

Teaching material design. Research on teaching methodology about materials in industrial design¹

Ensino de materiais para o design. Pesquisa sobre metodologia didática dos materiais em design e desenho industrial

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Abstract

This paper presents and advocates a method for teaching about materials in industrial design courses. The method has been developed by the authors in the academic sphere while teaching over the last six years on a number of degree courses – both the three-year basic programmes and the two-year specialist ones – at four Italian places of learning: the Politecnico di Milano, Sapienza University of Rome, the University of Palermo and ISIA (the Higher Institute for Artistic Industries) in Florence, which is now recognized as being equivalent to a degree course. The research has a focus on a specific area of the design field which has until now been undervalued, and not sufficiently expanded upon by teaching programmes, as it has always been seen as something which is simply there to be exploited. However, it has become more prominent in recent years, thanks in part to rapid technical and scientific development and the access to numerous new materials with unprecedented capabilities.

Key words: design, materials, creativity, experimentation, teaching methodology.

Resumo

Este trabalho apresenta e defende um método de ensino sobre materiais em cursos de desenho industrial. O método foi desenvolvido pelos autores no âmbito acadêmico, ao longo de seis anos durante o ensino em uma série de cursos de graduação – tanto em programas de três anos do básico como no de dois anos da especialização – em quatro lugares italianos de aprendizagem: o Politécnico di Milano, Universidade de Roma La Sapienza, da Universidade de Palermo e ISIA (Instituto Superior de Industrias Artísticas), em Florença, que agora oferece curso de graduação. O foco específico desta pesquisa inscreve-se no campo do design e envolve um aspecto que não é frequentemente tratado. No entanto, o estudo sobre materiais tornou-se mais proeminente nos últimos anos, em parte graças ao rápido desenvolvimento técnico e científico e a entrada em cena de novos materiais que possibilitam recursos sem precedentes.

Palavras-chave: design, materiais; criatividade; experimentação

¹ The paper was written by the authors on the basis of mutual agreement and extensive discussions. Are related to the two authors jointly sections: Abstract, Introduction, Research methodology and Didactic Method. These paragraphs were written by M. Ferrara: The creative approach to technology, and Close-up on teaching in Italy: Results of the data analysis and remarks. These paragraphs were written by S. Lucibello: The state of the art of Italian materials research and teaching, and Reflections on the Italian and international approaches to teaching about technology in the contemporary world.

Introduction

An essential premise for the research is the acknowledgement of the Italian design field's singular take on materials, which is defined here as a "creative approach to technology".

The objective is to put together teaching tools and methods which embrace the unique characteristics of the Italian approach to design and are able to deal with the changes in the professional and socio-cultural context that teaching has to take on board.

With this premise and objective, the research project is part of the series of studies that have contributed to the development of design teaching in Italy since 1994. The theoretical and critical foundations are provided by studies carried out in different countries, and most notably, the debate between the positivist position on design – which is seen as a science – of Herbert Simon (1969)² and the stance of Donald Schön (1983)³, who reassessed the "intelligence of action" and maintained that design involves a blend of theory and practice, and that it is possible to gain knowledge which can be applied in all spheres by observing and reflecting on design processes and their effects on their surroundings. Some Italian studies based on these factors and the phenomena observed (Bertola and Manzini, 2005) have attempted to classify professional practice in order to identify general rules and principles which can be used to train designers, while making the assumption that they will evolve in line with their points of view and surroundings (Husserl, 1965). Therefore, it was possible to outline an Italian design research and teaching identity based on the tradition of professional practice, which – especially in Milan – also took on a significant theoretical and critical dimension from the 1950s and made an important contribution to the revitalization of the industry in the period after the Second World War.

The creative approach to technology

Many historical and critical contributions (Doveil, 2002; Branzi, 1996) have focused on the distinctive nature of the Italian design culture and described how it managed to take precedence over the traditional engineering-based technical culture. This has led to the emergence of the idea of a typical means of design innovation with a carefully balanced blend of language, form, function and production quality, thanks to a creative process that brings together classical and technical culture.

The Italian design field has never seen technological innovation and materials solely as elements to be exploited in the creation of objects and part of a problem of constructive correctness. Instead, they have been used as forms of creative input and parts of the linguistic and poetic palette of a project which can be interpreted with their inherent potential for expression and use. This char-

acteristic of the Italian design has been constantly revived in the professional field and it has been particularly prominent in certain historical periods.

In the 1950s, Italian design was only just emerging, but together with the developing industrial field it soon conducted some original linguistic experimentation. One example was Moplen⁴. The company Kartell was founded to use it in the industry and it revolutionized the interiors of homes with the material. Designers used Moplen to make items and furnishings that completely shook up everyday imagery and gave it a specific identity: it was new, colourful, vivacious, light and democratic.

The 1970s was one of the most outstanding times for the Italian approach thanks to the "design primario" or "leading design" (Branzi, 1983) movement, which shifted the focus towards the *soft* qualities and the expressive/sensory identity of materials, extending the scope of design to reinventing surfaces and materials. This marked the beginning of "material design". The business world, led by Montefibre, showed a great deal of interest in seemingly minor production issues (such as colour manuals, the decorative patterns for fabrics, and research into surfaces and their reaction to light and sound) which were actually at the heart of sophisticated industrial strategies that sought to improve the quality of the interaction between people and the designed world⁵. The idea emerged that capabilities with materials and production processes were playing an increasingly important role in the work of designers, who were able to use them to innovate with products and processes.

The "silent revolution" of compounds in the late 1980s led design towards a new challenge: "previously unthought-of technology". Designers worked with the new capacities of materials and transferred technology from production sectors that make major investments in research to others that make small investments (notable transfers took place from the automotive industry to furniture). They went beyond technological boundaries and materials were pushed to their technical and symbolic limits, giving unprecedented and surprising visions of the nature of materials.

Alberto Meda is one of the exponents of this type of research. Other projects of this kind featured in a 1995 exhibition at New York's MoMA called "Mutant Materials in Contemporary Design", as well as appearing from 2003 in the "iMade" shows curated by Frida Doveil. The latter contained some interesting proposals from the Italian furniture industry in which new design ideas were developed using new materials and working processes.

In the 1990s, there was an upsurge in innovation in the field of materials. They grew in number and the implications of their use became more complex, so designers were no longer able to keep control of them with traditional forms of knowledge. The vast, bewildering range of choices (Manzini, 1986) made people feel the need for

² One commendable aspect of Herbert Simon's views is that they are in contrast with the idea of design as an individual bent similar to an artistic ability.

³ Donald Schön supports the idea of reflection in practice. One of the central topics of his reflection is moving beyond the traditional divide between thinking and acting, knowing and doing, deciding and implementing.

⁴ The polypropylene is an Italian patent that was invented by Natta between 1963 and 1969.

⁵ As demonstrated by the work of C. Trini Castelli between 1996 and 2008.

more information in order to find their way through the supermarket of materials. Starting with the founding of Material Connexion in 1997, physical and digital *materials libraries* began to appear (Campogrande, 2009) and gradually specialize in particular classes of materials in order to bridge the gap between production companies and design professionals. In addition to the renowned Material Connexion, amongst the many examples are the Rome-based Matrec, a database for recycled materials that is free to use, and the Materioteca⁶, which specializes in polymers and was created in Alessandria with the support of a group of manufacturers from the field. *Materials libraries* are places where materials can also serve as *input* to inspire creative processes. They provide knowledge of both the technological side of materials and their aesthetic potential.

In its short history, Italian design has made an important contribution to innovation with materials by coming up with design, experimentation methods and strategies that have led to the creation of products whose material qualities have inspired new forms of behaviour and lifestyles. By using the materials available at the time, carrying out linguistic and performance research, and/or transferring technology and pushing the boundaries of technical knowledge, designers have played a part in the evolution of materials and frequently helped to bring about genuine innovation in processes. Their focus on the expressive and communicative value of materials and control of the emotional qualities through expert management of the technological aspects means that they have made a tangible contribution to the establishment of new objects and material qualities.

Research methodology

These ideas underline the unique nature of Italian design's creative approach to technology. Taking them as its starting point, the research project looked into their effects on teaching about materials for design.

The research process involved feedback and constant fine-tuning, with three separate levels:

- (i) Data collection and analysis.
- (ii) Interpretation of the data and critical elaboration.
- (iii) Didactic experimentation.

There were two phases in the collection and quantitative/qualitative analysis of the data: a *close up* on teaching and a *close up* on the didactic research carried out in Italy in the last 10 years. The first phase involved gathering and analysing information about the courses and modules on technology and the study of materials in the teaching programmes of product and industrial design degrees in Italy⁶. The data collected came in the form of the teaching programmes outlined in descriptions of university courses and information gathered through interviews with the lecturers in charge of courses, which supplemented the findings from the desk research with details of the skills

used, the approaches and the methods. The second analysis phase focused on research into resources and methods that have been developed in academic circles for teaching about materials in the last ten years.

Analysis and interpretation of the data made it possible to produce a comprehensive overview of the methods and tools that are currently at the disposal of university education in the field of technology. By comparing the education in Italy and internationally, and taking into account the emerging phenomena in professional practice, critical thoughts were developed on the possibilities for technology teaching in a creative sphere and in a suitable way for the education of designers.

Carrying out critical reflection in parallel with didactic experimentation made it possible to progressively fine-tune the teaching method proposed by the authors, which aims to make the step forward from teaching about materials for design, to teaching material design.

Close-up on teaching in Italy: Results of the data analysis and remarks

While there is a great deal of variety in the local characteristics, the relative importance of the courses and the skills used, analysis of the data on teaching in the different universities studied shows that similar scheduling criteria and approaches are currently used in the organization of materials courses.

In short, in the first year of a basic three-year degree, teaching about technological matters is essentially based on a theoretical didactic approach to provide students with knowledge of the chemical, physical and mechanical properties of traditional materials and production processes. In most cases, the skills used are in the fields of chemical engineering (materials knowledge) and mechanical engineering (industrial processes). No time is devoted to craft techniques or practical assessments of materials; there are just little reference of the sectors and fields of use.

In the second and third years, there are theoretical courses on the materials with more in-depth study of technical and engineering matters compared to the basic course in the first year and broadening of the horizons to take in innovative materials and technologies. Only in a few cases are these theoretical courses supplemented by study and examination of the products that are considered emblematic of material innovation, for "retrospective" analysis of the entire design and production process. Analysis of the objects makes it possible to underline the correlations between their structures and properties in areas including performance and processability. It helps students to develop the ability to use the various traditional and innovative materials in the most appropriate way, understanding not only their technical characteristics but also their potential and physical limits, so that the material transformation processes and the stages in the life of a product can be managed without neglecting the

⁶ The research involved analysis of the product design courses at the following centres of learning: the Politecnico di Milano, Sapienza University of Rome, ISIA in Florence, the University of Florence, the University of Palermo, IUAV in Venice, the Politecnico di Torino, and the Free University of Bozen-Bolzano.

key aspects relating to “observation” of the aesthetic and perceptive properties.

Furthermore, alongside the activities carried out in design workshops in this phase, there are materials modules which aim to provide an understanding of the applicatory aspects focusing on selection of the materials to meet the requirements of the project and to evaluate the feasibility of the design. However, they continue to see materials purely as elements to be exploited for the purposes of the design. It should be pointed out that there is an almost complete lack of practical and experimental activities involving materials, which is often due to the fact that there are no workshops specifically for the purpose. Consequently, design research continues to focus largely on visual perception rather than other sensory aspects. This is also true of the specialist degree programmes, which feature theoretical courses on materials and cutting edge technology together with teaching modules about materials for design, with a particular focus on new forms of technology. Once again, the contribution of technology know-how is seen as a sort of consultancy that can aid a project rather than as an independent, vibrant design activity⁷.

The only exceptions to this type of approach are the ceramics workshop for students on the specialist degree course at IUAV in Venice and the teaching set-up at the Free University of Bozen-Bolzano, which is structured around “projects” and separate workshops for different materials (with a system similar to the Bauhaus teaching approach). Nonetheless, experimentation with materials is somewhat rare and it is left to the free choice of the students or the teacher who chooses the subjects for projects.

This organizational system for teaching with a purely theoretical and technical approach to materials does not reflect the rich heritage of the typically Italian design method.

In order to complete the overview, it is necessary to add some details about the characteristics of Italian didactics.

Design teaching in Italy is something that has been developed recently. It was only around the mid-1990s that the national university system began to organize educational programmes in this specific area. There was a great innovative drive behind it and – thanks to the new degree structures that were freed of the traditional disciplinary rigidity, in which architecture was taught solely by architects, engineering solely by engineers and so on – it brought together a huge variety of fields and areas of knowledge, ranging from anthropology to semiotics and from economics to chemical engineering.

Degree courses in design tend to develop in architecture faculties. It is necessary to use skills that are already present in the places of learning, so teaching about materials has involved the natural transposition of courses on architectural technology or process and chemical engineering, albeit with the small adjustments required. This explains the approach taken by materials courses, with their traditional and exclusively theoretical teaching based mainly on the study of the mechanical behaviour of traditional materials and certain construction techniques. This shows that the teaching system is behind the times

and that the educational activities do not cater to the real needs of contemporary production and research.

Only recently (in the last six years or so), specialist design skills have begun to be used in PhDs in the specific sphere of the relationship between design and materials, putting together those of a technical and scientific nature. The presence of these new skills is leading to changes in study programmes, with trials of a new approach to technology teaching taking place.

The state of the art of Italian materials research and teaching

From the early years of the 21st century, there has been a burst of fresh interest from the Italian design culture in innovation with materials with regard to design activities and the ability for technical innovation to encompass design input and new qualities for future products. Technology and the sciences are expanding rapidly and new challenges are opening up. There is a pressing need to develop new teaching methods so as to allow comprehension and envelopment of technical changes. They must provide an important critical capacity for designers, who must deal with technological innovation every day and present it in a way that aids the users to exploit it.

How can students be taught how to use materials properly? Which aspects must teachers take into consideration? Should they continue to focus exclusively on theoretical and technical matters and control for optimum use of the potential offered to designers by materials?

We believe that a purely technical and control-based outlook is not appropriate in the field of design. It is absolutely necessary to take into account the designer's need to combine technical and production matters with design-related elements for aesthetic experimentation on at least three levels: the level of perception, which reassesses the relationship of the senses during genuine experiences of things; the level of meanings, which emphasizes the importance of the cultural (artistic and conceptual) side of the relationship with technology; and the level of creativity, which uses the imagination to innovate and open up different scenarios compared to the past.

In the field of PhDs, design research has looked into the skills to be used, the abilities to be developed, and the approaches to be taken when teaching about the use of technology.

Mike Ashby a professor from the Engineering Department at Cambridge University (Ashby, 2002) made an important contribution to this area of research, He published a book that acknowledged the skill of designers in selecting materials to give products their own character, which is just as essential for the success of a project as consideration of the functional aspects. Ashby's book also underlines the need to find a means of joint communication between engineers and designers. The two categories of figures are so different that they take different approaches, which complement each other.

The early 21st century also saw the completion of a number of studies proposing theories and methods for

⁷ In this respect, it is important to underline that discussion of *ad hoc* material design was already taking place in the late 1980s (Manzini, 1986).

the interpretation of the silent heritage of technical and cultural information found in design products, with the objective of comprehending them and developing teaching methods.

In 2003, Marinella Ferrara⁸ (Ferrara, 2003, 2005) looked into the evolution of design paradigms as techniques and materials developed. She studied the history of design and explored the connection between technology and social aspirations as a driver of innovation in industrial products. For each of the three phases, she identified the successive technology and material paradigms that influenced the choices regarding meaning and design language. Ferrara used short profiles of objects to illustrate her views, utilizing them as a common thread to give an understanding of the profound, complex economic and cultural implications of designers' technological choices. In this way, she created a method for teaching about materials that encompasses history, technological knowledge and design.

Meanwhile, a number of research projects looked into materials as elements of the design language, means of expression and catalysts for experiences. The objective of these research schemes is to satisfy the need to develop a teaching method that encourages observation and guides the selection of materials in the design process so that it is no longer solely based on knowledge of technical properties but also on awareness of *soft* – i.e. sensory – qualities of materials, and therefore on perception. Some of the projects aim to lay down new criteria for the creation of materials libraries for teaching purposes, which are essential for direct evaluation of materials and characteristics which can be perceived through sensory experiences⁹.

From 2000 to 2003, Sabrina Lucibello carried out research with the Crossmodal Psychological Centre at the University of Oxford, which proposes a method to allow objective perception of the main qualities of materials (Lucibello, 2005). This method uses the five senses to assess material, which is the first, most direct interface between people and objects. It is based on a diagram with *Keywords* for the senses, each of which expresses a major characteristic of the material. The combination of the different characteristics can be used to guide the selection of the materials during the design process.

Valentina Rognoli and Marinella Levi have also investigated the expressive and sensory side of materials (Rognoli and Levi, 2005, 2011). As a teaching resource, they propose a sort of Atlas for the interpretation and management of some of the perceptive and sensory aspects of materials, which can be converted into engineering data. Their goal is to raise awareness among future designers of the main qualities of the materials (Karan, 2010).

Recently, Lerma *et al.* (2011) have developed an assessment method for the sensory properties and environmental friendliness of materials, using a *multi-criteria* model and taking into account the different cultural contexts. The method uses the Sensotact[®] – SounBe[®], Eye-tracking, Sensotact[®] and Gloss Scale tools to “measure” the sensory qualities of materials that enhance the use of products and aims to serve as a guide for the management of environmental sustainability aspects of products.

The growing complexity of the world of materials is however altering the role of the designer and leading to an increase in the numerous different professional and research activities that revolve around the relationship between materials and design. These aspects have been examined by a number of studies (Raimondo, 2004; Ferrara and Lucibello, 2009) that highlight shared ground between the various fields and sectors that conduct research into materials, using both deductive and inductive approaches and asserting that a multidisciplinary system is now necessary for scientific and applied research.

The broadening scenario of materials for design has been investigated and described by several research projects that focus on new categories of materials, i.e. smart materials (Cardillo and Ferrara, 2008), and “new material landscapes” (Langella, 2003).

Another emerging area of research is “bio-inspired” design. Its unprecedented combinations of design and biology form “hybrid” materials with new properties and capacities that cannot be classified with a material identity in the traditional sense. Carla Langella¹⁰ (2007) analysed some of the possibilities that have been opened up for design thanks to the development of biological knowledge, which is combined with computer technology in an effort to design “new tangible and intangible products that conceptually and concretely reflect some of the qualities found in the natural world.” Salvia *et al.* (2009) and Rognoli and Levi (2011) analysed the potential of the biomimetic approach and focused in particular on the publication and knowledge-sharing tools (such as blogs, specialist reviews and databases) that aim to provide support for designers in the forthcoming biomorphic era. The topic was also the specific focus of an issue of the magazine DIID (Lucibello, 2009), which concentrated on the enormous potential for design today, which can use nanotechnology not only to influence the form and function of products but also to establish the very DNA of the materials that will be used to make them. This is a very hot topic, as demonstrated by the fact that IUAV has set up a *Nano design* research group for design PhDs which uses the analytical and creative tools from the field to explore the applications of research in the

⁸ Ferrara's work was initially carried out as a dissertation for her design research PhD at the Design Department of the University of Palermo (1999-2002), then revised and published in the two volumes mentioned above.

⁹ The working materials libraries are: MaterialieDesign (1999) at the Politecnico di Milano, a physical and digital research centre that supports teaching about materials for design; ArTec at IUAV in Venice, an archive of techniques and materials for architecture and industrial design with samples of materials and models of technical components and parts for architecture projects and multimedia tools about Italian and European constructions; MATto (2004) at the Politecnico di Torino, an archive with more than 500 samples of materials and a training and research centre that focuses in particular on environmental friendliness and the expressive potential and sensory properties of materials. Other noteworthy schemes include: Material Design (2008), a material encyclopaedia and research workshop at the Architecture Faculty in Ferrara, with a special focus on stone materials; the Interdepartmental Design Centre (2011) at the Free University of Bozen-Bolzano, which was originally created as a computerized database and teaching room that aims to establish connections between technical, production and design information regarding old and contemporary objects.

¹⁰ The name “Hybrid Design” comes from a new type of synthetic materials which are made in laboratories by combining nanotechnology with the procedures and principles of molecular biology.

field of nanotechnology. At the same time, it carries out experimental research into potentially significant applications in order to guide basic research into nanotechnology. This activity outlines the different forms of relationships between technological innovation and product innovation.

This “critical mass” of research shows just how great the focus is on the topic of materials and knowledge of them through the specific design culture. There is a huge variety of approaches, teaching tools, experiences and complementary activities which have become part and are continuing to establish themselves in the educational programmes for future designers.

Reflections on the Italian and international approaches to teaching about technology in the contemporary world

A comparative examination of some interesting international experiences played a key role in the critical thinking behind the new teaching method for design materials that is presented here.

In some of the most renowned design schools in Northern Europe, there is an experimental approach to the use of materials which centres on practical experience.

One significant example is the Design Academy in Eindhoven, which is recognized as one of the most authoritative schools and promotes the development of independent judgement and a creative mentality in students. Teaching is not seen so much as training about the design process itself, but more as a form of “guidance” of the student’s personality through provision of the knowledge and “abilities” necessary to carry out the design process, which in turn is seen as the capacity to organize design research independently.

In particular, in the Atelier – which is one of the departments for specialization studies after the basic course – students consciously develop their intuition and outlook on design through a personal method. It starts with observation, creative drive and manual work, and encourages the search for new meanings for materials, forms, abilities and contexts. The Lab is another specialization department and a place where students carry out their methodical research. Here, in-depth experiments take place. Students are encouraged to take an analytical approach and develop their abstract thought. Each student uses a personal research method to carry out experiments. It can be scientific as well as intuitive, but it must always be recorded so as to ensure that it can be repeated. New materials and techniques are tested and pushed to the limit of their capabilities, as the students go beyond the boundaries of current knowledge.

The students of the Design Academy in Eindhoven have shown their ability to move away from the traditional approach to design. They have put together interesting concepts and technical innovations for processes and independently developed their own projects. However, independent working of this kind does not exclude the ability to interact with companies. Instead, it involves development of the capacity to give a powerful, important innovative and creative boost to companies in terms of production, with creative promotion of innovative products.

Riccardo Blumer was behind some other interesting teaching schemes in 2007, as part of the Industrial Design Degree at the University of the Republic of San Marino. They involved reassessment of manual work, such as experimentation with static load-bearing structures. The method employed focused on practical experimentation and moving food materials to new settings. It proposed taking a step back and going from the artificial to the natural in order to gain a better understanding of artificial elements (thus going against those who claim that newness and research are only possible through the discovery of new materials). With observation and practice, the students showed that it was possible to make small items of furniture (such as chairs, stools and hammocks) that were capable of supporting the weight of a person (the teacher himself) using nothing but food-stuff. As they said, “compressed puffed rice is similar to polystyrene, fish glue reinforced with strips of liquorice root is comparable to any carbon fibre/epoxy composite, and dry bread spread with animal glue is akin to a plastic box” (Blumer, 2007, p. 120). The course taught students a method for experimentation with forms at the limits of technical and aesthetic efficiency, in the relationship between materials and geometric structures.

These teaching experiences place the focus back on the creative approach used when teaching about technique.

It was also necessary to reflect on the consideration by teaching of emerging socio-economic tension: the effects of globalization and relocating production, automation of processes, the global economic and employment crisis, the new phenomena in professional practice, such as independent production, and the issues faced by a high-income society like Europe.

A response to these matters will be given by teaching choices in the near future. Renewed interest has already been taken in the possibility of rediscovering “craft know-how”, as well as in practical experience and individual entrepreneurialism. There are frequent mentions of the combination of a technical and theoretical approach and practical, experimental methods that encourage creativity, as well as the ability to thrive in multidisciplinary and communicative spheres.

Teaching is thus faced with two problematic issues: one of an *epistemological* nature and one of a *pedagogical* nature.

The first of the two, concerns the foundations of design teaching. The Bauhaus approach is still considered a sound reference model. In this system, the teaching was based on a blend of practice and theory, and it was led by two masters: one craft worker and one artist.

As Gropius explained, it was necessary to have two different groups of teachers because it was not possible to find anyone suitable to lead the workshops: the artists did not have sufficient technical skills and the craftsmen did not have enough imagination for artistic matters (Gropius, 1955, p. 29-30). The guiding principle was to use craftsmanship not as a romantic ideal but as a didactic means to train modern designers. There is no contrast between practical craft skills and industrial design work. Indeed, they can aid understanding of materials. Going back to the basics, Bruno Munari believed that handling and construction experiences involving a variety of materials can

develop the imagination in a logical process that requires inquisitiveness, attention, and the ability to act sensorily and give meaning to sensations. A system of this kind often offers encouragement to challenge technical conventions and move beyond existing rules, leading to the creation of new languages.

Alvar Aalto worked in a similar manner. When recording his experiments with curves in wood, he spoke of “abstract” trials with materials:

“At the exhibition in London, we showed an aspect of our work for the first time: abstract experiments with wood processing. These experiments should more or less be seen as games with materials and technical, formal trials with any immediate practical goals. We believe that a rational road that leads directly to a practical aim is a negative thing for architects, as it can easily bring about formal mechanisms and vulgar rationalism” (Blaser, 1981, p. 92).

The origins of the natural creativity of Italian design lie in the material culture of the country’s past, with its art and craftsmanship. It involves *homo faber*, who develops creative thoughts in his manual work, in an invention process that starts with sensory stimulation and results in parallel processing by the brain of visual, acoustic, tactile and symbolic/linguistic information.

The second pedagogical issue concerns the need to go beyond the organization of knowledge, which is still “split” into disciplines and needs to be rearranged in what could be called a *multiverse* way, which is capable of embracing the many sides of the profession and the skills required. The goal of higher education must be to “learn to learn” and “learn to be”. Furthermore, didactic methods which aim to develop creativity must be adopted, in an overhaul involving a number of significant changes. These are:

- (a) From products to processes.
- (b) From problem solving to lateral thinking.
- (c) From definitions to the search for horizons of meaning.
- (d) From knowledge of theories to the construction of hypotheses in a communicative context.
- (e) From the idea of sequential causality between teaching and learning to a systematic vision in which teaching and learning may be asymmetrical and asynchronous.
- (f) From the linear sequentiality of educational acts to the promotion of holism and contextualization, so as to keep all of the doors of learning (different languages, different styles of thinking) open in a genuinely multimedia environment that encourages dialogue.

Didactic method

There are a lot of sides to the study of materials (from science and materials engineering skills to specific design skills) and it also covers a number of fields of research (from functional and performance qualities to perceptive and sensory properties) and requires various capabilities (from appropriate use of materials to the *ability to innovate* by developing personal methods and visions of materials).

Consequently, there must also be numerous, complex teaching systems (from a *theoretical and analytical* approach to a *practical and experimental* one) with the goal of minimizing the gap between theory and practice and developing the analytical, design and communication skills of a figure that spans the areas of design and knows about materials but is also able to work with the metalanguages that bring together in a network, disciplines and production know-how in the area of meta-products and semi-finished goods. Continual interaction between the ability to think and technical and creative activities leads to the development of technological skills (Kimbell, 1996).

The activities and objectives of practical experimentation can be summed up as follows:

- (i) Observe, analyse and understand.
- (ii) Explore to start up creative processes.
- (iii) Experiment, record and document in order to acquire knowledge.

If a programme is to develop these complex skills, it must introduce more technical, laboratory subjects so as to enhance understanding of the primary elements in this area of knowledge. There must be design courses for experimentation with design methods for different areas and theoretical courses that comprehend and implement the languages of the complex material design network.

The teaching strategies must also aim to hybridize the traditional processes for materials with the more experimental procedures of architecture, design, engineering, communication, digital art and decoration. A key role must be played by exercises that seek to introduce opportunities for inductive learning in teaching of design with deductive foundations.

These views are behind the exercises for courses on materials for design that have been put together by the author over 6 years of teaching on Product Design Degree Courses (at the Politecnico di Milano, ISIA in Florence, Sapienza in Rome, and the University of Palermo), which introduce opportunities for inductive learning in teaching of design with deductive foundations.

There are five phases in the didactic method, along with a subsequent phase for the Specialization Degree course to develop planning and experimental thinking for the design of materials. These phases are:

- (i) Exercises to provide knowledge of the aesthetic and sensory qualities of materials. They involve observation and evaluation of the sensory characteristics of materials and practical, manual action to experiment with the modelling and characterization potential of materials without any practical purposes (taking the lead from A. Aalto’s experiments with wood). The students from the first year of the Product Design Degree Course did the exercises and the experimentation was introduced as part of didactic activities in the Design Workshop. This didactic experiment was then fine-tuned on the Technology course of the second year of the Design Degree at ISIA in Florence, with the introduction of scientific practice, precise documentation of the work done with materials and assessment of the results (Figure 1).
- (ii) Exercises to simulate and reproduce materials using alternative materials, so as to produce new visions of mate-



Figure 1. Sensorialità (Politecnico of Milan, student's exercises); Texture (ISIA of Florence, student's exercises); Texture Rame (ISIA Firenze, student's exercises).

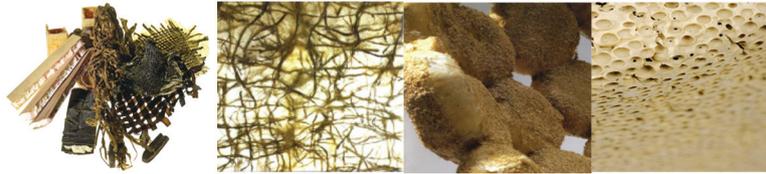


Figure 2. Natural materials (Sapienza University of Roma, student's exercises. Inspiration: Riccardo Blumer's University of San Marino Course).



Figure 3. Terra Cruda (University of Palermo, student's exercises).



Figure 4. Erosia Project ("Profonda Ceramica", Politecnico of Milan, Workshop).



Figure 5. The practical method allows students to explore for knowledge and to start up creation, design and production processes.



Figure 6. The practical method allows students to explore for knowledge and to start up creation, design and production processes.

rials. The didactic experimentation was carried out on the first and second year materials courses at Sapienza University of Rome, with the use of food materials (Figure 2).

(iii) Practical exercises to explore the physical and chemical properties of materials and develop possible new capabilities, going beyond conventional applications and using materials on the boundaries of their possibilities. The experimentation was carried out using ceramic materials as part of the Materials for Design course on the second year of the Industrial Design Degree at the University of Palermo (Figure 3).

(iv) "Design follows Materials" workshops, which involve starting with materials and designing simple products that bring out the characteristics of materials and experiment with new expressive languages, assessing the potential in the usability of the products (Figure 4).

(v) Independent construction exercises in the design workshops, through experimentation with processes to introduce small forms of innovation and documentation to ensure that the process can be repeated (Figure 5).

(vi) (For Specialization Degree Courses) Designing new materials in a multi-disciplinary sphere. This is the terrain on which teaching about materials for design will have to operate in the future. This method could mark the shift from teaching about materials for design to teaching material design (Figure 6).

References

- ASHBY, M.; JOHNSON, K. 2002. *Materials and Design, the Art and Science of Materials Selection in Product Design*. Oxford, Butterworth Heinemann, 223 p.
- BERTOLA, P.; MANZINI, E. 2005. *Design Multiverso. Appunti di Fenomenologia del Design*. Milano, Polidesign, 252 p.
- BLASER, W. 1981. *Mobili di Alvar Aalto*. Milano, Electa, 92 p.
- BLUMER, R. 2007. Insegnare tra architettura e design: paradossi inaspettati. *Domus 907*, p.118-125.
- BRANZI, A. 1996. *Il design italiano 1964-1990*. Milano, Electa e La Triennale di Milano, 291 p.
- BRANZI, A. 1983. Il design primario. In: A. BRANZI, *Merce e Metropoli. Esperienze del nuovo design italiano*. Palermo, Epos, p. 71-74.
- CAMPOGRANDE, S. 2009. Diffondere i materiali. In: M. FERRARA; S. LUCIBELLO, *Design Follows Materials*. Firenze, Alinea, p.66-73.
- CARDILLO, M., FERRARA, M. 2008. *Materiali intelligenti, sensibili, interattivi. 02 Materiali per il design*. Milano, Lupetti, 214 p.
- DOVEIL, F. 2002. Nuovi materiali e nuovi valori d'uso per la casa. In: G. BOSONI (ed.), *La cultura dell'abitare. Il design in Italia 1945-2001*. Milano, Skira, p. 184-199
- FERRARA, M. 2003. *Materiali e innovazioni nel design. Le microstorie*. Roma, Gangemi, 95 p.
- FERRARA, M. 2005. *Acciaio. 01 Materiali per il design*. Milano, Lupetti, 120 p.
- FERRARA, M.; LUCIBELLO, S. 2009. *Design follows materials*. Firenze, Alinea, 183 p.
- GROPIUS, W. 1955. My Conception of the Bauhaus Idea. In: W. GROPIUS, *Scope of total Architecture*. New York, Harper & Row, p. 23-34.
- HUSSERL, E. 1965 [1913]. Ideen zu einer reinen Phänomenologie und phänomenologischen Philosophie. Erstes Buch: Allgemeine Einführung in die reine Phänomenologie. In: E. FILIPPINI (ed., trans.), *Idee per una fenomenologia pura e per una filosofia fenomenologia (1913-1928)*. Torino, Einaudi, vol. II.
- KARAN, E. 2010. *Meanings of materials*. Saarbruken, LAP Lambert Academic Publishing, 268 p.
- KIMBELL, R. 1996. Technology tasks and pupils learning. In: A. WILLIAMS; J. WILLIAMS (eds.), *Technology education for teachers*. Melbourne, Macmillan.
- LANGELLA, C. 2003. *Nuovi paesaggi materici*. Firenze, Alinea, 207 p.
- LANGELLA, C. 2007. *Hybrid design*. Milano, Franco Angeli, 158 p.
- LERMA, B.; DE GIORGI, C.; ALLIONE, C. 2011. *Design e materiali*. Milano, Franco Angeli, 160 p.
- LUCIBELLO, S. 2005. *Materiali@design*. Roma, Librerie Editrici Dedalo, 114 p.
- LUCIBELLO, S. 2009. Back to the Future. diid Disegno industriale industrial design. *Nature & Materials in Design*, **38**:28-33.
- MANZINI, E. 1986. *La materia dell'invenzione*. Milano, Arcadia Edizioni, 255 p.
- RAIMONDO, C. 2004. Design dei materiali. In: E. Manzini; P. Bertola (ed.), *Design Multiverso. Appunti di fenomenologia del design*. Milano, Polidesign, p. 165-177.
- ROGNOLI, V.; LEVI, M. 2005. *Materiali per il design: espressività e sensorialità*. Milano, Polipress, 182 p.
- ROGNOLI, V.; LEVI, M. 2011. *Il senso dei materiali per il design*. Milano, Franco Angeli, 272 p.
- SALVIA, G.; ROGNOLI, V.; LEVI, M. 2009. *Il progetto della natura. Gli strumenti della biomimesi per il design*. Milano, Franco Angeli, 294 p.
- SCHÖN, D. 1983. *The Reflective Practitioner. How Professionals Think in Action*. New York, Basic Books, 374 p.
- SIMON, H.A. 1988 [1969]. *Le scienze dell'artificiale*. Bologna, Il Mulino, 244 p.

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