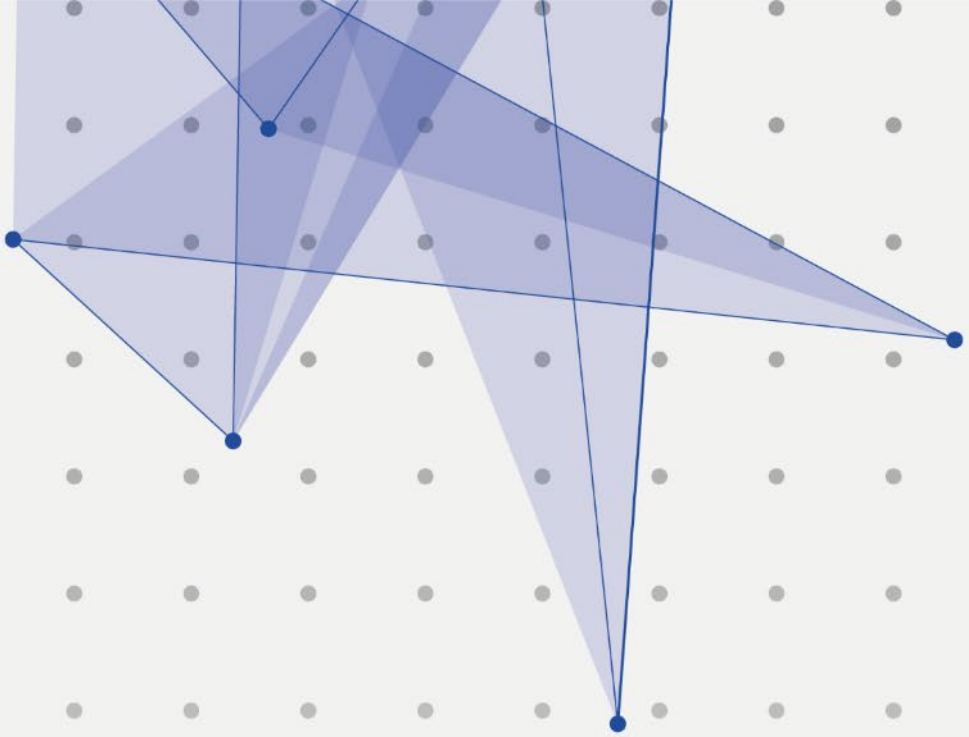


# Eksig 2023

"**From Abstractness to Concreteness** – experiential knowledge and the role of prototypes in design research"

# Proceedings

MILANO

19.06 — 20.06

2023 eksig
DRS special interest group on experiential knowledge

Design Research Society DRS

POLITECNICO MILANO 1863
DIPARTIMENTO DI DESIGN

# International Conference 2023 of the Design Research Society Special Interest Group on Experiential Knowledge (EKSIG)

## Conference Proceedings

## From Abstractness to Concreteness – experiential knowledge and the role of prototypes in design research

19-20 June 2023
Department of Design, Politecnico di Milano, Italy

Editors: Silvia Ferraris, Valentina Rognoli, Nithikul Nimkulrat

Published 2023 by
Politecnico di MIlano
ISBN: 9788894167436



eksig 2023 DRS special interest group on experiential knowledge

Design Research Society DRS

POLITECNICO MILANO 1863 DIPARTIMENTO DI DESIGN

# Table of Content

# Conference theme

Prototype and prototyping play a key role in experiential knowledge since they support the interconnections and collaboration among researchers and practitioners in many design fields. The role of prototypes in design research is characterised mainly by the general function of representing ideas and giving intelligible form to undetermined and abstract concepts pertaining to design solutions. Such a principle of transition from vagueness to clarity illustrates views on the role of prototypes which dot the diverse landscape of design research. Indeed, the evolution of design research in the past twenty years has led the path to a wide range of new possible prototypes applications.

Originally, in the industrial context, prototypes were made to test, evaluate, and improve the product until the final design and production phase. When design became an academic discipline, the scope of its enquiry expanded, embracing new areas of interest (i.e., sustainable design, materials design, participatory design, service design, user experience design, etc.), and their methodologies and scopes. During this evolution, the role that prototypes play in design research started to be questioned.

Indeed, nowadays, the role of the prototype encompasses several possibilities that link to the context and aim of the design research. When a general aim of the investigation is to develop a new design solution and make it *real* and available to users at the end of the process, prototypes support the transition from the idea to the final product. In this realm, prototypes play a crucial role, as they visualise, validate, experiment, and create such new solutions. Interestingly, prototypes for this kind of design research can be simple paper models that anticipate interactions up to complete *working* prototypes that are very close to the final product. In the digital field, provisional solutions are released on the market and updated afterwards. Prototypes, in this case, merge with the *final* products. New boundaries are broken between a final design and what is not.

Furthermore, the products that designers call to envision are becoming more and more complex. They are equipped with sensors, processors, and connected devices that support the interaction with digital interfaces, applications, and complex services. Hence, prototypes are meant to support design processes that rely on the supplementation of new kinds of expertise – such as user experience design, interaction design, material design and computer science – besides those traditionally integrated – such as product design, mechanical and electronic engineering). In this regard, the prototype embodies the translation of different design languages into a developing concept.  Moreover, design research that explores and discusses possibilities might go beyond the development of concrete

solutions and tackle significant issues (i.e., the impact of technology on society; climate change, social innovation) to reach new understating and develop new knowledge. This kind of design research usually occurs in academia and requires exploratory and speculative studies. Some of this design research is about tangible objects or is based on material experimentations. Typically, prototypes play an important role in the first explorative phases, in this realm since they enable the transition *from abstract to concrete* through immediate and factual experience. Designers research by envisioning solutions, imagining possible futures, exploring new fields, and feeding the design discourse with emerging contemporary issues and fictional scenarios.

Overall, the multifaceted landscape of today's design research opens to a wide range of meanings that define what a prototype is and does. The discussion on prototypes' identity is open. Instead of seeking to find an ultimate definition of prototype and its role in today's design research, the conference aims at eliciting a conversation around the current and multiform panorama of experimentations around and with prototypes.

The call for paper encourages contributions with the following:

- What are the new roles of prototypes in these evolutionary pathways in design research?
- How do new sophisticated, integrated, and advanced prototypes support research in various areas of design?
- How do different research contexts (practice, R&D, and academia) collaborate in design research due to the making and use of prototypes?
- How do prototypes enable the creation of theoretical knowledge and support speculative research?
- How do prototypes enable the creation of practical knowledge and support empirical research?
- How do prototypes enable the exploration of new research fields?

# Organisation

## Programme Committee

Silvia D. Ferraris, Politecnico di Milano, Italy

Valentina Rognoli, Politecnico di Milano, Italy

Nithikul Nimkulrat, OCAD University, Canada

Camilla Groth, University of South-Eastern Norway

## Scientific Committee

Camilla Groth, University of South-Eastern, Norway

Carla Langella, University of Naples Federico II, Italy

Eujin Pei, Brunel University London, United Kindom

Louise Valentine, The Design Journal, United Kindom

Lucia Rampino, Politecnico di Milano, Italy

Manuela Celi, Politecnico di Milano, Italy

Nithikul Nimkulrat, OCAD University, Canada

Owain Pedgley, METU, Turkey

Silvia D. Ferraris, Politecnico di Milano, Italy

Valentina Rognoli, Politecnico di Milano, Italy

Venere Ferraro, Politecnico di Milano, Italy

Martínez Torán Manuel, Universitat Politècnica de València, Spain

Youn-kyung Lim, KAIST, Republic of Korea

Jouke Verlinden, University of Antwerp, Belgium

## Organising Committee

Francesca Mattioli, Politecnico di Milano, Italy

Caterina Dastoli, Politecnico di Milano, Italy

Sofia Soledad Duarte Poblete, Politecnico di Milano, Italy

Alessia Romani, Politecnico di Milano, Italy

Francesco Leoni, Politecnico di Milano, Italy

# Keynotes

## Prototypes: Footholds to the future and footsteps from the future?

Pieter Jan Stappers – TU Delft, Netherlands

Prototyping is a core activity of design, and a large part of the contribution that design actions can make to the quest for new knowledge. In that quest it provides tangible points where the abstract (theory) meets the concrete ('real' world) on which we can base future steps: footholds. On the other sides prototypes may realize concrete experiences with as yet inexistent situations: they allow us to observe and collect data from a phenomenon that before the prototype was only speculation: footsteps.

As a part of industrial production, the term prototype has been around for about a century, in design research it has become prominent in the discourse for a few decades. And the term has functions in other disciplines too, as in psychology and philosophy.

There are several areas worth addressing:

- We should take care of both the noun prototype and the verb prototyping. They are not the same, even though in academic shorthand they are used interchangeably in sentences.
- How does prototyping relate to the core competencies of doing design: what is 'design' about them?
- Engineering, psychology, and industrial practice use the term differently? Can those differences inspire us to better understand what we are doing ourselves?
- How do we prototype the larger intangible outcomes of design, when design is addressing services, and global issues as sustainability, and the 'artefact in the museum' tells less about either the knowledge that it carries or the impact it may foretell.

*Pieter Jan Stappers* is professor of Design Techniques at Delft University, Faculty of Industrial Design Engineering. His research and teaching focus on the connections between research and design, such as techniques for user participation (codesign and context mapping), and the role of doing design as a part of doing research (research through design). Key terms include perception, creativity, visualization, empathy, systems thinking, and prototyping.

# Prototyping In Practice: for Research and Beyond

Kathryn Marinaro – Argodesign, Creative Director

Prototypes are useful beyond usability testing; they're a strategic tool to drive alignment, to communicate value and vision, and to get digital products built correctly in a more efficient manner. They help teams move quickly by making instead of swirling in ideas. Through her work at IBM and currently as a Creative Director at the digital product design agency, argodesign, Kathryn Marinaro has found that the best practical uses for prototypes are for qualitative and strategic purposes.

In this keynote, Kathryn will share her experience creating and utilizing prototypes to generate ideas with subject matter experts, to understand resonance and value with end-users, to explore new interaction models for emerging technology, and to communicate visions to stakeholders who control the direction of a product. She'll share examples of prototypes used throughout the process of the programs she leads and their outcomes and impact. Prototypes aren't just for testing, they're for delivering value.

Kathryn Marinaro is an award-winning Creative Director who envisions the future and develops products and strategies for a wide variety of clients at argodesign. She is the author of Prototyping for Designers, published by O'Reilly, and has employed user-centered methodologies to create and iterate on impactful experiences in health wearables, AI interaction patterns, AI image recognition and training interfaces, and cloud development tools, while working on world-class design teams like IBM Watson Visioneering and IBM Mobile Innovation Lab. She has gained recognition as one of Austin's Top 50 Female UX Designers and as part of the Advisory Board for the inaugural Austin Design Week. She's been featured in articles in Fast Company, Time Out New York, Architect Magazine, ArtInfo, Make Magazine, and the Visual Arts Journal.

# Advanced materials promoting sustainable practices

Aldo Sollazzo – Noumena, Founder and CEO

In this keynote address, Aldo Sollazzo, CEO of Pure.Tech, will delve into the crucial role of advanced materials in combating climate change and their potential to revolutionize various industries. The lecture will explore how Pure.Tech's innovative materials offer a novel concept of ecology, enabling sustainable solutions across sectors such as construction, fashion, packaging, and more. Sollazzo will discuss the urgent need to address climate change and highlight the impact of greenhouse gas emissions on our environment. He will showcase how advanced materials developed by Pure.Tech can effectively mitigate these challenges by reducing carbon footprints, improving air quality, and promoting sustainable practices. Notably, Sollazzo will highlight that implementation of the Pure.Tech in several projects world wide. These include the Spanish Pavilion 'Intelligent Forest' at Dubai Expo 2020, the world's first 3D printed retail store for sneakers by 'Presented by' in Dubai and Riyadh, BAFTA theater in London, and as well Pure.Ceiling a module false ceiling system for the interiors of commercial offices and retails spaces. Currently, Pure.Tech is also collaborating with several fashion brands across the world, actively developing various applications for the textile and fashion industry to promote sustainability and reduce environmental impact.

Aldo Sollazzo is an Italian entrepreneur and innovator, expert in robotics, computer vision, and computational design. He is the CEO of Noumena since 2011, a data-driven company implementing computer vision and machine learning to study and analyze spatial dynamics. As part of the Noumena Group, he is also the director of Reshape, a platform focused on the industrial application of material-driven sustainable technologies, and of LAMÁQUINA, a large-scale 3D printing factory, shaping new architectural solutions integrating advanced manufacturing and computation. At the Institute for Advanced Architecture of Catalunya in Barcelona, he is the Director of the Master in Robotics and Advanced Construction. In 2019 Aldo received, from the Italian President of the Republic, the title of Knight of the Order of the Star of Italy for the promotion of national prestige abroad as a recognition of his scientific and technological activities. Aldo has made many appearances as a guest speaker at Conferences and University Seminars, amongst them European Conference on Computer Vision, Barcelona Urban Tech, Future City Summit, The Venice Biennale and TEDx Barcelona.

# Paper index

## Hiperlinks to full papers

### Track 1 Interaction, Data and AI / 1



### Track 2 Service Design and Policymaking

## Track 3 Research processes and methods / 1

The Phenomenon of Low-Fidelity Prototyping – An Overview Across Design Practices Making Deliberately Simpler Models
Brändle, Rolf; Schuster, Paula L.

Cultivating and Eliciting Felt Experiences for Design Use: Physical Manifestations of Abstract Bodily Experiences
Demir, Arife Dila; Oktay, Nesli Hazal; Kuusk, Kristi

Creating translational knowledge: the role of visual communication design and prototyping methods in the research process
Hall, Cathryn Anneka; Knight, Laura H; Kapsali, Veronika

Prototyping an employee experience model. A participatory action research project to support organizations in redefining the working routines starting from Employee Experience Design
Melazzini, Michele; Colombo, Federica; Carella, Gianluca

## Track 4 Sustainable and Biological solutions

A Preliminary Investigation into Prototyping for Low Techs
Coulentianos, Marianna Joy

Designers prototyping in the lab: Introducing an extracurricular activity exploring bacterial colouring in a design educational setting
Hartvigsen, Monica Louise Gjøderum; Otersen, Shanice; Hasling, Karen Marie

Designing Fungal Kinship: From Material to Co-Creator Through Speculative Prototyping
Schacht, Ana; Kinch, Sofie

Designing matter across scales with microorganisms: The MMMM (Micro-Mezzo-Macro-Meta) approach
Sicher, Emma; Seçil, Uğur Yavuz; Nitzan, Cohen

Designing Sustainable and Affordable Smart Home Solutions: The Role of Prototyping
Spadoni, Elena; Carulli, Marina; Barone, Chiara; Bordegoni, Monica

## Track 5 Materials and Crafts

How ecodesign requirements fuel the design process for yarn production and what challenges must be overcome from a spinning perspective
Egloff, Brigitt Antonia

Prototyping a novel visual computation framework for craft-led textile design
Orynek, Sylwia; Thomas, Briony; McKay, Alison

Materials Libraries: designing the experiential knowledge transfer through prototyping
Romani, Alessia; Rognoli, Valentina; Levi, Marinella

New Textile Transmissions: Reviving traditional textile crafts through replication, unlearning and prototyping
Wang, Yuxi Leona; Cleveland, Donna; Joseph, Frances

Shimmering Wood – Design "Thinging" in Material Development Process
Yau, Noora; Klockras, Konrad; Niinimäki, Kirsi

## Track 6 Society and Health

Prototyping assistive devices in india using hybrid manufacturing: a case study on developing ankle foot orthosis (afo) for motor neuron disease (mnd)/ amyotrophic lateral sclerosis (als)
Bohre, Yash; Joshi, Purba; Page, Rowan

Prototypes as a Structured Information Source in Theory Nexus
Dezso, Renata

Uncovering Tacit Needs through Prototyping: Designing Post-Harvest Storage Solutions for Marginal Farmers in India
Sharma, Agnivesh; Sharma, Nishant

A virtual reality experiential prototyping tool for the application of anthropometry in complex, confined human environments
Schumacher, Peter Collin; Fraysse, Francois; Matthews, Brandon; Modra, Simon; Smith, Ross; Thewlis, Dominic; Langridge, Geoff; Beven, Jack

## Track 7 Materials and Digital

Exploring 3D Printing Strategies for Designers to Reach Circularity
Bolzan, Patrizia; Xu, Lexing

Adaptive Materials and The Role of Design[ers] (Research[ers]) in Shaping Transformative Futures
Fonseca Braga, Mariana; Blaney, Adam; Ozkan, Dilan; Pelit, Emel; John, John

Constructing e-textile prototypes to inspire improvised behaviour
Hernandez, Lucie

Feeling Fabrics: Prototyping Sensory Experiencees with Textiles and Digital Materials
Meiklejohn, Elizabeth; Devlin, Felicita; Silverman, Caroline; Ko, Joy

Beyond Boundaries: 3D Printing and Functional Materials as Boundary Objects to Mediate Interdisciplinary Collaboration
Swann, Levi; McKinnon, Heather; Boase, Nathan R. B.; Mirzaei, Mehrnoosh; Wiedbrauk, Sandra; Wigman, Samantha

## Track 8 Education processes and methods

To Prototype to Learn Fronting Uncertainties. A Pedagogy Based on Anti-Disciplinarity, Thinkering and Speculation
Guida, Francesco E.

Prototypes, translation and research in social design education
Mattozzi, Alvise; Ventura, Jonathan

Prototyping of theories
Schaldemose, Sisse

Role of Physical mock-ups in the Ideation phase: a thematic analysis of the Pedagogic approach
T N, Subramanya; B K, Chakravarthy; Joshi, Purba; Singh, Akanksha

From Prototype1.0 to Prototype3.0: Situated learning in Prototype design for Chinese labour education
Yang, Linlin; Zhang, Shangjie; Meng, Danqing; Lu, Ziwen; Fan, Fei

## Track 9 Research processes and methods / 2

Origins of design choices: retrospective analysis of the resulting prototype of a Research through Design project
Mertens, Audrey; Yönder, Çiğdem; Hamarat, Yaprak; Elsen, Catherine

What is Your (Freaking) Problem? Prototypes for problem exploration on early stages of design
Ruiz, Juan; Wever, Renee

Process as prototype: exploring complex knowledge exchange in the production of low-cost buoyancy aids in Zanzibar through the participatory design of a 'workflow system'
Shercliff, Emma; Devall, Lucy; Conrad, Franziska

The prototype-evaluation choreography
van Zeeland, Eveline

## Track 10 Mobility and Transportation

The social role of a motorcycle prototype in fostering collaboration in a self-guided team of students
Amadeo, Azul; Mattioli, Francesca

Proto-flighting in the wild: a creative technologist approach to drone prototyping
Cleveland, Peter; Joseph, Frances

DIY Bus: Exploring Boundary Objects in Participatory Design Research
Dhaundiyal, Dhriti; Sharma, Nishant

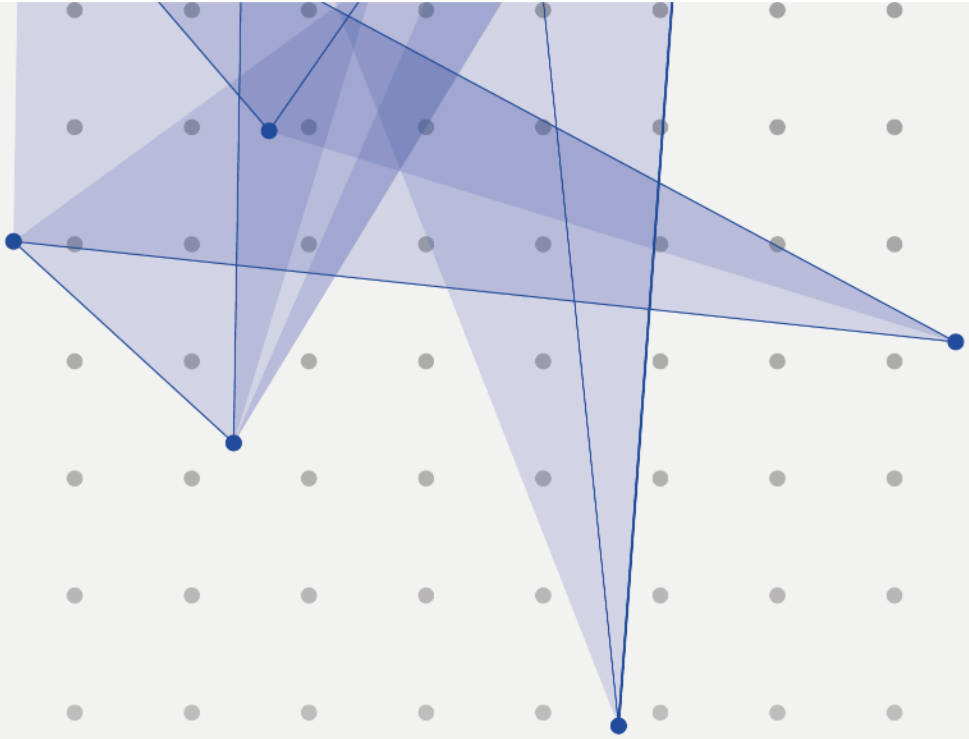
Using machine learning as a material to generate and refine aircraft design prototypes
Tan, Linus; Luke, Thom; Di Pietro, Adriano; Kocsis, Anita

## Track 11 Interaction, Data and AI / 2

The eloquent void: strangeness in data physicalization about loneliness
Guedes Mesquita, Rebeca; Thoring, Katja
The Artificial lyricist: Prototyping an Interactive Opera for Humans and Machines
Mattias Rylander, Hedvig Jalhed, Kristoffer Åberg
Graft-games: Experiential prototyping for the exploration of crossovers between craft and gaming
Potter, Gemma May
Idiotic Agents: Exploring more open-ended and creative interactions between humans and Intelligent Personal Assistants in the home
Tsilogianni, Maria

## Track 12 Fiction & Speculative design

Crafting e-waste through speculative narratives to raise material awareness
Burzio, Giorgia; Ferraro, Venere
Think with your hands: Exploring the Future via Prototyping
Gumus Ciftci, Hazal; Plymire, Konnor
Prototyping Dialogues
Ravnløkke, Louise; Binder, Thomas
Design Fiction Prototyping to tackle Societal Challenges And support Design for Sustainable Behaviours
Stepanovic, Mila
Materialization of the Future: The Demarcation Line between Prototypes and Demonstrators
Sviridova, Aleksandra; Verlinden, Jouke Casper



# Track 12: Fiction & Speculative design

- Crafting e-waste through speculative narratives to raise material awareness

- Think with your hands: Exploring the Future via Prototyping

- Prototyping Dialogues

- Design Fiction Prototyping to tackle Societal Challenges and support Design for Sustainable

- Materialization of the Future: The Demarcation Line between Prototypes and Demonstrators

# Crafting e-waste through speculative narratives to raise material awareness

**Giorgia Burzio,** Politecnico di Milano
**Venere Ferraro,** Politecnico di Milano

## Abstract

This paper presents a research project showing how the intangibility of the technology embedded in electronic devices can be made visible and tangible through hands-on experimentation and participatory approaches, converging in stages of multimedia prototyping.
The case study leverages research-through-design approach, intended as the crafting of the possible scenarios describing the social and environmental consequences of technologies. The crafting activity follows the process of “thinking through making”, defined as the generation of knowledge by the manipulation of matter.
By manipulating and disassembling electronic devices through a craft-oriented approach, the materials embodied in those objects become alive and active, with an agency of their own. Indeed, the paper claims that despite the “cloud” and “air” narrative with which electronic devices are described, they ultimately are geological objects that embody various materials, minerals, and processes. Do-It-Yourself, disassembling, experimenting with materials from waste are the main performed actions, through which the project aims to persuade and positively mobilize the audience towards responsible behaviours regarding the topics of e-waste and consumption. The project unfolds in key prototyping actions such as: (i) two workshops with 8 participants, aimed at exploring forms and material qualities of the Lithium-ion battery contained in most electronic devices; (ii) secondly, a disassembling activity of the metals contained inside a MacBook Pro, where the matter is manipulated through melting and casting of the recovered metals;(iii) visiting a recycling center in Kista (district in the Stockholm municipality) and recovering the metals from waste in order to build a low-tech series of batteries for experimentation. Ultimately, the project is presented in an exhibition context where different prototypes co-exist in the space, including an evocative film that mixes 3D animations, maps, and studio footage to support the narrative and spark conversations amongst the public.

Thinking-through-making; e-waste; DIY; electronic devices; materials.

Electronic devices are the fastest-growing waste group. A UN report from 2019 outlines the current state of things regarding recycling practices and future trends: only 20% of e-waste is correctly recycled, with 80% of products ending up in landfills or being illegally exported to other countries as second-hand (PACE & World Economic Forum, 2019). This amount of waste generates environmental and social harms, and it could be avoided through a total circular approach to their lifecycle, better eco-design strategies such as design for components and design for disassembly, and ultimately through a more responsible behaviour from people (Barbero & Cozzo, 2009). Nonetheless, research shows that people want to feel more empowered when they buy, use, and dispose of a consumer product, to a point where the notion of consumer in some cases might be replaced to the one more engaged of prosumers (Kotler, 2010). Bottom-up strategies and social enterprises such as “The Restart Project” (started 2013, UK) and “The Low-Tech Lab” (started 2010, Bangladesh), which aim at sharing knowledge and insights on how to sustainably reshape

our relationship with electronics, are getting more and more diffused. Others such as “HOP (Stop Planned Obsolescence - started 2017, France) are working towards more conscious EU strategies to obstruct planned obsolescence in consumer products, by improving product repairability and extending the product durability. Thus, people are open to change their behaviours and emotionally connect with climate issues, collaboratively imagining hopeful futures.

A renewed interest from scholars towards the role of materiality and the agency of materials could be explored within the artistic practice to emotionally connect with matter and potentially foster the above-mentioned behavioural changes in people (Jørgensen et all., 2018). According to the theoretical framework of *vital materialism* (Bennett, 2010), materials have a vibrancy of their own thus, are not to be considered dull matter but actual forces that shape the environment around them and that have trajectories of their own. Over the years, humans have been neglecting the vitality of matter and that prevented us from detecting a fuller range of non-human powers circulating amongst us, such as the way our waste is not only away in landfills but actively contaminating air, water and soil as we speak (Bennett, 2010). Seeing the materials as actants (Latour, 1992), something alive that the creator must compromise with in the making of something, could open up new wonderful understandings and drive artists, designers, creators, scientists and anyone that engages with matter. Making-with becomes thus a political act, a form of craft plus activism that sees in the compromise between the creator and the material a way to develop intuitive knowledge challenging emotive, political, social and economic values (ed. Black & Burisch, 2021) and not only an understanding of material qualities as something to exploit. Defined as “material tinkering”, this process can be described as the intuitive knowledge gained through an experiential learning through and with the material and it concurs to many possibilities in the development of research in material-oriented practices and multidisciplinary research (Mader & Dertien, 2016).

Moreover, different perspectives have been taken regarding the role of prototype within design research. Traditionally, in the design practice a prototype is defined as “first example” (from the Greek prōtotupos); by this definition, anything that takes an idea out of our head and makes it visible to others may be considered a prototype.

Recently, scholars have questioned the role assumed by the prototype in *Research through Design* as a tool to provoke, imagine, validate research hypotheses and reflect on the present and the future (Zimmerman et all 2010; Johnson, B 2011; Dunne, A., and Raby, F. 2013; Blythe 2014 ; Kymäläinen 2015 ).

Based on this ground, a prototype is more than a tool to manifest, communicate, or test an idea. It can envision possible futures to be investigated through designing, no matter how the prototype is, a physical object, a video scenario, a series of narratives, etc.

Following on the above-mentioned premises, authors posed the following research questions: (i) how do prototypes and manipulation of matter contribute to the crafting of the message that aims to persuade the audience about the issue? (ii) And how do prototypes of different natures come and act together to support the scenario that sparks interest and conversations amongst the public?

To this end, the paper aims to test how processes of thinking-through-making and craft can fulfil two main purposes: first, the gaining of knowledge about the objects investigated and

the conscious seek for information about the life cycle of high-tech smart devices; second, the behavioural change and audience's mobilisation towards better choices that could come as a consequence of the knowledge gained.

## Method: experiential knowledge from making-with materials

The current section describes the different stages of prototyping actions led over the course of the project, a master's degree project performed from December 2020 to June 2021 within the design department at Konstfack, and the Kista Mentorspace at KTH Royal Institute of Technology (Stockholm).

The typology of exploration was tightly linked to the expertise of the research group; indeed, the authors' skills were centred on tangible prototypes, material tinkering, and speculation.

The authors developed a series of material explorations to gain experiential knowledge through the materials and their processes. The processes were both predicted and "forced" to the material; but some happened in completely random and unexpected ways.

In this section the authors describe the different phases of the research: initial prototyping (*"Mining" e-waste*), prototyping refinement through participatory workshop (*From D.I.Y. Do-It-Yourself, to D.I.T. Do It Together*), insights from the workshop (*Insights from the participatory workshop)*, feedback on the final prototyping through a semi-structured interview, citizen's engagement through a public exhibition (*The exhibition space as engagement*).

### "Mining" e-waste

The described process happened alongside the first stages of the desk research while defining the research questions and the context of the project. Looking at e-waste streams it is immediately clear the number of materials such as metals and silicates that could be potentially extracted from waste in a safe way, rather than extracted from underground mining. In fact, a UN report from 2019 highlights how "as much as 7% of the world's gold may currently be contained in e-waste, with 100 times more gold in a tonne of e-waste than in a tonne of gold ore". It is probable that by 2080 there will be more minerals in our appliances, buildings, electronic products and infrastructures rather than underground (Formafantasma, 2017-2020). Besides this, there is an urgent need to move towards a zero-carbon economy thus metals such as Lithium and Cobalt are essential to transition towards the electric economy.

An alternative to underground mining that is currently being explored is the process of urban mining, which is defined as forms of extraction and purification of precious metals taken from e-waste streams (Zeng et all., 2018). Reflecting on the concept of urban mining, three different Apple devices were collected: from two retailers in the Stockholm municipality that were about to be thrown away. The devices collected were a MacBook Pro from 2012, an iPhone 6 and an Apple Magic Keyboard. The aim was to understand the complexity of disassembling the devices as much as possible with basic workshop tools. The exploration took place firstly in the sanding workshop and secondly in the metal workshop and required the following tools: a screwdriver, pliers, a chisel, and a small bandsaw. The Magic Keyboard was quite difficult to disassemble mostly because some parts were glued together, such as

the white plastic case and the aluminium frame. Thus, the object was impossible to recycle correctly. The MacBook Pro was less difficult to dismantle, even though a point is reached where parts are glued together and hard to separate with mechanical tools. The author then tried to “mine back” the metals it was possible and safe to isolate, in a long process that was led by intuition and not inspired by tutorials or online guides of metal scrappers. Occasionally the authors invited fellow students to participate in the activity. It took two days to isolate a few metals such as copper, silver, gold, and aluminium (fig.1). In an attempt to close a cycle, a few elements such as copper, aluminium and silver have been manipulated in the metal workshop by melting and casting stone shapes (fig.2). The tools used in the metal workshop were a sand-casting kit for jewellery making and a propane torch for melting the metals.

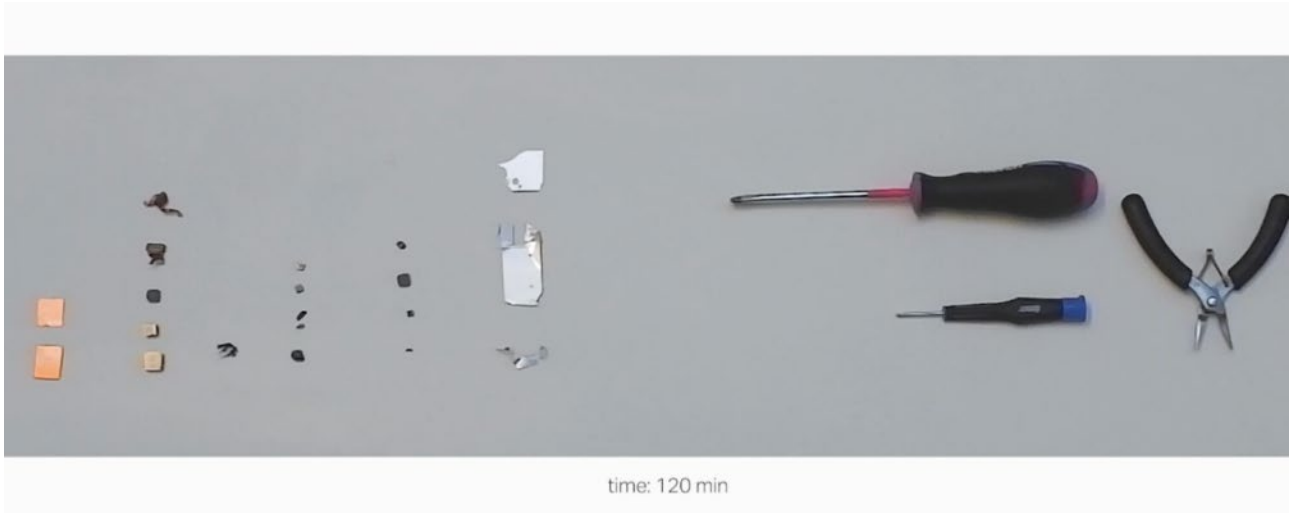



*Figure 1: Some of the metals recovered from an old MacBook Pro and the tools used. Still image from a video, credits: authors*

*Figure 2: Some of the metals recovered from an old MacBook Pro melted and casted. Still image from a video. Credits: authors*

While disassembling the devices, it was noticed many traces of human labour beyond the case such as kapton tape, marks, and irregular cuts. In a way, is it possible to see the human touch and the craft behind the mass-production making of devices. These artisanal findings sparked the curiosity of merging high-tech smart devices with the alchemy of fire and sand-casting, a very antique artisanal process of making jewellery and small-size figures.

## From D.I.Y. (Do-It-Yourself) to D.I.T. (Do-it-Together)

The process of gaining understanding through the making usually generates even more questions and different directions to explore. The battery inside the laptop resulted in being the most mysterious and inaccessible object to separate from the case, mainly for security reasons. In recent years there have been reported cases of electronic devices exploding because the battery inside overheated. One of the authors was intrigued by the inaccessibility of the designed black box, thus it was taken as a symbol of our relationship with high-tech smart devices. That converged in 2 workshops led by the author with 8 participants: half bachelor's design students and half master's design students from the product and spatial design department. The two workshops followed two facets of the topic of the battery: i) aesthetic of energy as material in design, thus working with energy from an aesthetic point of view; ii) reflective use/critical reflection through the object at hand (Broms et all., 2017).

### *Workshop on formgiving*

Brief: The participants were involved in a formgiving exercise about the formal qualities of a battery, from the current "black box" aesthetic to something that could communicate more effectively the concepts of "energy", "time", and "labour". The workshop took place in the clay workshop at Konstfack and lasted for one afternoon.

Tools: Firstly, the author shared with the participants a tool called "Deejay Sheet". In an A4 paper four variables (formal qualities) are written on the left side, and the four opposite variables are written on the right side of the paper. Then, lines are drawn between the variable A and its opposite, between the variable B and its opposite, and so on until there are four horizontal lines. Then each participant had to draw a circle on each line, in the point where she/he felt leaning towards (fig.3). The four circles were her/his formal qualities to achieve in the prototyping session with clay.

*Variable A: high-tech / low-tech*

*Variable B: machine-like / organic*

*Variable C: archaic / futuristic*

*Variable D: throw-away object / inherited object*

After the "Deejay Sheet" the participants engaged in hands-on prototyping and sketching, speculating on the possible shapes of a battery that could better communicate the notion of energy, time and labour (fig.4). While making, we embarked on discussions about the immediacy we are used to by simply plugging in our devices to electrical sources without thinking about the exhaustion that the act provokes, both material and mental as well. We speculated on the possibility of having the batteries outside the device's case, or how it

would be if the battery would change its shape when it gets exhausted. These discussions were only slightly guided by the author: they happened mostly spontaneously, sparked by the meditative making and the hands-on practice (fig.5).


*Figure 3: "Deejay sheets" during the first workshop. Credits: authors*

*Figure 4: Participant engaging in the formgiving exercise, from first workshop. Credits: authors*

*Figure 5: Some of the shapes, from first workshop. Credits: authors*

### *Do-It-Together workshop on low-tech batteries*

Brief: The second workshop took place in the sanding workshop at Konstfack. The same 8 participants joined in an explorative making of low-tech batteries inspired by an artefact found in ancient Persia, dated between 150 BC - 223 AD, that few archaeologists hypothesise was used as a tool for electrotherapy (Von Handorf & Crotty, 2002).

Tools: The author and the participants gathered from school and home the necessary equipment: glass jars, lemons almost gone bad, vinegar, foam to cover the lids, recycled copper and iron, copper wires, breadboards and LED lights (fig. 6).

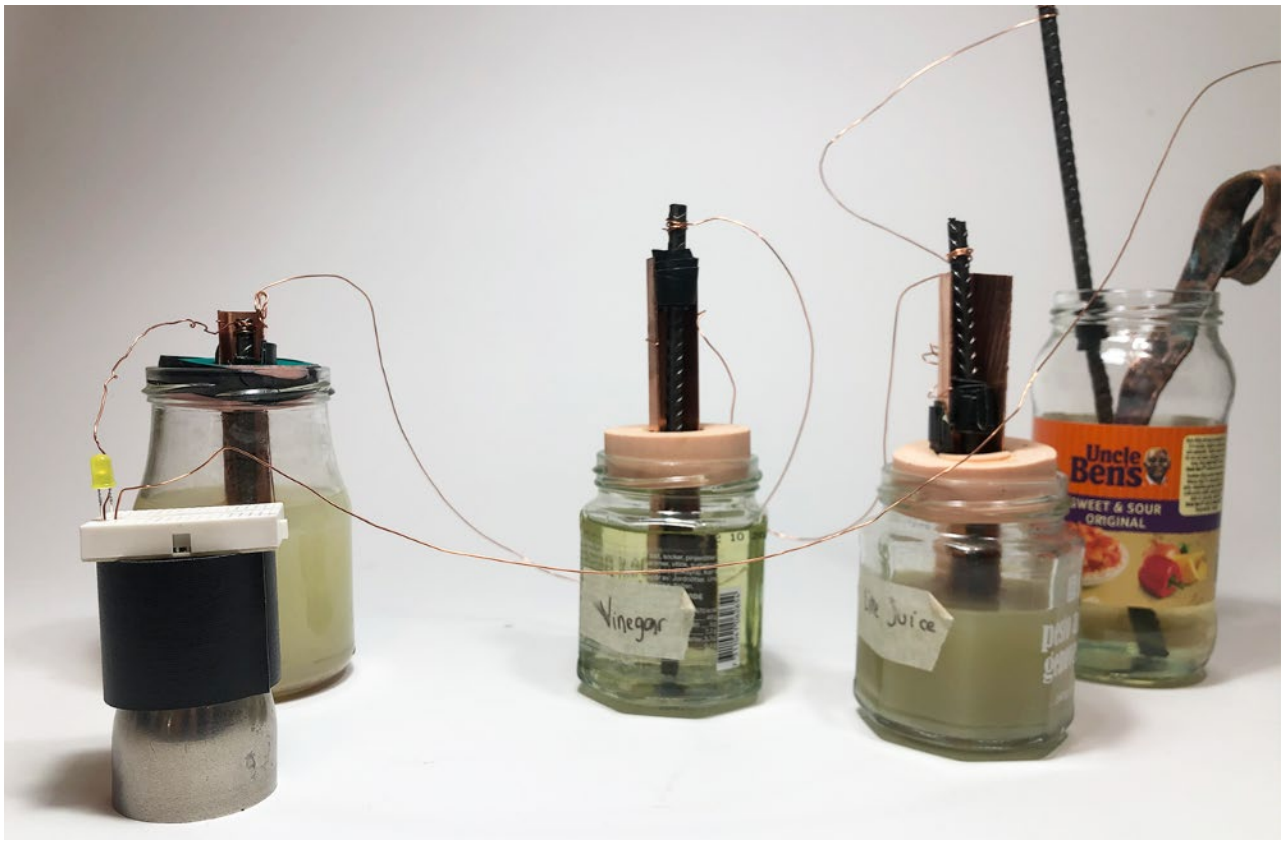



*Figure 6: Some of the batteries built from the participants, from the second workshop. Credits: authors*

The low-tech battery functioned as a galvanic cell with a cathode (copper) and an anode (iron) immersed in an acidic solution. Each participant chose a glass jar and started experimenting with the materials, by testing different proportions of lemon and vinegar for the liquid solution and thinking about the design of the cell.  After a few attempts, the participants connected all the batteries together with a copper wire and through the breadboard they could light up a yellow LED. The batteries functioned and powered the light for almost 20 days. After that time, the chemistry process of the galvanic cell through copper and iron ended and left formal marks in colours and textures on the metals (fig. 7). The colour-changing was then classified as an added material quality to the material finish that happened spontaneously and in an unpredicted manner.

*Figure 7: Finishes on copper samples after the process. Credits: authors*

## The final prototypes

Consequently, to the moments of collective prototyping and workshops developed to think-with and through the material, the authors started a process of individual formgiving and experimentation mainly approaching three materials: black clay, copper and iron. The exploration developed through two main paths according to the materials.

Black clay was chosen as the material to make the vessel and the container of the battery. We chose to work with black clay both for its material and colour qualities but also for its ability to vitrify at high temperatures (2100 °C) without the need of additional glazing and a second firing. The formal exploration followed different variables on the size of the vessels; the shape; and the textures. At first, we looked at the concept of clusters in nature developing small-scale containers that would work together as a colony of batteries. Later, we looked at the traditional amphoras merging the traditional shape with a texture given by electronic components pressed against the wet clay surface. Ultimately, the batteries took the shape of rocks both from the shape and the texture. The rock-like shape was reached by manipulating with strength the clay oval shape, being careful not to destroy and crack the wet material. The texture was given by many different rocks collected by the author, and carefully pressed against the wet clay's surfaces. When a satisfactory result was reached, the clay vessels were fired in a kiln for over 20 hours, reaching the 2400 °C temperature to vitrify and give the black colour to the ceramics. Once fired, the batteries were connected to each other and filled with an acidic solution made from lemons and vinegar tested in the previous workshop (fig. 8,9). The copper and iron used were given to the author from Ragn-sells, a recycling company based in Sweden that supported the project with materials and knowledge. Alongside the material exploration one of the authors visited a few recycling centres and conducted a semi-structured interview with the Innovation Coordinator and Strategist at the Swedish recycling company Ragn-sells, to develop a summary of recycling practices regarding e-waste in the Nordic region. The questions asked regarded the potentiality of a circular system that would recycle precious metals contained inside e-waste. During the interview, the expert mentioned a smelter located in the north of Sweden – one of the world's most efficient copper smelters – which the authors aimed to visit, but due to Covid-19 pandemics, the smelter could not receive outside visitors at that time.

*Figure 8: A cluster of batteries. Credits: Fredrik Sandin Carlson*

*Figure 9: One of the final batteries held by a workshop participant. Credits: Fredrik Sandin Carlson*

## Insights from the participatory workshop

This section reflects on the insights deriving from the participatory workshop that has been previously described. During the workshop, authors and participants engaged in a spontaneous exchange of reflections facilitated by the activity of making. Many of the outputs from the participants followed a “what if" type of question, opening a plausible space for the objects to exist in a speculative scenario, or narrative (Broms et all., 2017)). One of the “what if " questions looked at shape-changing materials for the manufacturing of the battery: the object would change shape according to the status of exhaustion of the metals inside. Further questions revolved around near-future scenarios of materials scarcity and how we might adapt to develop objects requiring way less energy to function compared to today’s standards.

After the second workshop, the same 8 participants were engaged in a focus group session. The aim of the focus group was the following: i) sense the reactions from the participants on the proposed activities; ii) choose and formulate any of the most interesting narratives coming from the “what if” questions; iii) suggest how this format could be further employed as an educational tool within materials and sustainability discourses. Three questions were asked and then discussed at the table. The discussion about the workshop activities results and engagement, is drawn upon the focus group conducted with the participants.

*Table 1: Topics of discussion during the focus group*

| Aims | Questions | Type of answers | Answers |
|---|---|---|---|
| i) Reactions on proposed activities | Which in your opinion were the variables that most fostered engagement before and during the workshops? | Priority order | Being a collective activity;<br>Being able to discuss while working with the materials;<br>Not being timed or supervised;<br>Having a common goal and interest;<br>Having a changing structure |

| | | | |
|---|---|---|---|
| ii) Narrative scenarios | Starting from one of the “what if” questions arose during the workshop, write a short story placed in a context | Open answers (paper)<br><br>15 minutes | *Described below* |
| iii) Insights on the feasibility of the method | How could this series of activities be further developed towards the creation of a method to use within design practice? | SWOT / Open answers (discussion)<br><br>15 minutes | *Described below* |

The focus group gave a great priority to the workshops being a collective activity, and by having a common goal/interest (i.e. making the battery and light a diode). That ensured engagement and an enjoyable atmosphere within the group. At the same time, the participants felt empowered by getting more familiar with such objects, taking on an active role as *prosumers* (Kotler, 2010). The participants were also engaged with the writing of stories, where few of them had as protagonist the participant itself. As stated by Barendregt, speculative design involves developing scenarios based on a central object or prototype. Since speculation is often concerned with alternative present and future states, speculative design could raise critical discussion and public engagement on science, technology, and society (Barendregt & Vaage, 2021). The following text is a description of a scenario that was collectively crafted by the authors and the participants from the workshop's insights (ii) and the prototype at hand.

*This is a future where materials are scarce. It is a world where we, humans, need to drastically reduce their imprint on the planet, thus change habits, be adaptive, and be self-sufficient. Build our own things and objects, share devices and technologies to store data. It is not a dystopian world but rather a world of renewed collectivism, bottom-up processes, and low-tech devices. Neighbourhoods in cities become networks where people share knowledge and competences on ways to adapt to the new present.*

*In the new present, recycling plants are diffused. They grew exponentially over the years in order to recover precious metals from the vast number of discarded objects left as a legacy by Capitalism and mass-production. The consequences of this mode of production resulted in an environmental and social crisis that lasted for years, but at some point, from its ashes something was born. A local, community-managed circular economy was put in place to exploit the potentialities of e-waste to get the resources that are no longer possible to get from the underground. Due to the scarcity of materials, electricity was no longer guaranteed 24 hours per day. Thus, people had to find new solutions, collectively. Someone looked back in history and re-introduced old, alchemic techniques to obtain energy from food waste and metals. Energy becomes something to be manufactured, to be crafted. Something that*

*people sense and live with, something they must care for. Below the ground, canteens are now used to store clusters of batteries connected with each other that power the energetic needs of each building when electricity is out. Citizens take turns in taking care of the clusters and replace the metals when they get exhausted. They go to the nearest metal collection point, which in most cases is located within a few miles for each neighbourhood.*

*In this world, homes change configurations, and the home spaces are now used in unconventional ways. People move towards a do-it-yourself approach and try to be self-sufficient: it starts with the production of energy with the cluster of batteries, and it goes to the use of fogponics and hydroponics techniques to grow food. Every week, citizens gather in common spaces in the neighborhood to share insights, new techniques, and knowledge on how to recycle, repair and reuse objects, how to extract materials from waste, and how to make their own bio-based materials. Societies change at large as well, becoming more and more decentralized meshes and moving "back" into smaller communities.*

The stories envisioned the described scenario where materials are scarce and urban mining is a common procedure. In some of the stories, participants imagined bottom-up processes where citizens would share knowledge on how to repair, re-use and build low-tech devices from waste. This aspect highlights the rising relevance that initiatives such the above-mentioned "The Restart Project" or "The Low-Tech Lab" could have in the next future within the field of repair and re-use of goods. An interesting point is that most of the narratives were not representing a dystopian world or a largely technological world, which is common talking about speculative design (Mitrović et all., 2021); on the contrary, the participants represented a world where collectivism and a renewed connection with natural resources are main paradigms.

As for the last point of the focus group, iii) insights on the feasibility of the method, the participants were able to write interesting opportunities of deployment but not as able in highlighting possible weaknesses or threats. It is possible that there was not enough knowledge and evidence to base this type of judgement on, both from the participants and from the authors. Thus, this point is a matter that needs to be further tested and explored.

## The exhibition space as engagement

The final prototyping action unfolded over an exhibition, which happened between 20th-28th of May 2020 at Konstfack University. That was a key moment where public audience could engage with the author and raise questions or start a discussion over the project. The space was painted black, with a wooden wall built to project a film edited by the authors. The film aimed to inform the public of the context of the research: the main character was a human figure holding an open laptop on one hand, with a rock on the other hand and playing with the two materialities, so similar but so different at the same time. Moreover, all the metals required to make an Apple iPhone work are listed one by one (Merchant, 2017). At the centre of the room there was a black podium with the batteries and other materials researched over the prototyping phases. Moving from left to right, the materials on the table showed a process from raw materials, to electronics, then to the melted rocks of the first prototypes, ending to the ceramic batteries attempting to light a LED bulb or potentially slowly charge a

smartphone (fig. 9). The closed cycle is symbolic in that case but aims to start discussions on the concrete strategies that could be developed and adopted from individuals, companies and policy makers for the necessity to “close the loop” within the electronic sector, and not only.

The exhibitions could play a significant role within experiential knowledge; not only in entertaining the public but also in educating the public to relevant issues and asking for their opinions or critiques (Barendregt & Vaage, 2021). Exhibitions are the fictional set where the audience discusses the speculative works, helping to imagine new future trajectories (Chen & Fu, 2021). Based on these assumptions, the exhibition space was intended as an open and accessible space to engage with the public on the topics of energy consumption and sustainability. The objects and material samples were purposely placed on a table accessible both for adults and children. The public was allowed to touch the materials and turn on the batteries. Giving the audience the freedom to interact with the space was useful because it helped reduce the barrier between the public and the artists/designers. Many interesting insights came especially from conversations with children, who were amazed to see a dark space filled with film, sound, and unusual objects on the table. While looking at the materials, few people engaged in a discussion on a possible future of material scarcity, where the ability of building DIY technologies and bio-based materials will be a public knowledge to share among citizens. It is interesting how four people that had never met each other before were discussing and designing a speculative scenario based on the experience of the exhibition and the prototypes.

*Figure 9: Panoramic view of the exhibition space. Credits: Jesper Malsten*

## Moving on: conclusion and further actions

Experimenting with materials and organising a workshop allowed the authors to answer the research questions posed at the beginning of the research activity: how prototyping through material crafting can elicit and trigger a particular message and how to deliver that message to an audience and generate awareness on the topic of e-waste and consumption.

The participants were all design students; thus, they were already familiar with participatory and hands-on activities. In particular, the experimentation made direct observations on the material behaviours and on the intuitive interactions between participants and materials and confirmed how making can be a tool to think and reflect (M.A. Fariello, 2005). While observing the workshops authors noticed how collective manipulation of matter can arouse feelings of oneness with nature and between each participant. Tackling hopeful discussions on behavioural change and, ultimately, through material actions, could create awareness of problems but spark positive improvements to every one's behaviour and mobilise them to make behavioural changes regarding climate issues and sustainability.

Regarding this issue, the authors realize that small shift in a limited number of persons can trigger a significant change towards sustainability at the community level. Even a simple workshop could activate medium and long-term behavioural change; the performed activities were proven to be valuable in triggering both a new mindset as a designer and a more aware and responsible both individual and collective behaviour.

Indeed, few of the participants stated how they got curious to apply the method to other objects as well, and one participant mentioned how the recovered precious metals such as gold and silver could be used for an artisanal jewellery production. These testimonies how such activities can be remembered from the participants, stimulate virtuous practices and perhaps even new projects, such as the student who mentioned to make jewels from e-waste; in the shared experimentation, participants collaborated, learned from each other, and developed new knowledge and skills.

Building up from these premises, the role that these practice-led activities could have in design practice, while engaging with material development, innovation, and energy (engineers, scientists, technologists) is promising for creating a so-called *community of practice*, where individuals can learn from one another, share best practices, and stay up to date on the latest developments in their field. (Hoadley, C. 2012)

Crafting materials and prototyping within structured protocols through design practitioners and citizens engagement can be expanded beyond the connotation of testing in the product design realm (testing if a prototype works, which materials are best to exploit etc.) towards educational training in imagining possible futures or worlding through sensorial connection with the materials, or making (Wargsgeo & Alvarado, 2019). The approach used for the case study here described proved to be effective but needs to be replicated and improved (in terms of protocols and numbers of participants) for future research by also exploring potentialities of edutainment in exhibitions and a democratic community engagement.

In this regard the authors are already planning to execute another experimentation regarding sustainability by using digital lamps and exploring forms and material qualities of the strip led used in most of nowadays lamps. The workshop would engage students at Master Level in Design and Engineering (Politecnico di Milano) and it would reflect on the potential role of

design in the creation of longer subject/object relationships to extend the product's life and defy the product's obsolescence (Cooper, 2010). Authors are proposing a collective activity based on the thinking-through-making approach where students would explore and test material qualities to embed in the design of their prototypes, with the aim of fostering a sense of care and forging speculative narratives with the object and materials in question, that blend the real with the yet-to-happen and the fictional (Helgason & Smyth, 2020). The activity will involve the scenario creation as well; authors are reasoning on implementing the co-created scenario through a backcasting framework, thus building a roadmap to the future envisioned and the necessary phases to get there. The results of the workshop in form of dynamic scenario, would be potentially shown in an exhibition where the public can access and give feedback on the experimentation, thus helping the students to move forward in their process and reflect on their own role as designers within the sustainability discourse.

## Acknowledgement

The project started as MFA (Master of Fine Arts) thesis in Design at Konstfack University of Arts, Crafts and Design, supervised by professor Katja Pettersson, Jenny Althoff and Martin Avila. Subsequently it evolved in deeper research within the Design Department at Politecnico di Milano.

### References

Acosta, A. (2017). Post-extractivism: from discourse to practice—reflections for action. In *Alternative pathways to sustainable development: Lessons from Latin America* (pp. 77-101). Brill Nijhoff.

Atzmon, L., & Boradkar, P. (Eds.). (2017). *Encountering things: Design and theories of things*. Bloomsbury Publishing.

Auger, J. (2013). Speculative design: crafting the speculation. *Digital Creativity*, *24*(1), 11-35.

Barbero, S., & Cozzo, B. (2009). *Ecodesign*. Ullmann.

Barendregt, L., & Vaage, N. S. (2021). Speculative design as thought experiment. *She Ji: The Journal of Design, Economics, and Innovation*, *7*(3), 374-402.

Black, A., & Burisch, N. (Eds.). (2020). *The New Politics of the Handmade: Craft, Art and Design*. Bloomsbury Publishing.

Blythe, M. (2014, April). Research through design fiction: narrative in real and imaginary abstracts. In *Proceedings of the SIGCHI conference on human factors in computing systems* (pp. 703-712).

Bennett, J. (2010). *Vibrant matter: A political ecology of things*. Duke University Press.

Broms, L., Wangel, J., & Andersson, C. (2017). Sensing energy: Forming stories through speculative design artefacts. *Energy Research & Social Science*, *31*, 194-204.

Broms, L. (2014). *Storyforming: Experiments in creating discursive engagements between people, things and environments* (Doctoral dissertation, KTH Royal Institute of Technology).

Coalition, E. W. (2019). A new circular vision for electronics: Time for a global reboot. World Economic Forum.

Cooper, T. (Ed.). (2010). *Longer lasting products: Alternatives to the throwaway society*. Gower Publishing, Ltd..

Dunne, A., & Raby, F. (2013). *Speculative everything: design, fiction, and social dreaming*. MIT press.

Fariello, M. A., & Owen, P. (Eds.). (2005). *Objects and Meaning: New Perspectives on Art and Craft*. Scarecrow Press.

Formafantasma (2017-2020). Ore Streams. Retrieved from http://www.orestreams.com/

Helgason, I., & Smyth, M. (2020, July). Ethnographic fictions: research for speculative design. In *Companion Publication of the 2020 ACM Designing Interactive Systems Conference* (pp. 203-207).

Hoadley, C. (2012). What is a community of practice and how can we support it?. In *Theoretical foundations of learning environments* (pp. 286-299). Routledge.

Johnson, B. D. (2011). Science fiction prototyping: Designing the future with science fiction. *Synthesis Lectures on Computer Science*, *3*(1), 1-190.

Jørgensen, N. J., Madsen, K. D., & Læssøe, J. (2018). Waste in education: the potential of materiality and practice. *Environmental Education Research*, *24*(6), 807-817.

Kappes, H. B., & Oettingen, G. (2011). Positive fantasies about idealized futures sap energy. *Journal of Experimental Social Psychology*, *47*(4), 719-729.

Kerridge, T. (2015). *Designing Debate: The entanglement of speculative design and upstream engagement* (Doctoral dissertation, Goldsmiths, University of London).

Kymäläinen, T. (2015). *Science fiction prototypes as design outcome of research*. Aalto University.

Kotler, P. (2010). The prosumer movement. In *Prosumer revisited* (pp. 51-60). VS Verlag für Sozialwissenschaften.

Latour, B. (1992). Where are the missing masses? The sociology of a few mundane artifacts. *Shaping technology/building society: Studies in sociotechnical change*, *1*, 225-258.

Lawson, L. (2021). The Anthropology of Precious Minerals. *The Journal of Gemmology*, *37*(5), 545-546.

Lionello, C. (2019). Broken Nature: Design takes on human survival, XXII° International Exhibition, La Triennale di Milano,«Op. cit.», n. 165, May 2019, pp. 77-80 (catalogue's review). *OP. CIT.*, *165*, 77-80.

Mader, A., & Dertien, E. (2016). Tinkering as method in academic teaching. In *DS 83: Proceedings of the 18th International Conference on Engineering and Product Design Education (E&PDE16), Design Education: Collaboration and Cross-Disciplinarity, Aalborg, Denmark, 8th-9th September 2016* (pp. 240-245).

Merchant, B. (2017). *The one device: The secret history of the iPhone*. Little, Brown.

Mitrović, I., Auger, J., Hanna, J., & Helgason, I. (2021). *Beyond speculative design: past–present–future*. University of Split.

Panu, P. (2020). Anxiety and the ecological crisis: An analysis of eco-anxiety and climate anxiety. *Sustainability*, *12*(19), 7836.

Peters, J. D. (2015). The marvelous clouds. In *The Marvelous Clouds*. University of Chicago Press.

Rognoli, V., & Parisi, S. (2021). Material Tinkering and Creativity. In *Materials Designers. Boosting talent towards circular economies* (pp. 20-25). Elisava.

Rozendaal, M. C., Heidingsfelder, M. L., & Kupper, F. (2016, August). Exploring embodied speculation in participatory design and innovation. In *Proceedings of the 14th Participatory Design Conference: Short Papers, Interactive Exhibitions, Workshops-Volume 2* (pp. 100-102).

Santulli, C., & Rognoli, V. (2020). Material tinkering for design education on waste upcycling. *Design And Technology Education: An International Journal, 25*(2), 50-73. Retrieved from https://ariadnestaging.lboro.ac.uk/DATE/article/view/2713

Tharp, B. M., & Tharp, S. M. (2022). *Discursive design: critical, speculative, and alternative things*. MIT press.

Von Handorf, D. R., & Crotty, D. E. (2002). The Baghdad Battery: Myth or reality?. *Plating and surface finishing*, *89*(5), 84-87.

Walker, C. J. (2010). Experiencing flow: Is doing it together better than doing it alone?. *The Journal of Positive Psychology*, *5*(1), 3-11.

Wargo, J. M., & Alvarado, J. (2020). Making as worlding: young children composing change through speculative design. *Literacy*, *54*(2), 13-21.

Williams, K. A. (2011). “Old Time Mem'ry”: Contemporary Urban Craftivism and the Politics of Doing-It-Yourself in Postindustrial America. *Utopian Studies*, *22*(2), 303-320.

Young, L., & Davies, K. (2013). A Distributed Ground: The Unknown Fields Division. *Architectural Design*, *83*(4), 38-45.
Zeng, X., Mathews, J. A., & Li, J. (2018). Urban mining of e-waste is becoming more cost-effective than virgin mining. *Environmental science & technology*, *52*(8), 4835-4841.

Zimmerman, J., Stolterman, E. & Forlizzi, J. 2010, “An analysis and critique of research through design: Towards a formalization of a research approach”, *Proceedings of the 8th ACM Conference on Designing Interactive Systems*, ACM, pp. 310-319.

**Giorgia Burzio**

Giorgia Burzio is an interdisciplinary designer and researcher. She is currently a Research Fellow at the Department of Design of Politecnico di Milano mainly collaborating to the project of D\Tank, the Think Tank of the Department.
In her work, she translates complex environmental dynamics and invisible phenomena into tangible objects, material experimentations, and experiences. She initially studied industrial product design at Politecnico di Torino, with a focus on systemic and material design, attentive to the social and environmental dimensions of the product. She subsequently moved to Stockholm, at Konstfack University of Arts, Crafts and Design, where she obtained a Master of Fine Arts (MFA) in design through a thesis project on the flow of materials used in electronic devices, proposing a thinking-through-making approach to co-create future scenarios on the use of such resources. She was a recipient of a merit scholarship offered by the Konstfack Rector in June 2021. She was artist-in-residence at Fabrica Research Centre (Treviso) and a contractual collaborator at POLI.design.

**Venere Ferraro**

Venere Ferraro, PhD in Design, is an Associate Professor at the Department of Design at Politecnico di Milano.

She has been Visiting Researcher at University of New South Wales of Sydney (2006) and at Media Lab of Massachusetts Institute of Technology (2009) where she run research on Wearable Systems and electronic textiles with the lens on design-driven and user-oriented approaches.
She participated in several International and National research both as coordinator (DATEMATS"-KA2-2018, POD: Plurisensorial-SAF€RA 2014 joint call) and as principal investigator (Destex- Strategic PA and In Transit- HEurope).
The research interests lie in the domain of *interaction design*, more in detail: the role of *wearable technologies, emerging materials, and big data* in designing experiential systems for digital care, with particular attention to *speculative tools and methods* for changing user behaviour.
There are two key elements that strategically guide her activity: the interdisciplinary and international dimension of the area of design research and practice and the integration between the research and the teaching activity. Specifically, the integration between the research and the teaching activity is developed through research projects mainly conducted for SMEs where the focus is to stress the design role as lever to achieve and improve innovation.