# PROCEEDINGS

## DRS LEARN X DESIGN 2019

insider knowledge

Fifth International Conference for
Design Education Researchers
9-12 July 2019
Middle East Technical University
Ankara, TURKEY

**Editors**
Naz A.G.Z. Börekçi
Dalsu Özgen Koçyıldırım
Fatma Korkut
Derek Jones

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# Material Education in Design: From Literature Review to Rethinking

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**Abstract:** The world of materials for design is continually changing and evolving, not only thanks to technological advancements, but also thanks to the continuous original applications by designers, as well as the reinterpretation and understanding by design researchers that reveal new ideas, suggestions and unconventional paths. It is essential and fundamental for design educators to understand how to educate students and let them be autonomous and prepared for the choice or creation of materials and processes to complete their projects nowadays. The material is not only the object but also the tool or media around which most of the design education shapes: transferring the knowledge of materials' technical properties or experiential qualities to design students is essential, and in the process on materialising the design projects, students are also being educated by their hands-on experiences. This paper provides a literature review to interpret the nature of material education in design and lists significant aspects. It is structured into four parts: the role of material in design education; learning through practice with materials; considerations on material in design; and the highlighted aspects in material teaching and learning processes. This paper lays the foundation for future material education research.

***Keywords:*** *material education; material experience; design education; material literacy*

## 1 Material in Design and Design Education

The material, as we are using here, refers to the substance of everything we see and touch. Designers have always appreciated materials because the design practice can also be interpreted as a process that allows shaping a better world thanks to materials and their qualities. The material is an essential element for transforming a design concept into reality, and furthermore, it can drive innovation, give inspirations and meaning to the project. All designers use materials and can express their judgments or formulate their thoughts about their relationship with that matter (Manzini, 1986; Ashby & Johnson, 2013). In the end, the understanding of design cannot be separate from the materials and processes that are useful in shaping it.

Nowadays, in design education, students are required to materialise their concepts with correct materials and more and more, they are encouraged to explore materials actively through practical activities as well. Based on the existing

literature and our experience as researchers and instructors, we believe that materials education is an essential part of design education as a whole.

This paper will provide a holistic view of materials and design education, and lead to a thorough inquiry on the past and present conditions of material education in the contest of design.

## 1.1 Design Education Background

We are discussing materials within the discipline of design, for which it is relatively difficult to propose a satisfactory and shared definition (Redström, 2017). However, this does not mean that scholars cease their efforts to formulate an adequate design definition. On the contrary, as a broad subject where people's diverse experiences as well as their cultural backgrounds are involved, design, as a term, has been given too much explanation (Findeli, 1990). The definition of design contains too much, depending on whether it is observed as a concept, knowledge, project, process, product, or even a way of being. These definitions and contents remind us that design is not a simple matter that can be performed according to a specific model. Regardless, the proliferation of theories justifies design itself, and the design education is interwoven with many things, for example: the combination and interaction of art and science, technology, the particularity and universality in different cultural contexts, and the diverse methods with which knowledge and experiences are acquired.

We want to start considering the theories related to design education beginning from what was formulated by John Dewey who proposed that the principal meaning of education is a matter of the ability to act intelligently, constantly cultivating the capability for a person to proceed in a changing world (Dewey, 1916; 1938; 1946). The psychological aspects of education emphasised that the personal intrinsic and inherent abilities provide a starting point for all educational activities. Learning is a process of understanding and improving personal skills, and teachers are asked to provide an environment and the guidance for that process. Besides, the social background gives an interpretation of individual capabilities in terms of social activity. Dewey emphasised the concept of *experience* —he believed that the teaching method should consider experience not only as the goal of education but as the method and process of achieving education as well (Cross, 1983).

The exploration and reflection of design education began with Bauhaus, universally considered the first school of design, where the issues related to design education were also addressed theoretically for the first time (Wick, 2000). The Bauhaus's educational approach was a dynamic and growing process with constant improvement to the professors' teaching curriculum (Cross, 1983), considering one's own sensations and expressions as the foundation (Itten, 1963). Here, the importance of experience and practice, and materials and processes were highlighted as vital components of the education approach. According to the Bauhaus Educative Scheme, the basic course was structured by "study of materials and tools", "study of nature", "study of materials", "space study - colour study - composition study", and in the third shell in which the centre of the circle is the material (*clay*, *stone*, *wood*, *metal*, *glass*), textiles, and colour. The principal aim was to encourage students to explore primary and unique material characteristics based on hands-on exploration (Rognoli & Levi, 2004).

Bauhaus was influenced by Dewey's philosophy of epistemology and constructed the practice-based knowledge generation within the courses accordingly (Moholy-Nagy, 1947; Fiedler & Feierabend, 1999). We can outline two main categories, one being the *plastic elements* such as line, shape, colour, texture and so forth, and another category being the materials and specific tools (Findeli, 1990). It had a clear purpose: offer "a test of students' abilities, ...help[] shorten the road of self-experience, …[and] give [the students] ample opportunities to make a careful choice of his field of specialisation later" (Educational Program, 1937-38). According to the methodological structure of this introductory course, the material is a tool and a media in design education. The practical process with materials and effective processing of materials helped the students understand their design methods and gain design capabilities.

## 1.2 Material as Design Knowledge

The characteristic of design knowledge is defined considering both the feature of knowledge and the design activities. It is a mix of designers' experience and contextual information about the production and use of products. Explicit knowledge refers to knowledge that is transmittable in formal and systematic language (Nonaka & Takeushi, 1995). In design activities, analytical and synthetic methods are the driving forces to promote the development of a design solution through formal structures (Jones 1970; Papanek, 1972; Woodham, 1997). Opposite to this, tacit knowledge is personal, context-specific and hard to formalize and communicate (Nonaka & Takeushi, 1995). It is embedded in individual experience and involves many personal intangible factors, such as belief, perspective, value system. Tacit

knowledge cannot be articulated easily, it generates through personal intuition and experience. These two types of knowledge interact and interweave to each other in design activities.

Material itself is design knowledge, it has technical attributes which can be transmitted from teacher to students formally. Furthermore, through intuitive experience of materials with the five senses, materials help people achieve tacit knowledge and perceive the world all around.

### 1.3 Material in Design Curriculum and Pedagogy

From the detailed curriculum in classical design schools we move our sights to the macro perspective of the educational model. There are two opposite poles in design education: content and pedagogy (Findeli, 1990). Some design schools are content-oriented; they emphasize the curriculum and deliver scientific and technical skills to students, while other design schools are pedagogic predominates, they are more humanistic (Read, 1943) and process-oriented. This dualism is intrinsic in design education: curriculum and pedagogy are two aspects that cannot be separated in design education, and effectiveness of education depends on how to achieve balance between them. In design education, besides the outward study and research on science and technology, students should be balanced by inward *looking, thinking and spiritual focus* (Itten, 1963), which means that students need to understand the necessary theoretical foundations and also establish their own ideological backgrounds for design in practice. Content and processes are equally important in design education.

Thinking through this dialectic dualism, material has two roles in design education. First, it is the content of design education: the knowledge of the materials itself (explicit knowledge) is essential to students —almost all of the design programs have a material mandatory course in the first year. Second, material is a tool and media in the design and design education process: by encouraging students to undertake practical activities and gain materials experience, students increase their design capabilities. In summary, teachers not only transfer explicit material knowledge to students, but also emphasize practice to cultivate students with their individual differences in design learning, engage them tinkering with materials, in order to understand the attributes of materials, select proper materials or create their own materials.

## 2 Learning through Practice with Materials

How do students learn through practice in design, with materials? John Dewey's theory of experience (Dewey, 1938) laid a solid foundation for later practice-based educational theory. Influenced by his and other scholars' (Montessori, Froebel, Pestalozzi, etc.) research, Jean Piaget coined a theory of learning known as "constructivism." He emphasized that knowledge in one's mind does not result from receiving information transmitted by others without an internal reprocessing — learners construct knowledge based on their experience (Piaget, 1976). Donald Schön generated more detailed and profound theories called reflective practice for clarifying this re-processing of knowledge, by introducing concepts such as reflection-on-action and reflection-in-action (Schön, 1983). Schön pointed out that, the developmental insight of people is based on paying critical attention to practical values and theories. In other words, "examining practice reflectively and reflexively" (Bolton, 2010). One of the most typical models of reflective practice is the experimental learning (Kolb, 1984), which provides a method where a person's abilities can be assessed in the same language that can be commensurability measured. It gives us a holistic perspective on learning, including experience, perception, cognition and behaviour — considering the journey on concrete experience, reflective observations, abstract conceptualization and active experimentation as a cyclic learning process.

In essence, these theories clarified how students acquaint design knowledge and acquire design capabilities in design practice; they can also inspire design educators with a large-scale picture of how to guide and engage students in the practice through materials. In the current design education context, two emerging phenomena concerning materials-related practice are highlighted: the emergence and democratization of makerspaces, and the emphasis of material tinkering.

With the development of science and technology and the popularity of fabrication tools, the democratization of individual fabrication brings the relationship between designers, technologies, production processes, and materials to a new dimension (Rognoli et al., 2015). The popularity of makerspaces as fab labs (Gershenfeld, 2007) in schools and universities (Blikstein, 2013; Martinez & Stager, 2013) gives students more access to materials and tools for processing materials, and engages students more with the knowledge of digital crafts and transformation of materials in novel and creative ways (Zhou et al., 2018). Besides, countless websites and social networks where makers share ideas facilitate and engage the learning and creating (Martinez & Stager, 2013).

As a behavioral level of material practice in design, scholars introduced the term of "material tinkering": the practice of direct, creative, and iterative experimentation on materials (Parisi et al., 2017). Tinkering is a mindset, which refers to a playful way to approach and solve problems through direct experience (Martinez & Stager, 2013; Wilson & Petrich, 2014). Through material tinkering, learners can directly be engaged with physical samples of materials and generate their own sensoriality of materials. Here it's important to elaborate the transition of the way designers view the material, and the impact it brings.

# 3 Materials in Design

## 3.1 Material Selection

From the past to now, the most fundamental consideration of material in design is to materialize the design concepts by selecting the proper materials. There are many tools and guidebooks on helping designers and design students to select the materials they want. The most comprehensive theory about material selection in design is from Ashby and Johnson (2009), in their book "Material and Design". It mentions that material selection relies on both deductive and inductive reasoning. Deductive reasoning (selection by analysis) is a matter for choosing the best materials that fits the functionality needs with perfect technical attributes, while the inductive method (selected by synthesis) is used on perception and visualization, which relies on the synthesis competence of designers and their previous experiences. Besides these two methods, there are also two other ways of selecting: by similarity or by inspiration. In short, designers use a comprehensive approach in selecting materials.

Materials are *multi-dimensional*: besides the engineering dimension (the technical attributes), they have a usability dimension related to ergonomics and interfaces, an environmental dimension considering their sustainability, an aesthetics value which elicits people's senses and set up their material *personalities*. With such considerations, the theories and methods of material selection are getting constantly enriched as well as going through a transition, which emphasizes the relation between *people* and *materials*.

## 3.2 Materials Experience

Designers also focus on the attributes that describe personality or character, not just the technical attributes of materials: their visual and tactile attributes (an aesthetic perspective), their associations and meanings (an ethical perspective), as well as the emotions they evoke (a humanities perspective). Following Ezio Manzini's seminal book "Material of Invention" (Manzini, 1986) where for the first time the human interactive and experiential qualities of materials were emphasized, many researches and theories for guiding students to explore and measure the experimental characteristics of materials emerged (e.g. van Kesteren, 2008; Ashby & Johnson, 2009; Karana, 2009; Pedgley, 2009; Rognoli, 2010; Zuo, 2010; Karana, Pedgley & Rognoli, 2014). In design education, students are encouraged to experience materials samples with their senses, to objectivize the samples intellectually and to realize them synthetically.

The experiential activities with materials play an increasingly important part in teaching and learning process of design, and the term of experience-centred materials selection emerged recently. Scholars refer to the experience that people have with and through the materials as *materials experience* (Karana et al., 2008). This is a concern for the experience of aesthetics, meaning being evoked and emotional being responded by materials. And, with the continuous development of relevant theories and research on this term, *materials experience* acknowledges the active role of materials "not only in shaping our internal dialogues with artifacts, but also in shaping ways of doing and practices" (Karana et al., 2015, p. 37). Accordingly, four levels of materials experience are being defined: sensorial, interpretative (meanings), affective (emotions), and performative (Giaccardi et al., 2015). All these four components of materials experience are highly intertwined with subject-, object-, context-, and time-dependent attributes (Karana et al., 2015). Related active learning for these components can deliver a good foundation for student appreciation and action on designing for material experiences (Pedgley et al., 2016).

## 3.3 Gaining Insight and Foresight

The transition from technical attributes of materials to materials experience witnesses the changing perspectives in the current didactic emphasis and approaches in design.

Material opens up our view of design, craftsmanship, history, culture and the future. From a craftsmanship perspective, designers are able to create *unique*, *personal* or *durable* products with the capabilities to feel the passage of time and recognize and rationally apply the imperfection of materials (Rognoli et al., 2015). In terms of a social and environmental perspective, sustainability of materials, revived materials and bio-based materials, are frequently

occurring issues in design programs, which gives a design project multi-levels of meaning and interpretation. Besides, the generation and development of novel materials such as DIY materials (Rognoli et al., 2015; Ayala-Garcia & Rognoli, 2017) and ICS materials (Rognoli et al., 2017; Parisi et al., 2018) are getting into the designer's and design educator's eyesight. Students are beginning to actively create new materials to achieve their design expression. These emerging materials are not only able to provide new and unique experiential qualities (Rognoli, 2015), but also appear to open the door to a new form of ethics and a possible aesthetic of the future (Celi et al., 2018).

# 4 Next Generation of Material Education in Design

In the following section, with respect to the state of the material in design and design education, we define the material education in design and highlight its important aspects.

## 4.1 Material Education in Design, for Design, through Design

We discuss the *material education* in design, which refers to the educational process centred on materials in design, or design education activities that consider material as an aspect. As we mentioned before, in design process material itself can be defined as knowledge and simultaneously, as a medium for acquiring design abilities (design-related tacit knowledge). Therefore, material education in design includes both the material knowledge transfer and the usage of materials as aspects or tools to cultivate students' insight and foresight in design.

Material education and design are multi-beneficial. First, the material education we are talking about starts from a design learning environment, training students to understand and use materials from a designers' perspective. Moreover, the outcome of material education is directly targeting design students and thereby future designers. Finally, design methods and mindset help investigate and analyse the process, and develop the requisite methodology and tools of material education.

## 4.2 Four Aspects in Material Education

There are many factors to be considered in the process of material education. Considering the nature of design and design education as well as the current state of materials in design, we can view material education from four aspects: competence, tool, space, and service (Figure 1).

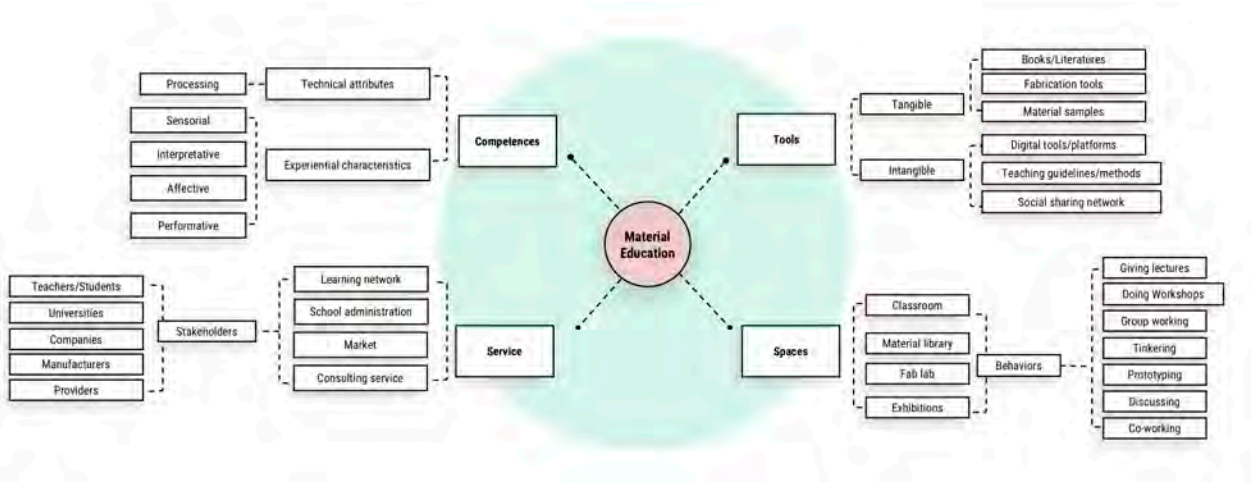


*Figure 1. Four aspects of material education in design.*

Competence refers to the material abilities designers need to have in design. It is not only a matter of explicit knowledge, but also tacit, experience-based knowledge. Therefore, in addition to direct knowledge transfer, design practice is essential. Students can have an intuitive feeling for the material itself through the encounter with material samples. The competence is also reflected in the proficiency of students in material practice and the mastery of relevant material processing methods.

Research on tools, spaces and services can answer the question of how to enhance material education in design. The tools refer to teachers' teaching methods, especially how teachers guide and encourage students to explore material experiences in driving their designs. Tools in material education can be a guideline, a touchpoint, or a combination of both. Currently, representative and classic tools in material education have different bias of contribution, some focus

on guiding students to clarify their experience with materials, and some start from technic, market or production perspectives to analyse materials. The significance of the tool is to encourage students to take the initiative to discover, experience and learn on materials or with materials. It starts with the student's personality and inner feelings, with the final aim of improving students' comprehensive design ability.

Material education activities can happen in diverse spaces; besides the classroom, the material library and fab lab can provide hands-on experiences to designers, navigate the materials selection process, considering that many aspects of materials are currently unquantifiable in experimental dimensions (Wilkes & Miodownik, 2018). For instance, a material library can provide access to physical samples of materials, which helps designers and design students translate material database and catalogue information to tangible experiences (Akın & Pedgley, 2016). Of course, such encounter behaviours may occur not only in the materials libraries, because these samples can be also presented during a lecture in front of a class, and students are allowed to touch and feel them.

Services can connect the environment and stakeholders together and enhance the educational process. In the university, the administrative system can provide an important service for students and teachers to share documents and slides, publish information and deliver homework. Besides, there are many material-related online services that can enhance design teaching and learning, such as the CES EduPack, with its comprehensive database of materials and processed information. Services provided by different companies may also help, by engaging transdisciplinary collaboration in design. Following on the material library example, a private company could coordinate the relationship between material researcher, designer and user needs (Wilkes & Miodownik, 2018). Design schools, as important stakeholder, can be also engaged in these kinds of collaborations.

Furthermore, material education should be viewed in a holistic context, and these aspects cannot be analysed in isolation. The material education research needs to be taken into account on the specifics of the competencies, skills, tools, services, and spaces best suited to enhance the concept of materials experience in design education and provide guidance for the future development of materials education.

# 5 Conclusion

This paper begins with a historical overview of the role of materials in design education and summarizes the state-of-the-art of material education. It provides a literature review, positioning material education in design within the existing knowledge (Figure 2), and highlights the important aspects of this teaching and learning journey. Material in design education is both the content and the pedagogic tool. Material education is not only for the cultivation of students' awareness and competence of materials, but is also for guiding students to actively tinker with materials, to achieve hands-on experience. The way designers view materials is going through a transition: they are starting to focus more on the experiential attributes, rather than the technical attributes.

The form of material education in design can be more diverse with the development of the four principal aspects: competences, tools, spaces, and services. Material education can enhance students' ability in materials and their design capabilities comprehensively from diverse starting points and perspectives. It can also encourage more practical design activities with hands-on experiences. Relevant creative spaces can be developed and applied to this teaching and learning, enabling students’ design works into a more open and collaborative process. Meanwhile, material education can become more transdisciplinary for future designers: more stakeholders could be involved into the educational process and share their knowledge. Material-related services could enter the universities’ classroom, providing students with more resources, connecting their projects to the market, and helping them get closer to their target users. These could be more helpful in opening up students’ minds compared to traditional didactics. Figure 3 shows how these four aspects (competence, tool, space, and service) would enhance future material education.

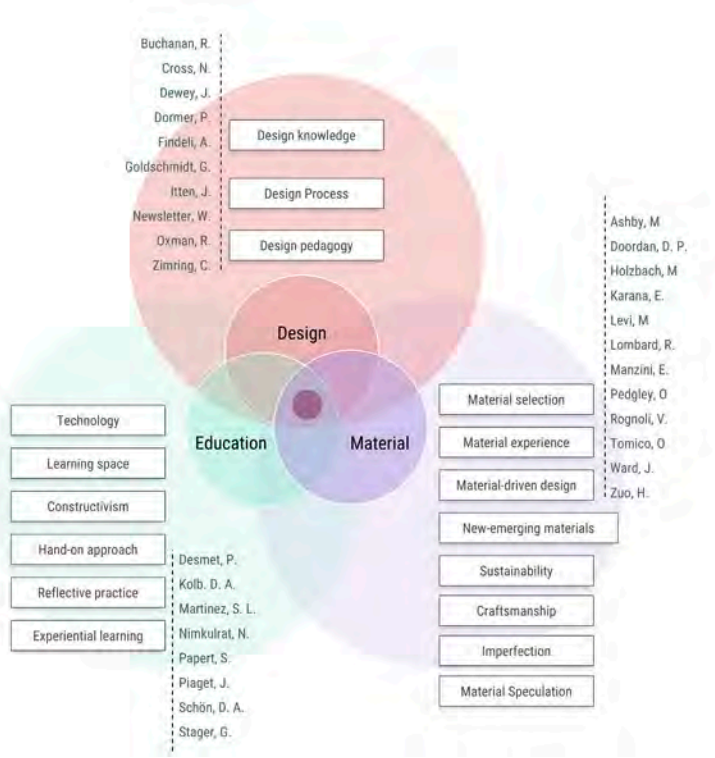


*Figure 2. Literature review map of Material education in design.*

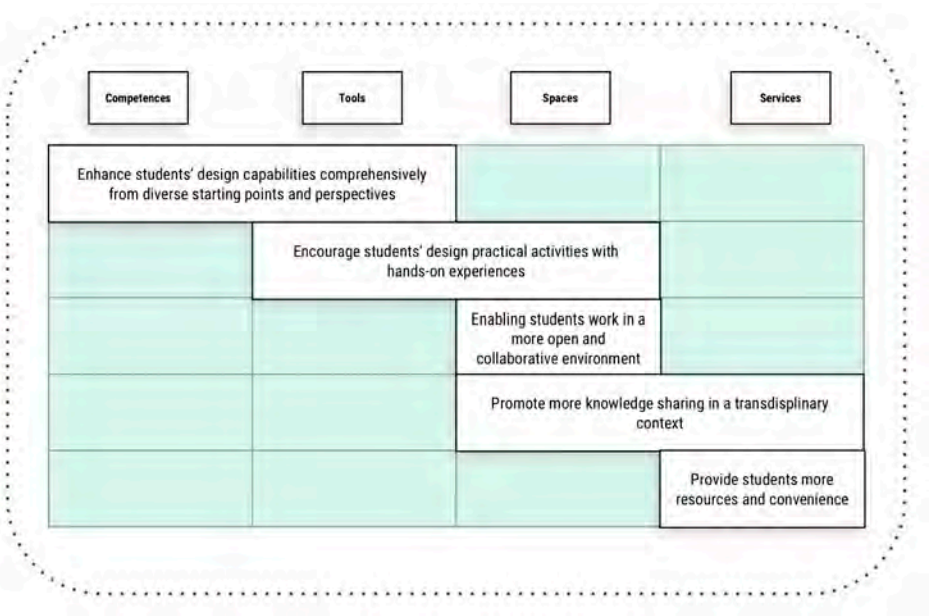


*Figure 3. How do material competences, tools, spaces, and service enhance material teaching and learning in design?*

Research of material education needs to be considered both for design and through design, since material education and design complement each other. Research and development on material education should keep pace with what is happening right now on this issue. Although re-elaborating the relationship between design, materials, and education can provide a theoretical basis for material-related educational process in this changing design world, material education research should contribute to the continued and regular discovery of current educational activities, in order to provide a vision of future materials education as well as design education.

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