

EMERGING MATERIALS & TECHNOLOGIES

New approaches in Design Teaching Methods
on four exemplified areas



edited by Venere Ferraro, Anke Pasold



Direction: Silvia Piardi

Scientific Board:

**Alessandro Biamonti, Alba Cappellieri, Mauro Ceconello,
Claudio Germak, Ezio Manzini, Carlo Martino, Francesca Tosi,
Mario Piazza, Promil Pande, Angelica Ponzio, Zang Yingchun**

The Design International series is born in 2017 as a cultural place for the sharing of ideas and experiences coming from the different fields of design research, becoming a place in which to discovering the wealth and variety of design, where different hypotheses and different answers have been presented, drawing up a fresh map of research in international design, with a specific focus on Italian design.

Different areas have been investigated through the books edited in these years, and other will be explored in the new proposals.

The Scientific Board, composed by experts in fashion, interior, graphic, communication, product and industrial, service and social innovation design, interaction and emotional design, guarantee the high level of the accepted books. After the first selection by the Scientific Board, the proposals are submitted to a double review by other international experts.



Il presente volume è pubblicato in open access, ossia il file dell'intero lavoro è liberamente scaricabile dalla piattaforma **FrancoAngeli Open Access** (<http://bit.ly/francoangeli-oa>).

FrancoAngeli Open Access è la piattaforma per pubblicare articoli e monografie, rispettando gli standard etici e qualitativi e la messa a disposizione dei contenuti ad accesso aperto. Oltre a garantire il deposito nei maggiori archivi e repository internazionali OA, la sua integrazione con tutto il ricco catalogo di riviste e collane FrancoAngeli massimizza la visibilità, favorisce facilità di ricerca per l'utente e possibilità di impatto per l'autore.

Per saperne di più:

http://www.francoangeli.it/come_publicare/publicare_19.asp

I lettori che desiderano informarsi sui libri e le riviste da noi pubblicati possono consultare il nostro sito Internet: www.francoangeli.it e iscriversi nella home page al servizio "Informatemi" per ricevere via e-mail le segnalazioni delle novità.

EMERGING MATERIALS & TECHNOLOGIES

New approaches in Design Teaching Methods
on four exemplified areas



edited by Venere Ferraro, Anke Pasold

D.I. **FRANCOANGELI** OPEN  ACCESS
DESIGN INTERNATIONAL



DATEMATS project (Knowledge & Technology Transfer of Emerging Materials & Technologies through a Design-Driven Approach Agreement Number: 600777-EPP-1-2018-1-IT-EPPKA2-KA) has been Co-funded by the Erasmus+ programme of the European Union. The European Commission support for the production of this leaflet does not constitute an endorsement of the contents which reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Copyright © 2020 by FrancoAngeli s.r.l., Milano, Italy.

This work, and each part thereof, is protected by copyright law and is published in this digital version under the license *Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International* (CC BY-NC-ND 4.0)

By downloading this work, the User accepts all the conditions of the license agreement for the work as stated and set out on the website

<https://creativecommons.org/licenses/by-nc-nd/4.0>

A Logical Framework for designing with and for Emerging Materials and Technologies (EM&Ts)

Stefano Parisi, Venere Ferraro

Introduction

This book aimed at giving an overview of the four exemplified areas of EM&Ts in term of meaning (what the four areas are), applications, teaching methods, gaps and potential solutions to be implemented in each EM&TS.

We presented the synthesis of the four EM&Ts highlighting similarities, differences for all of them, we gave an overview for each area in dedicated sections. We will now provide the setting up of a common and advanced method to teaching EM&Ts within HEIs, to create new professionals in young students, and to develop new guidelines and approach.

In this chapter authors will present the results of a hands-on Workshop held on October 2019 at Copenhagen School of Design and Technology (KEA) as part of DATEMATS project meeting.

The objective of the workshop was to detect all the information about the different EM&Ts approaches and methods used by each Higher Education Institutions as well as the European SMEs' needs in terms of issues and gaps related to EM&Ts knowledge transfers.

Experts coming from both Academia and SMEs shared the knowledge related to the literature review in current methods about EM&Ts, a survey to identify the gaps regarding EM&Ts between Academia and Industry, the identification of gaps, limits, and constraints related to EM&Ts teaching methods.

Through participatory sessions, participants carried out a proactive exchange of thoughts and knowledge to set the ground for the definition of the Contents of the new Design teaching Methods.

This chapter introduces the context of participatory workshops as a research method. Then, it describes the methodology applied for the setup and execution of the activities, the development of the toolkit based on canvases and frameworks, and for the collection and analysis of data.

Finally, the document presents the resulting Logical Framework as a universal and concise systematization of the items retrieved from the triangulation of the results emerged into the previous chapters, the use of the tools, and the participants' discussion in the workshop. In conclusion, limitations, implications, and further development of the Logical Framework and the related Transnational Workshop are discussed.

Participatory Workshop in Research

This chapter reports an Interdisciplinary Knowledge Sharing activity that took place during the Transnational meeting of the research project DATEMATS in Copenhagen, involving all the partners of the project and led by Design Department of Politecnico di Milano. The knowledge sharing activity consisted of the setting up of specific activities, such as co-design creative sessions for the sharing of the results related to company surveys, reports, best practices, methods and findings presented in the previous sections of the book.

The main findings have been formalized in a Logical Framework for an original teaching method that is used as a blueprint for setting the unique teaching method in the four EM&Ts area. To do so, a participatory workshop was carried out.

Participatory methods have been used from years in the context of Academic research (Creswell, 2012; MacDonald & Headlam, 2016), Educational Research (Creswell, 2009; Cohen, Manion, & Morrison, 2017), and specifically in Design Research and Practice (Sanders & Stappers, 2012).

In the landscape of Design Research (Sanders, 2006), a participatory mindset characterizes design researchers that are not only working and collaborating with people (i.e., users of a product or service), but involving them in all stages of the design development process, by co-creation practices, to help ensure that the designed product or service meets their needs (Sanders & Simons, 2009). A participatory approach to design research is characterized by the use of physical artefacts and tools, i.e., rationally designed devices that produce both tangible commodities and productive systems for intangible commodities (e.g., education, knowledge, or decisions) (Illich, 1973-75, via Sanders & Stappers, 2012). An example of the use of tools for participatory design applied in the educational context is the guidebook 'Design Thinking for Educators' (IDEO, 2012). In a participatory framework, tools and methods are used to stimulate creativity, and problem-definition and -solving capabilities, as a scaffold for collective creativity (Sanders & Stappers, 2012). Collective creativity is crucial to

solve wicked problems (Buchanan, 1992), i.e., the ones that are “difficult or impossible to solve because of incomplete, contradictory, complex interdependencies” (Rittel & Webber, 1973).

In the setting of participatory research, the format of the workshop arises as a method for qualitative research (Ahmed & Asraf, 2018; Ørngreen & Levinsen, 2017). Workshops provide an opportunity for researchers to identify and explore relevant factors in a domain, which are not evident to participants or researchers before the workshop process. Workshops are characterized by being events of a limited duration targeted to a group of participants, aiming to an outcome both for the organizers and the participants. Workshops are specifically designed to fulfil a pre-defined, though not predictable, purpose. Workshops encourage engagement through collaborative discussions and feedback between the facilitator and the participants (Ahmed & Asraf, 2018). Strategies and guidelines to organize and carry on a workshop properly are suggested by the literature (Chambers, 2002; MacDonald & Headlam, 2016).

Generally, workshops involve as participants a small group of people selected accordingly by a common domain, expertise, or interest, e.g., experts in the research field, users of products, or students. In particular, a workshop involving colleagues and project partners has the threefold aim of fulfilling participants’ expectations to achieve something related to their interests, fulfil a research purpose (Ørngreen & Levinsen, 2017), and knowledge sharing and alignment between the partners. In this particular type of workshop, the participation is characterized by a collaborative and collegiate modality. The researcher plays the complementary roles of the ‘clinician’, who focuses on participant needs, and the ethnographer’, who focuses on the research (Ørngreen & Levinsen, 2017). In the analysis of the results, the Design researcher works as a translator that translates insights, ideas, thoughts into a framework that inspires new design directions.

Based on this ground, a hands-on Workshop was set accordingly. Participants were divided into small teams (four participants per group), to encourage interaction and discussion. Groups had a heterogeneous composition of the members, i.e., from different organization involved in the project and countries, combining academic partners with non-academic ones (i.e. SMEs). A facilitator was in charge of introducing, explaining the activity and moved around the working tables to support the groups.

The hands-on Workshop

The setting and the performance of the participatory workshop needed an organized and clear synthesis of both literature review and the overview

of each area; in order to move forward the logical framework embracing them all, a poster named ‘Shared Ground’ describing and organizing in a graphical and concise way the common issues and aspects of the four EM&Ts was realized (Figure 1).

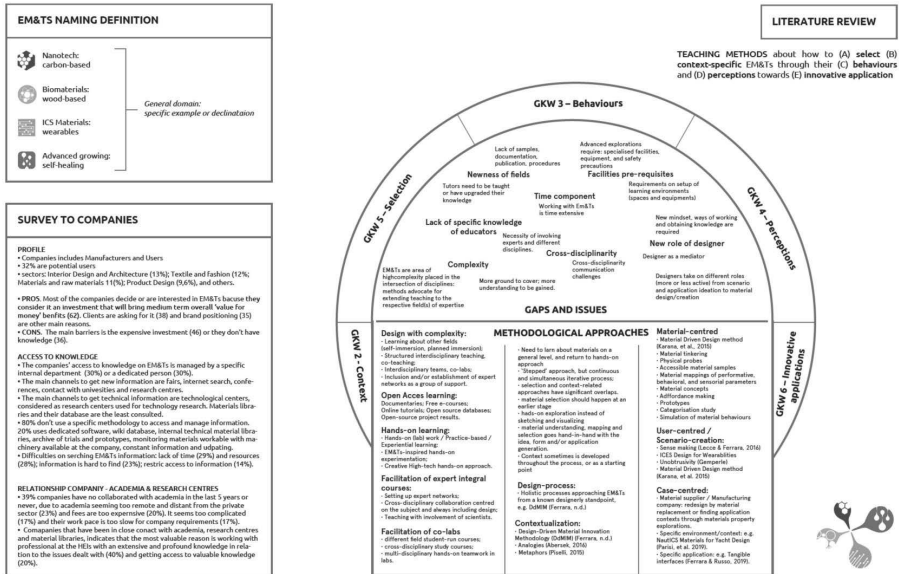


Fig. 1 - The 'shared ground' poster. Designed by Stefano Parisi, Politecnico di Milano

The poster has been designed by Design Department of Politecnico di Milano; structured on one page divided into different sections: one introductory section about the EM&Ts naming; one section about the highlights from the Survey to Companies interested in each EM&T; one section about the results from the Literature Review: common Gaps & Issues, and Methodological approaches, shared among the EM&Ts.

The poster was the starting point for discussion and setting of the canvases designed for the execution of the workshop and needed to be filled out by participants.

Indeed, after a discussion on the Shared Ground Canvas, separated canvases for each EM&Ts were elaborated: each canvas was provided with graphical elements, schemes, charts, and blank boxes to complete, supported by instructions and suggestions for each section. Rather than modules to complete in each section, the canvases were chosen for being

a flexible tool to facilitate thinking and debating; participants could decide to focus more on one canvas they found more significant than others, or to move from one canvas to another with no specific logical sequence. Also, participants were welcome to use any techniques to work on the canvases, e.g., writing notes, keywords, sentences, drawings, sketches, mapping. For each EM&T, four Canvases were produced for a total of sixteen having an identical structure and distribution of the contents:

1. ‘Sum up canvas’: a list of the single EM&T-specific gaps & issues from the literature review and the survey to companies (Figure 2). Also, it describes the role of the designer dealing with the EM&T area, as described in the literature review.

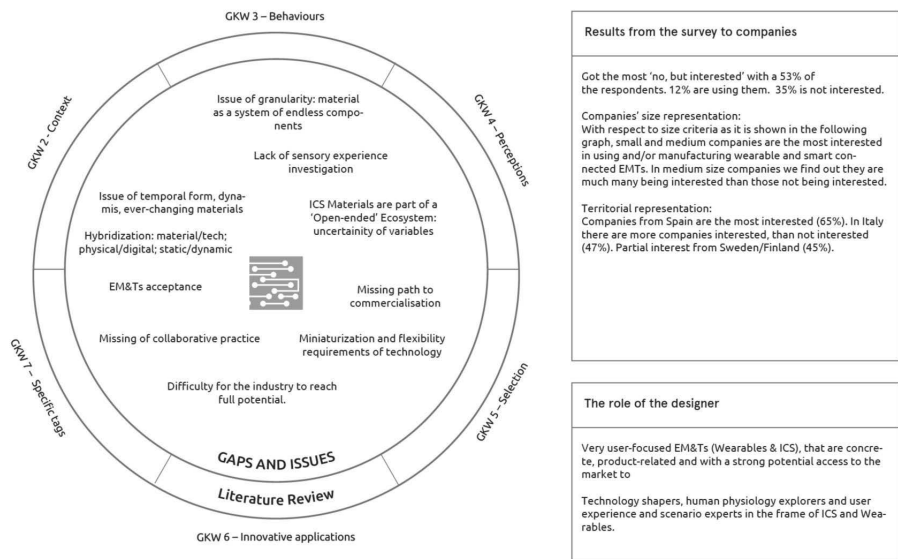


Fig. 2 - Example of The Sum Up Canvas for ICS Materials EM&Ts. Designed by Stefano Parisi, Politecnico di Milano

2. ‘The EM&T canvas’. The aim of this section was to identify the most relevant dimensions to describe the specific EM&T and position it on such aspects. This helps in characterizing the specific EM&T under a variety of lenses and perspectives, from the most technical and objective (e.g., price, performances, availability) to the most qualitative (e.g., self-communication, aesthetic values, authenticity). Also, it allows identifying criteria to compare and relate the different EM&Ts. In the canvas, participants were asked to identify some dimensions to posi-

tion the EM&T, using a set of scales (1-axes parallel charts): they were welcomed to propose values, polarities and optional intermediate positions on the scale, place the EM&T; but also visualize on the scale the current position, and the future or expected one. Some example scales with given values and polarities have been provided, e.g., the granularity of the EM&T (from nano to macro), the required technology (from low-tech to advanced), the availability (from low to high), the price (from cheap and expensive), technological readiness (from low to high). A blank box was also provided with the request to identify pillars that characterize the specific EM&Ts. Pillars might include approaches, mindset, methods, as well as tangible elements (Figure 3).

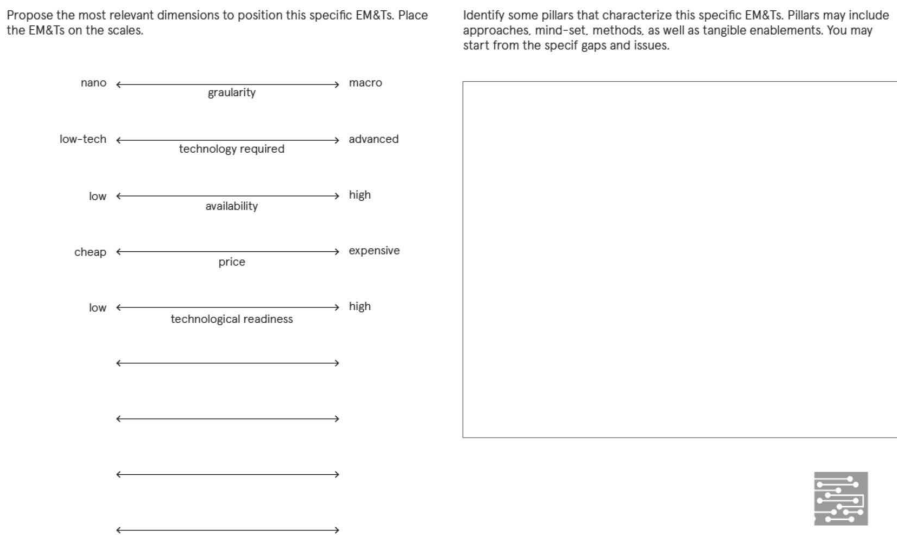


Fig. 3 - The EM&Ts Canvas. Designed by Stefano Parisi, Politecnico di Milano

3. ‘The role of the designer canvas.’ The aim of the section was to define the role of designers working in the specific EM&T and the kind of design process they apply (Figure 4).

Propose the most relevant dimensions to position the role of the designer working in this specific EM&Ts. Variations: you may visualize on the scale a current situation, and an expected one; you may name specific intermediate positions on the scale.

Use this space below to visualize an outline of the design process applicable in this specific EM&Ts. What is the starting point? What are the main steps? Are there any specific tools and methods that are required or suggested?

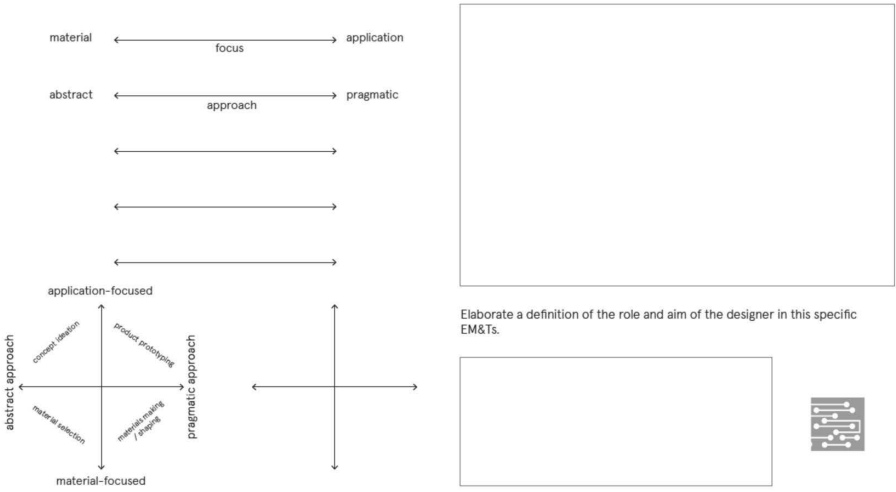


Fig. 4 - The role of the designer Canvas. Designed by Stefano Parisi, Politecnico di Milano

This plays a crucial role in determining the contents and formats of the DATEMATS unique teaching method. This can be achieved by identifying the most relevant dimensions to describe the role of the designer for the specific EM&T and position it on such aspects. Indeed, from the Literature Review a variety of roles and design tasks emerged in different EM&T (e.g., materials exploration, concept creator). This helps to characterize the designer activity and role under a variety of lenses and perspectives and to identify criteria to compare and relate the designers working in the different EM&Ts. A set of scales (1-axis charts) and cross-maps (double-axes charts) have been provided in order for participants to propose the most relevant dimensions to position the role of the designer working in this specific EM&Ts. Some example scales were presented, with given values and polarities, e.g., the focus (from the material to the application), the approach (from abstract to pragmatic). These example scales were intersected in an example cross-map, i.e., the value abstract/pragmatic approach crossing with the value application-/material-focuses identifying four areas in the quadrants: material selection, materials making, concept ideation, product prototyping. In addition, a blank box was provided with the request to visualize an outline of the design process to apply in this specific EM&T,

focusing on the starting point, the main steps, the required tools, and methods. Another blank box was added with the request to elaborate a definition of the role and aim of the designer in this specific EM&T.

4. ‘Cross-disciplinarity canvas’ (Figure 5). The aim of this canvas was to identify and name the intersecting disciplines framing the cross-disciplinarity for this specific EM&Ts. This activity will have a crucial role in determining contents, modules, teaching staff profiles, and other requisites in the formulation of the Datemats teaching method. The canvas provides a graphical scheme with intersecting bubbles representing the crossing disciplines working in the area, vaguely inspired by the Krebs Cycle of Creativity (Oxman, 2016). Participants were asked to identify the subjects and related practices and contents by filling the scheme. Then, they were asked to answer the following questions: how the cross-disciplinarity would affect the EM&T methodology set up, materials, and pre-requisites; What are the requirements to enable the cross-disciplinarity; Where to find resources and expertise.

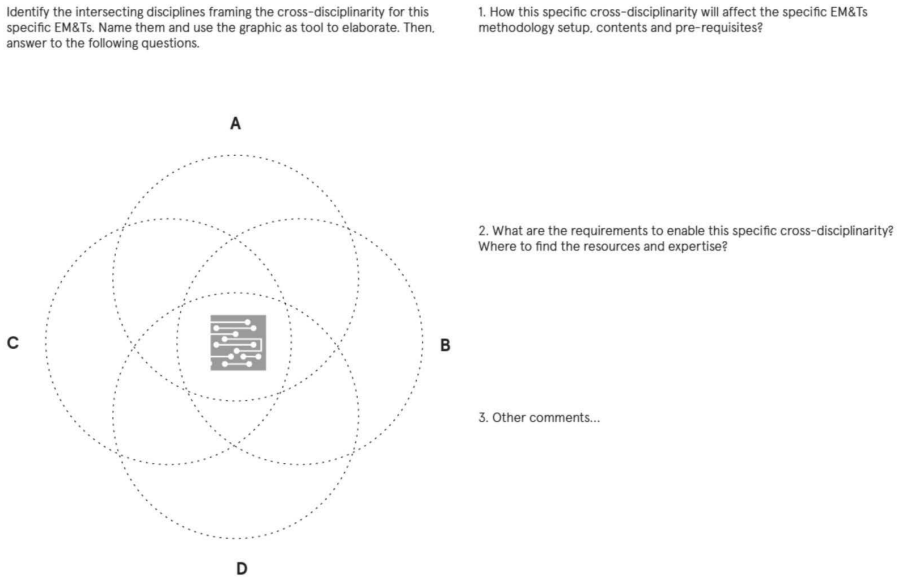


Fig. 5 - The cross disciplinarity Canvas. Designed by Stefano Parisi, Politecnico di Milano

The tools and activities were managed by researchers from Design Department of Politecnico di Milano (Figure 6). Participants were divided into small teams of four participants per group and the room was organ-

ized, exhibiting a set of samples of materials from each EM&T provided by the partners on four different tables. Therefore, each table was assigned to a specific EM&T.



Fig. 6 - Pictures portraying the workshop phases, from the explanation of the activities and tools, the use of the toolkit in small groups with the support of physical samples, the presentation of the results, followed by the collective discussion and the organization of the findings on a whiteboard. Pictures by Daniela Amandolese, Materially

Four copies (1 per group) of all the four canvases regarding each EM&T were displayed on the related table. In rotation, groups had to move from one table to another, discuss and fill empty canvases on 25 minutes turn, and then leave the filled canvases on the table and move to the next

one. At the end of the activity, participants were asked to verbalize their insights and opinions by presenting the results for each EM&Ts, 6 minutes for each EM&Ts. A 15 minutes collective discussion followed. A whiteboard was used by a facilitator to keep records and organize the most relevant points of the debate systematically. The activity took around 2 hours and a half, in total. One facilitator, from Design Department introduced the activity and moved around the working tables to support the groups. In addition, the facilitator had the role of checking the time and guarantee that the scheduling of the activity was respected.

Data collection was done by Politecnico di Milano by keeping all the filled canvases as a record, a tool for data collection and analysis. They were filled with notes, sketches, schemes containing opinions, and data generated by the groups' discussions on each EM&T. Also, audio-recording was used to collect data and opinions during the collective discussion and presentation for the results. The whiteboard used to record and organize the main relevant points of the debate was photographed and used for data collection. In addition, the facilitator took notes during the activity.

Collected data from all these sources have been analysed by Politecnico di Milano, producing transcripts of the audio tracks, and clustering relevant data on a digital wall. The obtained information has been organized in a graphical representation of the Logical Framework, considered as a blueprint for the development and implementation of the *unique teaching method*.

Towards the logical Framework

The Logical framework presents the common gaps and issues as well as the ones for the distinctive EM&Ts. In particular, it is worthy of mentioning the issues and gaps that might have a direct implication into the formulation of didactic contents and definition of the course structure such as the complexity and cross-disciplinarity of the field that leads to the need of experts from other disciplines and opening up a challenge about communication and languages to use; the newness of the field causing a lack of documentation and specific knowledge of educators; the need to identify and provide facilities and knowledge pre-requisites, and in particular guarantee safety and use low-cost equipment for didactic; the need to integrate tools and contents about the experience, intangible and sensorial qualities of materials, sustainability and environmental impact, commercialization and entrepreneurship.

Specifically, the ICS Materials EM&Ts area is characterized by the need for a holistic and hybrid approach considering material qualities & interactive behaviours, the physical & the digital, the system & the individual components, the technicalities & the experience. The Nanomaterials EM&Ts area is characterized by the need for specialized labs and high-cost equipment for experimenting, and the issue of scale and evidence of the technology. Both the areas share problematic lifecycle and environmental matters, controversial perception, and fluctuation in price and availability of the materials and techniques.

The Experimental Wood-based EM&Ts area is characterized by not aiming directly for real products or commercialization, which allows free ideation and ‘grazy’ experiments. The Advanced-growing EM&Ts area is characterized by a symbiotic relationship between the designer and the living material and the issue of ethics. Both areas share the issue of time needed for the material to grow and dry, which brings detachment from the intervention of the designer and the observation of the result. They share a recipe-based and hands-on approach that leads to endless possibilities in the experimentation with a low degree of repeatability and high-rate uncertainty and unreliability. Both are involved in the interplay between a scientific approach versus a phenomenological approach (Figure 7).

The clear and strong understanding from the literature review and the hands-on workshop is summarized into two words: ***cross-disciplinarity*** and ***co-teaching***. Design with the complexity means: learning about other fields by self-immersion or planned immersion; structure interdisciplinary teaching and co-teaching; building interdisciplinary teams and co-labs; including or establishing expert networks as a group of support. Cross-disciplinary teaching is characterized by Open Access learning (e.g., open-source project results, open-source databases, documentaries, free e-courses, online tutorials), Hands-on learning (e.g., lab work, practice-based, experiential learning), Facilitation of expert integral courses (setting up expert networks, cross-disciplinary collaboration, teaching with the involvement of scientists), and Facilitation of co-labs (e.g., diverse field students-run courses, cross-disciplinary study courses, multi-disciplinary hands-on teamwork in labs).

Each EM&T stands at the intersection of three primary disciplines. Besides some minor distinctions and specifications, Design and Materials & Manufacturing are common areas for each EM&Ts, while the third discipline is specific for each area.

finder, material selector, material explorer, material designer, application designer, concept and scenario ideator, etc. (i.e., Who?)

- And finally, how to inspire and motivate designers for: replacement, finding (new) applications, for people acceptance, for sustainability, for value-making, etc. (i.e., How?)

BRIEFING & POTENTIAL STARTING POINT(S)			
MATERIALS SELECTION What?	THE CHALLENGE Why?	APPLICATION CONTEXT Where?	CROSS-DISCIPLINARY DISCIPLINES With whom?
ROLE OF THE DESIGNER Who?	catalyst / communicator / mediator / bridge / users' advocator team builder / team leader / problem solver / problem finder material selector / materials explorer / material designer application designer / concept and scenario ideator/ ...		
HOW TO INSPIRE AND MOTIVATE THE DESIGNERS	for replacement / finding (new) applications for people acceptance / for sustainability for value-making /		

Fig. 8 - The 5 Ws of the original teaching method. Designed by Stefano Parisi, Politecnico di Milano

The teaching and learning process is both cognitive and physical and is based on the identification of three main didactic blocks: Understanding, Shaping/Experimenting, and Applying (Figure 9). Although the description of the process establishes a chronological succession of the three blocks, they are profoundly intertwined, iterating, and often simultaneous and overlapping in their definition.

‘Understanding’ is a module where the fundamental knowledge is given to students. It is based on a varied body of knowledge (e.g., explicit, tacit, theoretical, procedural, empirical) and the sources for acquiring knowledge can be a mix of material-produced (e.g., interaction with material samples), interpreter-produced (e.g., discussion with instructors, experts, and peers), and representation-produced (e.g., studying on texts and videos).

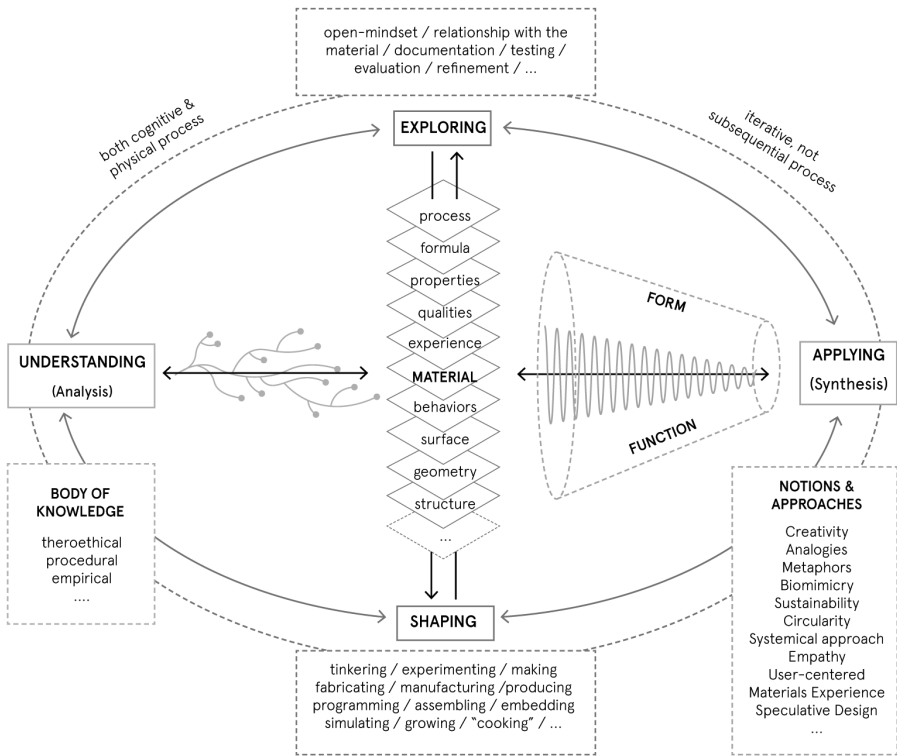


Fig. 9 - The Understanding, Shaping/Experimenting, and Applying Framework. Designed by Stefano Parisi, Politecnico di Milano

‘Shaping/Exploring’ is the connecting block between ‘Understanding’ and ‘Applying’. This is the block where tacit knowledge is mainly acquired. Exploring and Shaping represent two sides of the same block. While Exploring put emphasis on the designer getting knowledge on the materials and processes by iterating, documenting and evaluating, Shaping is focused on the material being manipulated in many ways, e.g., tinkering, making, fabricating, manufacturing, producing, programming, assembling, embedding, simulating, growing, cooking. The initial stages of this block move ahead from the Understanding phase by exploring all the different opportunities that the material can exploit, with trials and errors, obtaining successes and failures. Multiple directions or ‘branches’ are identified, outlining a divergent ‘branch-like’ process. In this block, the material is experimented and shaped on its multiple dimensions, namely the process, the formula, the properties, the qualities, the experience, the behaviours,

the surface, the geometry, the structure, etc. Approaching the ‘Applying’ block, only one direction – or ‘branch’ – for material development is selected, and a converging and iterative process is applied, targeting the definition of form and function.

‘Applying’ block represents the synthesis of the process when the material is embedded and encoded into a project. In this block, the main strategies and approaches that are applied are: creativity, analogies, metaphors, biomimicry, sustainability, circularity, systemic approach, empathy, user-centred design, materials experience, speculative design, etc.

Discussion and further development

The present book contains the preliminary findings of the ongoing research project “DATEMATS” funded by the European Commission - aimed at developing novel teaching methods for both design and engineering students in the field of Emerging Materials & Technologies (EM&Ts).

Particularly, we presented a logical framework for four exemplified EM&Ts areas as results of the methods, gaps and issues related to their teaching methods.

In this chapter the logical framework was presented as output of a hands-on workshop aimed at sharing knowledge and creating a consensus and clarification among the researchers around the four EM&Ts areas.

Moreover, the Workshop supported the implementation at a Transnational level of all the key information collected via desk research and already implemented at each National level; according to the specific needs, the partners have brought a more in-depth national view.

The framework here presented was based on the literature review and collective discussion on a participatory activity in order to obtain the highest agreement between partners and a proper degree of scientific referencing to academic sources.

The framework has an inclusive nature, which tends to accommodate every definition and elements. However, it is evident that each area and institution have its own specific needs and characteristics. In order to create a universal and common framework for all areas and institutions, it may happen that some aspects are banalized in the process of universalization. Efforts have been made to avoid banalization, e.g., avoid creating the

5. DATEMATS project (Knowledge & Technology Transfer of Emerging Materials & Technologies through a Design-Driven Approach Agreement Number: 600777-EPP-1-2018-1-IT-EPPKA2-KA) is co-funded by the Erasmus+ programme of the European Union.

neat distinction between explicit knowledge delegated to learning theory in a traditional classroom and tacit knowledge destined only to practical activities in workshops, which separation is outdated and characteristic of a surpassed way of teaching design.

Another challenge was faced when some concepts that are typical of an area have been extended to other areas, with the risk to become irrelevant. Efforts have been made to highlight when elements are distinctive of one EM&T area, when elements are belonging to two or more EM&Ts, and when shared by all, creating distinctions.

Attention was dedicated to preserving and reporting definitions and categories already identified in previous deliverables, enriching and updating them with new information, instead of altering them.

The Logical Framework arises as one pillar of the challenge posed by European Agenda that is to support creativity-driven (e.g. design-driven) innovation by reducing the knowledge and communication gaps between the material scientists and engineers, the designers and creative communities and the producers.

It will have direct implications in the definition of new four syllabus developed and further applied in the curricula of the four European University: School of Design, Politecnico di Milano, Copenhagen School of Design and Technology, Tecnum, Universidad de Navarra and Aalto University.

References

- Ahmed, S., & Asraf, R.M. (2018). The Workshop as a Qualitative Research Approach: Lessons Learnt from “Critical Thinking Through Writing” Workshop. *Turkish Online Journal of Design, Art and Communication*, September (Special Edition), 1504-1510. <https://doi.org/10.7456/1080SSE/201>
- Buchanan, R. (1992). Wicked problems in design thinking. *Design Issues*, 5-21.
- Chambers, R. (2002). *Participatory workshops: a sourcebook of 21 sets of ideas and activities*. London: Earthscan.
- Cohen, L., Manion, L., & Morrison, K. (2017). Research Methods in Education. In *Research Methods in Education*. <https://doi.org/10.4324/9781315456539>
- Creswell, J.W. (2009). *Educational research: planning, conducting and evaluating quantitative and qualitative research*. Thousand Oaks: SAGE.
- IDEO (2012). *Design Thinking for Educators*. <https://designthinkingforeducators.com/toolkit>
- Illich, I. (1973). *Tools for Conviviality*. Harper & Row.
- MacDonald, S. & Headlam, N. (2016). *Research Methods Handbook*. CLES.
- Ørngreen, R., & Levinsen, K. (2017). Workshops as a research methodology. *Electronic Journal of E-Learning*, 15(1), 70-81.
- Oxman, N. (2016). Age of entanglement. *Journal of Design and Science*.

- Rittel, Horst, & Melvin Webber (1973). Dilemmas in a General Theory of Planning. *Policy Sciences*, Vol. 4, 155-169. Amsterdam: Elsevier Scientific Publishing Company, Inc. [Reprinted in Cross, N. (ed.) (1984). *Developments in Design Methodology* (pp. 135-144). Chichester: J. Wiley & Sons].
- Sanders, E. (2006). Design Research in 2006. *Design Research Quarterly*, 1(September), 1-25.
- Sanders, E.B.N., & Stappers, P.J. (2012). *The convivial toolbox: generative research for the front end of design*. BIS publisher.
- Sanders, L., & Simons, G. (2009). A Social Vision for Value Co-creation in Design. *Open Source Business Resource*, (December 2009). <http://timreview.ca/article/310>

Authors' Affiliation

- Venere Ferraro**, PhD Assistant Professor, Department of Design, Politecnico di Milano.
- Anke Pasold**, Associate Professor, Material Design Lab, Copenhagen School of Design and Technology.
- Pirjo Kääriäinen**, Associate Professor, Department of Design, Aalto University.
- Sara Lucia Rueda Mejia**, Doctoral Candidate, Department of Design, Aalto University.
- Tarja-Kaarina Laamanen**, PhD Postdoctoral Researcher, Department of Design, Aalto University.
- Jari Laine**, PhD Senior Innovation Advisor, The School of Chemical Engineering, Aalto University.
- Paz Morer-Camo**, PhD, Associate Professor, Department of Mechanical Engineering and Materials, University of Navarra-TECNUN.
- Aitor Cazón-Martín**, PhD, Associate Professor, Department of Mechanical Engineering and Materials, University of Navarra-TECNUN.
- María Isabel Rodríguez-Ferradas**, PhD, Assistant Professor, Department of Mechanical Engineering and Materials, University of Navarra-TECNUN.
- Robert D. Thompson Casas**, Scientific Director of Materfad, the Barcelona's Materials Centre of FAD (Fostering Arts and Design).
- Stefano Parisi**, Doctoral Candidate, Department of Design, Politecnico di Milano.
- Valentina Rognoli**, PhD Associate Professor, Department of Design, Politecnico di Milano.