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HOW, WHAT AND WHERE IS POSSIBLE TO LEARN DESIGN MATERIALS?

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ABSTRACT
The aim of the dissertation is to deepen the understanding of the modality on which the Didactic of the materials in the formation of the designer could be based. The research encompasses the past and present didactic of materials and focuses on future developments with a cautious view on the possible cross-fertilization with other didactic methods developed in other disciplines. Fundamental to this scope is to illustrate in detail the actual phenomenon of the birth of library of materials as research centres on materials for design. Substantial differences will be evidenced between different typologies and reality, such as private and universitarian. An explicit table will be compiled of existing didactic material (books, experts, manuals, data banks, publications, magazines) formulating a classification based on diverse typologies and scopes. What needs to emerge is the potential utility of each typology during the formative period of the designer.
The Bauhaus approach to materials' theme is here considered as the first exemple of effective and contemporary teaching methodology.
The focus shall be on the case study of a project for a didactic laboratory of materials for design. The prefixed result is that of showing which of the tools reveal themselves useful on the modality of the project.
Individualized the positives and deficiencies, the guideline will emerge explicitly for an adequate set of instruments available for the didactic of the material in a context of the project. From a conceptual point of view the basic theme of the dissertation will focus on the possibility of consolidation and/or creation, where non-exists, points of contact between the culture of engineering and that of design, reflecting on possible interactions and feedback useful for a possible enrichment of both.

Keyword: design materials, materials library, pedagogic tools

1 THE DIDACTIC OF THE MATERIALS IN THE HISTORY OF THE INDUSTRIAL DESIGN

The Bauhaus, which literally means "construction house" was founded at Weimar in 1919 following the fusion of the arts and trades schools, at the will of the architect Walter Gropius. Speaking of this at this place is useful for two fundamental motives; in the first place, based on a mutual idea, the Bauhaus is considered as being the first school of finalized industrial design, for a lengthy portion of its existence, at the formation of he who would have given form to the birth of the industry; in second place, it is opportune to show the original pedagogical approach primarily in reference to the didactics related to the materials of the project.
The first phase of the Bauhaus, boldly expressive and animated with strong community spirit had been influenced by Johannes Itten, painter and master of art, who remained at

the school from 1919 to 1923. The Vorkurs, a preparatory 6-month course and structural basis of instruction that unfolds a central role in the middle of the pedagogic system for the entire existence of the Bauhaus, was idealized by him, whose intent was "...as a platform for an integral education for complete human beings."[8]
In the Vorkurs, Itten taught the Theory of Contrast. "The chiaroscuro contrast, the material and the texture studies, the theory of form and colors, the rhythm and the expressive forms were discussed and demostrated in terms of their contrast effect. Finding and listing the various possibilities of contrast was always one of the most exciting subjects, because the students realized that a completely new world was opening up to them. Such contrasts are: large-small, long-short, broad-narrow, thick-thin, black-white, much-little, straight-curved, pointed-blunt, horizontal-vertical, diagonal-circular, high-low, area-line, area-body, line-body, smooth-rough, hard-soft, still-moving, light-heavy, trasparent-opaque, continuous-intermittent, liquid-solid, sweet-sour, strong-weak, loud-soft, as well as the seven color contrasts.… The students had to approach the contrasts from three direction: they had to experience them with their senses, objectivize them intellectually, and realize them synthetically. Contrast such as black-white, large-small, and cold-hot are particulary powerful examples of this complex. As life and beauty unfold in the regions between the North Pole and the South Pole of our planet, so life and beauty of the world of contrast are to be found in the graduation between the poles of contrast."[3] Examples of these contrasts were made via samples of material used for sculptures and compositions; the study of contrasts increased the sensitivity for the material and prepared one for work in the laboratories. The organization of the laboratories constituted the other grand innovation of the pedagogic method of the school.
Already from 1920 each laboratory was countersigned with material used there and the work was oriented in a way particular to the problems of the materials and the composition. The laboratories activated during the entire duration of the school were: the laboratory of ceramics, of textiles, of metals, of furniture (wood), of decoration of murals and on glass, of sculpture in wood and stone, and bindings. Initially all the laboratories were strongly influenced by the strong personality of Itten and his Vorkurs. In Itten's Vorkurs, the studies on the expressive capacity of the materials such as texture, on finishing and on phenomenologic aspect were initiated. Even before the technical description, the expressive and sensory characterization of the material became considered fundamental in the formation. The study of the nature of the materials had the purpose of showing what in each matter is diverse and essential, in a manner that each one refined their own sensibility for the matter. Itten organized exercises in sensitization for the materials also on the basis of the proper theoretical formulations. "In the Basic Course at the Bauhaus exercises with materials and textures were found particularly stimulating. As an introduction long lists of the various materials, such as wood, glass, fabrics, bark, furs, metals, and stones were compiled. I then had the visual and tactile sensations of these materials entered against them in further columns. But knowledge of the words describing the properties was not enough; it was necessary to experience and to demonstrate the character of the materials. Contrasts such as smooth-rough, hard-soft, light-heavy had not only to be seen, but also felt. … At the Bauhaus, I had a long chromatic series of material samples made for the tactile assessment of the various textures. The students had to feel these sequences of textures with their fingertips, their eyes closed. After a short while their sense of touch improved dramatically. I then asked them to make texture montages of contrasting

materials. Fantastic structures were produced and their effects were completely novel at the time."[3]
In 1923 Itten resigned from the Bauhaus, thus permitting the pedagogical redirection of the school, which passed from the centrality of a single individual to the creation of new products in line with the requirements of the industry. All the elements involved with the formation of the individual personality were relinquished and room was left for the development of an objective and technical line: a new union between art and technique. Lazlo Moholy-Nagy, together with Josef Albers, ex student of Bauhaus promoted to Meister in the same year 1923, would think of ways to reinforce this new orientation. "In 1926, the decision was made to complete the name of the institute with the addition of Hochschule fur Gestaltung (superior school (high school) of planning) to better focus on the fundamental task."[4]
The road taken by Itten was then advanced and developed, in accordance with the capacity and individual sentiment of Moholy-Nagy and of Albers. In 1925 the school was transferred due to heavy political pressure to Dessau, where it remained until 1930, but even here the propaedeutic courses continued to represent an essential part of the basic formation of the students. The Vorkurs of Albers revealed itself of utmost importance, which in the period of six months to a year, showed a sort of technical teaching, *werklehre*, together with the traditional technical-artisan formation, in which visits to factories and artisan establishments were carried out, and where elementary ideas about the most important properties of the materials and the fundamental principles of the construction were furnished. Albers moved towards a visual technique which points to knowledge of the intimate structure of the material in relation with the hand, with the body, and with other materials. When his understanding that the visits to the factories and artisan establishments were pedagogically inadequate because they were influencing the students in an imitative and conservative logic of the traditional techniques, instead of creating a desired thrust towards innovation, Albers rebuilds his Vorkurs on two important pillars: "…on the exercises with matière (Matter) and materials (Material) – two terms that, because of their similarity, have naturally been confused again and again."[8] The objective of the "exercises with the matter" was to explore the external appearance, the epidermis (outer thin skin) of things, that led to the feel of the material through opposing and desired relations. The materials used were industrial products and not waste or scrap, which instead were used in Itten's course. The students no longer had to work with any type of material, but contrarily, they had to follow a very precise plan: glass, paper and metal, and these had to be worked in such a way as to eliminate all waste: frugality was the most important principle. The principal scope of Albers' teaching was the creative use of the materials in accordance with the criteria of frugality and functionality. This was evident in the "exercises with the materials". "Here we find what is clearly Albers's most original and unmistakable contribution to the pedagogy of the Bauhaus. As we have seen, we must distinguish strictly between matèrie and material exercises. In contrast with the matèrie exercises, which aimed to help develop the sensory recognition of the surfaces of materials, the material exercises were concerned with exploring immanent features of the materials, such as stability, load-bearing capacity, strength, and so on, that is, to examine their inner energies."[8] Albers' fundamental contribution, whose Vorkurs was in effect till 1933, at the pedagogic approach of the Bauhaus, was to consider the materials as contributing factors in the problematic of the project.
While the principle of Itten's Vorkurs focussed on the sensible vibrations , perceptive, imaginative, on suggestion, on emotional impact, on the emotional text created on

observation, in listening, in the sensorial exploration of the materials, seeking to act contemporaneously on the individual attitudes, Moholy-Nagy, though conserving the intuitive and sensual fundamentals, found a way to develop experimental methods of new materials and the utilization of new technologies, useful and interesting for the emerging dimension of productivity ("produttivista").

The production of models for the industry pertains particularly to the period of the Dessau and it brought with it the study and experimentation of new materials, and to the strictest formality it unites the research of a functional optimization. The educational program of the Bauhaus of Dessau, which sees the propedeutic courses of Albers and Moholy running simultaneously, is that of establishing organic ties between creative forces and industry. The Bauhaus became a focal point for the new creative forces that welcomes the challenges with a new technical process, with its own recognition of social responsibility. Some realizations in the key of functionality of the Bauhaus constitute fundamental moments of industrial design and of experimentation of materials; for example, we can cite the steel tube furniture of Breuer and others, which was dealt with more thoroughly previously.

Moholy's lessons, called “studies in composition”, concentrated on the composition in the space of diverse and original materials; among these are found the new synthetic polymers, from which the new aesthetic-perceptive aspects were investigated, such as transparency and superficial homogeneity. Moholy also resumed the tradition of tactile tables already used by Itten under clear futuristic influence, with the scope of refining the sensibility of the students for the materials. “...Everyone is endowed by nature to receive and assimilate sensory experiences. Everyone is sensitive to tones and colours, everyone has a feeling of safety and a realization of space, and so on. This signifies that by nature everyone is capable of taking part in all the pleasures of the sensorial experience.... Objective (of the Vorkurs) is spontaneity and inventiveness to give those students a universal vision and to make them conscious of their creative forces. Here the student experiments with tools and machines, wood, metal, rubber, glass, textiles, paper and plastics; ...working with diverse materials he gradually discovers their genuine potential and acquires a complete awareness of their structure, weaving and of superficial treatment.... The fundamental idea of this education is that every man is endowed with talent, and once the elementary course has activated his emotional and intellectual strengths, he will be capable of producing creative work.”[7] Another important observation considers the “tactile exercises” that Moholy proposed to give the students knowledge of the materials even from a technological point of view, and not only sensorial or expressive. Perhaps in this consist the difference and the evolution with respect to Itten. “…Moholoy foresaw a special place for the experience with the material by means of primitive tactile exercises. Instead of the school of seeing Moholoy stands for the sense of touch, which has drastically degenerated in modern man. …for example, in order to exercise the haptic faculties, Moholy-Nagy had tactile tables, wheels, and ribbons made on which materials were arranged according to fixed, defined criteria, usually in the form of two line scales that could be held at the same time, for example, from smooth to rough or from sharp to dull. …The exercises for training the tactile and optical senses do not appear to have been fundamentally different from those Itten gave in his preliminary course. There are, however, two significant differences: first, in the new formal language, which was now indebted to costructivism; second, Itten’s tactile exercises always retained sensualist, emotional, and experiential qualities, whereas Moholy sought to objectify what was subjectively felt by

means of tactile diagrams and in this way made accessible to an intersubjective reconstruction."[8]
To the tactile exercises were adjoined some "exercises on the treatment of the surface", the importance of which resides in the strict observation of the materials which they were obligated to make. "The student in his initial exercises, studies the materials principally by means of his own sense of feeling. He gathers a great variety of materials so that he can. He collects a large variety of materials in this way he can record as many sensations as possible. He groups the materials in tactile tables which contain sensations, some of them are related and some contrasting. ... It is well known that tactile exercises offer a wide range of possibilities to practical scopes. They give a solid base on which deal with materials on the technology side or on the artistic side. ...Since tactile values are registered singularly by each individual it seemed good to register individual reactions in a "diagram of tact". Later it could be possible to refer to these diagrams to check for any possible change in perceptions"[7] Albers and Moholy realized that, referring to sensoriality of materials, it was good to promote a project way oriented to a design that brings sensation and emotional expressions; surely Marinetti's "Manifesto del Tattilismo" (1921) influenced deeply his contemporary "artistic" culture, but at the Bauhaus the willing of teach a new form of arts disappeared, they were concentrated on everything could be useful in terms of industrial quality.
For the first time in the history of the relationship between men and materials there are project aimed intentionally to the expression and senses of materials, with the willing to understand completely the essential and indicative character of every material.
As for every other job also in design field comes out the need of knowing deeply the needed tools, and in the Bauhaus, and in his pedagogic approach it becomes a priority in the designer education. The Bauhaus experience, regarding the didactic of materials, has been really important. The systematic study of materials of their characteristics and the possible way they can be used in the arts, is set at the basis of the planning of industrial or architect objects.
The aim of get closer art and industry implicates a new relationship with materials, it can be seen also in the manual work useful to learn technical and formal aspects of materials to be put beside their expressive sensorial dimension.

2 THE DIDACTIC OF THE MATERIALS IN THE CONTEMPORARY UNIVERSITY DIMENSION

Today's schools of design have generally inherited a lot from Bauhaus.
In the contemporary Italian panorama the didactic of design is carried out both in private schools and in important university contexts, among them it is opportune to mention the "Politecnico di Milano" (the first one to establish, since 1993, a graduate program in industrial design), the IUAV in Venice, the Turin and Rome faculties, it is also important to underline that there are faculties beginning and evolving activities in this field.
In this work we will refer mainly the university context, without mentioning, on purpose, to the Milan reality, but it is important to tell that both of us studied and work in this environment, then this is the university context that we know better.
It is a while since in Italy it has been understood the importance, in the education of a designer, of the communication between the project and the engineering culture. It is commonly thought that a designer is that kind of professional that has to be able to move in different contexts, he has to be able to relate himself to different characters with different educations (technicians, engineers, sales agents, artists, men of letters,)

often all these characters speak different languages. During its formation a designer has to learn the more possible different languages, to be able to communicate his ideas and to have them transformed in real projects. The designer should have an eclectic character. In order to have such mental attitude it is necessary that the designer receives an education that makes him open-minded, that he gets in contact with all these different environments, that he will get in contact with during his working life.

Under this point of view, the theme of this paper is of great importance. It is easy to demonstrate that it is necessary for the designer acquire a know-how related to the matter, taking an heavy contribution from engineering. As a matter of facts this discipline has a long scientific and technological tradition of studies on matter, it has also a rational and organized didactic.

Differently to the antique craftsmen the modern designer does not have a direct approach with matter, and most important, he does not have time to establish an empiric contact with materials, since materials are multiplying at incredible speed, the designer has to refer to the engineering knowledge, therefore to a prescriptive knowledge, "...it is a knowledge that treatise a material as known when its performances are known, therefore codified in numerical shape."[6] In the considered university dimension it became clear that put side by side materials courses and technology of material courses (held by engineers) and project laboratories (held by architects and designers) was not enough, therefore the next step was to have the engineers involved in the laboratory experiences; surely this was a nice experience for both sides, because it should not be forgotten that there are positive feed-back for the engineers too.

To give an answer to the need of communication between the two cultures, with the aim of connecting the expressive-sensorial dimension of materials with the technical and technological know how of engineers, the idea of finding a physical place to this project should be realized, by creating a laboratory dedicated to the materials for design.

In fact, it is important to underline here how the laboratory dimension and the union of technical and artistic are direct heritage of Bauhaus.

This should be a place where engineers and designers could meet, where could take place the communication needed for a common work and a common research. The most important place into this laboratory should be the "materials library", it is a physical archive of samples of materials, where students and professors can find many kinds of information on materials and related technologies, in this way it could be possible to bring back in contact the designer and the matter, avoiding the only abstract and hybrid knowledge.

The laboratory shall be a research center on materials for design, with the cooperation of the departments that research in materials and design fields, where different knowledge get together to create contents that are coherent, efficient and useful to didactics. According to this logic, the materials library should be an up to date catalogue of samples of materials directly related to the manufacture or transformation companies, and, relaying on this information, it should give a consulting service, and a series of events and meetings related to its activities. In our opinion a correct pedagogic approach to the designer education should be based on a direct contact with materials, suppliers and transformers. Materials library should be a place available for the consultation, where it is possible to see and touch, where one can feel free to create. We are convinced that watch pictures are not enough to designers, just neither is read books or watch charts, "…manipulate it as a creative tool."[1]

In the laboratory would find a place many didactic tools, like a selected library, magazines, catalogues of visited exhibitions, documents on shows and museums, soft

wares, etc. The government should pay for keeping up to date the materials library "...technologies of materials and their impact have to be related to the design function..." [2]; Starting from what we said before, it would be desirable that the updating and the collecting of information on materials for design shall become a materials library's job into the university field. University has mainly an educational scope, then it should give information and consulting service, all these features should be free and of a good quality, because this is a way to transmit a research on materials method, and this is part of the educational process too.
With all the university reforms, positive and not, which are already in place or are coming in the future, in Italy; new undergraduate, three years based, courses have been created, these are followed by specialistic graduate degrees. One of the new degree that has been created is a "engineering & design" course, this is a double way in course opened to, both, engineers and designers, In this degree there are heterogeneous courses held by professionals coming from different areas. In this prospective the role played by the materials and design laboratory should be even more important and strategic, and as said above, it should start a consulting service, given is first place to professors, who could find a service functioning as a technological advisor ready to give and receive stimuli in order to improve the quality of didactics.

3 THE DIDACTIC SUPPORT IUSSUE

A didactic of good quality can be obtained also spending some energy and time in researching on what could be used as didactic tool, and in the case that something is missing, some tools could be designed on purpose. It is not in our intention to compile a complete catalogue of the existing products that can be used in didactic of materials, instead we would like to mention the good things done in Europe, in this field.
"In higher education the same discrepancy appears: the teaching of the science and technical application of materials is highly developed and systematized, supported by numerous texts, software, journal and conference; there is no similar abundance of support for the teaching of materials in industrial design."[1]
First of all one should ask himself which kind of information about materials is needed to a designer. They talk about materials in a way that looks even too easy to engineers. What is absolutely clear to both of them is that materials can be described in different ways: technical, expressive-sensorial and environmental, to do that many different information coming from different sources are needed. All these sources will supply different information but all of them are useful to the education of the designer.
Regarding the technical profile of materials it is needed to take the information from the formalized and structured engineering literature, and going a step forward it is possible to find interesting ways to display the information on materials. The Ashby maps developed at Cambridge are a perfect example of a good way of visualizing the technical characteristics of materials. Using the principle of coupling some properties (e.g. elastic modulus and density) it is possible to create a map where all the classes of materials are reported according to the values of their properties. It is really easy to read this map and in it can be condensed many useful technical information, on the other hand it is easy to see similarities between materials that could not be seen in any other way.
There are some software that are just as interesting and useful as maps, these are materials selection software, the most known among them is C.E.S. [1], it was developed in Cambridge by Ashby in the framework of the researches started by

Cornish [2] who already believed in the validity of databases for the selection of materials for professional and didactic uses.
Willing to create new profiles of materials for the design, and convinced that the education of a designer needs an organized and structured engineering knowledge, it is possible to connect this knowledge with the phenomenological appearance of matter, and it is the appearance that brings us to obtain a expressive-sensorial profile of things.
In this work it is important to remark the importance of researches that aim to relate the expressive-sensorial dimension with technical properties of materials. The sensorial side is the one that can be recognised as the most important in the project activity, the designer has to be able to make the decisions that will satisfy his material image of the product, using the right material and choosing the right technology.

4 CONCLUDING REMARKS

The university education seems to be the better possible to learn materials in the way they are useful to the designer. It emerged that it is necessary to redirect the didactic approach to materials following up to date methods and using dedicated structures and tolls, above all watching what is happening on the international scene. Concluding, the university education in the design field should aim to the possibility to supply knowledge that allows to choose the most suitable material in a project, regarding the technical performances and the expressive-sensorial characterization, this is what turns the idea into reality.
The next steps of this study will be based on researching, deepening and comparing different programs of different national/international schools and universities.
This will get a proper vision of the context and let us think about a project for university networks of laboratories of materials.

REFERENCES

[1] Ashby M., Johnson K., *Materials and design*, Butterworth, Oxford 2002
[2] Cornish H., *Materials and the designers*, Cambridge University Press, Cambridge 1987
[3] Itten J., *Design and form*, John Wiley & Sons, New York 2002 (1963)
[4] Maldonado T., *Disegno industriale: un riesame,* Feltrinelli, Milano 1976
[5] Manzini E., *La materia dell'invenzione*, Arcadia, Milano 1986
[6] Manzini E., *Il sapere del progettista*, "Modo" n.77, Milano 1985
[7] Moholy-Nagy L., *Dal materiale all'architettura*, Sergio Los (Eds.), Istituto Universitario di Architettura, Istituto di Tecnologia, Venezia 1969
[8] Wick R. K., *Teaching at the Bauhaus*, Hatje Cantz, Ostfildern-Ruit, DE 2000

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