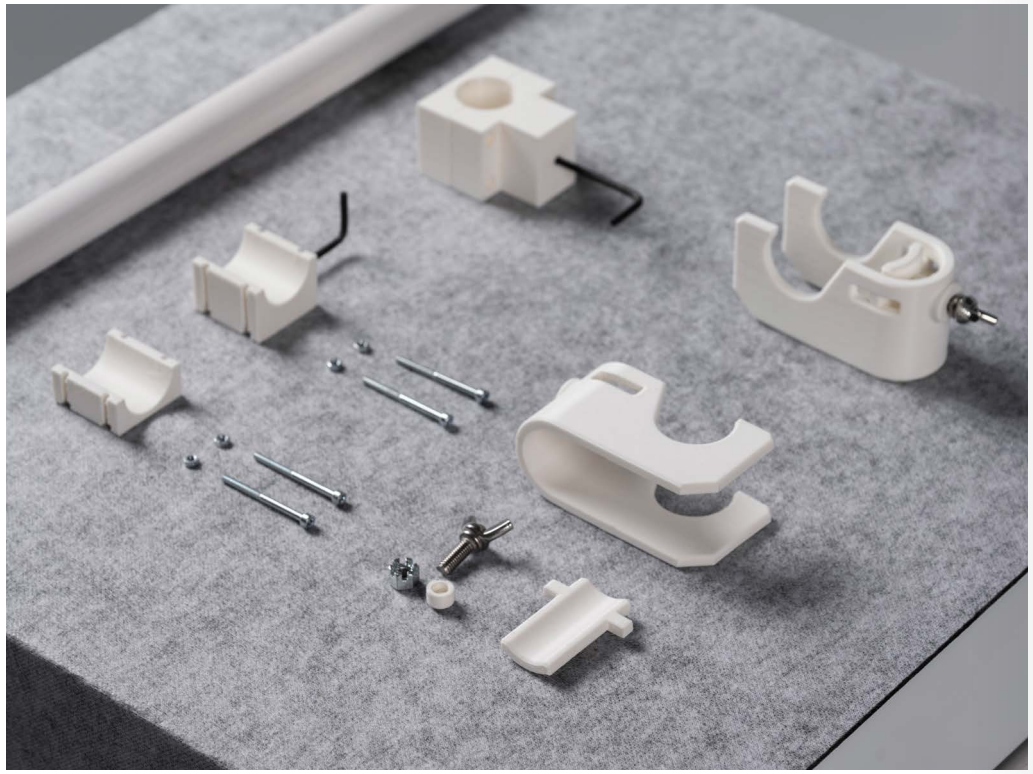
The starting point for designing is the existing material - industrial waste. In this project phase, two companies have already agreed to participate in the research: the previously mentioned company SK-TEX s.r.o. from Senica and Mitsubishi Chemical Advanced Materials Composites s.r.o. from Nitra. SK-TEX s.r.o. is a company systematically focused on processing textile waste and producing isolation materials formed by a mixture of textile fibers, which has been their main activity since 1998. On the other hand, Mitsubishi Chemical Advanced Materials Composites s.r.o. produces a specific material, SymaLITE®, used mainly in the automotive industry.

Most of the experimentation to date has been carried out with the SymaLITE® material, partly because the larger volume of its samples was obtained first. The first step in the process of applying industrial waste in interior design is a case study of a modular display system used in the first DESIGN × SCIENCE exhibition project at Prague’s Designblok ‘23 - the intention of the authors (Martin Som-

Top: 3D printing of joining components in STU Scientic Park at FAD STU

Bottom: Laser cutting of SymaLITE® boards
Next page: Details of modular display system DIY Scaffolding





“SymaLITE® is essentially designed as a material for circular production - scraps from the production of the material, as well as scraps from its processors, can be reused in the production of new plates, creating potential for the hypothetical 100% recyclability of the material.”

abathy and František Dorko) was to carry out a design exercise aimed at creating a functional prototype, with the priority of minimizing its impact on the environment.

Mitsubishi describes the material on its website as “low-weight reinforced thermoplastic (LWRT),” i.e., lightweight reinforced thermoplastic (Mitsubishi, 2023). The material is composed of a mixture of plastic and glass fibers that can be made into textiles or solid plates of different thicknesses or with different surface treatments. The properties of SymaLITE® include sound absorption, impact and weather resistance, oleo and hydrophobicity, and the ability to create spatially shaped components using low-pressure molding.

The production line located in Nitra produces SymaLITE® in the form of 3 mm thick plates. The main part of the plate consists of a mixture of 50% glass and 50% polypropylene fibers, on which either non-woven fabric or foil is laminated on the top and bottom sides, according to the specifications of the order from the customer. This iteration of the material was donated to the purpose of the proposed research.

SymaLITE® is essentially designed as a material for circular production - scraps from the production of the material and its processors can be reused in the production of new plates, creating the potential for the hypothetical 100% recyclability of the material. As Sombathy claims in his report, “during production from time to time a situation arises when plates leave the line that do not meet the strict tolerances required by the industry. In such a case, the plates can be ground up and used again, but from an environmental point of view it is definitely more appropriate to find a use for them.” (Sombathy, 2024)

Since SymaLITE® contains 50% glass fibers, from the point of view of the safety of the technologies available at STU's Science Park, laser cutting was the most suitable choice for dividing the material. At the same time, laser cutting technology enables the shape variability of the manufactured parts, and, above all, it is possible to modify the parts during their development quickly. At the same time, the design uses exclusively mechanical joining of material and shaped joints without additional materials.

Sombathy describes their formal inspiration and final design solution for the modular exhibition design system as follows:

“DESIGN x SCIENCE is presenting projects that are building blocks of solutions to com-

plex social problems. We, therefore, decided to display the objects on modular platforms inspired by construction scaffolding. The main structural element of the exhibition system is commonly available wooden (beech) rods with a diameter of 25 mm painted with a white water-soluble glaze. The rods are connected by a clamp custom-made on a 3d printer (FDM technology) from industrially compostable white PLA plastic. Tightening and loosening of the clamp are ensured by the wing screw and nut (M6). Individual projects are displayed on the shelves made from waste SymaLITE® donated by Mitsubishi. None of the design elements were glued. The entire exhibition system can be disassembled into individual material sources, and each part can be easily replaced in case of damage. Easy folding and disassembling of modular elements also save space when transporting the exhibition."

The next planned step in the dissertation is to continue experimentation with the materials obtained in cooperation with local furniture manufacturers. The cooperation's goal should be to find a suitable application for the mentioned materials and to compare the environmental impact of a product made from primary raw materials with a waste-using product.

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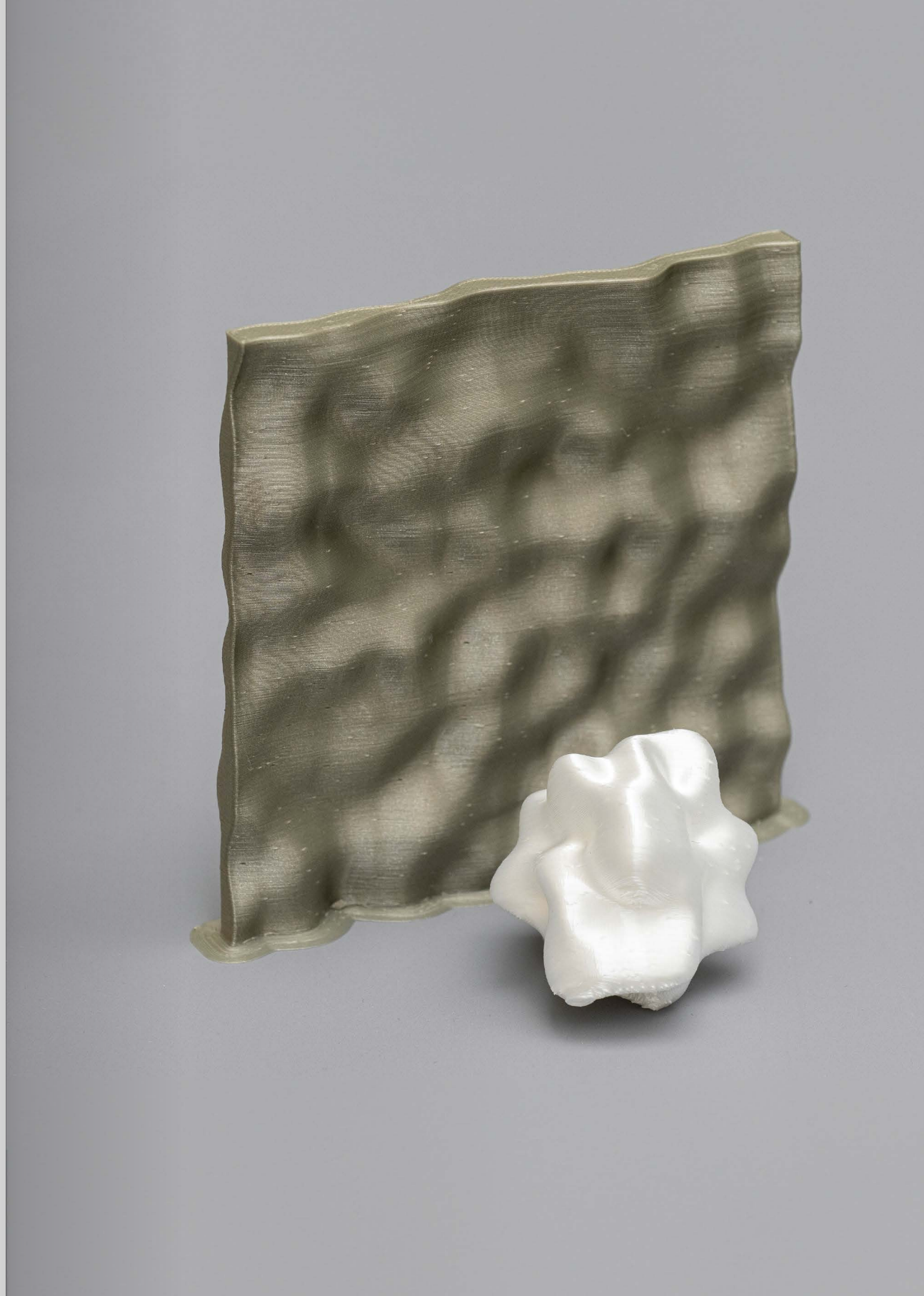
Modular display system
DIY Scaffolding

Phygital Materiality

Sense-driven CMF design and experimental material library by Lucia Suchá

Doctoral research:	Innovative approaches to CMF design in automotive industry
Realization:	2022 — ongoing
Researcher:	Mgr. art. Lucia Suchá
Research supervisor:	Assoc. Prof. Michala Lipková, ArtD.
Text:	Michala Lipková



The doctoral research aims to investigate the possibilities of integrating design and multidisciplinary research in designing materials, surfaces, and color solutions (CMF design). The presented material study aims to test the different perceptions of materials, their surface structures, and color variants when changing the environment and sensory perceptions. In the real world, we experience the materiality of objects through multiple senses, which are additionally influenced by our sensory memory. How does this change in the technically augmented forms of reality?

The contribution to the exhibition is a collection of material samples whose shape was differentiated by (1) parameters used in the 3D modeling software, (2) different 3D printing settings, and (3) the selection of the material. Combining all three aspects affects the final sensory properties of each sample. How do the nuances of the seemingly organic shape, shaped and materialized by digital technology, influence one's perception of the bipolar 'natural to artificial' scale?

In Designing Design, Kenya Hara argues that technology "has no point unless it subtly awakens and activates the senses of the recipient." Describing the current mainstream design as one 'deteriorating human senses,' Hara calls for a 'sense-driven' world:

"Some are of the opinion that we gain far more than we lose. It's true that newly invented technology and media have immense possibilities for cultivating wisdom and our senses. Anything that matures changes shape. Human beings and cultures both mature and metamorphose. But our desire is to metamorphose into better things. Sense-driven describes a situation in which progress pivots on our sensory perceptions. Let's pit this concept against that of the technology-driven world. Reviewing the world based on our senses would be sound and meaningful for the technology as well." (Hara, 2007, pp 144-146)

Color, Materials, Finish (CMF) is an area of industrial design that focuses on the chromatic, tactile and decorative identity of products and environments (Becerra, 2016, p.12). Very often, the focus on the form and function of a product results in overlooking the color solution and surface treatment as part of the holistic design solution. In industrial design, sensory features, unfortunately, tend to be neglected as a secondary nuance. At the same time, we can argue that products that work with a stronger perception of materials and active involvement of the senses can help improve products for people with disabilities or even the aging population.

Today, many new or reinvented sustainable materials are gaining attention across industries. Therefore, the sensory aspects of selected materials become crucial in relation to available technologies. Current trends can help break out of the conventional way of designing, add value to a product, and improve its usability and sensory experience overall.

The dissertation research of Lucia Suchá takes place in a period of accelerating increase in consumption on the one hand and in a time of rapid development of new materials on the other. Increased production means more waste and dwindling material resources. Not only within the framework of the circular economy, there is a need and growing demand for materials created through the process of recycling or upcycling as composites or completely new types of material based on waste. Nevertheless, the choice and implementation of emerging materials in industrial design are still insufficient. While virgin materials and natural resources are still available, the use of recycled or alternatively sourced materials is not yet a commonly preferred option.

In her ongoing research, Lucia Suchá has identified the following underlying reasons behind the above-described problems, which her project is aiming to address:

- **Problematic access to material samples:** Reading about many emerging materials and seeing their photos is possible, but deciding on material application by purely visual perception is highly risky. Testing and viewing a physical sample or high-quality material simulation in VR or AR applications is the crucial step to accelerating the use of emerging materials in common product design applications.

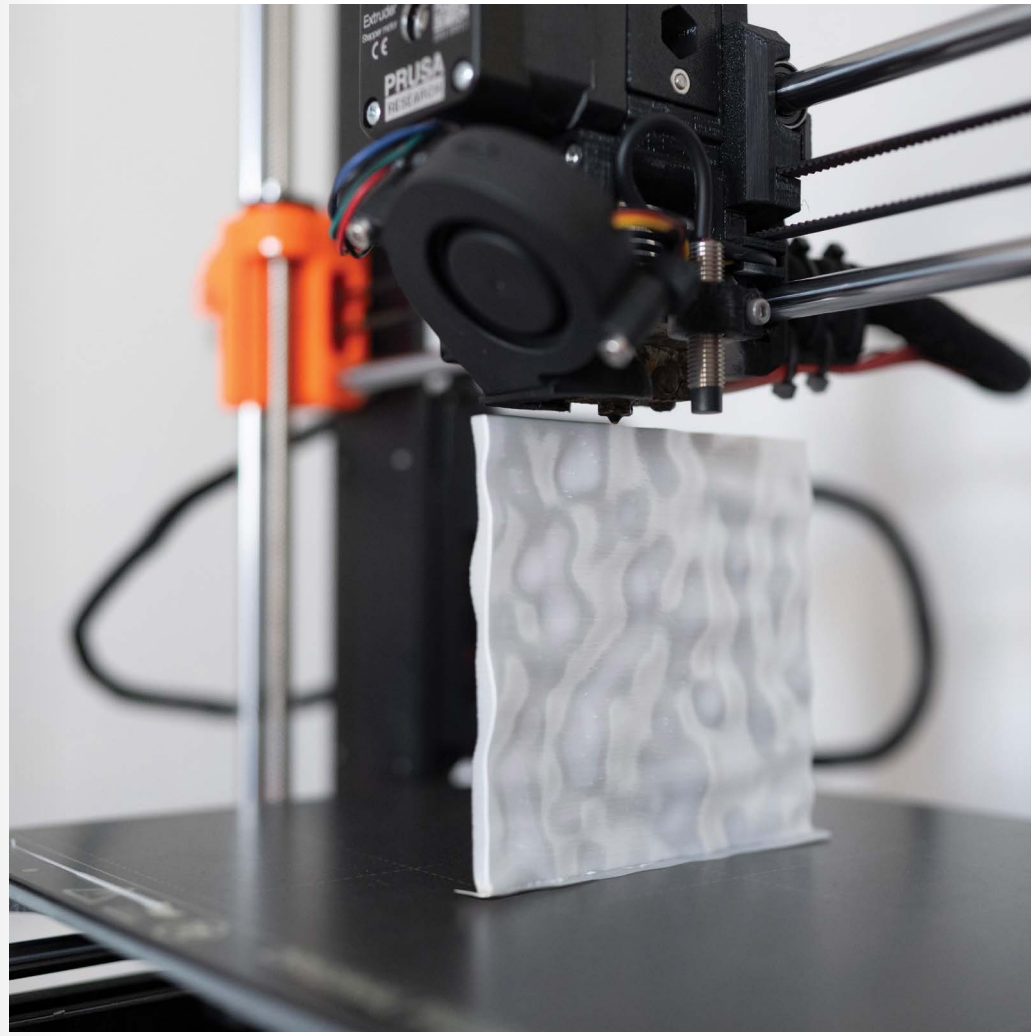
- **The material experience gap:** Since emerging materials are not yet widely used, first-hand experience with them in daily products is rare. The lack of knowledge about the performance, sensoric features, possible applications, and manufacturing limits maintains the experience gap that prevents applying them in one's design.

Working with emerging materials opens questions about their acceptance by the users. In her work-in-progress research notes, Suchá asks:

"How can we predict user perception of a CMF design solution, the form of which was created in a digital environment and which was subsequently implemented in material with which he or she has no previous experience?"

Based on the two earlier defined problems, Suchá's doctoral research sets the following qualitative goals:

- **Establish connections between specialized workplaces.** Through the process of creation of innovative material samples, the goal of the research is to connect experts within (or beyond) Slovak University of Technology and establish a working network of researchers who would kickstart long-term cooperation and boost interdisciplinary projects in the field of circular design and material development for industrial applications (material science and R&D, prototyping and production technologies, etc.).



Top: FDM 3D printing of material samples

Next page: Virtual models of material samples in Cinema 4D (top) and physical 3D printed results (bottom)

“How can we predict user perception of a CMF design solution, the form of which was created in a digital environment and which was subsequently implemented in material with which he or she has no previous experience?”

- **Set the foundation for an experimental material library.** The dissertation research is carried out at the recently established scientific and research workplace MX lab, which specializes in cooperation with partners from the automotive industry. The workplace has the ambition (and the need) to build its database of material experiments created within the framework of pre-development projects implemented with the involvement of bachelor and master students. Therefore, one of the goals of Suchá’s research is to suggest a possible classification and form of documentation and display of experimental material samples as a part of the practical part of her thesis.

Besides the mentioned qualitative contribution, the doctoral research plans to deliver tangible outputs, listed below:

- **A phygital collection of innovative material samples.** The collection aims to outline a new approach to designing in CMF design. The collection should contribute to popularizing unconventional or emerging materials within the educational process and beyond the academic environment.

- **Transfer of the collected know-how to a virtual environment.** Another goal of the dissertation research project is to transfer the gained knowledge to the digital realm, making the experimental material designs accessible on a large scale and allowing them to be used in immersive applications (AR/VR industrial design simulations) as high-quality digital material assets.

- **Documentation and retrospective analysis** of the design process will form the focus of the theoretical part of the dissertation, and it will aim to contribute innovative findings to the current state of knowledge in CMF design.

The very first collection of experimental material samples, presented as a contribution to the DESIGN × SCIENCE exhibition at BASE Milano 2024, is a collection of material samples, fully designed and materialized through digital technologies. The shape of each sample was differentiated by (1) numerical parameters used in the 3D modeling software, (2) different 3D printing settings on an additive FDM 3D printer and (3) by the selection of the material.

The objects were printed with PLA 1.75mm filaments by Polish manufacturer Spectrum (distributed under the name “Pearl White”) and recycled Prusament by Czech manufacturer Prusa (distributed under the name “Pearl Mouse”). The two PLA filaments were deliberately chosen for their contrasting vi-

sual characteristics - the "Pearl White" filament claims a silk-like, satin structure effect. On the opposite side, "Pearl Mouse" claims "neutral color," "warm grey with a goldish/greenish hint," analogous to RAL 210-M or #a5a99b HEX color code.

Each change in settings, material, and color creates a material sample of other properties. The combination of parameters affects the final sensory properties of each sample. The samples explore connections between manufacturing technology and different types of materials to achieve unexpected effects. Through experiments with digital sculpting, material parameters, and simulations in Cinema 4D software, Suchá explores possibilities of digital material sculpting with different intensities and scales. The color perception of each sample is influenced by the intensity of structure and chosen material, while the surface finish is affected by the 3D printing technology settings.

The presented samples open discussion on how the nuances of the seemingly organic shape, shaped and materialized by digital technology, influence one's perception on the bipolar 'natural to artificial' scale.

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Lucia Suchá graduated in Product Design from the FAD STU Bratislava. During her studies, she interned at the crafting plastics! studio and brand Metaformi. She completed an exchange stay in the Integrated Product Design program at Coburg University in Germany. She is a certified instructor of traditional Slovak Bobbin Lace-Making. In 2020, Lucia was selected for the Michelangelo Foundation's Young Ambassadors Programme.

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