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A USER-CENTRED MATERIALS SELECTION APPROACH FOR PRODUCT DESIGNERS

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In the materials selection process of user-centred design projects, the emphasis shifts from technology towards user-interaction aspects of products. Materials form the interface of the product with the user and influence the sense of quality, pleasantness of interaction, personality of the product, and the way it can be used. The human senses, as the interface of the user, play essential roles in this interaction. A new materials selection model has been created for the purpose of understanding the context in which materials are selected. The *Materials Selection Activities* (MSA) model describes the activities of product designers. It emphasizes the iterative character of the materials selection process, the relevance of creating a clear material profile and the role of information therein. Creating an effective material profile is not easy and a new technique has been developed to formulate a profile in the form of the required sensorial properties of the materials (the *Materials in Products Selection* (MiPS) technique). Four tools were developed to support the techniques, namely: 1) 'question tool', which goes through the sensorial aspects of materials during several phases of the user-product interaction; 2) 'picture tool', which brings pictures of product examples and the materials these products are made of into the discussion; 3) 'sample tool', which offers tangible material samples; and 4) 'relation tool', which enables technology-oriented material specialists to include user-interaction requirements in their material considerations and evaluations. The tools not only aid the discussions about user-interaction aspects of materials, but also support the translation of these into sensorial properties of materials.

INTRODUCTION

One of the youngest fields in product design is user experience design. The scope of this field is directed at affecting "all aspects of the user's interaction with the product: how it is perceived, learned, and used" (Norman, 1998). The materials that a product is made of influence how

Figure 1. Examples of products in which the materials play a significant role in the user experience.

users can interact with it. For example, materials with a high thermal conductivity can make tea glasses difficult to handle as they become hot when containing hot water, and mother of pearl materials can create a soft and luxury look (**Figure 1**). Product designers use materials to increase the quality of the interaction with a product. In order to do so, it is necessary to carefully select the user-interaction aspects of materials, which are the properties that influence the use and personality of a product. These effects are becoming increasingly important in the highly competitive consumer market.

Product design and materials selection processes are well studied and various techniques are being developed to support product designers. However, for the inclusion of user-interaction aspects in the materials selection process, hardly any examples can be found in the literature. As a consequence, product designers, and especially those who are learning their skills, are not supported in the complex decision making required for materials selection for high quality products. Therefore, the challenge is to improve this by developing new techniques and tools for user-centred materials selection. This is the intended accomplishment of this paper.

The paper is divided into three parts. The first part illustrates the role of materials in user-product interaction. It explains how sensorial properties act as an intermediary between the materials used to make products and the end user. Part two describes the *Materials Selection Activities* model, a model that was developed to explain how product designers select materials. The third part introduces a materials selection approach and supportive tools for product designers and students.

SENSORIAL PROPERTIES IN USER-PRODUCT INTERACTION

Materials contribute more than technical quality to products; they impact on the way users can interact with the product. In literature, many acknowledge the significant role of materials in creating user-interaction qualities of products (e.g. Cupchik, 1999; Ferrante et al., 2000; Karana et al., 2008; Lefteri, 2006; Ljungberg and Edwards, 2003; Rognoli and Levi, 2004; Wastiels et al., 2007).

When people interact with products, their senses are in contact with the materials used in those products. Users see the colours of materials, feel the texture and the weight and hear the sounds materials make when moving an object. These sensory perceptions determine the usability of the product

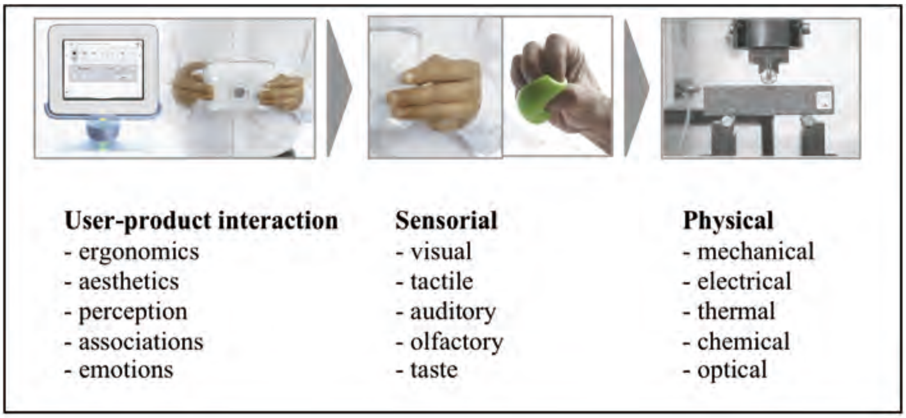

Figure 2. From user-interaction to materials via sensorial properties.

and the experiences of the user. Product designers use materials to create these sensory perceptions. In addition, product designers select materials directed at eliciting certain associations. Examples are the bright coloured plastics used in children's toys that express playfulness and the materials that resemble chocolate in the similar named phone of LG.

During the interaction with the material world, our senses serve as a medium that gives rise to perceived sensations, which act as a stimulus for emotions. Furthermore, visual and tactile properties of products strongly contribute to the first overall quality judgement by the user. A product is sensed via its materials, which can be considered as part of the product's interface.

Figure 2 illustrates that the specific material properties that influence the senses are the sensorial properties, such as gloss, colour, texture, smell and flexibility. Sensorial properties are made up of material characteristics that can be measured and these properties have direct relations to the following physical properties of materials. For example, the sensorial property glossiness or scattering is connected with the physical properties reflection coefficient, surface roughness, orientation of pigments, and index of refraction. Hence, the sensorial properties and the related physical properties act as an intermediary between material technology and the user-product interaction.

MATERIALS SELECTION ACTIVITIES MODEL

Several models exist to describe the materials selection process. However, most of these models do not include user-interaction aspects. Furthermore, they emphasise the results of the selection activities, rather than the selection activities themselves. By showing students the activities within the materials selection process, they can be provided with practical steps in the process of learning to select materials.

A new model has been created, which has gone through two phases:

1. **Preliminary model:** Based on open interviews with 13 product designers working in various industries;

2. **Reworked model:** Validation of the preliminary model through 15 case studies discussed with product designers from design studios.

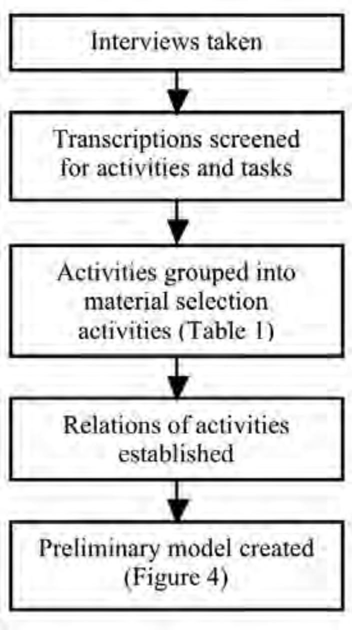

Figure 3. Flow diagram of the research steps taken to create the preliminary model.

This paper reports on the outcomes of the studies rather than the studies themselves. The methodology and results are described in detail in van Kesteren (2008), van Kesteren et al. (2007b) and van Kesteren et al. (2006).

PRELIMINARY MODEL

The preliminary model was formed based on the materials selection activities that were mentioned by the interviewed product designers (**Figure 3**). The notes made during the interviews were screened for those occasions in which the participants mentioned a task or a piece of work (e.g. drawing, consulting a colleague, negotiating with a client).

Eleven groups of material selection activities were found, which are described in van Kesteren et al. (2006). Seven of these activities were used to form the preliminary model. **Table 1** explains these activities. The materials selection activities are not performed randomly. Some activities are always followed by others (these are the basic activities) and some activities are performed during other activities (these are the supportive activities). For example, the supportive information activity is performed during the basic criteria activity. The basic activities are performed anywhere between a single occasion to several times before the necessary materials are specified.

The relations between the different materials selection activities can be described in different cycles, namely the basic materials selection cycle, the testing cycle, and information and consulting cycles. These cycles are combined into the model named the *Material Selection Activities* (MSA) model (**Figure 4**). The model shows one cycle of materials selection activities but represents the many cycles performed during the materials selection process.

Basic Materials Selection Cycle

The basic materials selection cycle connects the basic activities (No. 1 to 4 in **Table 1**). The activities are performed in this order and the results of an activity are used in the subsequent activity. The results of the choosing activity (No. 4) lead to the selected materials. Although basic activities might follow each other quickly and might therefore not be recognized as separate activities, all four activities are needed to select a number of adequate candidate materials. Subsequent basic materials selection cycles narrow down the number of candidate materials.

Especially in the early design phases, it is not necessary to fully know all the relevant details of the chosen material options. Therefore, the results of basic materials selection cycles change in the amount of detail during the design phases. The first basic cycles result in selected material families (e.g. wood, metal, plastic, composite). The next cycles result in identifying material classes (e.g. plastics such as ABS and PC or elastomers such as silicones) and the last cycles result in producing full material specifications. This classification is similar to the one proposed by Johnson et al. (2002). They classified the kingdom of materials from family and class (e.g. polymers, metals, composites; e.g., steels, Al- alloys, Pb- alloys), to sub-class and member (e.g. grades of steel such as 4000, 5000, 6000; and in more detail such as 6060, 6061, 6062) to more specific attributes (e.g. density, price, modulus of a specific member). The basic materials selection cycle is repeated until the materials are specified to the required detail.

The selected candidate materials may lead to new design requirements, e.g. on the aspects of costs or manufacturability. Furthermore, choices on

ACTIVITY NO.	SHORTHAND	EXPLANATION
1. Formulating material objectives and constraints (basic activity)	Criteria activity	Translating the solution boundaries or requirements for the product that is to be designed into material objectives and constraints or criteria. Formulating material criteria is an activity that is performed during all design phases and they become clearer and more complete throughout the project.
2. Making a set of candidate materials (basic activity)	Set activity	Obtaining a set of candidate materials from all available materials that fit the design objectives and constraints. The sets made by the product designers often contained some 3 to 4 options: a number considered adequate by the product designers to make efficient comparisons. As a consequence, a set contains general labels of materials, such as plastic, wood or metal in the early design phases, and these subsequently become more refined, specifying alloys or types of plastics. During this activity, the number of candidate materials is increased.
3. Comparing candidate materials (basic activity)	Comparing activity	Establishing the suitability of different candidate materials.
4. Choosing candidate materials (basic activity)	Choosing activity	Deciding, based on the evaluated materials, to continue with a reduced number of candidate materials.
5. Testing materials (supporting activity)	Testing activity	Making prototypes at various design stages to test the materials as such or in combination with other aspects in the design. Testing is carried out with the help of simulations (e.g. with finite element calculations), physically with three-dimensional prototypes, or with two-dimensional presentations. In visual models, materials are evaluated in combination with colour, form and shape details.
6. Gathering information about materials (supporting activity)	Information activity	Reducing uncertainty about material topics in relation to specific aspects of the product such as technical performances and manufacturability of materials. In addition, information is gathered about the visual and tactile aspects of materials by ordering material samples from suppliers, or examples of materials in existing products are found.
7. Cooperating and consulting about materials (supporting activity)	Consulting activity	Consulting material related parties such as suppliers, experts and manufacturers. Product designers, together with materials experts, make an integral evaluation of candidate materials.

Table 1. Activities in the materials selection process, forming the basis for the Materials Selection Activities model.

other aspects in the design project can lead to new material objectives and constraints. In every basic materials selection cycle, the material objectives and constraints are therefore reconsidered, if necessary, resulting in more extensive criteria. The activity of formulating material objectives and constraints (No. 1) is for that reason positioned in the basic materials selection cycle.

Testing Cycle

Figure 4 shows that the testing cycle connects the testing activity (No. 5) with the basic materials selection cycle at the comparing activity (No. 3) Materials are tested when product designers need information that is not available in literature or directly from the supplier but is needed to evaluate the candidate materials. To obtain this information, product designers plan and perform a test or simulation, both with or without materials experts at hand.

Information and Consulting Cycles

The information cycles and consulting cycles represent the relations between the information activity (No. 6), the consulting activity (No. 7) and the basic materials selection cycle. Although both cycles are used during

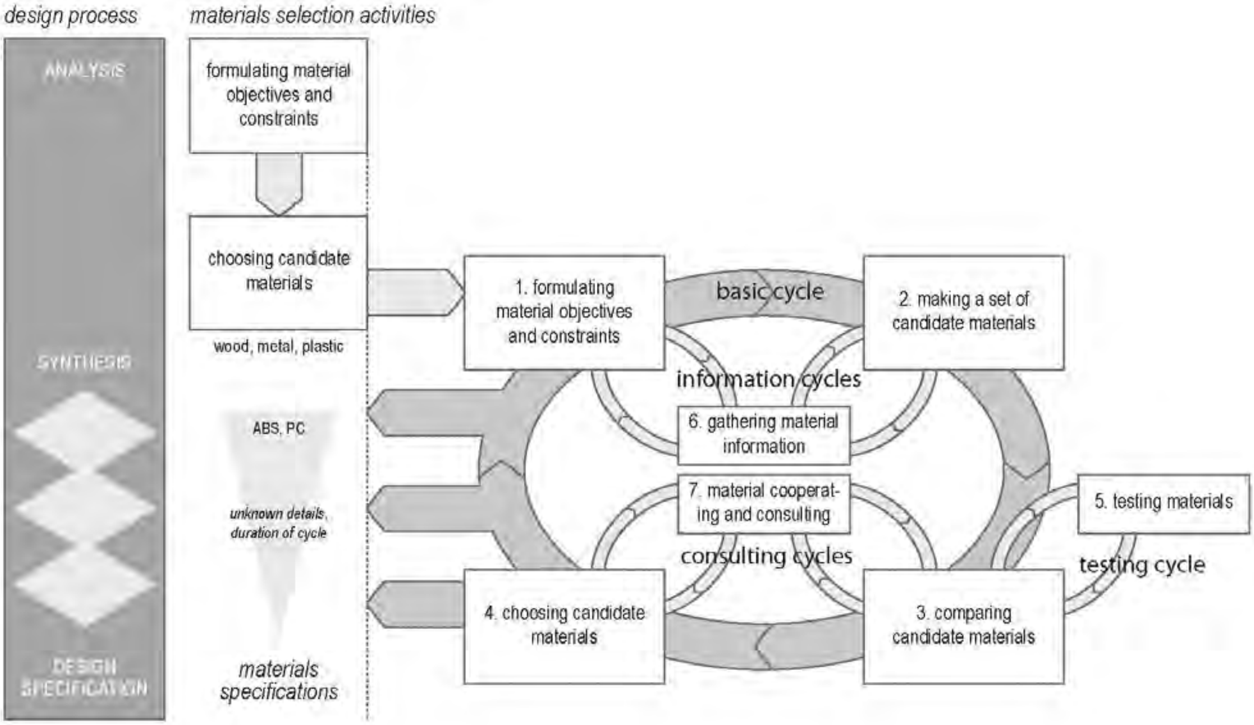

Figure 4. Validated Material Selection Activities (MSA) model.

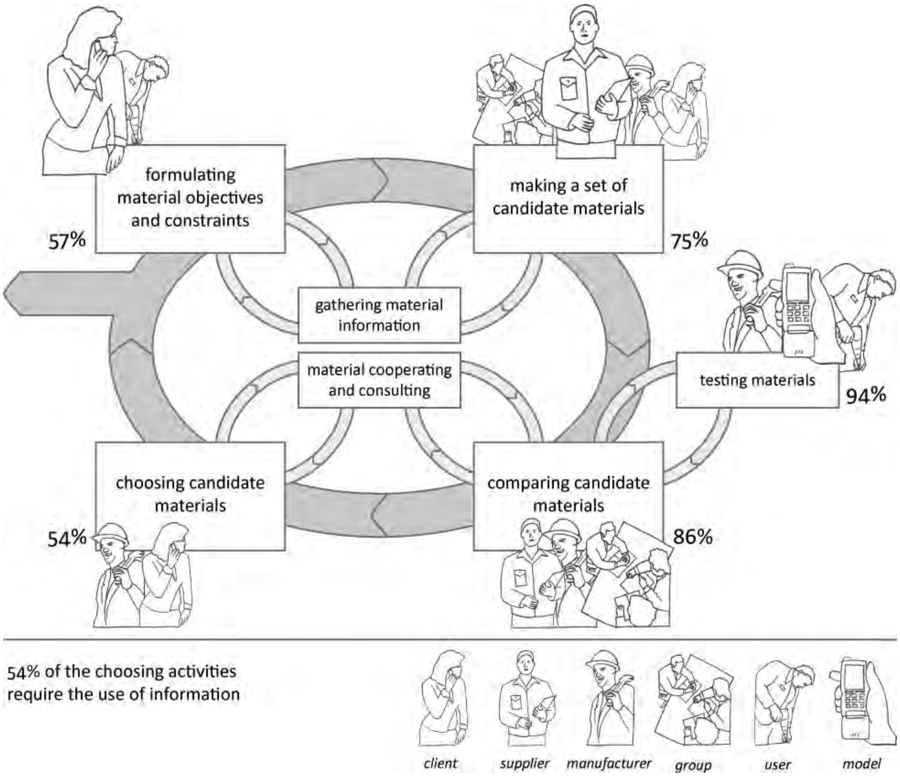

Figure 5. Information sources used in materials selection.

the basic four activities, the information activity is mainly performed in conjunction with criteria activity (No. 1) and the making a set activity (No. 2). Equally, the consulting activity is mainly performed in conjunction with comparing and choosing activities (No. 3 and 4).

VALIDATION OF THE MODEL

The particular characteristics of the MSA model are threefold: 1) the selection of materials is performed in a sequence of iterative activities, 2) the activity of formulating material objectives and constraints is centrally placed in these iterations and 3) the activities of gathering information and consulting information providers are specifically included in the MSA model. The aim of the validation, described in van Kesteren et al. (2007b), was to fine-tune the MSA model on two particular characteristics via the following research questions.

Question 1. Is the sequential order of activities in the MSA model similar to that in design projects?

Question 2. How often do product designers use information in their materials selection process and does this justify the central role assigned to the information and consulting activities in the MSA model?

Based on an analysis of the 15 case studies, the MSA model is successful in describing the materials selection activities in user-centred design projects. The model is complete in describing all activities that are performed in iteration. It was found that between 54% and 94% of the project activities involved the consultation or use of information sources (**Figure 5**), leading us to be confident that the information activities placed in the MSA model are relevant.

The main information sources used by product designers are as follows: the persons that contracted the designers to design a product (the client); information available from material suppliers previously worked with or newly acquainted (suppliers); persons from the company that is to make the designed product (manufacturer); persons that represent the end-user (user); different kinds of product models made during the design process (models); and finally a group of people. The group of people often consisted of the designer, a material expert, the client and/or a manufacturer or supplier. It was found that the consulted sources differed from activity to activity.

- The client is mainly used as an information source when formulating objectives and constraints and during choosing. The rest of the activities are left to the designer, which is logical because the client appoints the product designer to do this job. However, during the set activity, the client may provide the commonly used materials and therefore, by implication, suggest manufacturing processes available at the client company (or vice versa).
- Manufacturers are consulted during all activities except for formulating objectives and constraints. However, they can indirectly influence objectives and constraints as these are sometimes adjusted during other activities.
- Users are an information source for formulating objectives and constraints, for example in the problem analysis phase of a project. They are also used in the testing materials activity.

- Product models are used as an information source during the testing materials activity.
- The activities of making a set of candidate materials and of comparing materials are sometimes performed with a group of people, using information from different sources in a discussion. The results, however, show that the choice is left to the designer, client and manufacturer.
- Materials suppliers are not involved in the formulation of objectives or constraints, nor in the choosing activity.

The only discrepancy between the MSA model and practice is that the order of activities followed in practice does not always follow the same order as described in the model. For that reason, the model was reworked by adding two activities before the basic selection cycles started (**Figure 4**). These two activities, criteria and choosing, should be performed in the analysis design phase and result in choosing the material families (e.g. wood or plastics). Adding this to the model emphasises that in practice product designers often start their materials selection process already with a set of commonly used materials in their mind. This point is emphasized by the practical constraints and directions imposed on materials selection identified by Pedgley (2009).

The Use of the Model in Education

The MSA model can be used, together with the model in which the information providers are included (**Figure 5**), to teach young product designers a structure for making considered material choices for a new design. They can learn from the relation between the design process and the materials selection process in that materials selection starts at the beginning of a project and that continued effort is needed throughout the project. The model can help to divide the materials selection process in understandable steps. In addition, the structure can be used by instructors to assess the critical evaluation employed by students in the materials selection process. Hence, project reports can be scanned for implementation of the different activities.

Cross (2000) states that design students tend to become bogged down in attempts to understand the problem before they start generating solutions. The MSA model helps students to realize that not all material criteria need to be known at the beginning of a project, but such details evolve along the way. For example, the activity of formulating material criteria is given a place in the basic selection cycle. Hence, with every cycle the material needs will be better formulated. Moreover, the MSA model explains that materials selection is a selection process in which several solutions are searched for and compared. By considering a greater number of solutions, the quality of products can be increased.

Students tend to stick to one solution, due to limited knowledge about materials, especially in the first years of their education (Wright, 1998). The MSA model shows that limited knowledge and experience are normal in the materials selection process, even for experienced product designers. The activities of gathering information and consulting material experts show that students need to be actively involved in looking for information and that the model can help in the planning of this within their design process.

The model shows that the materials selection process does not simply stop at the suggestion of material families such as wood or plastics, but that much more detailed choices are required for a finalized design. Students need to be encouraged to find information based on their pre-selections and use this information to make more detailed choices. In the mean time, they learn and so expand their materials selection experience, and so should be able to make better pre-selections in future projects.

Although the MSA model can show the activities and significant role of information, it does not indicate where to find the information or how to adequately process it for design decisions. Students, however, frequently ask for such advice. Using the model in a degree level materials and design course should thus be accompanied with a considerable number of examples of where to find information about materials. Indicating the information providers in the model can stimulate students to not only search for information in databases and on the Internet, but also to talk to suppliers and manufacturers. The advantage of getting information from these specialists is that students learn new possibilities and start making a material information network. However, one disadvantage is that a supplier may encourage selection from a biased view and a limited range of materials. The model can be extended by providing some interesting information sources at different selection phases and activities and by allowing students to find their own mix of sources.

TOOLS TO ACCOMPANY THE MATERIALS SELECTION PROCESS

The efficiency of the materials selection process for product designers depends on a clear and usable view about the required material properties. Previous interviews with product designers revealed it to be difficult for them to formulate material objectives and constraints that concern user-interaction aspects of materials. For example, a perpetual question is: which sensorial properties contribute to a desired product personality? (van Kesteren, 2008; van Kesteren et al., 2007a) Therefore, a technique and supporting tools were developed to ease up the thinking process about desired material properties for a new product. These tools are intended for use in the preliminary phases of a design project.

The new technique aims at describing a material profile that includes required user-interaction aspects of the new product. Making a profile first requires defining what is needed for the interaction qualities of the product and second putting these needs in an orderly and understandable way. Thereafter, the material profile can be used as a basis for materials searches. This technique is called the *Materials in Products - Selection* (MiPS) technique. Its development and evaluation is described in van Kesteren (2008) and van Kesteren et al. (2007c).

Materials in Products Selection (Mips) Technique

The sensorial interaction with a product is a key aspect in the use and experience of that product. Sensorial perceptions are furthermore closely connected with the materials from which a product is made. Our senses are the first point of contact with the physical product and Adank and Warell (2006) argue that the senses should be a valuable source of information in the development of products. Defining user-interaction aspects in sensorial terms therefore is expected to lead to a minimum of interpretation steps in materials searches. Consequently it is expected that finding candidate materials based on sensorial terms can lead to materials that better match

CATEGORY	DESCRIPTION	EXAMPLES
Perception	Most abstract; includes perception, emotions, associations of materials, references to brands or products	Outdoor look, modern, personal, recognizable, fit the target group, natural
Use	All words related to the usage	Usability, withstand dirty environment, hygienic
Sensorial	Less abstract; All aspects of materials that can be perceived by the senses	Texture, warmth, colour, soft, smooth, stiff
Physical	Least abstract; Material and manufacturing properties	Scratch resistance, durable, price, producible in mass
Material labels	Most specific: material names	Plastics, wood, metals

Table 2. Categories in which materials can be described.

the required user-product interaction. For example, it is much clearer to look for high gloss and white materials (sensorial terms) than for a material that expresses high quality (perception term). **Table 2** gives examples of such categorization of materials.

The MiPS technique has three steps: 1) defining, 2) translating, and 3) usage. In the defining step, the designer considers the user-interaction aspects of the new product in a structured way. The sensorial properties that make up the user-interaction are central in this step. The result coming from this step is a material profile expressed as sensorial properties. In the translation step, the user-interaction criteria are made understandable to be able to use them with technologically oriented information sources. In the usage step, the material profile is used in the synthesis design phase to search for adequate materials. The usage step forms a basis for finding candidate materials, comparing them and choosing them. Furthermore, the material profile, when necessary, forms the basis for the reformulation of criteria.

THREE TOOLS FOR THE DEFINING STEP

The definition of a clear material profile is not easy, especially for non-experienced designers. To define a profile it helps to have a structure or checklist and examples of these are found in the product design field (e.g. Pugh, 1981; Roozenburg and Eekels, 1995). The first tool of the MiPS technique provides this structure by letting product designers consider the sensorial aspects of materials during several phases of the user-product interaction (tool 1: questions tool). The questions tool helps to discuss, either alone or in teams, the sensorial properties in the user-product interaction in different usage phases. It offers example questions on relevant issues in a specific interaction phase. While considering the interaction issues, the designer is stimulated to explore the sensorial properties in the interaction. The pictures tool (tool 2) and sample tool (tool 3) can help with this. **Figure 6** illustrates how the tools are integrated in the materials selection process, with the example of a toy design.

Questions Tool

The questions tool offers example questions to start consideration and discussion about desired sensorial material properties. The questions are organized in six sub-phases, i.e. 1) first contact phase, 2) try out phase, 3) transport phase, 4) unwrapping phase, 5) usage phase and 6) rest phase

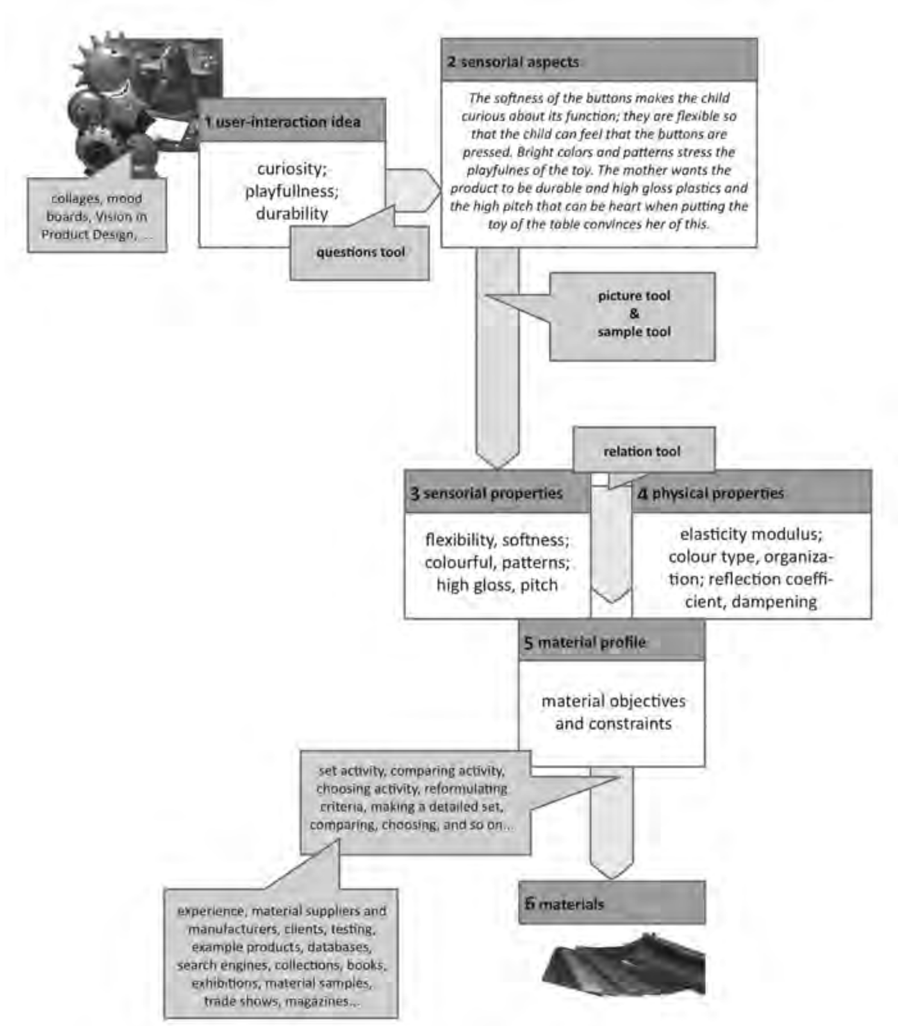

Figure 6. Example of how the Materials in Products Selection (MiPS) technique and tools can be used in materials selection processes.

(**Table 3**). Here, the designer attempts to project his or her mind into the interactions that an end-user is likely to have with a new product in a specific phase. A discussion dealing with every phase should end with the question: 'Which sensory aspects play a role in this?' The answers to this question provide an understanding about the sensorial properties required of a material spanning different use phases.

In every interaction phase, other sensorial perceptions can be relevant. For example, in the first contact phase, the product should attract attention to stimulate the user's curiosity, so as to get closer and to try the product. The visual, auditory and smell characteristics of the product are more relevant in this phase than the tactile characteristics. During the try out phase, the tactile aspects become more relevant as the user will try the product, so touching it. The sense of touch is an important aspect in the perception of quality of the product (Sonneveld, 2004), and hence an important factor in persuading the user to try the product again or to purchase it.

Most products are transported from the place that they were bought to the place where they will be used. This is an interesting phase, as the transport phase enables the product to come in contact with people other than the end user, e.g. people on the street. The product designer can decide how the product is transported and what feedback the product

PHASE	QUESTIONS	
1. First contact		
distinctiveness	How will the product attract attention? How does the product differentiate itself? **Which sensory aspects play a role in this?**	
2. Try out		
distinctiveness	How will the product convince when trying it out? **Which sensory aspects play a role in this?**	
3. Transport		
product experiences	Which feedback will the product give during transport? **Which sensory aspects play a role in this?**	
4. Unwrapping		
product experiences	Which lasting experiences will the product evoke? **Which sensory aspects play a role in this?**	
5. Usage		
functional use	Which interaction takes place in using the product? How does the product provide feedback? **Which sensory aspects play a role in this?**	
6. Rest		
product experiences	How will the product convince to be used again? How will the product fit in its environment and with related products? How will the product say good bye? **Which sensory aspects play a role in this?**	

Table 3. Phases in the user-interaction that are prompted by the 'questions tool'.

should give during transport, e.g. using a transparent window in the box. Is the product, for example, hidden in the back of a truck or displayed on the dashboard because the user is proud to show that he has just bought the product? Furthermore, what experience should the user have when unwrapping the product and making it ready for use? The sensorial properties of the product can create a positive experience in these phases, which increases the user-interaction quality with the product.

The usage phase is probably the most extensive phase in the defining of the material profile. The usability of a product is highly influenced by the sensorial properties of the materials of which product is made. For example, different coloured buttons of a remote control can help to find the right one and a high gloss display of an ATM machine is problematic to read outside with sunlight reflecting in it. Discussing the sensorial properties associated with the interaction can increase the usability of a product.

The last phase is the rest phase. The end-user stores the product for a certain period of time at a certain place, e.g. places his or her cell phone on the office desk during the day or places a pasta maker in its box on top of a kitchen cabinet after its monthly use. It is interesting to note how the product fits in its surroundings and with the related products. For example, how does your refrigerator fit with the design of the rest of your kitchen? Does it look like a separate item or can you hardly see which of the cabinets the refrigerator is? The product designer considers whether it will be the aim (or at least acceptable) to let the product create a contrast with the surroundings, or to make the product blend in. Hence, he or she considers what sensorial properties are needed to create that? The rest phase is also about using the product again and the sensorial properties that can convince the user to do this.

Pictures Tool

The pictures tool consists of cards with visual examples of products and the sensorial properties of materials (**Figure 7**). A properly prepared set of cards should show possible relationships between example products and personalities such as businesslike, cute, easy-going or modest along with the sensorial properties. The cards can be used to promote discussion by sorting the pictures according to user-product interaction ideas (**Figure 8**). The cards are two-sided and used in two steps. In the first step, the example products can be sorted intuitively. In the second step, the reverse

Figure 7. Examples of pictures tool (left, centre) and samples tool (right).

Figure 8. Use of the tools in a discussion about the material profile for a design project.

side of the card can be used, which holds a set of sensorial properties that are perceivable in the example products. Sensorial properties that appear in the sorted groups can then be discussed in detail.

Experience showed that the set of cards appear very useful from the very start of a project. Later, more specific cards are likely to be needed. Designers are therefore stimulated to extend the set of cards by adding their own and to show the nuances of sensorial experience suggested by them, for example, after studying the target group of the new product. These cards should contain some relevant images on one side and the sensorial properties on the other side.

Extending the set of cards has been found to have several benefits. First, the cards can be effective in showing the design directions in a specific project. The options are then limited in a discussion e.g. with designers in a team of supervisors or clients. Second, the examples used can better reflect current trends and possibilities. The prepared set consists of products released in the last few years and will thus need to be replaced with time. A third advantage is that the product designer can build an archive of cards showing the product designer's personal style.

Samples Tool

The samples tool supports discussion about sensorial material properties and makes the properties more tangible. The material samples represent a wide range of sensorial properties, divided between visual and tactile properties and acting as examples of the different properties (**Figure 7**). These samples can be used to explore and discuss the property before a client meeting. After exploring the sensorial properties, the samples can be selected to help find example products and product parts for the meetings. All types of materials should be present in the set, e.g. wood, cork, plastics, elastomers, ceramics, metals, composites and fabrics, in order to be able to gain inspiration for properties beyond the conventionally used materials in a product category. It is therefore perfect for brainstorming sessions to derive sensorial properties from user-product interaction ideas.

ONE TOOL FOR THE TRANSLATING STEP

A set of desirable sensorial properties is a difficult starting point when looking for candidate materials in technologically based material information sources. Fortunately, it is possible to put a relation between the sensorial properties of a material and its technical properties. A relation sheet was developed as a tool in the translation step. This sheet provides an indication of the properties that can be varied to create a particular sensorial effect. For example, when transparency is defined as a key property to create an interesting product, the sheet shows that transparency is determined by the light transmission per thickness properties and the refraction index properties. Candidate materials can be compared with respect to these properties. Furthermore, variations of these properties can be made, to fine-tune the transparency of the material. **Table 4** shows an extract of the sheet, while the whole sheet is found in van Kesteren (2008).

Materials that are suitable for a specific application do not only fulfil the user-interaction requirements, but also the functional, environmental, cost and manufacturing requirements. Before choosing a material, all the properties that affect these areas must be considered. Selecting materials based on sensorial properties alone can lead to unnecessary iterations; for example, glass may well fulfil the user-interaction requirements,

VISUAL PROPERTIES	PHYSICAL PROPERTIES	
Light reflection		
Reflection *(reflective - not reflective)*	• Reflection coefficient • Surface roughness • Light absorption Above properties are wavelength specific (UV, IR, visual light)	Tuning by • Surface treatment • Geometry • Additives External influences • Light source spectrum • Light source intensity Alternative • Surface layer
Glossiness, scattering *(glossy - matt)*	• Reflection coefficient • Surface roughness • Orientation of pigments • Index of refraction Above properties are wavelength specific (UV, IR, visual light)	Tuning by • Surface treatment External influences • Light source spectrum • Light source intensity Alternative • Surface layer
Transparency *(transparent - translucent - opaque)*	• Transparency (light transmission per thickness) • Index of refraction Above properties are wavelength specific (UV, IR, visual light)	Tuning by • Surface treatment • Geometry External influences • Light source spectrum • Light source intensity Alternative • Surface layer

Table 4. Fragment of the 'relations tool', giving relations between sensorial and physical material properties

but not the safety requirements. Furthermore, new materials for which the properties are known can be considered, using a profile based on properties.

The use of the Model in Education

The MiPS technique and tools were developed for product designers in design agencies, but could offer design students an attractive way to acquaint themselves with the knowledge and skills needed for selecting materials. The technique offers students a step-wise approach to help to define a clear and usable material profile in an intuitive and attractive way. This material profile will be a good start with which to structure their materials selection process. The tools help to break down the question: "Which materials do I need" into smaller questions. Furthermore, it teaches students to first focus on the required properties before thinking about the possible solutions.

Especially the pictures tool triggers a way of looking at products, and the materials these products are made of, that helps students in their future design projects. Furthermore, students raise their awareness of materials selection processes and the relevance of getting familiar with the technical vocabulary of materials science when implementing the MiPS technique and tools.

The relation tool helps students with the link between sensorial and physical material properties. This can not only help them to understand the relevance of material science to their design education, but also help to use the more technical oriented material information sources.

CONCLUSIONS

Young product designers are challenged to select materials not only for product functionality but also for the user-interaction qualities of the products they design. The sensorial properties of materials form the interface between product and user. This means that both physical and sensorial material properties are relevant in the selection process.

The materials selection process is described in the *Materials Selection Activities* model and shows that selecting materials resembles a design process. Finding and using information is found to be fundamental in selecting materials.

A clear and usable material profile helps to perform information searches. The *Materials in Products Selection* techniques and tools enable product designers to create a material profile in terms of sensorial and physical properties. It supports young designers to break down a material question into smaller pieces, which makes the materials selection process more graspable.

REFERENCES

ADANK, R., WARELL, A. (2006) Assessing the Sensory Experience of Product Design: Towards a Method for 'Five Senses Testing, *Proceedings of the Fifth International Conference on Design and Emotion,* Chalmers University of Technology, Gothenburg.

CROSS, N. (2000) *Engineering Design Methods: Strategies for Product Design*, (Third Edition), John Wiley and Sons Ltd., Chichester.

CUPCHIK, G. C. (1999) Emotion and Industrial Design: Reconciling Meanings and Feelings, *Proceedings of the First International Conference on Design and Emotion,* University of Technology, Delft; 75-82.

FERRANTE, M., SANTOS, S., CASTRO J. de (2000) Materials Selection as an Interdisciplinary Technical Activity: Basic Methodology and Case Studies, *Materials Research,* 3 (2) 1-9.

JOHNSON, K., LANGDON, P., ASHBY, M. (2002) Grouping Materials and Processes for the Designer: An Application of Cluster Analysis, *Materials and Design*, 23 (1) 1-10.

KARANA, E., HEKKERT, P., KANDACHAR, P. (2008) Materials Considerations in Product Design: A Survey on Crucial Material Aspects Used By Product Designers, *Materials and Design,* 29 (6) 1081-9.

KESTEREN, I. E. H. van (2008) *Selecting Materials in Product Design*, unpublished Ph.D. Thesis, Faculty of Industrial Design Engineering, TUDelft.

KESTEREN, I. E. H. van, BRUIJN, J. C. M. de, STAPPERS, P. J. (2007a) Evaluation of Materials Selection Activities in User-Centred Design Projects, *Journal of Engineering Design*, 19 (5) 417-29.

KESTEREN, I. E. H. van, KANDACHAR, P. V., STAPPERS, P. J. (2007b) Activities in Selecting Materials from the Perspective of Product Designers, *International Journal of Design Engineering,* 1 (1) 83-103.

KESTEREN, I. E. H. van, STAPPERS, P. J., BRUIJN, J. C. M. de (2007c) Materials in Products-Selection: Tools for Including User-Interaction Aspects in Materials Selection, *International Journal of Design*, 1(3) 41-55.

KESTEREN, I. E. H. van, STAPPERS, P. J., KANDACHAR, P. V. (2006) Activities in Selecting Materials by Product Designers, *Proceedings of the International Conference on Advanced Design and Manufacture*, ADMEC, Nottingham; 145-50.

LEFTERI, C. (2006) *Materials for Inspirational Design*, Rotovision, Mies.

LJUNGBERG, L., EDWARDS, K. (2003) Design, Materials Selection and Marketing of Successful Products, *Materials and Design,* 24 (7) 519-29.

NORMAN, D.A. (1998) *The Invisible Computer*, MIT Press, Cambridge.

PEDGLEY, O. (2009) Influence of Stakeholders on Industrial Design Materials and Manufacturing Selection, *International Journal of Design,* 3 (1) 1-15.

PUGH, S. (1981) Concept Selection: A Method That Works, *Proceedings of the International Conference on Engineering Design*, Heurista, Zurich; 497-506.

ROGNOLI, V., LEVI, M. (2004) How, What and Where is it Possible to Learn Design Materials?, *Proceedings of The International Conference on Engineering and Product Design Education*, University of Technology, Delft; 647-54.

ROOZENBURG, N., EEKELS, J. (1995) *Product Design, Fundamentals and Methods*, Wiley, Chichester.

SONNEVELD, M. (2004) Dreamy Hands: Exploring Tactile Aesthetics in Design, in *Design and Emotion: The Experience of Everyday Things,* D. McDonagh, P. Hekkert, J. van Erp, D. Gyi, eds., Taylor and Francis, London.

WASTIELS, L., WOUTERS, I., LINDEKENS, J. (2007) Material Knowledge for Design: The Architect's Vocabulary, *Proceedings of the International Association of Societies of Design Research*, The Hong Kong Polytechnic, Hong Kong.

WRIGHT, I.C. (1998) *Design Methods in Engineering and Product Design*, The McGraw-Hill Publishing Company, Cambridge.

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Anahtar Sözcükler: malzeme seçimi; ürün tasarımı; kullanıcı-ürün etkileşimi; teknik ve araçlar; tasarım eğitimi.

ÜRÜN TASARIMCILARINA YÖNELİK KULLANICI-MERKEZLİ BİR MALZEME SEÇİMİ YAKLAŞIMI

Kullanıcı odaklı malzeme seçme süreci kullanan tasarım projelerinde, ürünün vurgulanan özelliği teknolojiden kullanıcı- etkileşimli yönlere kaymaktadır. Malzeme kullanıcı ile ilişkinin arayüzünü oluşturmakta ve ürün nitelik algısını, ilişkinin hoşluğunu, ürünün kişiselleş(tiril)mesini ve kullanım yönünü etkileyip belirlemektedir. İnsanın beş duyusu, bir arayüz olarak, bu etkileşimde başrolü oynamaktadır. Malzeme seçimi sürecinin bağlamını daha iyi anlayabilmek için yeni binr malzeme seçimi modeli oluşturulmuştur. *Malzeme Seçimi Eylemleri* (MSE) model olarak ürün tasarımcılarının eylemlerini tanımlamaktadır. Model, malzeme seçimi sürecinin tekrar ede karakterini vurgulayarak temiz bir malzeme profili elde etmeyi ve bu profilin içindeki bilginin kendisini önemsemektedir. Etkin bir malzeme profili oluşturmak o kadar da kolay değildir ve burada, malzemenin duyumsal özelliklerini listeleyen bir profil yeni bir teknik olarak geliştirilmektedir. *Ürün Malzemesi Seçimi* (ÜMS) tekniği adı verilen modelin dört aracı geliştirilmiştir: a. 'Soru aracı', kullanıcı-ürün etkileşiminde malzemenin bir dizi duyumsal yönünü ortaya çıkarmaya çalışmakta; b. 'Resim aracı', ürün örnekleri ile bu ürünlerin farklı malzemelerden yapılmış örneklerini tartışmaya çalışmakta; c. 'Örneklem aracı' dokunulabilir ürün örneklerini gündeme getirmekte; d. 'İlinti aracı' ise teknoloji yönelimli malzeme uzmanlarının değerlendirmelerine kullanıcı-etkileşimli beklentileri katmalarını sağlamaya odaklanmaktadır. Bu araçlar hem malzemenin kullanıcı-etkileşimli yönlerini tartışmamızı desteklemekte, hem de malzemenin duyumsal özelliklerinin ortaya çıkarılmasına katkıda bulunmaktadırlar.

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