ARTICULATING MATERIAL CRITERIA

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ABSTRACT

This paper discusses the experiences and potentials with materials teaching at the Institute for Product Design at Kolding School of Design, using materials teaching as experiments in my PhD project. The project intents to create a stronger material awareness among product design students with emphasis on sustainability. The experiments aim to develop an understanding of, how product design students include materials in their design practice and how tools can be developed that further enhance this. Hence experiments are essential for the progress of the PhD project as they help to observe, imitate and articulate the students' inclusion of materials.

This paper particularly discusses the experiences made and ideas generated after the execution of a material science course for second year students, with emphasis on the concept of the *material selection matrix* as an educational tool for material exploration. The course was the first course I was involved in as a PhD student and has served as the first observation case in my project. The purpose of this analysis has been to explore and demonstrate that data from material selection matrices generated during the course, help mature the tool. Furthermore the purpose is to initiate a discussion on, how to create educational tools for material awareness creation in the design education e.g. by applying objective and quantitative methods in an otherwise often subjective design process.

INTRODUCTION

Koskinen et al. (2012) have proposed experiments as being *lab, field* or *showroom*. In the experiments I will discuss, I stress that they should try to evade interfering with students' work to give an objective impression of the present situation. This setting has *fieldwork* characteristics. However the extracting and structuring of experimental data with the purpose of re-introducing the tool in a course as well as planning workshops and discussion groups that aim to test the project's hypotheses and analyse results in a set context with *lab* characteristics.

According to Koskinen et al. one of the main differences between the lab experiment and the fieldwork is that the lab experiment stresses to be subjective, whereas fieldwork should emphasize on objectivity (Ibid). As a result I would like to propose the concept of the *field experiment* (also discussed by e.g. Harrison and List, 2004) that incorporates both subjective and objective analyses. This makes it possible to use the material science course as the frame for the experiment, to test the hypothesis that material evaluation tools are important for creating material awareness, and hence to produce evidence for my further research.

MATERIAL TEACHING IN DESIGN SCHOOLS

Materials are the physical representations of product design and therefore they play a large and essential role in creating the identity of a product. This accounts for technical properties such as mechanical, physical, thermal, electrical and optical properties, but just as much for sensorial properties that are more difficult to define.

The project aims to develop the material education in design schools with introducing tools and teaching methods that strengthen the student's ability to evaluate and select right materials in the design process. An approach is to develop the concept of 'learning through materials' that finds its inspiration in theories from practice-based research with origin in Dewey's definition of learning by doing (1938). It should be acknowledged that design is a highly non-objective discipline with a weight on sensorial sensitivity. This accounts for the sense of vision as aesthetics and for the sense of touch as tactility or haptic experience. It is however difficult to structure sensorial impressions, as they are affected by individual preferences and previous experiences.

The material science teaching is highly practice-oriented with continuous links to theory; therefore the project seeks to communicate and develop the balance between practice and theory. The understanding of practice-based knowledge creation in the design education can be traced back to the 20s and 30s Bauhaus School's foundational courses in material understanding taught by Itten, Moholy-Nagy and Albers and the following specialization courses in practical workshops (Moholy-Nagy, 1947; Fiedler and Feierabend, 1999). At Kolding School of Design the experience is that students reflect upon theoretical knowledge when it is used in practice (Leerberg et al., 2010). As a result a strong correlation between theoretical knowledge and practice-based experience is fundamental for creating an active and progressive material understanding in the design schools. Schön designates this approach with the concept of the 'reflecting practitioner', that builds upon the importance of reflection and subjective knowledge creation as vital factors in creative practices such as architecture and design (Schön, 1983, 1987). Hence it is important to create awareness among the students that activates their senses and structures their experiences when working with materials. Furthermore they should be encouraged and allowed to create their own method for categorizing materials. However they still have to be able to articulate their needs and wants in a 'standardised' language understandable for others, also people outside the design profession. Learning through materials should prepare students to being open-minded in the choice of materials and be able to validate materials subjectively as well as objectively. With growing practical knowledge it becomes easier to structure and store input for future use. The learning through materials didactics aim to help creating coherence between tacit practical experience and structured information that can be articulated to others. This knowledge translation improves the hierarchical status of the knowledge, as from what Schön calls "technical skills of day-to-day practice" to "applied science"(1987).

DESCRIPTION OF THE COURSES

The students at Institute for Product Design, being fashion, textiles, and industrial design students, are taught in two materials science courses in their second and third semester of their undergrad studies. The knowledge obtained in these courses intents to work as the foundation of material knowledge applied to and used in other courses during the studies.

The first material course introduces the students to the fundamentals of materials, with focus on textiles and plastics whereas the second courses aims to strengthen the students' sustainable awareness in product design. In the first course the students have introductory lectures on textiles and plastics in combination with explorative exercises followed by an individual assignment in a total of four weeks. In the second material course groups of three to five students are assigned to develop a sustainable design concept in the three weeks the course runs.

With the privilege of having two succeeding material courses with an interval of half a year and within the first one and a half year of the students' education, there is a potential in enhancing attention to the material courses and creating a stronger connection between. This not only in the two material courses, but also in any other practical course at the institute. It is believed that this can improve the material inclusion, and enrich the discussion and reflection upon the creation of individual material understandings among students.

This paper discusses selected experiences from the second material science course. Here information input is given as theoretical lectures in sustainability issues, potentially green materials and material functionalities, and as continuous group guidance and discussion throughout the course. It is important to stress that the course is structured as a design project, using materials as a frame. This means that the course also emphasized on improving design process skills and therefore also weighted brainstorming, identification of problem spaces, ideation, concept development etc.

With starting point in the subject 'children', groups worked with various issues such as infantile bladder problems, hygienic and activating lunch boxes, toys to enhance child inclusion when cooking dinner, and customizable garments for over consumptive teenagers. As a result the degree of sustainability considerations in the projects also varied, but the students were obliged and encouraged to discuss the relevance of sustainability for the given concepts for all stages in their lifecycles, e.g. in terms of material choice, production, use and longevity, and disposal.

METHOD

As a part of the course curriculum the students were obliged to consider relevant materials for their concepts, and evaluate these with respect to their application. This was done as a material selection matrix where different materials are benchmarked in terms of identified material properties (or material criteria). The concept is rather simple: 1) a number of relevant material criteria are identified, 2) a number of potential materials are listed, 3) the materials are given grades for each criteria, 4) the grades are summed, 5a) the material with the best grades '*wins*', 5b) and usually the students continue developing their concept with this material.

An example of a material selection matrix made in the course shown in figure 1. In this matrix potential materials are listed vertically and the material criteria are listed horizontally. For each material criterion this group has chosen to mark the material with the best rank.

Figure 1: Example of a material selection matrix from the material science course.

My experiment, however, pays little attention to the result of the material selection matrix, but to the nature of the identified material criteria used in the selection, and how they have been articulated. This is to understand, how tools can help identifying essential material criteria not only to improve the quality of products, but also to expand the knowledge of materials and their potentials. The exploration is based on a discussion of some of the experiences acquired from discussions with groups during the course and with the attempt to create a structure and construct a taxonomy to help recognizing unidentified material criteria.

HOW CAN MATERIAL CRITERIA BE ARTICULATED? – REFLECTIONS ON THE OUTCOMES OF THE COURSE

It became apparent how difficult it was for many students to set up criteria and compare materials in respect to them. For some it was difficult to identify demands as well as potential useful materials, which partly seemed to be due to an unacquainted technical material vocabulary necessary to understand and discuss properties in material literature and databases and partly because of general insecurity of how strict the material comparison had to be.

The nature of criteria for individual projects varied significantly and ranged from being 'soft' and intangible to highly quantifiable. In groups using many qualitative criteria, these were further discussed in the attempt to 'normalize' or translate the intended thought to comparable criteria. Not only was the intention to give the students something to work from, but also to take them a step further and make them discuss, what material properties are and why the ones they had identified were important.

The distribution of material criteria of the products' lifecycle among the groups differentiated. It was not considered possible to require a minimum of criteria for each phase, as criteria depend on the individual project. Furthermore rating the materials seemed complicated and the higher the degree of intangible properties, the more complex it was to make material comparisons and the more subjective the rating became.

Because of the multifarious nature of projects, it was not possible to make general guidelines for neither criteria nor materials. Understanding a product also includes understanding its potentials and drawbacks and the identification of criteria helped the students to strengthen their projects.

A MATERIAL SELECTION TAXONOMY

The use of the material selection matrix is an attempt to apply objective and quantifiable tools to an otherwise often subjective design process. However in practice it is not entirely possible. Many criteria will be identified and included, but some will always be missing, as it is only possible to consider material properties or functions you are aware of exist and these have to be fully understood. Comparing materials is simpler, if the definition of the criteria is clear-cut, which requires a strong material knowledge. Criteria usually vary with concept, but for design students that are untrained in material selection, a guideline with a list of properties could be useful.. However the risk is that such a guideline is used uncritically. Additionally too many criteria make a good comparison difficult, especially because not all criteria are valid for all materials, but too few criteria make a material selection unreliable.

No matter the diversity of student projects the nature of the identified criteria and their distribution in different classes help to understand in which areas the material

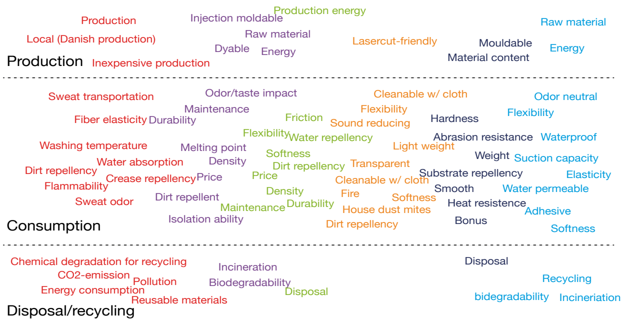

Figure 2: Structuring of material criteria for six groups in the course structured by three main phases in a product lifecycle. Each colour indicates a criterion identified by individual project groups and the horizontal line indicates the differentiation of material criteria in the production, consumption and disposal/recycling respectively.

awareness among the students could be strengthened.

The material criteria identified for six groups in the course were put in a criterion map separated in three main phases of a product lifecycle. As the course were held in Danish, the criteria were translated, which might have caused a 'standardisation' of the formulation of the criteria to fit more technical and common-used material criteria.

Even though the students were asked to make criteria for the material's entire life cycle, criteria identified for the consumption/properties phase account for two thirds of all criteria, which can be seen in figure 2. This could be an indication that these are more tangible and understandable for the students. Both production and disposal are taught and discussed in the course, but the consumption phase is real and less abstract. Nevertheless with an emphasis on sustainable product development both raw materials/production and disposal are essential to consider.

Another interesting point is that products often consist of multiple elements with different functions and as Karana et al. (2010) state, it is important to distinguish between the material itself and the product the material(s) is embodied in. As a result it can make sense to use different materials that each have the properties desired for the product and thereby the material selection process can benefit from defining material criteria for elements rather than for the entire product; especially if the product contains different and separate functions. A group tried this and even though some criteria continued to be identical, the separation of element functions opened up to identification of new material criteria as well as a deeper discussion of other materials, which were relevant to introduce in this stage.

CLUSTERING CRITERIA

The material criteria grouped in the consumption phase were further analysed. The majority of properties here could be related to physical attributes, but also mechanical and thermal properties are represented. The physical properties have been divided into *function* that includes absorption and transportation of media such as water, air and light, *maintenance* that relates to the use of materials in terms of multiple repellences and cleaning, and *hand and touch* that contain properties related to 'direct use' and the senses.

The use of different colours in figure 3 illustrates the distribution of criteria for each project. This uneven distribution can be the result of at least two things: a) projects have different focus and therefore different criteria have been identified, b) people that define criteria have different knowledge and experience which affect their identified criteria.

If a) is the case, a differentiation and clustering of criteria can help illuminate, which areas of criteria that have to be further elaborated. It can be applicable to define primary and secondary criteria, where primary criteria account for essential properties whereas secondary criteria can include relevant criteria that are desirable but not crucial. If b) is the case it can be helpful to have others evaluate criteria with respect to the concept, as this can contribute to an identification of 'tacit' or 'unknown' criteria. In a course situation the quality of criteria can benefit with having groups evaluating each other's criteria and add the ones that have been identified in this step.

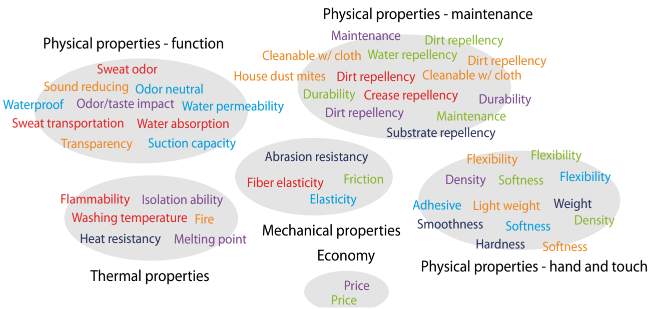

Figure 3: Clustering material criteria identified as being in the consumption phase in categories of properties for six groups in the course. The colours indicate the different groups and as a result some criteria might occur more than one time.

CONCLUSION

This paper has demonstrated that one way to obtain knowledge of students' practice is to regard the material science course as a field experiment, which includes properties from both the traditional experiment and fieldwork defined by Koskinen et al. (2012).

Using the field experiment as a methodological tool helps to break down barriers between subjective and objective observations and experiences and enables in this case the combination of the personal and subjective in the creation of the material selection matrices with the systematic and objective analysis of generated data to create a meta-outcome of the material science course.

The purpose was to mature the concept of the material selection matrix as a tool to enhance the material awareness among students and using the data it generated to recognize where students might experience difficulties.

An approach is to create a taxonomy where criteria are structured in phase of lifecycle and in clusters in the lifecycle phases that can help illuminate if some areas of the potential criteria space has been left out or could be strengthened. This further introduced the idea of different natures of criteria where the tacit criterion is one. Using this in combination with the taxonomy it is believed that articulation of material properties can be enhanced.

Another kind of taxonomy is to perceive the design concept as the sum of multiple elements or functions that require various material properties and therefore material selection matrices could be made for each of them. This could help students to dissect otherwise complex products. Related to this could be the introduction of separate material selection matrices that handle tangible and intangible properties respectively.

The essence of the study is to make material awareness an integrated part of the design process. The material selection matrix is a tool for this, but the material selection method should become an unconscious part of the practice to create a stronger material integration in the design process. The experiment has shown that there is potential in the tool and further experiments will continue this exploration, e.g. in how earlier introduction to the tool combined with continuous guiding and use of the tool throughout courses affect the material inclusion in the design process.

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