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DEVELOPMENTS IN USER-CENTRED MATERIALS SELECTION FOR INDUSTRIAL DESIGN

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ABSTRACT
To meet the varied needs and desires of customers, the selection of materials for industrially manufactured products requires careful balancing of functional and expressive material requirements. However, the majority of material selection advice and resources continues to be oriented to functional and technical considerations. This paper provides a review and comparison of recently assembled research into user-centred materials selection, which seeks not only to bolster industrial designers' expertise in the area of expressively driven materials decisions but also to find a more confident place alongside utilitarian decisions. Five principal themes are identified from a collection of journal articles invited by the author for inclusion in a special file on materials and industrial design education: (1) development of a sensorial-expressive language of materials; (2) generation of materials knowledge via samples and product exemplars; (3) consideration of materials as a user interface; (4) awareness of contextual considerations; and (5) availability of new material selection tools. The intention is to inform design educators about how to shift materials teaching from a predominantly technical subject to one that has product experience at its core.

Keywords: Industrial design, materials selection, product experience, human factors

1 INTRODUCTION

Materials selection in product design is traditionally a technically dominated subject [1, 2, 3], focused on choosing materials having properties such as strength, durability and low weight that match a desired product performance at an acceptable cost. Ashby and Johnson [4] were notable in initiating a shift towards human factors in product material selection, exposing how selection activities are practised as 'art' (for product expression and aesthetics) as much as 'science' (for product performance and utility). In the intervening years, independent efforts have been made by researchers distributed around the world to try to transform the 'art' activities to a 'science'. The most important factor driving this work has been a desire to provide designers with an evidence base on which they can design for product expression and aesthetics beyond their own intuitions and idiosyncratic methods.

Support for materials selection in industrial design – as a specialist function within new product development – mostly takes the form of technical advice and engineering performance data. Such information is entirely appropriate for screening and choosing materials that can deliver a desired level of product utility. However, industrial designers have an additional concern to convey certain meanings and associations through products, for which engineering sources are found noticeably inadequate. For this reason, research into the humanistic aspect of materials selection is vital, and its importance has been neatly summarized [5].

"...if the designer changes the product's material - let's say from aluminium to plastics - this change has consequences for its tactual and visual aesthetics, for the symbolic and social meaning attached to the product, for the emotions it can elicit, and for its durability, reliability and performance. Hence, this decision affects the way the product is experienced in multiple ways, and it will ultimately affect the quality of the life experience this product is supposed to support."

Despite its obvious centrality to industrial design decisions, elaboration of the experiential perspective on user-material-product relations has been grossly neglected. This situation leaves question marks over the efficacy of undergraduate course content in materials and design, especially given the general dominance of 'harder' utilitarian-led selection activities presented in engineering courses, which are often delivered to industrial design students because of lack of materials expertise 'in-house'.

Certainly the 'softer' perspective of human-factors based material selection is not any less important, but it is under-developed as a field of study and has a much lower profile as a formal component of design practice.
To elaborate by means of an explanation, in Figure 1 three types of fruit juicer can be seen: each made from a different material family (plastic, glass and metal respectively). Each is a valid marketable product and will be attractive to certain cross-sections of the population. This begs several questions: why are people attracted or repulsed by products in certain materials? what drives their material reactions and experiences? and how can we be sure to select materials that people will love, and avoid those they will hate? These are the kinds of materials questions that are of concern to an industrial designer, and it is through a user-centred approach to materials selection that answers can be generated.

Figure 1. Fruit juicers manufactured from different material families

The purpose of this paper is to take a step towards redressing the technical-aesthetic imbalance that exists in materials selection. It critically reviews most recent thinking and research results that are *defining a new area of user-centred materials selection* for industrial design. Five researchers pioneering work in the area were invited to contribute summary articles of their theoretical and empirical findings to a 'special file' of a design journal published in 2010 and edited by the author [6]. For this paper, the researchers' articles have been cross-examined to expose commonalities in philosophy and findings for how to achieve user-centred materials selection. The aim was to try to identify and map-out a shared perspective on how materials selection for product expression and meaning can be (a) intelligently structured, and (b) delivered in an appropriate manner to student industrial designers. The work disseminated through the special file is suggested to be precisely the kind of work that has been needed to strengthen the subject of materials selection targeted at industrial designers.

2 THE SPECIAL FILE ARTICLES

The special file of the *METU Journal of the Faculty of Architecture* brought together research and thoughts of five academics in the formative stages of their careers, each contributing to the growing area of user-led materials selection and product experiences, and each carrying out work that evidently had important implications for industrial design education [7, 8, 9, 10, 11]. Furthermore, each author completed his/her PhD in the last decade in the area of materials and design [12, 13, 14, 15, 16] and therefore possessed considerable expertise on the limited provision of materials selection advice for industrial design. The contributors all carried out their research in Europe, and now work at institutions in the Netherlands, Italy, China and Turkey, helping to bring a global perspective to the issues raised. The aims of the special file were phrased as follows.

- To identify the most important subjects influencing materials selection in contemporary industrial design, and to explore how those subjects may be best integrated into design education.
- To disseminate critical new thinking on materials and design education.
- To refresh the materials and design education agenda and stimulate debate.
- To bring together into a single source contributions from relatively young researchers who are influencing the materials education of new generations of designer.

The general emphasis within the articles was empirical research and pragmatism of application.

3 PRINCIPAL THEMES IN USER-CENTRED MATERIALS SELECTION

A content analysis of the special file articles was undertaken to try to find threads and themes that connected each author's work conceptually, despite differences in use of terminology. Five principal themes were identified that represented the major shared arguments of the authors. It is proposed that these principal themes can be combined to create a coherent intellectual structure for user-centred materials selection, and that each theme can contribute significantly to realizing a user-centred approach to industrial design materials education. The themes are as follows, with each theme introduced in more detail shortly.

1. Sensorial-expressive language of materials
2. Samples and product exemplars
3. Materials as a user interface
4. Contextual considerations
5. New material selection tools

3.1 Sensorial-expressive language of materials

Materials are to be admired, handled, evaluated and otherwise experienced. If we take an interactional view of user-material-product relationships, then the starting point for all experiences is the sensorial information that emanates from a product (or more specifically for this paper, emanating from the materials of that product). In everyday acquaintances, we experience materials based on the sense data that we detect from them, spanning visual, tactile, kinesthetic, acoustic, olfactory, and gustatory modalities. Consequently we try to attribute meaning or reasoning to the sensorial information, building a personal appraisal of the material and – possibly, depending on circumstances – becoming affected on an emotional level by the material or its presence within a product.

All of the special file authors identified sensorial information as a fundamental building block for influencing users' experiences of a product or for creating 'sensual' impact [10, 17]. In other words, they agreed that materials could be usefully regarded as sensorial items. What is significant about this is that it departs from the way that material properties are classically categorized in academic sources according to technical performance. The everyday language of materials – the language that end-users can relate to – can be very colloquial (e.g. like an iPod, like Oakley sunglasses, like a bicycle seat) or can reveal direct appreciation of sensorial information (e.g. bendy, strong, slippery, stretchy). Thus if we are to take a user-centred approach to materials selection, our language of materials must be appropriate. This is especially the case if any kind of participatory design approach is to be taken. End users are unlikely to comprehend the practical implication of materials properties expressed in engineering language, for example: a Shore D value of 75, a coefficient of friction of 0.04 or a yield stress of 500 MNm^{-2}. The principle educational action under this theme is to allow students to develop a dual language of materials that can be cross-referenced at any time: one language based on first-hand material experiences, and another based on numerical and ranked data. Bilingual skills are suggested to be necessary to effectively involve all stakeholders into materials decision-making, especially users and manufacturers [8, 9].

3.2 Samples and product exemplars

Our material judgments are continually renewed through sensory experiences arising from acquaintance with new or newly applied materials. Materials can surprise us with their properties once we are drawn-in and engaged with them beyond just visual appreciation. Thus, what we see, touch, handle, hear, smell, and taste when interacting with materials greatly influences what we think about materials.

The second theme arising from the special file articles is an imperative to use material and product samples within material selection processes, and by implication to avoid selection processes that are entirely computer or paper based. Essentially this theme is a continuation of the first (sensorial-expressive language of materials) but for teaching materials it suggests a practical solution to assist the transition from *materials knowledge* to *materials experience*. Material samples allow easy cross-comparison of sensorial information, whereas product samples go a stage further and connect properties of a material and manufacturing processes within a realized form. In an educational context, this theme requires students to have access to material libraries where they can experience materials first-hand.

3.3 Materials as a user interface

The third theme identified amongst the special file articles is a growing trend to view the materials that a product is made from as a contributor to the total 'user interface' of that product. By this, we mean that materials can affect the interactions we have with a product in the same way that interactions are led by choices of buttons, controls, displays, and so forth. This is especially the case for products that are held continually or considerably during use. When viewed as part of the user interface, materials adopt a dynamic rather than passive role in affecting user experiences. Furthermore, as an interactive element, materials have a strong role in defining the first and lasting impressions of a product. For example, on the basis of the materials used, we assign figurative meanings, pass judgments, make referenced comparisons or attach personal contexts to a product. Visual appraisals of materials have been dominant in literature, helping to strengthen our understanding of the role of materials in product perception, but complementary research into experiences attributed to tactile material properties has been undertaken by two of the special file authors [10, 11].

3.4 Contextual considerations

Awareness of wider contextual matters that influence materials selection, to avoid self-centred or ill-informed materials decisions, is the fourth theme raised throughout the special file articles. Examples include proper consideration of the influences of stakeholders (e.g. clients, manufacturers) on materials selection activities, alongside more thorough understanding of how user attributes (e.g. gender, age, culture, experience) affect material evaluations. These issues echo the general direction within user-product interaction studies to better understand how external factors implicate not only designers' decisions for the specification of a new product but ultimately the ways in which users will experience those products once in their grasp or possession.

3.5 New material selection tools

Perhaps the most challenging but stimulating line of work reported through the special file articles is the development of new material selection tools that operate on the basis of expressive and meaning-driven selection criteria. Without a firm grip on the role of materials for creating particular meanings, industrial designers will not be able to progress beyond personal experiences and gut reaction decision-making [7]. The fifth and final theme is therefore the most directly influential on design practice: how to support student and professional designers to select materials that will positively affect people's product experiences beyond just functionality. Both software and physical tools for achieving this have been developed, although these are yet to be available as commercial releases.

Karana's *Meanings of Materials* software tool encourages designers to search for 'meaning evoking patterns', by which they can identify and manipulate various factors that influence people's attribution of meanings to materials [12]. She concedes that people seeking a simple causative or one-to-one relationship between materials and meanings will be disappointed: the situation is far more complex but richer because of it. Zuo presents the *Material-Aesthetics Database*, which is of use to designers who seek certain sensorial information from a product but need guidance about which materials can deliver such information [11]. The main difference between the *Meanings of Materials* tool and the *Material-Aesthetics Database* is the greater concentration on user tests of material surfaces in the latter and people's perceptual frameworks for materials evaluation in the former.

Rognoli has developed physical material atlases and accompanying documentation to help designers navigate through the sensorial-expressive domain of materials selection [10]. Van Kesteren trialed four material selection tools: a 'question tool', 'picture tool', 'sample tool' and 'relation tool' [8], each with the aim of directing designers' attention to material perception and user appreciation. Collectively, these various tools represent the state-of-the-art in creating material profiles that span both functional and expressive attributes of a product, thereby serving the needs of industrial designers.

4 MAPPING THE THEMES FOR INDUSTRIAL DESIGN EDUCATION

The five principal themes raised in this paper each have a potentially profound effect on how materials can be taught to industrial design undergraduates. However, a question remains as to how the themes can be combined and how they fit relative to each other. Figure 2 is suggested as a useful overview of the educational challenges, presenting a generic user-product interaction model onto which each of the five themes has been placed. It can be appreciated that most of the themes fit neatly to a single element

of the model: the user, the product or the interaction between the two. Only the 'new material selection tools' are problematic in this regard, relating to the entire materials experience and not easily deconstructed to constituent components. Perhaps the main point to be taken from Figure 2 is that industrial design education would benefit from adopting an interactional model for materials teaching, if the subject is to be delivered in a holistic, relevant and energizing manner.

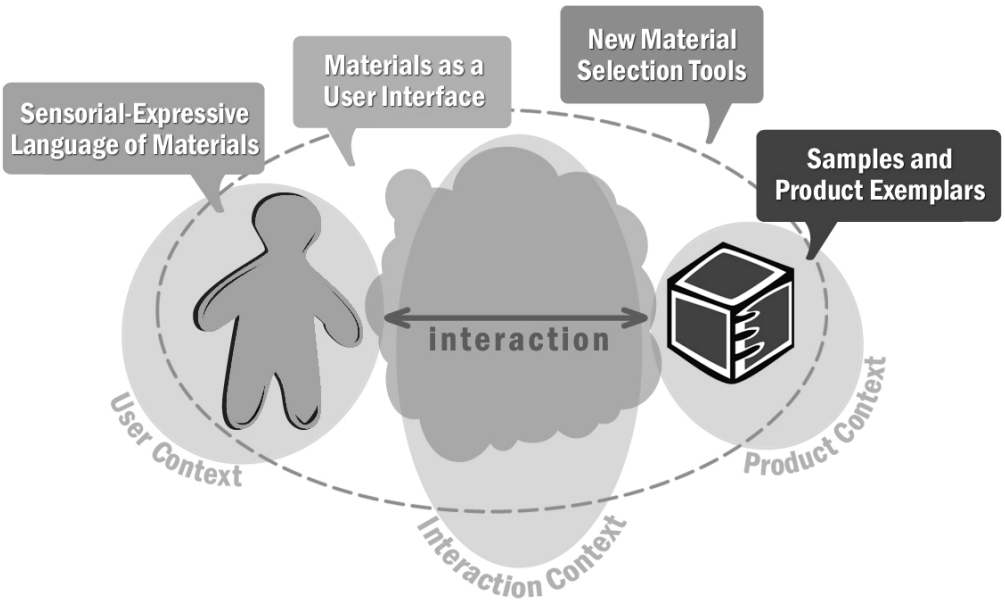

Figure 2. Relative position of principal themes for user-centred materials selection

5 DISCUSSION AND CONCLUSIONS

This paper has argued for adoption of what may be called a more 'designerly' perspective [18] to materials selection activities and related education, targeted at industrial designers who require user experiences to be the core consideration. In this respect, the perspective is different but complementary to technical perspectives of engineering. The perspective necessarily demands that design educators undertake an assessment of their materials teaching languages, the role of experiential learning, the development of selection skills, and the prioritization of constituent subject areas to be included in course curricula.

The general approach to materials for industrial design communicated through this paper is to develop an evidence base for decision-making that goes beyond just the technical. To do this, it is necessary for designers to be exposed to *tangible* aspects of materials (e.g. strength, friction, transparency) that are vital for the practical task of product materialization, alongside *intangible* aspects (e.g. meanings, labels, emotions) that are vital for influencing the richer experiences that are integral to contemporary product design. It is clear from the discussions raised by all of the authors of the special file articles on which this paper draws, that industrial design education has for too long borrowed an overly technical and numerical perspective on materials selection, which in turn has sat uncomfortably with the user-centred values that define industrial design. It is proposed that the technical-aesthetic imbalance can start to be addressed in an educational context by integrating the five themes identified in this paper into new course structures and curricula. Further studies will of course be needed to gauge the impact and effectiveness on student learning and capabilities arising from such course adjustments, and to validate any particular approaches to implementation.

As design educators, we need to embrace the complexity of user-product interaction and to take time to comprehend the considerable variety of factors that contribute to people's material perceptions and experiences of materials. The paper, at the very least, can hopefully inform design educators intending to shift materials teaching from a predominantly technical subject to one that has product experience as its centrepiece.

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