





## DOCTORAL PROGRAM IN DESIGN

Chair:  
**Prof. Paola Bertola**

### Field of study

The Politecnico di Milano established a PhD programme in the field of design already in 1990. Based on this tradition, the current PhD programme in Design was established in 2008, resulting from a substantial review of how design was researched at a doctoral level.

The overall aim of the PhD programme in Design is to develop skills to carry out high quality research, reflecting on the overall nature of design, with its aesthetic, performance and meaning values as well as its capability of being an agent of social change.

The PhD programme in Design deals with various research strands, each of them carried out by a given research team within the Department of Design. All the teams cluster around three Sections:

- Design and Cultures
- Products, Strategies and Services
- Design for Environments, Landscape and Mobility

The programme aims at educating researchers who will contribute original knowledge to the field of design as an established academic field by tackling the problems and identifying the potential of contemporary society.

Their contribution may be brought to bear in:

- creating designs, visions, and proposals (research through design);
- developing tools and methods for putting these into practice (research for design);
- developing critical analysis of design and its application domain (research on design).

The Programme develops project and analytical abilities, proposes different methodologies of research, promotes the attitude to collaborate, and offers working opportunities in universities and research centres, design enterprises and public corporate bodies.

### Mission and goals

The programme develops design skills and analytical abilities, proposes various research methodologies and promotes a collaborative disposition.

The main academic field is Design. Other academic fields partially covered are: Philosophy; Language Theory; Sociology of Cultural Processes; History of Art; Science and Technology of Materials; Industrial Engineering.

The achievement of the PhD qualification in Design requires a study and research activity equivalent to at least three years of full-time study. During this period, both educational and research activities are provided.

At the beginning of the programme, candidates become effective members of a research team, within which they develop an original research topic: this activity is the core of the learning process. Parallel to this, candidates are involved in *training* and *specialist* activities.

Moreover, the activities of the PhD in Design include participation in conferences (as listeners or speakers) and writing of research papers and/or journal articles.

The programme offers doctoral candidates the following opportunities:

- to develop an original theme of research, becoming an effective member of a research team;
- to attend courses and seminars on design research and on research in general, developing skills concerning the discipline of design and the profession of the researcher;
- to attend courses and seminars referred to a specific field of research, developing high-level specialist skills and acquiring knowledge and tools for the development of their own research;
- to develop the ability to clearly and effectively present the contents of their own work;
- to spend a period abroad as visiting researcher in a research centre to verify the assumptions, the methodologies and the results of their doctoral work.

### Qualifications

The PhD program in Design intends to educate a flexible figure: a designer who knows how to carry out research and a researcher who uses design tools. At the same time, she is also an expert in knowledge management, in constructive

interaction among different actors and in the sharing of ideas and proposals.

The combination of these skills is useful in a variety of work environments. Specifically: in institutions expressly dedicated to the development of design research, such as universities and research centres; in design agencies and in design-oriented companies; in public corporate bodies and in organizations for territorial development which, increasingly, are faced with complex problems, which the designer-researcher can effectively address, analyse and contribute to resolve.

### DOCTORAL PROGRAMME BOARD

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# IF WALLS COULD TALK. NEW NARRATIVES AND EXHIBIT DESIGN FOR PLACES OF WORK AND LIFE.

Chiara Fauda Pichet - Supervisor: Giampiero Bosoni

## Inclusion – Perception – Design

In the chapter HouseMuseum MankindMusuem written for the exhibition *Ospiti Inaspettati*, hosted by the Houses of Circuito Case Museo Milanesi in 2010, Alessandro Mendini wrote:

*It seems clear to me that any HOUSE at all can also be considered a MUSEUM. [...]*

*It all depends on how one approaches it. [...]*

*In addition to writing your name on the door, you can also write MUSEUM. Then when you enter, once you've crossed the threshold, your approach to your house will be different, more attentive.*

(Mendini, 2010)

With these few precise words, Mendini describes the creation process of a museum. Three points mainly concern the research. The idea of inclusion embedded in the world any; **any** HOUSE can be considered a museum; the fact that the switch from perceiving a house to perceive a museum is **a matter of attitude**. And last but not least, Mendini suggests that in order to generate this change of perception, a design action is necessary. "In addition to writing your name on the door, you can also **write** MUSEUM."

Studios and ateliers are places of work and creativity, understood in the etymological sense of the term,

such as an attitude to creation. And exhibit design is a process that acts as a medium to bring other layers into these spaces, transforming them into intimate and domestic places in which the different stories of art, aesthetics, technology, society, and customs converge.

In this context, the role of the exhibition designer is to present a content operating within the limits of this extraordinary creative space, lying somewhere between architecture, design, set design and artistic installations.

## Methodology

The study investigated theoretical-methodological questions of a museological, museographical and design nature. Aim of the research is to generate multidisciplinary and systemic insights capable to enhance museum fruition. To be applied into twentieth-century Italian artists and designers' studios and ateliers, that have been converted in cultural institutions. **Literature review** was used to build the theoretical basis that supports the qualitative research, and a **census** was carried out to investigate the Italian state of the art, combined with interviews and the analysis of case studies. Referring to interdisciplinarity was central to elaborate the final methodology and mainly used to analyse the space. The research refers to phenomenological science,

philosophy and literature as well as history of art and architecture, while the investigation on exhibit design took advantage of history of design as well as arts practices and neuroscience.

## The magician workshops

In studios, ateliers, and workshops, the idea of inhabiting corresponds to spend a massive number of daily hours in a place where the main activity is the work. Studios and atelier are intimate but at the same time, public places, with the peculiarity of having an active channel for communication with the outside world through the works realized by the own tenant.

They are inhabited interiors, specifically or predominantly dedicated to "doing art and design." Workspaces inhabited in everyday life, interiors used to do research and/or artistic and design production; places where the creative and design process coincides in different ways with the dimension of living.

## From Space To Place: Adding Meaning To Square Feet

Space is the leading actor of the research. To understand the shift in the meaning of a space that moves from a workspace to a place of memory, the study moved towards anthropology and semiotics and conclude by exploring possible solutions through the practice of

exhibition design, recognized as a primary communication tool and narrative constructor.

Space is a concept of intuition, or at least it should be, but this is not clear from a scientific point of view. As often happens, language, as a significant descriptor of space, could come to our aid.

It is not unusual for a language to become spatialized, finding greater adherence to reality.

The internal walls can, therefore, become the limits within which arrange the elements of the narration. Moreover, a narration generated by a fluid and continuous movement, can become the instrument through which provide the logical joints that connect, the interior of time dilation and restriction, spaces, scenes (and narrative elements) seamlessly.

## Census

A census was carried out, to reconstruct the state of the art of studios and ateliers on the Italian territory. It includes museum-like places, as well as public and private institutions with a prominent vocation for fruition even if sporadic.

It was useful to deepen the state of the art of this kind of cultural realities and to reconstruct the institutional and administrative framework, plus the work of research, conservation and dissemination drive by the institution. Data obtained from the survey underlined an unequal distribution among the nation with a higher concentration in northern Italy which gradually decreases towards the south and the islands. The results have revealed a lack of awareness of exhibit design role by those directors and manager, often associated with a communication deficit.

Images, and video, the primary

tool for architecture analysis, had a substantial impact on this section. Census results helped me to identify 7 categories that could be used as an analysis tool to describe physical features of places: **Void, Light and Atmosphere, Eyesight, Customized design, Anecdotes, Objects and Colors.**

## Ca.Ra.

Home can be read as a space defined and marked by a daily pictorial ritual celebrated by the painter. A place where the succession of many of the main proponents of twentieth-century art history has left evident signs, traceable in the spaces and in the influences on the artistic language of Carol Rama. A lexicon that, in addition of being expressed on paintings, can be found among the furnishings and objects. Objects that, following an interpretation of the interiors close to the thought of Carlo Mollino, can be seen as destabilizing presences between scenography, photography, sculpture and decoration. Through the study of Carol Rama's house studio, I worked alongside the presences of her life: friends, as well as objects. Trying to feel the temperatures, retrace the affinities and explore the artist's work through new perspectives and points of view, in order to make a first investigation of the spaces.

## Outcomes and results

The outcomes of the research were mainly the mapping of a cultural resource spread over the national territory connected by shared values, although separated from the vast riches and uniqueness that distinguish it.

The research highlighted a question on preservation criteria, even if it

did not focus on reasons behind the choice to preserve a place instead of another. The definition of heritage and preservation issues are a complex problem that cannot be addressed only through design-based research. The problem requires collaboration among different disciplines, such as business, social studies, and management. This thesis was not the correct place for an investigation of this kind, but the census could be a starting point for new analysis. The second output is the necessity to integrate narrative strategy within the studio and atelier museum space. An indirect result of the research is an open question on the value and the composition of a personal archive. It is possible to reformulate the idea of a personal archives, including every material that could represent a layer of the personal story of a creative. The seven categories applied to Casa Rama demonstrate their capability to highlight spatial characteristics. Those could be used as a starting point that allows cultural operator to see something new in the spaces they are working.

*"It is not known and should not be known if you are penetrating a picture, a dream, a diary page, or the inventory of the unconfessable ..."*  
(Lea Vergine, 1985)

## DESIGN DRIVEN APPROACHES IN HEALTHCARE: AN ACTION RESEARCH THROUGH EUROPEAN PROJECTS PARTICIPATION

**Maria Renata Guarneri - Supervisor: Giuseppe Andreoni**

### Rationale and background

Healthcare is undergoing a true revolution towards new paradigms for all actors involved. First of all, on the scientific and clinical side, the traditional approach based on symptoms and disease management is progressively giving way to a systemic approach oriented to predictive, proactive, preventive and personalised - P4 - medicine. The concept of P4 medicine was introduced and illustrated by Leroy Hood in "A personal view on Systems medicine and the emergence of proactive P4 medicine: predictive, preventive, personalised and participatory". In such new trends, technological innovation – ICT and mobile health - and more specifically the digital transformation, with Big Data and Artificial Intelligence, play the role of key enablers. Such digital transformation is encompassing all economic sectors: new models for healthcare will emerge.

The role of the individuals, that more and more take interest in managing their own health, also in unconventional ways is central to such revolution. Consumers – citizens and patients – and their new attitudes and awareness with regard to health are actually driving the transformation in healthcare. The advent of eHealth with the digital management of patient information and the wide adoption of Electronic Health Records (EHR), concepts such as

patient empowerment, personalised medicine will have an impact on the development of new healthcare models that will become patient-centric as opposite to the current disease-centric models. Within this trend, novel healthcare models based on e-health and m-health are being adopted with an approach that has initially focused on services and is now gradually moving towards the support of clinical aspects. Several initiatives are taking place to promote full adoption of e-health, which must include the entire healthcare ecosystem, the patient first of all, with a participative approach that starts from prevention. The P4 medicine calls for an increased role of the patients, which need to be more empowered and become managers of their own health starting from the status of being healthy and taking action before the onset of disease. Current EU research has stressed the central role of the patient for the development of new healthcare models and asks for projects showing evidence of User Centred Design in the proposed research approach.

### Approach

"The nature of design as an integrative discipline places it at the intersection of several large fields, fields of thinking and pure research and fields of practice and applied research" (Friedman 2000). In his view there are four areas of design

research: Philosophy and theory of design, **research methods and research practices**, design education and **design practice**. Accordingly, the PhD work, analysing the application of design research tools and methods to a specific discipline, in the area of human professions, services and technology, focuses on an **application of design practices in the field of healthcare**. The application of design approaches to social challenges has significantly expanded over the last several decades, and design research has developed to cover multi-dimensional and multi-disciplinary research. Health and healthcare services are among the social challenges that are at the focus of significant interest for both design practitioners and design researchers. For example, **service design** has led to new opportunities to address improved products and services in the field of healthcare; focussing on prevention **behaviour design** – based on psychology and behaviour change theories – allows to design products and solutions able to influence human behaviour. Furthermore, the advent of digital transformation and the impact on all economic sectors, public and private, calls for innovative approaches in the field of public health, in the broader definition as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity" (WHO 1948),

therefore encompassing prevention and social determinants, and **focussing on the person**, rather than on the illness.

### Research and main outcomes

The complexity of problems in healthcare requires different competences and expertise to approach the problem. Generally, looking into problems with a multidisciplinary approach, enhancing technology and information transfer among different disciplines, has provided new insights and original viewpoints leading to innovation in many industrial sectors. However, as Dunchan and Breslin wrote, "*While the discipline of design is the core of innovation in many industries, it is not widely known or practiced in health service organizations despite a natural affinity between design and medicine. Understanding and employing the power of design in health services will allow medical institutions to develop more effective health services, enhance patient satisfaction, and meet important human needs.*"

The research has the ambition of contributing a design perspective to the debate on the future of healthcare with focus on the 4P medicine. More specifically, adopting a practice based approach through the preparation and (partial) implementation of three projects within the EU framework, the research provides a view on how **design can be integrated in the overall transformation** that healthcare is undergoing; and how design, as a discipline, **can contribute to respond to the grand challenges** of healthcare that are driving transformation.

The following table shows the main focus and design characteristics of the projects driving the doctoral research.

PROJECT	GRAND CHALLENGE	APPROACH AND MOTIVATIONAL THEORIES	DESIGN FOCUS	THE OBJECT OF DESIGN
PEGASO	Juvenile Obesity	Challenge teens in their playfields: smartphones, games and gamification.  Behaviour change: COM-B and BCW	Product and Interaction Design	Apps and Wearables (sensorised garments)
NESTORE	Healthy Ageing	Leverage on residual strengths and interests to enhance failing capabilities.  Gentle nudge to maintain wellbeing: SOC and HAPA	Service and Solution Design	Wellbeing pathways and home sensing system
SHARP@Work	Ageing in the WorkPlace	Workability and motivation to work  Ensuring a <i>good fit</i> of the changing personal needs and abilities with age and the work environment: P-E Fit and I-deals	System Design and Design for Co-creation	Negotiation platform and tools to co-create personalised solutions

Tab.1

The work performed in the projects has shown that use of participatory design is important for users to appropriate novel approaches and become active part in the health system. Methods that allow users to be creative, and the adoption of Design Thinking as a methodological approach, have proven effective as they leverage people's beliefs and values. Understanding such values is fundamental to develop prevention models. The adoption of specific psychological and behavioural theories informing the design activities has been an important innovation and added value.

For an actual take up of models based on prevention it is important to integrate the role of the empowered citizen within the world of the professional healthcare. It should be possible to integrate user generated data with the data provided by the healthcare system and health practitioners need to be engaged and empowered to make use of such rich information in their daily practice. This is what is postulated by 4P medicine. European research is going in this direction, with new calls on personalised medicine. The results from this future research will inform the development of new business models for healthcare based on prevention and user participation.

# TRANSFORMING PUBLIC SECTOR ORGANIZATIONS THROUGH DESIGN CULTURE: THE RELATIONSHIP BETWEEN DESIGN PRACTICE, INNOVATION AND ORGANIZATIONAL CHANGE

Tamami Komatsu Cipriani - Supervisor: Alessandro Deserti

While governments have always responded to difficult and complicated problems, those of the 21<sup>st</sup> century are ‘wicked’ and emergent in nature, with large user bases, high levels of interdependency and no clear solutions. Often times, more knowledge will not contribute to a solution, requiring instead a holistic and participative approach that relies on the contribution of multiple actors. The environmental turbulence surrounding innovation in public sector organizations has not only been stimulated by emerging social and environmental concerns but also by advances in technology (e.g. e-government, blockchain technology, social media, etc.) that have changed the paradigm of government-citizen interaction, in terms of: governance, service delivery and policymaking. As a result, the paradigms that govern the public sector have evolved, seeing a growing importance in the role of exploring and fostering co-production in public value creation, as seen in the spread of government innovation labs across Europe. Design is being increasingly used in the public sector via internal and outsourced teams. While the design experiments are still in an early stage, questions nevertheless arise as to the effective integration of the resulting knowledge into the sector’s working practices, service delivery and ultimately, culture. In addition, given the networked and interdependent

web of actors that span across different levels of government, the transfer, reception and application of knowledge becomes ever more important. This is especially true for design as a discipline if it wants to maintain relevance as an asset for innovation in the sector. The rise in ‘popularity’ of design as a resource for innovation can be attributed to a push away from material objects to the application of the methods and processes of expert designers to solve just about any problem. Deserti and Rizzo sustain that in order for design to be truly effective in organizations, it must become a part of its culture, situated in its *practices*, requiring continual negotiation and alignment in its innovation process. Taking a design practice perspective, the dissertation explores how (and if) design is contributing to innovation in the public sector by grounding the research in the tacit dimension of design, and the practices of the multiple actors that take part in it. In this backdrop, a focus on the design culture of public sector organizations could emerge as a generative tool for co-designing public value. A design culture approach mediates between both the public administration’s and the citizen’s worlds, assuming a joint-perspective. In other words, the process of co-designing services could allow for a new or more evolved design culture to emerge and take

shape and eventually influence a transformation of the culture of public sector organizations and the surrounding ecosystem. To this end, however, differences in ‘knowing’ have problematized the uptake of design practice in the sector, uncovering the emerging need for public sector organizations to open up their boundaries to different forms of support and knowledge, and to develop interactive learning partnerships with other actors in the system to achieve results that are valued by citizens. This will require them to build the capacity to continuously change to survive. Central to the discussion on organizational change lies the organization’s capacity to act and learn. The learning process underpinning the design process has been an object of study in literature. The models namely illustrate the correlation between Kolb’s experiential learning framework and the iterative cycles in design. While they effectively capture the learning processes occurring during the design process, they fail to capture the transfer of the learning outcomes into the organization (if this happens at all), which is important for understanding any links between design practice and organizational change. The current research builds off these models and investigates how to transfer the learning outcomes of the design process back to

the organization. This is done by investigating the design process as a double-loop learning process, using Argyris and Schön’s model, focusing on the aspect of meta-learning. In this context, the dissertation explores the role of design in public sector innovation efforts and the overall impact of these experiments in terms of organizational change. In doing so, the research explores how and if the knowledge and outcomes of the design process survive the end of the experiment and what, if any, impact they have on the organization’s capacity to act in the layered realities shaping innovation in the sector. The dissertation, therefore, theorizes on how design acts as a medium for external knowledge to be

recognized, valued, assimilated and applied in the working practices of public sector organizations, and in the process: (1) enhance its capacity for future innovations; and (2) provide a learning mechanism and environment for continuous change. The research focused on two primary questions: **RQ1:** What is the relationship between design practice and organizational change in public sector organizations? **RQ2:** How can design advance the innovation capacity of public sector organizations? The empirical research involved desk analysis of 15 cases of design for public sector innovation across Europe. From the initial short list of 15 cases, 5 were selected for use

as in-depth, innovation biographies. The thesis then presents insights stemming from a comparative analysis of the cases. The two main contributions of the research are the following frameworks. The Triple Diamond Design Process for Organizational Transformation clearly builds off the double diamond by adding a third diamond encouraging designers to leave artifacts that encode the knowledge into the organization. In doing so, they give form to the experiential architecture of the organization’s emerging culture: embodying how it is perceived, felt, understood and ultimately known. The Design-based Learning Framework for Public Value Creation and Organizational Transformation includes not only the first model but also Moore’s strategic triangle. We can see design culture as a product of the process, on both the actor and organizational level, while also fueling iterations of further use in different projects and fields of application. What was observed was the role of design practice in preparing contexts to receive innovation through the development of a (new) culture of design and the criticality of participation in transferring design knowledge outcomes into the organization.

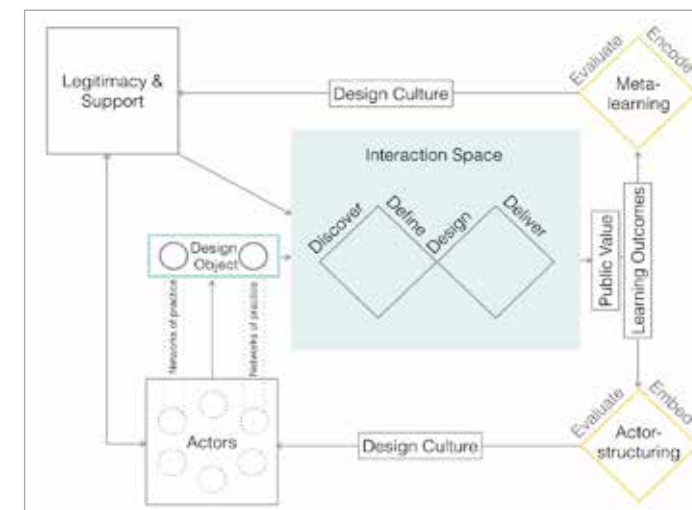


Fig. 1 - Design-based Learning Framework for Public Value Creation and Organizational Transformation

# INTERACTIVE COMMUNICATION TOOLS FOR ACTIVE LEARNING

## GUIDELINES FOR THE ADOPTION OF TECHNOLOGICAL COMMUNICATION TOOLS FOR HYBRID LEARNING PROCESSES

Andrea Maciaracina - Supervisor: Luisa Collina

Global competition has led universities to review their actions concerning learning environments, focussing towards technological innovation and experimentation with active learning strategies. At the heart of this research is the relationship between space, pedagogy and technology, with an important focus on the latter. Technology, as understood by the writer, is the connecting element that relates to all the contexts analysed. The research is inspired by a broader project conducted in the Department of Design, within the processes and projects of innovation that the Politecnico di Milano has carried out in recent decades. The Politecnico has decided to launch a project for the design of innovative and technological classrooms able to support new active learning methods. The research, which began with a focus on physical spatial constants, was completed in a historic period marked by the global health emergency of the COVID-19 pandemic. This emergency has given life to a comparison between two contexts of comprehension, the on-site (physical) and the online (digital).

The need for academic institutions to change their physical spaces in order to compete and attract more and more students is a subject of discussion, even if the connections between the design and use of space in higher education, and the outcomes of teaching, learning and

research are not well understood. The “learning experience” will then be further investigated and supported by a review of the works of principal authors in the field. There is an increasing need to adapt learning spaces to suit new theories and learning approaches, to the extent that teaching places are already changing to reach and embrace new theories of learning. The central of this change is the relationship between space, pedagogy and technology. Space becomes vital with its flexibility and capacity to quickly transform, as well as its capacity to integrate educational technologies. It is crucial in order to understand what are the innovative dynamics that can be implemented concerning one of the three elements that become pivotal for this research, that is technology. Therefore, the need arises for new relationships between the technologies present within the physical space and the personal

technologies owned by users. This tripolar system should make a shift to a four-element system, underlying the central role of the user, that becomes “pivotal” and the core of innovative learning environments.

In a learning environment, users are players and directors, facilitators and sources of resistance, students and teachers, learners and tutors. Active learning can create better alliances among users. It has as its core the active role of the users and the role of the teacher as a director and a facilitator; therefore, the teacher must be able to design and construct active learning activities.

The research activities developed in this thesis aim to compare on-site and online learning contexts, creating dualisms and parallels in the search for information and data. This includes the analysis of case studies of innovative learning environments; the design of innovative learning

spaces for the Politecnico di Milano; an evaluation of possible new policies and hybrid learning processes; the monitoring of an active learning physical environment; the evaluation of the experience of distance learning at the Politecnico di Milano; and verification of the use of technologies in a context of stress.

A choice of 12 technologies has been made for the implementation of subsequent project activities. The choice was made on the basis of the research actions undertaken. Technology can be enhanced and inserted into a space, triggering collaborative dynamics and the tools that can be used as personal technologies or in close synergy with personal devices are recognised as the most effective.

The research strongly demonstrates the necessity for some rules regarding the correct selection of the educational technologies affecting the learning activities. Users must be

able to select the most appropriate technologies concerning the type of learning clusters implemented. The final output of the research is the conception of a tool, (supported by design-oriented scenarios and the creation of plausible innovative learning contexts) conceived by teachers for the design of the construction of courses and didactic activities enriched by technologies. The tool offered and tested with Politecnico’s teachers strives to answer needs and challenges acknowledged during an emergency concerning the construction of hybrid learning processes.

The application of the tool is supported by a manual of rules including information both methodological (derived from research) and instrumental (derived from the experimentation of the instrument), and built based on experiences with users.

The research contributes to knowledge by proposing a description of the connection between pedagogy, space and technology, with the insertion of the user as the fourth element. It thus offers a conceptualisation of technologies for innovative learning environments with the creation of a grid of technologies for active approaches. It reflects deeply on the comparison between the on-site and online learning environments with a focus on a stressful context, offering and discussing a learning design tool to support teachers. The tool can trigger considerations and reflections by creating new hybrid processes where the physical and digital setting in which users perform their work, including tools, documents and other devices, coexist together to create an innovative learning environment.

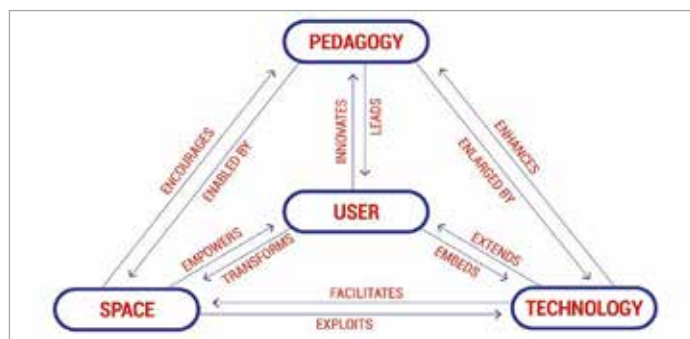


Fig. 1 - PSTU Framework, the evolution of PST Framework

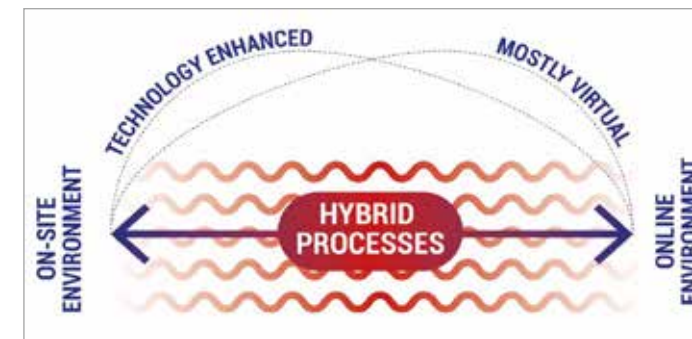


Fig. 2 - Spectrum of hybrid learning process

# DESIGN-ORIENTED EVIDENCE-BASED INVESTIGATION & MODELLING OF UX WITH INTERACTIVE ARTEFACTS

**Alessandra Mazzola - Supervisor: Margherita Pillan**

In a context of rapid growth of technological innovation, in which interactive systems are getting more and more complex, the improvement of the evaluation methodologies represents an actual and relevant topic for who designs.

In this thesis, I investigate the inclusion of evidence-based techniques in the development of interactive systems, as a resource for the better understanding of UX (User Experience).

The goal is to integrate traditional qualitative design techniques with instruments measuring biological parameters to reveal reactions and engagement, in order to obtain a richer understanding of users' behaviour, emotional and attentional responses, and decision making mechanisms, based on unconscious processes.

This research focuses on the use of eye movements analysis as a tool for interpreting human behaviour within the context of UX design. My aim is to understand how eye tracking analysis can be useful to the design of interactive systems, and how to apply this knowledge to industrial innovation processes.

In this thesis I identify the design framework in which to make experimentation, including usability, UCD (User Centred Design) and perceived experience. The measurement of unconscious physiological manifestations gives

indications about how people react, evaluate and filter interaction stimuli that can be influenced by many factors. My aim is to recognize the impact of the different variables, and provide a complete and correct representation of actual wishes and behaviours of individuals.

In this thesis, the accuracy and systematic of the scientific method, and the sensitivity of the typical qualitative tools of human sciences coexist: my approach combines the standardization of measurement criteria in the conditions of experiments with users, and a high attention to the design issues.

My outcomes are a set of guidelines, indications and principles that can orient the design strategies during the development, optimization and assessment of existing and new interactive solutions. These multi-purpose guidelines are extremely versatile, and suitable to various ambits, extending from design, to marketing, to the IT sector. The methodology I developed during my PhD consists in a knowledge framework and a repeatable workflow for the evidence-based investigations of UX, that supports researchers on experience and practitioners in the design oriented evaluation experiments. The methodology includes different research steps in order to gather a complete evaluation, specifically tailored to the typology of test to be performed. The testing flow

produces guidelines, key questions, synthetic indicators, verification tools and procedures for each phase. The research points out the proper use of eye tracking analysis in coordination with other measurements for the analysis of the factors impacting UX in heterogeneous conditions: in the use of innovative design solutions including different interaction levels; in complex actions, which require specific expertise and involve a certain security risk – like driving or piloting.

The application of my approach in different fields has validated and assessed my outcomes, pointing out limits and opportunities of the tools, and providing a valuable contribution in eliciting design industrial innovation perspectives within companies and institutions.

The research methodology bases on a critical and iterative research approach, and includes two main phases: the *exploratory* and the *experimental* phase. During the *exploratory phase*, I sketched the state-of-the art in design research, focusing on those theories and approaches that put the final users of innovative solutions at the core of the process. In this stage I defined the macro-areas of investigation, including different disciplines, extending from design, psychology, experimental procedures, and eye tracking methodology: “How

*do evidence-based investigation enter the design process?”; “How are evidence-based investigations applied in UX design?”.* As I refined my research, I focused on the application of eye movements analysis to the evaluation of interactive products and systems, in order to address my research questions: “*How effective evaluations can be performed?”.*

During the *experimental* phase I've been working on test and iteration, focusing on the typologies of engagement produced by the UX with interactive artefacts: “*What can evidence-based investigations reveal about the experience with such artefacts?”.* Combining different design objectives, qualitative and quantitative methods, I explored some concrete applications of evidence-based techniques, and their inclusion in different phases of the design process. I discussed different testing protocols I developed during the PhD path, in order to provide answer to further research questions: “*How can we engage subjects in a meaningful and realistic experience during the tests?”; “How can we understand the variety of attitudes and reactions exhibited by the subjects involved in the experiments?”.* I illustrated the developed UX testing methodology, which defines on-purpose intervention strategies including different phases: from the definition of the objectives, to the

development of protocols, to the design of the experiments. For each research phase, I identified research actions, questions and needs. Along the whole PhD path, I carried out tests, iterations, and validation of the testing methodology, through different experiments, and several didactic and dissemination activities. My research and professional context allowed me to apply the methodology in several design projects and study fields at the Ph.E.E.L. (Physiology, Emotions, and Experience) Laboratory. The cooperation with companies operating in different ambits – such as automotive, the IT sector, entertainment, advertisement, web and TV content providers, GDO, and marketing – enabled to a constant refinement and validation of design evaluations strategies, increasing my testing practices both in rigour and adaptability, and providing a contribution to the work-in-progress of this emerging and promising field of study.

The dissertation is structured in 5 chapters. In Chapter 1 I introduce and present the research, describing my research methodology and path, the aims, objectives, and innovation of my research, and the professional context I'm part of. In Chapter 2 I make an overview of the design theories and methods that pay attention to the final users of the innovative solutions, in which my research collocates,

focusing on those that make use of the experimental approach. I describe physiological, behavioural, and psychological aspects of eye movements, in order to identify a model that connect eye movements to the underlying cognitive processes, the measurement techniques, and the main fields of application of eye tracking methodology. Chapters 3 and 4 are the very heart of the research: in Chapter 3 I present and discuss the developed testing methodology; this rigorous but flexible workflow aims to design and implement effective testing approaches, from the protocol development to the production of design insights. In Chapter 4 I report some privileged fields of application of the methodology, through the description of specific case studies that are part of the huge experimental activities I've performed during the PhD path. In Chapter 5 I revisit the larger picture, and discuss limits and potentialities of my research.

# DESIGN FOR HYBRID MATERIAL SYSTEMS. A MATERIAL AUGMENTATION FRAMEWORK FOR MEANINGFUL EXPERIENCES.

Stefano Parisi - Supervisor: Valentina Rognoli

The PhD research is focused on the emerging field of Hybrid Material Systems, i.e., material-based systems combining inactive materials, smart material components, and embedded sensing, computing, and actuating technologies. They arise as potential enablers of meaningful dynamic and interactive experiences as tangible interfaces in a diversity of applications, from smart objects to wearable devices and interactive environments. However, the design space lacks a systematised set of directions and a roadmap to approach the specific requirements of these materials.

Although designers and labs worldwide are experimenting with these materials, the results are still underdeveloped prototypes and experimental demonstrators. Technological limitations related to the seamless integration of components in the materials still exist, but in a future perspective will be solved with the increasing miniaturisation of components. For this reason, the research adopts a speculative dimension. Besides technological aspects, one emerging and crucial challenge is identifying meaningful and purposeful ways for materials augmentation. Indeed, these novel materials imply complex and novel experiences that designers need to comprehend and master to design or integrate them into applications that foster people's appreciation and

acceptance. Materials Experience appears as a critical notion for understanding, augmentation, and integration into a concept artefact. The research is positioned at the intersection of design, new materials, and interaction. However, the research's focal point is material, instead of technology, as the aim is achieving a material augmentation, instead of technology integration, therefore starting from the material. For this reason, the research considers a material-centred approach focused on the physical and tangible components of materials, technologies, and processes instead of the digital ones, e.g., software. The research focuses on Hybrid Material Systems based on alternative bio-based materials with embedded electronics and smart components, which offers great potential as a raw material for tinkering and iterative experimentation and responding to the demand for more sustainable materials.

The purpose of the research is to develop a methodological framework for design practitioners and students to understand and design for Hybrid Material Systems, enabling material augmentation for meaningful experiences. Therefore, the central question is: the central question is: what is a proper framework to design for Hybrid Material Systems? The principal question is framed into sub-questions to find the necessary elements

building the framework: 1) What are such materials, their components, and categories, 2) What are the relations between their layers? 3) What are the fabrication processes and techniques for materials augmentation? 4) What are the design tools and methods to ideate and support them? 5) What are the meaningful experiential patterns they enable and imply for users and designers? 6) What might be the potential application and societal implications?

To answer those questions and ultimately build the framework, a set of studies based on interviews, questionnaires, and observations, preceded by preliminary studies and case studies, has been performed,



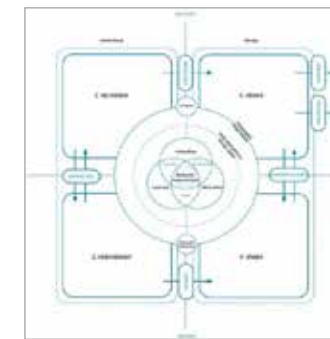
**Fig. 1 - A case study: exploratory workshop with participants aiming to observe the critical experiential patterns enabled and implied by Transformative Paper, 2019. Sample courtesy of Florian Hundt and Dr. Markus Holzabach, Institute for Material Design at HfG Offenbach, in collaboration with BMW.**

using a mixed-methods design mainly based on qualitative data. A systematic literature review was conducted to identify the State of the Art. Since the research is at the intersection of Design, Materials and Manufacturing, and Human-Computer Interaction, literature from the three areas has been reviewed. Part of the literature review focuses on identifying methods and tools to Design (to ideate and prototype) with and for Hybrid Material Systems used in education and practice. Literature was an iterative and progressive effort that helped identify gaps in the research area and craft and refine the research questions. Preliminary studies, like best examples collection and classification, aim to propose a first framing and mapping



**Fig. 2 - Elements of the toolkit: Concept Canvas and Scenario boards used in a design workshop addressed to students as tools to ideate Hybrid Material Systems concepts integrated into a context. Design workshop 'NautiCS Materials' in the Master of Yacht Design, XVI edition, Poli.Design, 2018.**

of Hybrid Material Systems, resulting in defining an Ontology (what Hybrid Material Systems are and how they are defined), Anatomy (what the components of Hybrid Material Systems and their relations are), and Taxonomy (what the categories of Hybrid Material Systems are). Two case studies follow using a qualitative observation and analysis protocol based on the model of Materials Experience to unfold the critical experiential pattern and issues enabled and implied by Hybrid Material Systems, by self-observation and participants observation through a workshop (Fig. 1). Finally, Research-through-Design has been applied through design workshops with students and personal experimentation, testing tools, methods, and contents,



**Fig. 3 - A visualisation of the methodological Framework to Design for Hybrid Material Systems through material augmentation for meaningful experiences, with its foundational elements at the core of the model, surrounded by the four blocks characterised by their relations and results. 2020.**

and producing concepts, prototypes, samples and observations (Fig. 2).

The resulting guidelines, tools, and methods have been progressively tested and updated through the workshops. The research outcomes are a body of knowledge around the topic, formalised in a methodological Framework to Design for Hybrid Material Systems through material augmentation for meaningful experiences (Fig. 3). This framework is a modular blueprint consisting of four phases (Introduce, Experiment, Shape, and Ideate) with supporting tools, recommendations, and methods. It can be used both in practice and the education of designers, aiming to understand Hybrid Material Systems and design for them. The research's methodological framework's foundational inputs are materials and their relations with technologies and fabrication techniques, scenarios, and materials experiences, allowing meaningful experiences through establishing a multi-disciplinary design space. This contributes to informing and updating the current theoretical and methodological framework for materials design, considering methods, tools, and enablement for practice and education, including practical implication in formalising novel teaching experiences and updating materials libraries.



## A CONVERSATION ON CONVERSATIONAL SMART PRODUCTS: HOW THE DIFFUSION OF CONVERSATIONAL INTERFACES IMPACTS PRODUCTS AND THE DESIGN PRACTICE

Ilaria Vitali - Supervisor: Venanzio Arquilla

Since the birth of smart speakers and with the spread of voice assistants such as Alexa, Google Assistant, and Siri, we are witnessing the diffusion of domestic smart products able to communicate through text and voice. The thesis defines Conversational Smart Products (or ConvSP) these novel products that incorporate and embody Conversational User Interfaces (CUI) in the form of Chatbots, Voice User Interfaces, Virtual Personal Assistants, and Embodied Conversational Agents. CUIs are gaining importance within the field of Human-Computer Interaction, and there is a drive to formalize Conversational UX Design as a new UX-design subfield and provide immediate training for current and future designers. However, the literature review revealed a lack of product-related investigations and a need for explorations on how to integrate CUIs into domestic products. Current studies only consider robots and smart speakers, and there is a lack of resources, guidelines, insights, and design tools concerning the development of ConvSP and the role of designers in the process. The thesis approaches this topic with five broad literature review chapters, that provide the readers with technological background knowledge about IoT, AI, Smart Products design, CUI and Conversational design, and progressively outline the research gap and questions.

The thesis' research question is twofold: "how do conversational interfaces impact products and design practice?" To address the question, four main activities were carried out. (Activity 1) A multiple case study analysis on 40 ConvSP samples that led to a descriptive analysis framework and categorization of ConvSP, with product-related insights. (Activity 2) A Conversational Survey that employed a chatbot agent to collect 175 design students' perspectives, revealing a desire for tech literacy, and insights on the user experience and shape evaluation of ConvSP. (Activity 3) Twelve "Expert Conversations" interviews with researchers and experienced professionals, that allowed to collect direct insights on the conversational design process and frame designers' role and skills. (Activity 4) Practical Design Activities

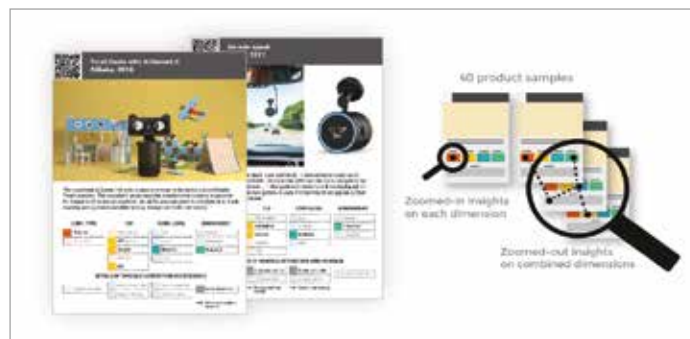


Fig. 1 - Analyzing Conversational Smart Products with an original framework

and an internship experience at the Dutch agency Robocopy Conversational Academy applied the findings of previous activities and allowed to develop original design tools. The research results frame how CUIs impact products in terms of embodiment, shape, and tangibility, and how CUIs impact design practice in terms of relevance, role, and designer skills. The thesis opens the way to an informed reflection of ConvSP by identifying relevant dimensions, insights on the design process, and initial tools used for didactic and professional activities. The main contributions of the thesis can be summarized in five points. (1) Proposes a descriptive analysis framework, grounded in the literature about CUI & social robots, that can be used to analyze and describe physical products that integrate CUIs. The multiple case studies analysis (Activity 1) applied this framework to

categorize ConvSP and collect insights on their shape, CUI embodiment, and tangible aspects of interaction and feedback. (2) Offers a classification of five different types of Conversational Smart products and delves into some of the critical issues in their design. Since ConvSP are not a homogeneous category of products, the classification offers a first way to design them with more awareness. (3) Defines 8 dimensions useful to guide the ConvSP design process. There are three strategic dimensions (Conversation purpose and desirability, Conversational level, Embodiment necessity), and five design dimensions (Visibility of agent's presence, Anthropomorphic or machine-like shapes, Complexity of listening and talking feedback, Need for physical controls, Branding value of the CUI) (4) Discusses the process of CUI and ConvSP design, including insights

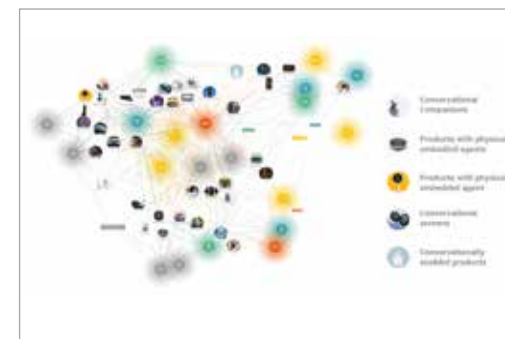


Fig. 2 - Classification of 5 types of ConvSP

into the current process and phases, highlighting what are the roles, activities, and skills expected from designers in this field. (5) Provides design tools that can be used for didactic and professional activities. Those are the material for a "Conversational Apprentice" online course to learn the basics of CUI and Conversational Design; a "Conversational Strategy Canvas" to discuss a conversational project from the start; a "Conversational Smart Product Idea Canvas" to structure a ConvSP concept; a set of 79 "Knowledge cards" with relevant notions for the design of CUI & ConvSP.



Fig. 3 - Design tools to support the development of CUI and ConvSP

## IMMERSIVE LEARNING FOR BASIC DESIGN: AN INNOVATIVE APPROACH BASED ON SENSORY AND NARRATIVE

Liu Yuan - Supervisor: Dina Riccò

Co-supervisor: Daniela Anna Calabi

### Keywords:

*Innovative teaching; Basic design; Immersive learning; Communication design; Synaesthesia; Virtual learning environment; Distance learning; E-learning; Online learning; Web-conferencing tools*

This research addresses the theoretical approach to immersive learning within design education based on the re-definition of literature concepts and broad secondary research among case studies. Technologies raise up new possibilities for design education, including innovative teaching methods, models for learning, and tools to teach. Students are also more involved in learning activities as contributors, which supports the trend of constructivist learning. As a fundamental means of building design capability, the need for innovatively teaching design has become essential.

The problems remain, as virtual technologies have their limitations regarding visualizing abstract concepts. The pedagogical approach of immersion, usually identifies as immersive learning/teaching, has been understood as an innovative method to teach, especially within the studies of medical treatment, military and safety training.

That requires us to consider the subjective expression of abstract

content while applying new technology to real teaching activities, which is also the main theoretical approach regarding to this thesis. Basic design is both the starting point and the main purpose, although it does not appear much in the final results, the urge to build immersive experience with “sensory” and “narrative” is under the specific context of basic design.

It is possible to answer other design disciplines under the sufficient simulation of the real scenes, yet an abstract environment is essential for basic design learning.

The main hypothesis of this research is to understand immersive learning as an innovative method to teach basic design. The reason for its remarkability is twofold: it has great potential to enhance the effectiveness of learning and support virtual narratives, and it aids in transforming learning from visual communication to multisensory, enriching basic design both through interactivity and learning content. The main secondary research relies on the sensory realization of immersive tools, along with the didactic framework of virtual learning and tasks. The essential research question relates to how to produce a didactic framework which supports basic design within the virtual environment.

To answer these questions, the

present study proposes a theoretical framework, starting with redefining the concepts of “immersion” and “presence”, to understand the experience of immersion from a cognitive perspective. First, this work categorizes the factors of presence into a three-dimensional framework that includes “personal”, “social” and “environmental”. Second, we move on to the secondary research to revise the theoretical concepts including two groups of case studies. This also produces related methodologies for establishing an immersive didactic environment. The first group of case studies includes 24 spatial virtual exhibitions, while the second group of case studies includes 14 scientific learning approaches. The current study categorizes four typologies of immersion and addresses related factors of presence to support achieving different types and degrees of immersion. Two in-class models are presented, namely: behavior correction and free exploration.

Further, this thesis divides the practical approaches of virtual learning into two parts for discussing: spatial virtual learning like CAVE, and the online virtual classroom based on distance learning. This approach considers the impact of COVID-19 pandemic to envisage the possibility of immersion for distance learning. This dissertation classifies and analyzes existing online tools

and offers suggestions of how to transform the immersive framework with them as a means to support both synchronous and asynchronous learning. To visualize the theoretical approaches, we propose the idea of an online platform, as it is able to carry large amounts of media content, in the meantime maintain open access to new approaches. We introduce literature and case studies through browsing videos and text introduction. Web-based course framing tools, which could support the collection of interactive components, are presented as heuristic tools for structuring the immersive learning experience for instructors and users. What we pursue is not the meaning of immersion under the online virtual dialogue, but a discussion of the possibility of transforming spatial immersive teaching with online tools. This part of research is still in the early stages, but we believe it has great potential and value for subsequent divergences.

As the research has been conducted from a design perspective, the role of design appears on several demands. First of all, design plays an essential role to build sensory narrative among the determinants of cognitive immersion. It is mainly reflected in several components: sensory realism; way of interaction; synthetic sensory stimuli and media characteristic. Design as both the

method to balance immersive factors and the means to build narrative context, made attempt to lay the basis for developing a theory of immersive learning, rather than technological displays and tools as usual. Secondly, the design of didactic activities means to understand the virtual learning addressed from design approach, also brings new possibilities to innovative teaching. The primary research in the basic design field largely relies on the interventions of learning methods, while this research bridges the gap between technology and design activities. Although the teaching/learning models based on spatial environment (CAVE) and distance learning (Online tools) still remain in the theoretical stage, they provide the possibility to construct a diversified educational narrative and environment, also bring ideas for the educational design spaces in the future.

To bridge the gap between design education and virtual technology is rather unusual. That limits the beneficials of virtual technology, while highly realistic simulations, low cost for damage control, and the flexibility of virtual dialogue remain the core beneficial. We consider the involvement of virtual tools based on the demand of sensory and synaesthetic training in basic design, which has been studied for decades, yet the teaching methods and tools

still rely heavily on traditional models. It appears to be a challenge for both designers and educators, as basic design builds the fundamental qualities to lead a design activity.

To sum up, the main approach of this research is to frame the theoretical background of how to use immersion for basic design learning. This research is relatively advanced. It discusses a new topic between immersion and the suitability of design education, leading to two primary limitations. The first is that framing the theoretical parts cost much more time than we assumed, and we will not have enough time to run some experiments and put them into the CAVE. The second point is that, out of consideration for COVID-19 pandemic, we have combined the previous immersive framework and network tools and explored existing tools as a means to achieve distance immersion. These two points can be considered as the future works.

# UNVEILING AND ACTIVATING THE TEXTILE HERITAGE IN CHINA, FROM 'UNCERTAIN HERITAGE' TO THE SHARING COMMUNITY

Yang Yuxin - Supervisor: Eleonora Lupo

Co-supervisor: Federica Vacca

This research explores the Chinese textile heritage using a design-based research approach to illustrate the novel paradigms that can promote the value of this heritage and empower the related actors and stakeholders. Since the promulgation of the 'Regulations on Protection of Traditional Arts and Crafts' in 1997, China began paying the attention to preserving and reviving traditional craftsmanship. The country released four batches of national intangible cultural heritage lists in 2006, 2008, 2011 and 2014, respectively, and officially recognised textile heritage as an individual category of intangible cultural heritage in 2016. At the same time, the value of textile heritage is gradually being realised by the public and has attracted interest in the design field. The emergence of this trend relies upon the notion that tangible evidence of a textile heritage can portray a specific aesthetic characteristic and describe a particular cultural history. Meanwhile, the intangible values of cultural identity and traditional know-how that the craftspeople represent are as important as the heritage artefacts they produce.

In a cultural heritage activation project, design can inject new value and meaning into a heritage and make it more accessible in a contemporary social context. In addition to the artistic and aesthetic contribution of design, using

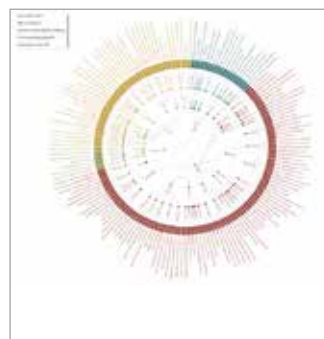
participatory design can strengthen the sustainable development of a heritage community and the activation of traditional craftsmanship. With rising global uncertainties, many textile craftspeople, alongside other traditional artisans and textile heritage communities, have struggled to adapt to globalisation, mass production, environmental and climatic pressures, social conditions, and changes in cultural preferences. In China, despite top-down policy implementations and design interventions, textile heritage and its meaning to the heritage community remain under threat; the likelihood of younger generations inheriting this history is diminishing. Moreover, due to the late recognition of textiles as a heritage category, there is a need to re-organise and evaluate the entire Chinese textile heritage system.

Based on this context, this research has applied the concept of uncertain heritage to the example of Chinese textile heritage, using secondary research and a case study as a critical research method to respond to the complexity of the research focus. The primary research methods of interviews and surveys also support the study in collecting and analysing the respondents' feedback regarding participatory design.

The research offers a holistic understanding of China's textile heritage and provides a design-based criterion to identify and alleviate the

uncertainties of textile heritage. The three contributions made by this research are introduced in the PhD dissertation.

Contribution I: Re-organising Chinese textile heritage as a whole system. In the initial stage of this research, the work of unveiling China's textile heritage was essential. Although this research is based on China's national intangible cultural heritage, the official textile ICH office was formally established in 2016; as such, this research needed to re-organise Chinese national textile heritage as a whole. Based on the literature review and contextual research, this research organised, summarised, and translated 160 of China's national textile heritage items in Chapter 2.



**Fig. 1 - Full list of 160 national Chinese textile heritage.**  
Figure source: Analysed and designed by the author.  
For detailed information, please reference the link of <https://preview.flourish.studio/3942960/Y5bEaNiinT9ORLQet6NiiyLYCYhj7qa1Nf8e-MVlyOQBFvd4CwLQqRJONcAoMV66/>.

The study also classified the heritage items based on five technique types and the four areas of China.

Contribution II: A new criteria for analysing textile heritage. In order to understand and explain the current status of traditional craftsmanship and China's textile heritage, this research adopted the concept of 'uncertain heritage'. Chapter 1 discussed eight valuing parameters (cultural, social, geographical, temporal, economic, aesthetic, technical and intellectual) to describe the uncertain and certain heritage values of traditional arts and crafts based on a review of this notion. A set of evaluation criteria was subsequently generated in Chapter 3. These evaluation criteria were based on a study of the definition of Chinese and international regulations and policies, an exploration of value recognition with the goal of design activation, and an introduction of

existing measurement methods on the basis of qualitative research. Contribution III: A design methodology from unveiling to activating. As the primary outcome of this research, a design-driven framework aimed at creating a shared community with different activation strategies and approaches that are capable of catalysing the involved and potential actors and stakeholders. After establishing the evaluation system and conducting an in-depth analysis of 16 case studies, this research designed a methodology, from unveiling to activating, for China's textile heritage based on the design strategies and design-driven methods. The methodology aims to consider the uncertainty of textile intangible cultural heritage on different levels based on comprehensive and specialised approaches. Various strategies are applied to textile intangible cultural heritage in different

active states, and through the distinct goals of each strategy, the textile heritage carries out the corresponding unveiling or activating actions.



**Fig. 2 - The design-driven framework.**  
Figure source: Analysed and designed by the author.