EMERGING MATERIALS & TECHNOLOGIES

New approaches in Design Teaching Methods
on four exemplified areas

edited by Venere Ferraro, Anke Pasold

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Table of Contents

Emerging Materials & Technologies: Meaning, Understanding and Issues, *Venere Ferraro* pag. 7

The Four EM&Ts - A synthesis of a literature review, *Anke Pasold* » 17

1. Experimental Wood-based Materials » 29
1.1. Experimental Wood-based Materials: Towards a sustainable material world, *Pirjo Kääriäinen, Sara Lucía Rueda Mejía* » 29
1.2. Collaborative strategies in education and research, *Pirjo Kääriäinen, Sara Lucía Rueda Mejía, Tarja-Kaarina Laamanen* » 37
1.3. The hands-on approach to Wood-based Materials, *Pirjo Kääriäinen, Sara Lucía Rueda Mejía, Tarja-Kaarina Laamanen* » 45
1.4. From ideas to innovations: sharing and scaling up, *Pirjo Kääriäinen, Jari Laine, Sara Lucía Rueda Mejía* » 51

2. Nanomaterials » 57
2.1. Carbon-based & Nanomaterials and its relevance to Design Practice, *Paz Morer, Aitor Cazón, María Isabel Rodríguez-Ferradas, Robert D. Thompson Casas* » 57
2.2. The selection of Didactic Methods in Design Process, *Paz Morer, Aitor Cazón, María Isabel Rodríguez-Ferradas, Robert D. Thompson Casas* » 67
2.3. The need for a holistic approach, *Paz Morer, Aitor Cazón, María Isabel Rodríguez-Ferradas, Robert D. Thompson Casas* » 71

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2.4. New perspective and suggestions for teaching with and for NanoTech, *Paz Morer, Aitor Cazón, María Isabel Rodríguez-Ferradas, Robert D. Thompson Casas* pag. 75

3. ICS Materials, Wearable Based » 82
3.1. Wearable Textile Systems: design layered intelligence materials, *Venere Ferraro* » 82
3.2. Towards the definition of ICS Materials in Design Education: Approaches in specific teaching methods, *Stefano Parisi* » 92
3.3. Dynamism as an emerging materials experience for ICS Materials, *Valentina Rognoli* » 105
3.4. What do we need to design innovative teaching methods for ICS Materials in wearable domain?, *Venere Ferraro, Stefano Parisi* » 115

4. Advanced Growing Materials » 126
4.1. Advanced Growing Materials - Designing with Living Matter, *Anke Pasold* » 126
4.2. Didactics for designing in Complex, Open Systems, *Anke Pasold* » 135
4.3. Experimental-Experiential Approaches to Designing With Advanced Growing Materials, *Anke Pasold* » 141
4.4. Enabling for Designing with Advanced Growing Materials, *Anke Pasold* » 147

A Logical Framework for designing with and for Emerging Materials and Technologies (EM&Ts), *Stefano Parisi, Venere Ferraro* » 153

Authors' Affiliation » 171

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Emerging Materials & Technologies: Meaning, Understanding and Issues

Venere Ferraro

Introduction

Currently, research in new emerging materials and technologies is one of the major drivers of this innovation and is also evolving at a rapid pace on many fronts in both industry and academia. This includes improved understanding and prediction of material properties and qualities, accelerated design and development of functional and multi-functional materials, the discovery of radical new materials and new materials processing technologies. The diversity and speed of change of this landscape provides great opportunity for an open innovation approach in which Knowledge Intensive SME's and Universities play a critical role in realizing the potential economic benefits. The interface between professionals with expertise in the field of design, engineer and material science has therefore assumed a new importance in the European Innovation agenda, both for accelerating the development of high value products and technologies and the delivery of solutions to major societal challenges (Innovation Material Project, 2013).

It is now understood that interdisciplinary collaboration and ***Emerging Materials and Technologies*** (EM&Ts) know-how in the design phase are essential elements in the way towards a circular economy.

Materials are key to technological advances in many fields, and particularly important for the success of the creative industries, one of the most promising fields of economic activity in highly developed economies. The materials industry has well established technological competences (technology push) whereas the creative industry is stronger in interpreting the context of using materials and the users' needs (design-driven).

A gap between the creative design of products that meet user needs, and the research and development of new materials by academia to be transferred to creative sectors has been identified (Commission Green Paper "Unlocking the potential of cultural and creative industries", 2010).

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To do so there is a need in the academic landscape to ***educate future professionals*** in materials and technologies field and to involve enterprises (corporations and SMEs) to develop ideas towards commercial products and new business opportunities.

The present book contains the preliminary findings of an ongoing research project "DATEMATS"[1] 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 will present a logical framework for four exemplified EM&Ts areas as results of the methods, gaps and issues related to their teaching methods.

We will first provide a summary of the four literature reviews conducted at respectively Aalto University on Experimental Wood-Based EM&Ts, Design Department of Politecnico di Milano on Interactive Connected Smart (ICS), Materials Wearable-based Tecnun University on Carbon-based & Nanotech EM&Ts and Copenhagen School of Design and Technology (KEA) on Advanced Growing. This to give a comprehensive overview of the overall findings, the four EM&Ts and their respective implications, the methodologies identified and the issues and gaps that were encountered.

Starting from the literature review an exhaustive explanation of each area will be given.

Precisely, the section one will be dedicated to definition, approaches and new teaching method related to a novel area of materials that is ***experimental wood-based materials***. Given, the novelty of the topic, the section will represent the area results of experimentation and activities developed inside ***Chemarts*** a long-term collaboration between two Aalto University schools, the School of Chemical Engineering (CHEM) and the School of Arts, Design and Architecture (ARTS).

The second section is instead dedicated to ***Nanotech materials*** by giving an overview related to materials meaning and potentialities of application, a synthesis of existing teaching methods and suggestion for new ones; this by using an in-depth literature review.

ICS Materials Wearable Based will be the focus of the third section; authors will give definition of wearable textile systems by highlighting potentialities and limits, they will stress the need of using ICS Materials,

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define the meaning of ICS Materials and suggest new teaching methods in this regard.

Finally, the last section will describe ***Advanced Growing Materials*** by explaining meaning, the complexity of this open living system and suggestion for how to approach this topic in academia and teaching activities.

Each section has been cured and written by different authors belonging to the four different Universities, starting out from the literature review paving also emphasis on own experience.

Through the all book, different background, approaches and writing styles will be evident: this has been acknowledged as added value for dealing with the complex landscape of EM&Ts.

Needs, challenges related to the four EM&Ts areas

In the creative sector we are witnessing the need 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. All actors capable of adding value to products and processes should be considered upstream in material development.

Innovative materials and emerging technologies are often thought as mainly related to a science (chemistry, physics, and engineering) in industry practice, as well as in the education field. Nevertheless, materials and technologies represent a key-factor not only to obtain better performances and innovative solutions but also to enhance the product language in term of new experiences and original expressive-sensorial dimensions. Materials can revitalise design, creating new business opportunities, transforming industrial activities and conceiving more sustainable solutions. ***Emergent materials and technologies (EM&Ts)*** are already at the leading edge in several sectors and are one of the key-elements through which industries can stimulate innovation processes and foster creativity. The new landscapes of EM&Ts require new interdisciplinary and transdisciplinary higher educational approaches in the field of design to provide unique competencies and skills to design students who will be asked to be able to exploit the innovative potentials of specific EM&Ts and simultaneously to adopt a more entrepreneurial attitude.

Nowadays, in the field of design, specific exploitation processes are required both into material and technology categories (how to design with and for them) and in the commercialisation of the resulting innovative products/demonstrators (be entrepreneurs/start-upper). All of these issues should be included in new educational approaches. EM&Ts need

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to be analysed and used also considering their no technological dimension: *expressive characteristics, potentials for new meanings, the end-user perspective, the socio-cultural and economic trends.*

In this regards, new competencies are today required: not just technical issues, but also *socio-cultural factors, entrepreneurial skills and market trends* that are typical of the design culture.

The Educators' goal is to train professionals in combining the cultural and social sides of design also with technical-engineering skills capable of generating innovations reducing the gap between Universities and Industrial Worlds.

In particular, speaking of knowledge connected to the field of EM&Ts education for industrial design, an *inter, multi and transdisciplinary didactic approach* is needed: to achieve that, educators are in need to investigate: (i) teaching models, (ii) how they could be useful to our idea of materials education.

We need to teach ***students with a mixed background (design & engineering***) to know how to exploit the innovative potentials of specific EM&T, ***generate innovation and to share this knowledge with companies*** in order to figure out what the real word require from a professional skilled in designing materials experiences; ***a professional that could be a manager, a start-upper, a new innovator***.

In this book we present the preliminary results of the ongoing research project "DATEMATS" aimed creating a transnational network among HEIs, Research Centres and Companies in order ***to develop and implement interdisciplinary and transdisciplinary methods for emerging materials and technologies education in the field of industrial design***.

The aim of the project is also to educate a designer able to deal with EM&Ts, taking into account the cultural and social aspect of the design process, developing demonstrators/products able to inspire new business.

The project deals with the wide area of emerging materials and technologies and to transfer knowledge about them both to students and industries. We present four exemplified EM&Ts Arear covered by four Universities with strong expertise in each area. In particular:

1. *Design Department, Politecnico di Milano_ICS Materials (Wearable-based) EM&Ts*
   - Educational method to design with ICS Materials and wearable technologies (currently developed with a technology driven one) into a multidisciplinary teamwork.
   - Knowledge about how to use ICS Materials (Interactive, connected materials) for wearable technologies.
   - Tools to teach entrepreneurial skills to students in order to master the exploitation of the design practice results (design thinking, co-design etc.).

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2. *Material Design Lab, Copenhagen School of Design and Technology_ Advanced growing EM&Ts*
   - Methods for teaching material understanding, exploration and application in an interdisciplinary setting.
   - Knowledge from research to design and production.
   - Offering lab-residencies to designers working on new sustainable materials.
3. *Tecnun, Universidad de Navarra_NanoTech EM&Ts*
   - Evaluating the learning methodologies developed in the consortium.
   - Organizing and staging workshops/educational activities on the EM&Ts.
4. *Aalto University_Experimental Wood-Based EM&Ts*
   - Providing educational methods for interdisciplinary collaboration between design and chemical engineering in the field of biomaterials.
   - Collaboration models between science and design both in education and research.
   - Explorative hands-on sessions with biomaterials.
   - Integrating creative practices and design thinking in the education of chemical engineers.

The new landscape of EM&Ts between teaching and practice

Researchers in EM&Ts have to understand market needs and the competitive landscape, while designers and businesspeople have to know how new materials such as graphene can be implemented in their products. We are at a time of change in social and industrial eras, which is giving rise to a digital industrial revolution.

In this regard, several indications have been given by European Commission:

- integrate design and technological research and innovation;
- support creativity driven (e.g. design-driven);
- develop and promote platforms that support material development and innovation, involving designers, scientists, end-users but also societal stakeholders, anthropologists etc. and allow capturing and, when possible, making available unused knowledge and existing functional materials transfer;
- final user-oriented model should be adopted, and cross sectorial use of materials fully exploited.

Based on this ground Higher Education Institutions need to upgrade education models by means of innovative approaches targeted to:

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- boosting new higher educational models where interdisciplinary (among universities with private and public organizations) and shared knowledge among different HEIs area key milestone;
- networking among design-HEIs highly specialized in specific fields of innovation in order to create a common, shared and new pedagogical approach framework laid down into specific "technology areas" (emerging material areas, also defined sub-sector, that is connected materials/wearable technologies, advanced smart materials, bio-materials, etc.) related to the expertise of each design-HEIs;
- reducing the gap in the higher education field related to EM&Ts providing novel education methods;
- developing new competences and skills into the design culture for "designing" with the EM&Ts (how to design with specific new technologies categories);
- educating professionals able to boost the new paradigms related to specific EM&Ts innovations (how to exploit their potentials).

The methodologies developed for each EM&T presented in each section of this book (from section one to section four) would represent ***an improvement in the education of new skills for industrial design engineering students***.

Final Remarks

Among Europe Policy priorities for University there is: encouraging *the creativity, the innovation, the entrepreneurial spirit* at all training and education levels.

If we specifically refer to new emerging material technologies it is largely recognized that a "creative approach in conceiving, developing, producing, using, and recycling materials can be effective in strengthening the competitiveness and success of all European industries, particularly of industries where technological advances are exploited in a creative way to increase the perceived value of a product or service" (European Commission 2012; European Commission 2010; Council of the European Union 2010).

Industry has continued to invest strongly in innovation despite recent economic uncertainties. In response to the economic and societal challenges we face today, companies are increasingly looking to new methodologies linking together consumers, designers, technologists and other stakeholders in new ways to enhance and accelerate their investment in product and process innovation and create competitive advantage.

In each section we will see how diversified and even complex are the four EM&Ts: they all stand at the intersection of three primary disciplines.

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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.

ICS Materials EM&Ts area is situated in the intersection of Design (e.g., Human-centred design, Design for Disassembly, Interaction Design, Visual Design), Materials & Manufacturing (e.g., Textiles), and Computer Science (e.g., digital technologies). By the triangulation of these disciplines, the design practice about this EM&Ts is unfolded as 'Embedding & programming'. Other relevant disciplines and knowledge fields involved in the area are Ergonomics, Psychology & Perception, and Sustainability & Circular Economy. The definition of the application sector emerges as fundamental, e.g., health, sports, but not limited to wearables, e.g., automotive, architecture, furniture.

Nanomaterials EM&Ts area is situated in the intersection of Design (e.g., Creativity and Design Thinking for innovative application), Manufacturing Processes, and 'Hardcore' Science (e.g., Material science, Chemistry, Physics). By the interplay of these disciplines, the design practice in relation to this EM&T is unfolded as 'Super-empowering & Biomimicry'. Other relevant disciplines and knowledge fields involved in the area are Sustainability, Economics & Marketing, Psychology & Perception.

Experimental Wood-based EM&Ts area is situated in the intersection of Design (e.g., material exploration, User-centred design), Manufacturing (e.g., crafting, making, fabrication, and producing), and Chemistry (e.g., chemical engineering, material sciences). By the triangulation of these disciplines, the design practice concerning this EM&T is unfolded as 'experimental cooking'. Other relevant disciplines and knowledge fields involved in the area are Biology, Engineering, Arts, Psychology & Perception, and Sustainability & Ecology. The interaction with the Service sector emerges as fundamental, e.g., new businesses for recycling and reuse for composting.

Advanced Growing EM&Ts area is situated in the intersection of Design (e.g., material exploration), Manufacturing (e.g., crafting, making, producing), and Biology (e.g., biotechnological Science). By the triangulation of these disciplines, the design practice in relation to EM&Ts is unfolded as 'growing'. Other relevant disciplines and knowledge fields involved in the area are Chemistry, Ethics, Communication, Psychology & Perception, and Sustainability (e.g., engineering for production processes and lifecycles).

In this book we will present the synthesis of the four EM&Ts highlighting similarity, differences for all of them (see chapter The Four EM&Ts - A synthesis of a Literature Review), we will give an overview for each area in dedicated section presenting the meaning, the different approaches

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used and developed for each EM&Ts area, finally we will provide (see chapter "A Logical Framework for designing with and for Emerging Materials and Technologies") the setting up of a common and ***advanced methods to teaching EM&Ts within HEIs*, to create *new professional in young students, and to develop new guidelines and approach***.

Regarding the four EM&Ts several potential methods have been already classified in: case-centred (e.g., for specific material suppliers/ manufacturing company, specific environment/context, specific application); contextualization (e.g., the use of analogies, metaphors, biomimicry); user-centred/scenario-creation (e.g., sense-making, unobtrusivity, and wearability); material-centred (e.g., material-driven design, material tinkering, experimental pedagogy, material mappings, material meanings, physical probes and material samples, material concepts, prototypes, simulation of material behaviours, affordance making); Design process.

This will be a holistic and 'stepped' but continuous and simultaneous iterative Design Process based on leaning materials on a general-level and returning to a hands-on approach. A process that may place material selection at an earlier stage, and context definition as a starting point or developed throughout the process. The process would prioritize hands-on exploration over sketching and visualizing. Material understanding, mapping, and selection would go hand-in-hand with the idea, form and application generation.

We will see how this will be implemented and merged into a **unique design teaching method for students with a mixed background** (design&engineering) in the field of EM&Ts.

The creation of the unique design teaching methods will and has having been possible thanks to:

- *Permitting to integrate the different HEIs approaches in an international coherent body of knowledge expandable to all EM&Ts*. Integrating the different EM&Ts teaching and exploiting methods through an inter-disciplinary approach, that goes beyond the simple coordination, and involves different stakeholders, increases the knowledge-exchange of different cognitive approaches and methodologies to EM&Ts and collectively redefines a new common method. Only through an interdisciplinary approach (design/creative, engineering/ technology) together with inter-competencies methods (different EM&Ts specialization) into an international cooperation on interconnected topics (different methods about EM&Ts) can create a cross-breed methodology and a consistent and common body of knowledge on the teaching and exploitation of EM&Ts.
- Enhancing the development of *human capital through modernised higher education system*, *improving entrepreneurship skills* and

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providing to student's *new methods to manage and exploit EM&Ts and their innovation potentials*, is a constantly increasing EU challenge, which can be solved by implementing coherent active strategies. An EU based approach is needed, focusing at exploiting new innovative skills in a learner-centred and problem-based way. This issue cannot be faced univocally, but needs to be jointly defined by different actors, calibrating opportunities that derive from a collaboration of organizations across national borders.

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