RESEARCH AND DESIGN FOR A MATERIAL SAMPLE INFORMATION SYSTEM APPROPRIATE TO INDUSTRIAL DESIGN STUDENTS

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ABSTRACT

RESEARCH AND DESIGN FOR A MATERIAL SAMPLE INFORMATION SYSTEM APPROPRIATE TO INDUSTRIAL DESIGN STUDENTS

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The material of a product is one of the most important elements of product design that an industrial designer considers. It is also a major aspect of product innovation. Unfortunately, most of today's material selection systems have been built on a technical basis and with an engineering perspective on product design. Current research shows that a physical environment allowing industrial designers to interact with material samples would greatly enhance designers' material judgements and expertise and, therefore, the quality of subsequent product designs. Such an environment is argued to require different types of material samples and, in addition, to provide access to supplementary sample information that can support industrial designers' decision-making. Different levels of materials information detail are required for different design phases. The information needed in the concept generation phase of a product is not the same as in the finalization stage. Furthermore, design students have different material information needs than design professionals. Through the thesis, existing material sample environments and sample tagging solutions, along with related literature, are explored and different types of information systems are analyzed to arrive at a set of specifications for a material sample information system appropriate to industrial design students, during the concept generation phase of a product. Utilizing a research through design approach, a solution for a material sample information system is proposed and justified against the developed design specifications.

Keywords: materials education in industrial design, material sample, material library, material information needs of industrial designers, material tag, initial level information on materials

ÖZ

ENDÜSTRİ ÜRÜNLERİ TASARIMI ÖĞRENCİLERİNE UYGUN BİR MALZEME BİLGİSİ SİSTEMİ ARAŞTIRMASI VE TASARIMI

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Yüksek Lisans, Endüstri Ürünleri Tasarımı Bölümü

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Endüstri ürünleri tasarımcılarının bir ürünü geliştirirken dikkat ettikleri en önemli unsurlardan bir tanesi malzemedir. Malzeme seçimi aynı zamanda yenilikçi bir ürün oluşturmada da rol oynar. Ne yazık ki günümüzdeki bir çok malzeme seçim sistemleri teknik bilgi ağırlıklı ve mühendislik bakış açısıyla geliştirilmiştir. Yakın zamandaki araştırmalar tasarımcıların malzeme örnekleriyle fiziksel temas kurmaları halinde malzemeler hakkında karar yetilerinin ve bilgilerinin arttığını göstermiştir, bu yüzden de tasarımlarının daha başaralı olmasını sağladığını ortaya koymuştur. Böyle fiziksel bir temasa olanak sağlayan bir ortamın farklı malzeme örnekleri haricinde bunlara ait malzeme bilgileri de sunması gerekmektedir. Tasarım sürecinin farkli aşamalarında farklı düzeyde bilgi detayı gerekmektedir. Mesela kavramsal tasarım aşamasındaki bilgi ihtiyacı tasarım sürecinin ileri düzeydeki detaylandırma aşamasındaki bilgi ihtiyacından farklıdır. Bunun ötesinde tasarım öğrencilerinin profosyonel tasarımcılardan farklı malzeme bilgisi ihtiyaçları vardır. Tezim içerisinde var olan malzeme kütüphaneleri, örnek malzeme etiketleri ve bu yerler ile ilgili kaynaklar araştırılıyor, farklı malzeme bilgisi sistemleri analiz edilip endüstri ürünleri tasarımı öğrencilerine yönelik kavramsal tasarım sürecinde kullanılması öngörülen bir malzeme bilgisi sisteminin özellileri ortaya konuluyor. Calişma, tasarım süreci üzerinden araştırma yöntemiyle yapıldığından, bir malzeme bilgisi sisteminin tasarlanmasını ve özelliklerinin doğrulanmasını içermektedir.

Anahtar Kelimeler: endüstri ürünleri tasarımında malzeme bilgisi eğitimi, malzeme örnekleri, malzeme kütüphanesi, endüstri ürünleri tasarımcılarının malzeme bilgisi ihtiyaçları, malzeme etiketi

To my family and friends…

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CHAPTER 1

INTRODUCTION

1.1 Motivations

Industrial design brings very different areas into one activity, which is design. Marketing, ergonomics, anthropology, sociology, mechanical engineering are a few of them. Although an industrial designer is neither a mechanical engineer nor a sociologist he or she has to have some knowledge about these subjects. Communicating with different departments in a company is not the only reason why a designer should be trained somewhat in those areas, it is also the nature of design that can be seen as a connection point for the above mentioned areas besides having discipline-specific tools and knowledge.

One of the areas that a designer should have good knowledge about is materials. Materialization of an idea is a core activity of an industrial designer. Ideas in the designer's head have very limited effect on our world. When those ideas begin to have a form and a material, then discussions can be made about them. The impact of the materiality to our world is obvious. This impact should be enough to understand that we should be more aware of the materialization of our ideas.

Classes on materials and manufacturing are a core asset of industrial design education. Through these classes, students can learn the impact of materials and how to use them effectively, and also which ideas deserve to be materialized and which do not. Materialized ideas are not only solve problem, they also produce new ones.

Therefore it is important to make research on materials education. How can we enhance this education, and how to make it more effective for designers are essential subjects to work on.

1.2 Problem Definition

One of the core ways that industrial designers adopt to innovate and distinguish their work is through materials (Beylerian et al., 2005). Materials have continued to develop since mankind started out using natural resources to form basic objects. The journey, which began with stone, leather, metal and earthenware, has now reached tens of thousands of members.

This makes materials an inevitable and also exciting source for the development of new industrial designs.

Industrial designers have responsibility to create new products, whether through the use of established materials or by proposing the use of superior materials not yet used in a given product sector. Material scientists and engineers, on the other hand, create and develop materials, which are appropriate for certain conditions (Ashby & Johnson, 2002). Designers on the other side are using these materials, which were developed by material scientists (Fulton, 1992). Clearly, it is essential that designers have more than just superficial knowledge about the subject of materials and manufacturing methods. Furthermore, this knowledge must be established appropriately during the period of designers' formal education. To use materials effectively, designers must have access to, and knowledge about, various material properties across a variety of material families.

In recent years, the industrial design profession has focused more on human-related aspects of products. For example, the function of a product is now taken more for granted by end users – a product has to be functioning well in order to be on the market (Ashby & Johnson, 2003). Beyond functionality, we now see much greater attention paid to designing for experiences, emotions and meanings that are planned to be evoked by the new product. These experiential concerns become reflected in distinctive features of a product that make it differentiated, and for the manufacturer hopefully highly successful, on the market. In parallel, design educators and academicians are becoming increasingly focused on the subject of how materials can be used to affect the experiential qualities of a new product. More and more design professionals consider senso-expressive properties of materials as an important factor in their choice of materials. As a result, there exists a responsibility within design education to direct teaching and learning not only towards technical properties of materials, but also sensorial, expressive and meaning related aspects of materials.

It is hard to define sensorial and expressive properties of materials (Ashby & Johnson, 2002). Putting these properties on paper is not an effective solution – the consensus is that materials must be experienced first-hand, as physical objects, for their sensorial and expressive qualities to be appreciated and understood. For this reason, we can see that around the world material libraries have become established and grown in number. As well as organized material collections that can be consulted, sometimes industrial designers and design firms prepare their own personal material collections to overcome the problem of translating datasheets and catalogues into tangible material properties. Thus, materials themselves become a very rich source of information for sensorial properties (Pedgley, 2010a). Libraries and collections allow designers to experience materials directly so they can

judge more easily whether the sensorial and expressive features of a material fit the intentions they have for their new products. Access to such facilities also eases the selection process (van Kesteren, 2008b).

Beyond commercial consulting, material libraries have an important role for design education. Educators are generally agreed that such libraries provide an effective way to convey information about materials, spanning technical, sensorial and expressive properties (Ward, 2008). Touching materials and making sensory appraisals is considered a highly relevant and useful experience for design students. The provision of material libraries or equivalent facilities can be seen as an essential part of a contemporary materials education for industrial design students.

Although material libraries and collections are an important tool for design professionals and design students, sometimes an essential part is missing. Often it is the case that these libraries and collections have a good range of different materials (as physical samples), but the related necessary follow-up information about the samples is missing (Aldersey-Williams, 2010). That information is quite often located somewhere else, away from the sample itself, in the form of a datasheet of the material, a reference book or a database.

1.3 Aims and Research Questions

The area to be investigated through this thesis concerns the relationship between physical material samples within a library or collection, and the necessary additional information that ought to accompany those materials to convey aspects of the material usage and material properties. In this work the relationship between information and samples will be explored and the kinds of additional materials information that may be appropriate to supply to industrial designers will be investigated. More specifically, the work will aim to find an appropriate information solution for materials libraries that are targeted to industrial design students, to connect material samples with information about them. To reach this aim, in the study answers to the following research questions will be searched:

-Which material information is important for industrial designers?

-How do the information needs of designers and engineers differ?

-How do the information needs of industrial design professionals and industrial design students differ?

-What are the existing solutions of accompanying information for material samples in material collections and libraries around the world?

-What design specifications should a material information system have, so that it is effective for teaching and learning of material properties to industrial design students?

1.4 Structure of the Research

The research has four layers. In the first layer, recent literature on the materials information needs of industrial designers has been investigated. Also significant literature about materials selection and information for designers has been read. In the second layer, materials libraries around the world have been searched and information about them has been collected. Special focus has been put into how these libraries and collections deal with the connection between samples and materials information. In the third layer, some existing materials information designs - created by graduate students of industrial design at METU – have been evaluated by METU industrial design undergraduates.

The outcomes from these three layers of research have been turned into a requirements list for the design process of supplementary information to be provided in educational material libraries and collections as the fourth layer. The specific application is the in-development 'Materials Experience Laboratory' at Middle East Technical University, Department of Industrial Design.

On the diagram (Figure 1-1) those four layers can be seen. Literature review and web research on material libraries provided a background on material information needs of designers and design students. Evaluations of existing material information designs and online survey with material libraries created the necessary insight about the information systems. Through these background information and the insights a new material information design and the thesis has been created.

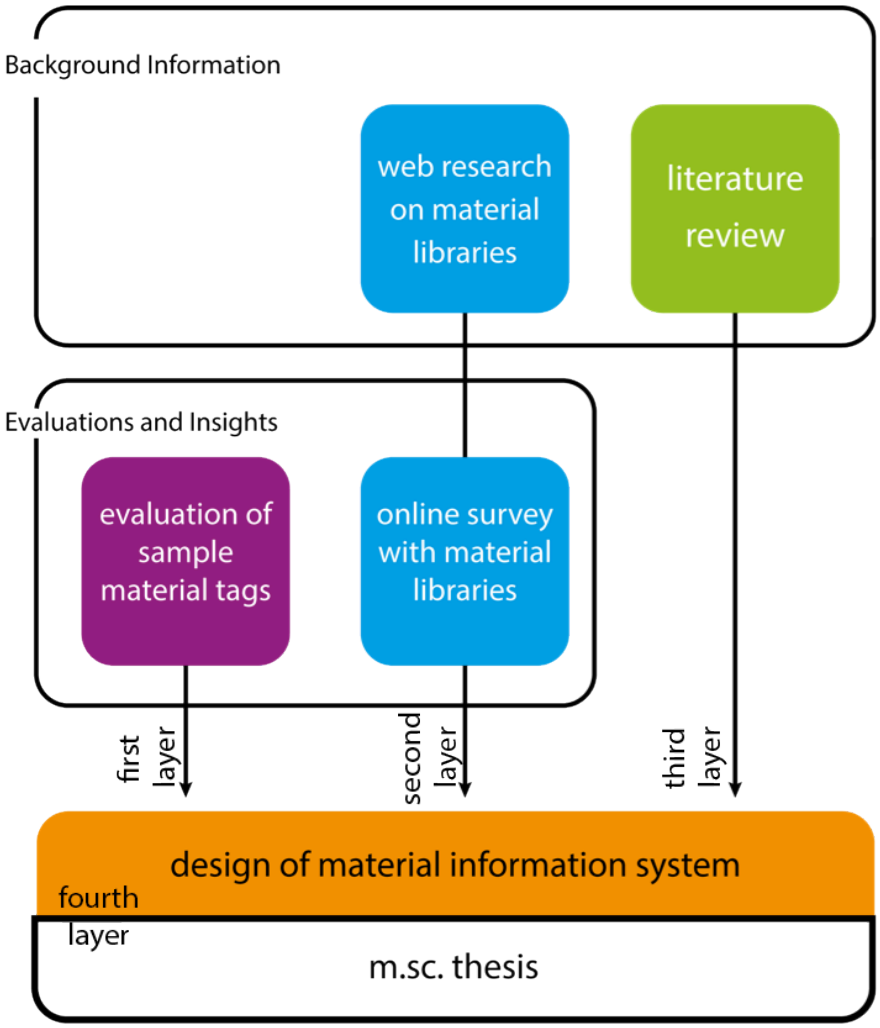


Figure 1-1 Structure of the Research

CHAPTER 2

MATERIALS SELECTION AND INFORMATION IN DESIGN

In this chapter literature about the subjects material selection methods for industrial designers and material information needs of industrial designers are examined. Recent articles about these subjects were the main sources. Also some doctorate dissertations were consulted. Some older resources with an important impact on the issue are the other basis for this chapter.

Some of the research questions were the main starting point for this literature review such as the kinds of information that industrial designers need and the differences of this need compared to engineers and design students.

2.1 Importance of Materials for Product Development Processes

Materials are one of the main driving forces behind innovations in product design, therefore many design studios put a special emphasis on materials (Lefteri, 2009). Not only designers use materials effectively, but also for artists it is a major field to distinguish their work from others (Beylerian et al., 2005). We can see that designers with a deeper knowledge on materials have helped create successful products (Ashby & Johnson, 2002). Material choices are one of the influences affecting whether a product is successful or not in our competitive market (Beylerian et al., 2005).

The number of available materials on the market is more than 100.000 (Ljungberg, 2007). In the last 20 years, more new materials have been created than in the entire history of material science (Brownell, 2006). The journey of mankind began with only five materials: 'wood, rock, horn, bone and leather' (Manzini, 1989). Now we have an enormous variety of natural and manmade materials. The effects of materials on design and art can be seen also in the aesthetic trends and art movements; new available materials at points during history were influential for these movements (Ramalhete et al., 2010; Ashby & Johnson, 2003).

For a long time the developments in the field of materials were not so rapid. Crafts people could spend a long time on one material to know its every detail, but now designers do not have this time to learn the details of a material and deeply experiment with it (Manzini, 1989). Another difficulty designers encounter today is the number of choices they have;

sometimes reliable information about materials is hard to find (Thompson, 2007). Designers need to know many details on how to produce and materialize a product (Norman et al.,1988). This is also true for students. If they want to produce realistic (i.e. producible) ideas, a good knowledge about materials and manufacturing is essential (Lesko, 1999).

Increasingly material suppliers give more importance to designers. Because designers can be seen as people who bring together new materials and users, so they help to grow the materials industry (Van Kesteren, 2008b; Ward, 2008). ASM International, formerly the American Society for Metals, and a major source of material information, has recognized designers as one of their target audiences for providing information about materials (Marshall, 2006). This can be seen as a consequence of what we mentioned before.

The importance of materials for turning ideas into physical objects is obvious. A product's function depends on the choice of its material but nowadays the product's successful service is taken for granted. Today, aesthetic qualities, perception of the product and its interaction with users are more important and these qualities are also affected by material choices (Ashby & Johnson, 2003). To create pleasurable products, materials are considered to have an important role (Jordan, 2002). Besides building the functional and structural presence of a product, materials have effects on the sensorial experience of the user (Karana, 2010; Pedgley, 2010b; Karana, 2009). Ashby & Johnson mention this issue by explaining that materials also have an intangible side (2003). Similarly, Rognoli & Levi (2004) explain that the form and material of a product are two parts that affect the emotional relationship with the user.

2.2 Material Information Needs of Industrial Designers

To understand the kinds of materials information that industrial designers need, it is important to examine the selection process of materials. How is this process carried out? Where do designers find information? These questions should lead us to the necessary knowledge about what type of information is appropriate, and in which form, for industrial designers.

2.2.1 Materials Selection Methodology

Choosing a material for a product is one of the first activities in the product development process (Cornish, 1987). Manzini (1989) states that the only way to be satisfied with the outcome of the selection process is to explore all possible materials and shaping processes. Often material choice affects the production technique, and the other way around (Cuffero et al., 2006). An ideal material selection methodology for designers should include both structured and chaotic parts (Ashby & Johnson, 2002).

Material selection processes described by different authors are quite similar. Cornish (1987) suggests that the following steps should be performed to select a material for a product:

- define criteria about the function and the operation environment of the product
- define technical and aesthetic properties of the material
- ask an expert for the opinion about the material
- search literature about the material
- take into account the manufacturing abilities of the firm, environmental and legal issues and the life cycle of the product

Van Kesteren (2008b) carried out interviews with designers having different experience levels and concluded that the following activities build a base for the material selection process:

- setting criteria for searching materials
- building up a group of possible material choices according to the criteria
- making a comparison within the group of possible material solutions
- decrease the number of possible material solutions
- making some test with the chosen materials
- getting detailed information about the test materials
- evaluating the material choices with outsiders

Pedgley (2010b) summarizes the necessary steps for selecting materials as follows:

- forming a criteria list
- eliminating materials which do not match with the criteria
- making a candidate group composed of materials best matching the criteria
- building some prototypes from materials within the candidate group
- gathering information about advantages and disadvantages of the materials in the candidate group

It can be seen that the selection process can be grouped into three main phases. In the first phase, requirements of the material are determined; in the second phase, the number of possible materials are limited to a group; and in the last phase, a few materials are selected to be explored more thoroughly (Ashby & Johnson, 2002).

Also Dobrzanski (2001) mentions a similar workflow: first, criteria are formed to search on the databases for appropriate materials. Then later on, candidate materials are explored whether they are suitable or not for the specific needs (cited in Van Kesteren, 2008a).

Ashby and Johnson (2002) recommend using a selection method that uses analysis, synthesis, similarities and inputs.

2.2.2 Selection Criteria of Materials for Products

The review of material selection activities showed that the common starting point is setting requirements for the material to be used in a product. Formulating those criteria is a critical point for designers when they are searching for information. During the product design process, criteria set at the beginning of a project can change over time, resulting in unnecessary work. Therefore, building proper criteria for searching materials is a key activity of designers (Van Kesteren et. Al., 2008). But this activity is not easy. It is hard for a designer to state his/her need for a material properties; it is even harder when considering versatile materials like many plastics which you can control many properties of them (Lefteri, 2008). Those designers interviewed by Van Kesteren (2008a) stated that it is not common that a clear requirements list of materials properties is ready at the beginning of a project.

A designer is not free when setting these criteria. Various factors have to be taken into account before formulating requirements. Turning a design into a materialized form has a considerable effect on the final attributes of a manufactured product. Karana (2009) mentions the following factors that affect material selection:

- technical requirements for product functionality
- manufacturing plant of the company
- material supply
- price
- time span
- tangible and intangible properties of the material

According to Ljungberg (2007), the following are the forces that determine which materials are more appropriate for a specific need:

- manufacturing processes
- functional and structural requirements of a product
- user
- design
- money
- ecological aspects
- life cycle

It is not only technical aspects about a material that are important for designers. In recent years, non-technical, non-physical aspects of materials have become more prominent. Accordingly, it is commentated that material selection activities of designers should comprise different aspects of the product such functionality, production requirements, life cycle requirements, ecological aspects, sensorial properties and perception (Karana, 2011; Zuo, 2010).

2.2.3 Kinds of Information that Designers Deed to Know

A deep knowledge on materials is essential for designing successful products (Lauglin, 2010). Using a material appropriate to its properties is important; therefore a detailed knowledge is needed. But also a wide perspective is essential for designers. It is an important issue that designers follow the latest trends in materials and production techniques (Cornish, 1987). Many new materials become available each year, but their application can be limited. If we look at the materials used in architecture, we can conclude that it is still dominated by traditional materials, and accordingly architecture education does not place large effort on emerging materials (Brownell, 2006). If we look to products on the marketplace, this observation is extended beyond architecture.

On the other hand, knowing relatively little about the technical details of a material can sometimes turn to the designer's advantage, according to Dow Corning's in-house designer Kevin Shinn. He maintains that in these circumstances, designers come up with more creative ideas (Lefteri, 2009). Fulton (1992) also agrees with the point that designers do not have to know every single detail of a material; he regards designers as 'consumers' of material.

Designers' knowledge about materials is different than that of engineers or scientists. It is not only the technical properties of a material that are important, but also sensorial characteristics and meanings. A material conveys to the user these intangible aspects, which forms a special kind of knowledge that a designer has to know (Lefteri, 2008). In the first decade of the 2000's, several research studies were made that examined not only technical aspects of materials but also sensorial properties and meanings, considered as basic material information needed for designing products (Pedgley, 2010b). Designers go to fairs, exhibitions and conferences to discover materials in physical environments and to obtain information beyond the technical aspects of the material (Karana, 2009). Finding information about the personality of a material is difficult because it is hard to measure a material's personality (Van Kesteren, 2008a). Therefore physical samples and example products are gaining more importance as an information source. But Ramalhete et al. (2010) says that the trend of current researchers' emphasis on sensorial information about materials

should not be understood that technical properties of materials are unimportant for designers. Pedgley (2010b) also mentions that for designers it is essential to know engineering terminology otherwise it would be hard to communicate the intended material properties to engineers.

2.2.4 Industrial Designers' Material Information Sources

Designers use different kinds of sources to obtain information on materials. Most of the time the source choice of designers depends on what they are searching for. For example, an inexperienced designer will search for quite broad information about materials, whereas experienced designers search for very specific information on materials, such as manufacturing possibilities or life-cycle characteristics (Van Kesteren, 2008a). A designer's three main sources for material information are: suppliers of materials, the firm for whom they are working for, and users (Van Kesteren, 2008a; Van Kesteren et al., 2008). Karana's research (2009) showed that some of the resources used by designers for obtaining material information are as follows.

- Suppliers' sources
- Exhibitions and conferences
- Handbooks about materials
- Technical books about materials
- Inspirational books about materials, especially Chris Lefteri's book series
- Material selection software such as CES, Plascams
- Online Databases

Prototypes of designed objects with different materials are also one of the information sources designers use (Van Kesteren, 2010). Written resources exemplified by the book series of Chris Lefteri are an essential reference and inspiration source for designers (Laughlin, 2010). On the other side, patents, industry guidelines, and regulations are other written sources that designers use. For information such as a material's availability, its price, and properties, contact is often made with a salesperson (Van Kesteren, 2008b). But resources dependent on suppliers are not always objective (Ashby & Johnson, 2002). For example, it is possible that companies write their best test result for their material's property. Also, an emerging information source is the 'material library', especially for finding new trends and developments in the area of materials and design (Karana, 2011). More and more we encounter companies who are offering assistance to designers who want to have help about material choices (Brownell, 2006). These companies often have a collection of materials in their workplace. An alternative approach to visiting material libraries is to make field research. Searching for inspiration within stores and from other products, whether

directly related or not, is one of the sources designers use for information about materials and their use (Ashby & Johnson, 2002).

2.2.4.1 Software as information sources

Software such as Plascams or Cambridge Engineering Selector (CES) are popular among designers, too. These databases help designers to get information about a specific material or let them compare different materials. GranataDesign, the company who developed the CES Selector, summarizes some advantages of their tool as follows (cited in Laughlin, 2010):

- the software can support both early and later design phases
- the software can help to reduce material costs through exploring same properties in cheaper materials
- ability to consider a vast amount of different materials for possible design decisions
- ability to find similar or equivalent materials
- enhances communication of material thoughts within the development group
- encourages organizations to develop material thoughts in the early phases of a project

Young (2003) mentions that for software to be successfully used by designers, it should have a good structure about the information, should ease the sharing of information, and should be updatable. But a database about materials and their properties sometimes is not appropriate for design work. Especially in the early development phases of a design project, databases, which can be searched through material properties, can be disadvantageous for designers, because in the earliest phases designers mostly do not know which properties they are looking for (Van Kesteren, 2008b) (Albinana & Vila, 2012). Most probably advances in material selection software technology will continue. And in the future material selection process for products will be handled by artificial intelligence (Albinana & Vila, 2012).

2.2.4.2 Experts as Information Sources

Experts are also one of the information sources that designers use. Besides information from suppliers, manufacturers, the Internet, and catalogues, an expert's opinion is also valuable (Van Kesteren, 2008b) (Cornish, 1987). Manzini (1989) emphasises the importance of experience when selecting a material. Technical properties and theoretical knowledge can be replaced by software and databases, but practical knowledge cannot be replaced. An expert is also crucial for designers when they want to ask a specific question about a material (Van Kesteren et al., 2008)

2.2.4.3 Product Samples as Information Sources

The interviewees in Van Kesteren's research (2008a) stated that it is important to see materials used in a product form, because sometimes it is difficult to foresee how a material will behave when it is turned into a product. Also some of the material libraries worldwide provide not only material samples but also product samples. To judge the performance of a material, it is a good exercise to see that material in a form of product (Van Kesteren, 2008a). Ashby and Johnson (2002) also state that broken or damaged products are a very valuable source of information for companies. Designers use product samples as information source, to turn ideas into prototypes with different materials so they can be judged better (Van Kesteren, 2008b). Exploring an older version of a product, in preparation for designing a newer version, is also a common practice among designers (Van Kesteren, 2008b).

2.2.5 The Form of Materials Information Appropriate to Designers' Needs

Information about materials is traditionally an engineering field. Before there emerged works appropriate to designers, engineering resources were used. Manzini's work entitled 'Material of Invention' (1989) can be seen as the first work about materials, targeted explicitly to designers (cited in Rognoli, 2010). Another important book source is Ashby and Johnson (2002), who presented technical information about materials in the form of charts. Through the task of turning the numberical data of material properties (Cornish, 1987) into maps and graphs, Ashby and Johnson (2003) took an important step towards establish a necessary background for material information targeted to designers (Rognoli, 2010). Presenting information visually can help the designer more easily see similarities or differences between materials (Ashby & Johnson, 2002). Norman (1998) states that showing materials' properties in the form of charts helps designers to understand them better and therefore the Cambridge Engineering Selector (CES) can be seen as a successful tool for design education (cited in Pedgley, 2010b).

Images of materials are also an appropriate information type for designers. As designers are visually oriented people, they put more emphasis on such elements. Van Kesteren (2008) and Karana (2008) state that designers like to have information about materials in a form of images with little writing for preliminary material selection process (cited in Karana,2011).

An important feature of information about materials is that it should be structured well, and should have different depth levels. Associated methods of materials selection should be applied to projects at both a conceptual level and a developed level (Ashby & Johnson, 2002). Accordingly, it is stated by Ashby & Johnson (2002) that designers begin searching for appropriate materials for their projects across a wide range of materials; therefore it is necessary to be able to compare different materials. So designers prefer material information

to be presented in ways to ease comparisons (Van Kesteren, 2008b). Another problem designers encounter during information research about materials is that it is hard to find knowledge about technical properties and aesthetic qualities of a material in one place (Van Kesteren et al., 2008).

2.2.6 Multilevel Materials Information for Designers

Authors who write about materials information needs of designers emphasise that there are different levels of knowledge which designers need in different phases of design process. According to their interviews with designers Karana et al. (2008) divide the information needs of designers concerning materials into two sections: during the concept generation phase, designers need more information about sensorial properties and perception of materials, whereas during design detailing process they need more information about technical aspects of the material. In the first periods of the design process, sometimes it is only necessary to decide on the material family (Van Kesteren, 2010). A detailed level of information typically arises from the product development phase. In the first phase, information about many materials is required but this information is not deep. In the second phase deeper knowledge is required for a smaller number of materials. In the third phase of the design process very precise information is required for a few materials (Ashby & Johnson, 2002). In the first phase of the project, designers need to have information about materials for inspiration. In this phase images and inspiring applications are needed. In the further phases of the project, designers need detailed information about technical properties. In this phase, the numbers and specifications about materials are more important. Van Kesteren (2008b) calls this feature of the information 'multiple detail levels'. Ramalhete et al. (2010) divides the different levels of information into three, distinguishing amongst concept generation level, implementation level and finalization level.

2.3 Differences of Materials Information Appropriate to Designers and Engineers

The materials information field has been dominated for a considerable time by engineering knowledge. Designers have had to use sources that were developed for technical professionals. It is important to understand the differences between designers and engineers with regards to material information, to indicate on what ways information sources should be designed to be different.

Material selection methods, until Ashby and Johnson's work in 2002, were generally suggested to follow an analytical and stepped approach (Van Kesteren, 2008). In the material selection process not only technical people are involved but also professionals including staff from marketing, trend forecasting and designers (Ferrante et al., 2000). These technical-oriented methods were not appropriate for all the kinds of professionals who are

dealing with material selection. Decisions in the engineering field are supported by technical information and numerical data (Albinana &Villa, 2012). For engineers to have concrete evidence materials is essential for design decision-making. According to Manzini (1986), an engineer can say that he 'knows' a material when he can describe its properties in numbers. Engineers describe a material through its technical properties, whereas designers describe it through its sensorial characteristics. Lefteri (2008) defines this as the 'personality' of the material. These observations of course affect the way engineers choose a material. We explored in the previous part which factors are important for designers when they are choosing a material. Engineers on the other side consider different points when choosing a material. For Ferrante et al. (2000), a material selection process should include the following considerations:

- function of the product
- service environment
- life cyle of the product
- price of the material

For making decisions about the usage of a material in the engineering field, the following aspects are important (Albinana & Villa, 2012):

- supply of the material
- human resources for manufacturing
- energy used for production
- manufacturing facilities available

Ljungberg (2003) differentiates a product's development process into two areas: one physical, and the other metaphysical. Within the physical development are technical and material aspects of the product such as life cycle, function, and environmental impact.

Karana et al. (2008) reviewed several engineering resources to determine what kind of information is commonly needed for selecting a material. Most of the reviewed sources include technical material properties, economical consideration and manufacturing details. (Figure 2-1)

Review of different sources defining the effective material aspects for materials selection process

Materials (1967)	Patton (1968)	Esin (1980)	Ashby (1992)	Lindbeck (1995)	Budinski (1996)	Mangonon (1999)	Ashby & Johnson (2002)	Ashby (2005)
– Mechanical properties – Cost	– Service requirements – Fabrication requirements – Economic requirements	– Production requirements – Economic requirements – Maintenance	– General properties – Mechanical properties – Thermal properties – Wear – Corrosion/ oxidation	– Mechanical properties – Physical properties – Chemical properties – Electrical properties – Acoustical properties – Optical properties	– Chemical properties – Physical properties – Mechanical properties – Dimensional properties – Business issues	– Physical factors – Mechanical factors – Processing and fabricability – Life of compo- nent factors – Cost and availability – Codes, statu- tory and other – Property profile – Processing profile – Environmental profile	– General attributes – Technical attributes – Eco- attributes – Aesthetic attributes	– General properties – Mechanical properties – Thermal properties – Electrical properties – Optical properties – Eco-properties – Environmental resistence

Figure 2-1 Table of different material considerations, extracted from Karana et al. (2008)

The technical side of materials research tries to understand material properties and how to change them according to utilitarian needs. This is a very developed field and through such knowledge it is possible to create new materials (Ashby & Johnson, 2002).

As it can be seen from the resources in Figure 2, the engineer's perspective on material selection is quite different than designers. Material selection tools used for engineering and architectural design do not include sensorial information about materials (Wastiels et al., 2007). Most of the factors engineers seek to be satisfied by materials can be represented in numbers very objectively. This is related to the engineering knowledge and how it is transferred. Engineering knowledge can be conveyed more easily than design knowledge because it consists of analytical and structural information, rather then somewhat subjective, tacit or indeterminate. This is because design builds upon experimentation, modelling, visual representation, telling a story, and conveying a message, which are all harder to define and transfer (Ashby & Johnson, 2002). Throughout the history of mankind, we can differentiate between two different ways of knowing. One is the knowledge of technical oriented people, whereas the other is the knowledge of crafts people. Craftspeople develop knowledge in the process of creating things. Technical people, on the other hand, first obtain knowledge and later on apply it to a design task (Manzini, 1989). Myerson (as cited in Pedgley, 2010) distinguishes between engineering education and design education with respect of the order of learning and practice. Typically, engineers first learn and then practice, whereas designers first practice and then learn. Engineering can be defined as a field that is certain about what it does and is highly systematic; if experimentation is involved, engineers complete the related maths so that they can predict what will happen. This is in contrast to crafts people, who often use observations and experimentation to generate knowledge (Manzini, 1989).

It can be concluded that engineers have developed new materials and with their knowledge on material properties they have refined many materials. But their viewpoint towards materials is different than designers. That is why for designers it is not appropriate to use tools and methods developed for engineers, but instead they should ideally use tools and methods specifically targeted at designers' ways of working.

2.4 Difference of Materials Information Needs of Design Students and Design Professionals

To be able to use materials successfully, it is essential that students know the sources of material properties and how these properties can be manipulated (Norman et al., 1988). But a classical design education doesn't provide a deep knowledge in materials; in this case, designers try to fulfil this need through their self-efforts (Laughlin, 2010). Students find it difficult to obtain information about materials in a way that is beneficial for them, with the result that they tend to select a material at the end of a design process rather than consider materials early on in a way that can influence design directions (Karana, 2011). Wright (as cited in Van Kesteren, 2010) mentions that students focus on one solution for materials and don't explore different kind of solutions. The reason for this is the limited amount of knowledge they have about the subject.

Educators try to fill this gap with different kinds of didactic approaches. In the relatively short time of a semester-length course, there is insufficient time to teach a full and deep materials knowledge to students. Instead, only a basic foundational understanding of materials and their effects is achievable. Pedgley (2010b) mentions the following for the aim of his course "ID236 Manufacturing Materials":

- establishing an appreciation for materials in design
- understanding the drivers affecting material choices
- establishing knowledge about materials, shaping, finishing processes and joining methods
- generating an ability to turn ideas into materialized forms

Zuo (2010) concludes in his article that a successful materials course should let students perform some experiments and explore different kinds of materials, but at the same time a structured knowledge with the help of selection software and databases should be given in the course. Design education for a long time used resources about material information from engineering departments, but later on educators interpreted are re-presented those resources according to the needs of designers (Rognoli, 2010). Nevertheless, it is valuable also to know engineering information about materials. Pedgley (2010b) emphasizes the importance

of teaching technical terms about materials in order to have a good communication between designers and engineers in their professional life.

A very important development for materials education in design schools is establishing libraries with samples of materials and their applications. A collection providing physical samples is an effective tool for design education (Ward, 2008). Physical contact with materials and products is considered an appropriate method for design teaching and learning. Zuo (2010) suggests that if students carry out experiments and conduct practical work about materials, they are more likely to learn better. Taking apart products is a good exercise for students to learn information about joints and structures (Pedgley, 2010b). If there is a materials library in the school, professors who are teaching the subject should encourage students to use those libraries whenever students receive new project briefs (Ward, 2008). One recommendation of Pedgley (2010b) is to use as much material samples and example products as possible during the education of designers, in order to establish a broad and practically-oriented material experience. The material selection method developed by Van Kesteren is recommended to be used in conjunction with material samples (Van Kesteren, 2010).

The information that design students need is slightly different than the information needs of design professionals. In her interviews with students and professionals, Van Kesteren (2008a) found out that both groups prefer to have information about general material properties and sensorial aspects of the material. The two groups also liked to have data presented in a form of tables and graphs with pictures. Design professionals wanted to have exact numerical values for material properties, whereas design students wanted to have a range (i.e. relative positioning) for the properties' values. Students mentioned that Van Kesteren's material selection method for them was hard to implement in the design process and they viewed it as restrictive with regard to creativity (Van Kesteren, 2008b).

2.5 Importance of Sensorial Information about Materials

Schifferstein and Hekkert (2008) claim that material selection is increasingly turning to a 'softer' process and that user interaction is becoming the driving force for the process. This is also observed to be the case in the context of design education. For example, Rognoli (2010) developed a tool, entitled the 'expressive-sensorial atlas' that helps students to categorize a material through its sensory and perceptive properties. It can be said that material selection processes nowadays focus more on satisfying user-interaction needs of products than their technical requirements (Van Kesteren, 2010).

Selecting materials is not only limited to physical requirements. Materials not only have technical properties but they also have cultural meanings (Doordan, 2003). Ashby &

Johnson (2003) claim that materials have 'personalities' and that this personality is created by the material itself or by associated shaping processes. Designers not only select materials for technical requirements, they also consider which associations and perceptions these materials evoke (Van Kesteren et al., 2008). For example it is possible that plastics can evoke some negative associations and users would judge products made of plastic as, for example, 'cheap' (Fisher, 2004).

In the traditional engineering sources about material information, technical properties form the majority of information. But in recent years sources such as Ashby and Johnson (2002) emphasize the importance of 'intangible' properties of materials (Karana et al., 2008). Both sensorial and technical properties of a material should be considered for a 'proper' material selection process (Karana, 2010; Rognoli, 2010; Van Kesteren, 2010; Zuo, 2010; Ljungberg, 2003)

Actually, sensorial properties and material perception has been an issue for design education at least since the 1920s. Educators including Moholy Nagy and Albers were concerned with these matters (Rognoli, 2010). Cornish (1987) also emphasises that knowledge about the surface qualities of a material should be given more importance as these qualities have a major effect on the aesthetics of the product. The non-physical value of a product can be increased through successful selection of materials, design and advertisements (Ljungberg, 2003).

2.6 Integration of a Materials Collection into Selection Processes

The sensorial information of a material is difficult to convey through photography and even harder through verbal descriptions. Therefore, instead, samples are an essential source for experiencing sensorial information first-hand (Daniel Linden in Lefteri, 2007). Most material databases lack information about sensorial properties of materials, which can be seen as a limiting factor for their ability to assist materials selection (Ramalhete et al., 2010). Material samples can be seen as a vast source of sensorial information, which comes with a responsibility to be convey this knowledge to design students in a structured and a methodological way (Pedgley, 2010a). There is no need to have a background on material science if the aim is to understand how rigid or how smooth a material is, since with human senses important features of materials can be experienced and understood (Ashby & Johnson, 2002). In Van Kesteren's thesis (2008b) and subsequent article (2008a), one of the information needs of designers about materials is a physical sample. Designers can evaluate and judge sensorial and expressive properties of materials through exploring samples.

Properties about the aesthetics and the perception of materials are harder to define than technical properties, but for a complete materials selection process it is still necessary to be

achieved (Ashby & Johnson, 2002). Material samples are an invaluable source for these kinds of properties. One of the sources for how to obtain sensorial properties of materials is to order material samples from suppliers. Unfortunately sometimes it is difficult to obtain a physical sample from manufacturers due to production costs (Van Kesteren 2008b). Pedgley (2010) underlines the importance of physical samples in his course on materials, through emphasizing the value of students personally experiencing materials .

The design firm IDEO uses their own collection of material samples , called Tech Box. This collection is accompanied with basic information and there exists a database which can be accessed through an intranet. The database contains more specific information and comments, obtained from previous users of the material (Van Kesteren, 2008a). One criticism of material samples is that they are interesting, but frequently designers seek further information about the materials from an expert (Aldersey-Williams, 2010). Material libraries have emerged around the world as a resource to help designers in the selection of materials (Van Kesteren, 2008b). Three types of material libraries can be identified: commercial, academic and institutional (Laughlin, 2010). It has been observed that material libraries are especially beneficial for design education (Ward, 2008). Ashby & Johnson (2002) state that materials libraries should be accompanied by images and general features of the material, to fit to designers' materials information needs.

Another use of material samples by designers is to communicate ideas and also to gain inspiration (Van Kesteren, 2008a). Material samples are an effective tool for creativity and inspiration (Ashby & Johnson, 2002). Material samples can enhance the creativity of students and help them to decide on the material they might want to use in new design (Zuo, 2010). A materials library, where materials and people meet each other, becomes an inspirational place to exchange information (Laughlin, 2010).

The number of materials libraries worldwide is increasing, whilst the recognition of the need for such libraries is also growing. Furthermore, most of the users of these libraries do not have a background in materials; the issue of , how to build and present material samples and any accompanying information is therefore a critical matter (Laughlin, 2010). For example, material samples play an important role for giving information about a material's sensorial properties. But in most libraries, supplementary information about technical properties or other features of the material cannot be found accompanying the material sample or within the material library (Aldersey-Williams, 2010).

2.7 Conclusion

In this chapter from literature it was found out that the world of materials has been increasing in recent decades enormous and for industrial designers it can be a problem to

have enough knowledge for each different material. Material selection methodologies have been developed historically for more scientific and engineering activities. Recent works on this subject also covers the need of industrial designers and focuses on issues that are important for designers such as sensorial aspects of materials. The form of information is another feature of the material that differs from information that is developed for engineers in regards to information appropriate for industrial designers. An important finding from the literature is the source of information about materials for designers. As there is limited amount of sources that is developed for industrial designers, it is common that designers use very different sources such as technical handbooks, used product examples, prototypes and databases. Literature review also revealed distinctions of needs of design professionals and design students. Design professionals are seeking for more detailed and specific information compared to students who are more keen on finding general information. It was also obvious after reading the related literature that during the design process different information is needed, for example in the beginning of a design activitiy material information for inspiration is needed and during the finalization of the design very specific technical information is needed.

CHAPTER 3

METHODOLOGY OF THE RESEARCH

The research, aiming to inform the design of a material information sample tag appropriate to industrial design students, and to be used in the proposed materials library at Middle East Technical University Department of Industrial Design, consists of four main parts (Figure 3-1). The first part is the literature review on the subject of material information needs of designers. The second part is evaluating sample tags, which were designed by the graduate students of the "ID725 Materials Experience" course. The third part is gathering information about materials libraries from around the world. Finally, the fourth part is the design of a sample tag taking into account the findings of the previous three parts.

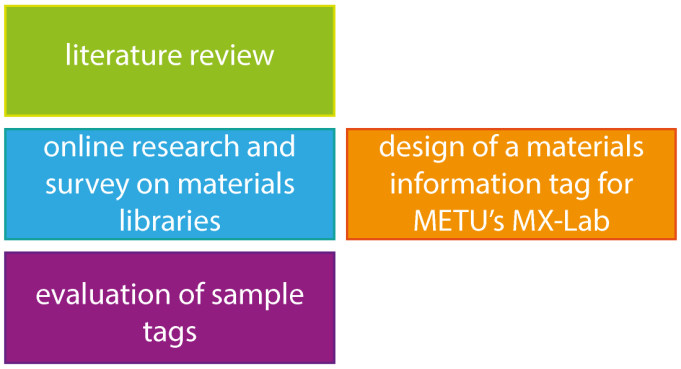


Figure 3-1 Four main parts of the research

3.1 Literature Review

Literature on materials information has a long tradition in the engineering field (Karana et al., 2008). Resources are typically adapted from engineering backgrounds by design educators so that it can be suitable for teaching designers about materials (Rognoli, 2010). One of the first resources written for designers is the "Materials and Design" book from Ashby and Johnson (2002). The book series by Lefteri (2002) is also an early resource which designers use. Later, several reference books including Ultra Materials (Beylerian et al., 2007) and Manufacturing Methods for Design Professionals (Thompson, 2007) emerged. Also important older books are consulted, including Manzini (1989) and Cornish (1987), but the main part of the literature which was used were articles written in more recent years, for example the papers authored separately by Karana, van Kesteren, Pedgley and Rognoli.

These authors focus more on the senso-expressive side of materials and its relation to industrial design decision-making. Current thinking on materials selection for design puts greater attention on qualities beyond functionality (Van Kesteren, 2010). Another valuable resource for my research was the dissertations of Laughlin and van Kesteren on the subjects of material selection methods for designers and the importance of material samples in this process. For the literature review, I conducted research using several online databases using the following keywords: material information needs, designers and material selection processes, material experience, material collections, and material libraries.

3.2 Online Research and Survey about Materials Libraries

This part of the research consists of two sections. One is an online web-based search about material libraries; the other involved carrying out an online survey participated by people responsible for managing those material libraries.

One of the first researches which was performed was to gather information about existing material libraries from around the world. Search engines on the Internet were used with the key words: material library, material lab, material collection, material resource, material archive. Through this online research, and with additional correspondence with Dr Valentina Rognoli of the Politecnico di Milano materials library, a list of around 30 material libraries and collections around the world could be made. I built up a document with information from the websites of these libraries. Some of the websites provided quite thorough information whilst others were not so informative. Most probably the situation is so because of the libraries' different conditions: some of them are commercial, some institutional and others are educational.

In the second section of the research on material libraries, an online survey was prepared, which would enable us to obtain more structured and detailed data about the various material collections. The survey was prepared in consultation with the advisor of this thesis and later asked for opinions of the Research Assistants in the Department of Industrial Design regarding the survey legibility and usability. After these consultations, I modified the questionnaire into a finalized version. The online survey was open for 2 months and 14 corresponding people made completed submissions (out of 30 material libraries approached).

The results of the survey were directed according to three categories of information dividing up the survey. One was background information about the collections; the second was material information systems of the libraries; and the third was thoughts about material libraries in general and their specific library.

It was agreed with participants that as an appreciation of their effort, an example of the results will be send to them.

3.3 Evaluation of Sample Tags

A core part of the research involved evaluating sample tag designs, created during the graduate course ID 725 Materials Experience, instructed by Pedgley (2012). This course has a focus on material qualities that are related to aesthetics, meanings and emotions. At the end of the Fall 2011-12 semester, students from this course were asked to design a material information system that would enable undergraduate students to learn "supra-physical" properties of materials. The primary outcome of this project comprised 10 different tag designs intended to accompany product and material samples in a library where students can experience materials first-hand (Figure 3-2). By conducting a systematic evaluation of those tags, a knowledge pool of most preferred features of tags could be built up and those findings could be used in creating new tag designs.

Figure 3-2 Example material information tag from the ID 725 Materials Experience course

The principal target group of the materials library at METU would be undergraduate students. The intention of the library (named 'Materials Experience Laboratory') is to help students learn basic knowledge and thinking about materials and production techniques. On

the METU Industrial Design BID programme, courses about materials and manufacturing are given at the sophomore level. Therefore the ten sample tags generated during the ID725 course were evaluated by students attending the ID 236 Manufacturing Materials course. A questionnaire was organized with the 38 students from this course. At the time the students answered the questions, it was their final week of teaching, so they already possessed knowledge about materials and their application in design.

The questionnare which was carried out consisted of open-ended questions and Likert-scale grading. Sample tags were prepared by the graduate students physically, so the stimulus during the questionnaires was 10 different tags connected to 10 different material or product samples. My questionnaire was divided into two different parts. In the first part, five criteria were set and graded. In the second part, students were asked to write down what they liked and disliked especially about each tag. The criteria, which are set in the first part, originated from informal evaluations of the sample tags with graduate students during the ID 725 Course (Appendix A). This informal evaluation session showed that the tags should be evaluated whether they are informative, understandable, relevant to students' need, inspirational for material selection in industrial design, have attractive graphics. A five point Likert scale is used to grade the sample tags according to those criteria.

Every student received a questionnaire paper with 2 pages, containing questions for all 10 tags. The students discussed each sample tag in groups of 3 to 4 people for approximately 5 minutes and later on personally filled in the questionnaire, which took approximately 3 minutes. There were 10 groups and each group was evaluating and discussing one sample tag, later on they moved on to the next tag. So each student discussed all 10 tags with the group and individually filled the questionnaire for all 10 tags. In total, the session took approximately 2 hours and was carried out during the ID 236 class. At the end, 38 evaluations of each sample tag were obtained.

During the evaluation session of undergraduate students it was mentioned to them that they should not evaluate the connection detail of the tags to the material and product samples. The tags demonstrated various approaches for how to connect the two elements (tag and sample). The connection details were evaluated by author according to negative and positive criteria, with the result that the connection detail of sample tag 2 was found the most successful. During the research on material libraries, the same detail came out being put to use across different libraries. Therefore it can be concluded that it was an effective way to connect such parts.

The analysis of the outcomes from the questionnaire session with undergraduate students took quite a considerable amount of time and effort. Because there were two parts to the

questionnaire, a Likert grading and a text part, at least two different analyses were required to be made. In the end, three different analyses were made: for the first part a quantitative analysis was made; and for the open-ended questions, both qualitative and quantitative analyses were made.

In the analysis of the first part for each criteria, the most successful tag design is identified. Also, the tag that is overall graded highest is found out. Paired T-Test and 1-Way ANOVA / Tukey HSD tests were performed to find out how much 'better' the results from certain tags were, compared with other tags. These statistical tests were chosen because they reveal whether the differences between two values within a data set are significantly different (or not), and therefore whether those differences are worthy of special mention and explanation (or not).

For the analysis of the second part, all comments of the students were typed into MS Word and then categorized as to whether they mentioned something negative or positive about the tag. These negative and positive comments about the sample tags are then grouped, so similar comments could be put under a headline. For each sample tag a visual is prepared that enables us to see the positive comments and negative comments on the tags.

After evaluating comments according to the tags, all the comments were put together. In this phase the number of comments was important where a part of the tag is commented by many students or not. Also on this table it was important to see whether a feature of the tag is commented only negatively or positively. Later on, comments are put into three categories according to their essential meaning or connotations: content, presentation and materialization. After making these categories, it was easier to formulate design recommendations according to the comments (Appendix F).

3.4 Design of a Tag for the Proposed Materials Library at METU

After the preparation of a design recommendation list from the findings of the studies detailed in this section, the design of a new ('ideal') tag began. The production techniques of the tag and available card sizes were defined in the project constraints..

The next step of the design process was to make some wireframe designs. After producing 8 different wireframe designs, it was obvious that the design requirements were clear. Later on, I turned one of the drawings into an Illustrator file as a preliminary design for a tag.

After the first design, discussion was made with the advisor of this thesis – as an expert in the domain – about further ways in which the tag could be improved. This resulted in a

revised version of the tag being created. Following further critiques with the expert, three example sample tags representing three different material families were made.

CHAPTER 4

RESEARCH ON EXISTING MATERIAL LIBRARIES

The first research activity performed during the Master's study was to collect information on existing libraries around the world. As mentioned in the literature review, material libraries are important tools in current industrial design education. For professional designers these libraries also have an important role. They have been used for inspiration and information resources.

The intended end application for the research and design presented in this thesis is a material information system for industrial design students, based on samples contained within a material library. It was therefore essential to collect information about existing material libraries and examine how these libraries solve the problem of bringing material samples and materials information together.

In the beginning of the chapter short information about material libraries as informal learning environments from literature will be given. Later on, findings from the research about material libraries are going to be presented. This section of the research had two steps. In the first step, information from the Web was used to collect knowledge about existing material libraries around the world. In the second step, an online survey was sent to the responsible people at each of these libraries. Because the results from the online survey were much more detailed and structured compared with the 'search findings' originating from analysis of library websites, online survey results are presented first. In the second section of the chapter, findings relating to material libraries who declined to contribute to the online survey are presented, based on the findings of the online search.

4.1 Material Libraries as an informal learning environment

Informal leaning can be defined as all the learning activities occurring outside the academic curriculum (Schugurensky, 2000). It is important to note that the definition also includes learning in the academic facilities. Libraries, laboratories and different reseources in the school that can be used outside the classes are places where informal learning occurs. Libraries are an essential resource for self motivated learners (McNicol & Dalton, 2003). Material libraries can be seen also in this group of resource.

Material Libraries are places where students can touch, feel and sense materials. Experiential learning means “hands on learning”, which means that you learn things when you are more involved in the process (Herod, 2012). Experiential learning theory involves that the learners are interacting with their environment subjective and objective, as they build up experiences. (Kolb, 1984)

According to David Kolb experiential learning fits very well for adult learning (Herod, 2012). One of the popular learning methods is experiential learning which means acquiring knowledge through own experiences of the learner. In this kind of method is learners’ sensorial stimulus is the foundation for the knowledge (McNicol & Dalton, 2003). Material libraries can be seen as an effective tool for this kind of learning methods. Foster and Gibbons (2007) underline that using different tools and technologies enhance the leaning capabilities in the schools (SCUP, 2013). Nowadays teaching and learning environments are full of different kinds of media (Woolfolk, 2011). Actively engagements are a core point to make transfer of knowledge happen (Hakel & Haplern, 2005).

Another feature that libraries provide for teaching is that these places work as a hub for meeting people and resources. Redcliff et al. (2008) sees also libraries as place for interacting other students and disciplines (SCUP, 2013). Learning environments have a big influence on how people gather knowledge about a certain subject; these environments have several dimensions (Woolfolk, 2011). Collaborative learning also eases the transfer of knowledge, interacting within a group is an effective tool (Hakel & Haplern, 2005).

4.2 Online Survey with Material Libraries’ Correspondents

As an initial activity, a list was prepared of existing material libraries around the world, uncovered during Web searches and literature review. The list contained 30 libraries (Table 4-1). These libraries could be identified as commercial, institutional and educational. Of the 30 libraries invited, 17 agreed to participate in the survey, which had 5 parts. The parts were divided according to different grouped subjects: background information, samples in the libraries, supplementary resources, experiences about material libraries, and images. The survey questions can be found in the Appendix B. After uploading the questions to the survey website, small changes were made according to the comments of a pilot group of participants (three Research Assistants within the Department of Industrial Design, METU). On the briefing page for the survey, participants were informed that they were free to skip any question if they so wished. So although there were 17 participants, not every question was answered by all 17. Furthermore, there was an option to participate in the survey anonymously: three of the libraries wanted to participate anonymously.

Table 4-1: List of material libraries to which the survey has sent (grey = educational, green = institutional, red = commercial).

	Institution / Company	Resource Name	Country	Website	Participant ?
1	Delft University of Technology	Made of	Netherlands	www.io.tudelft.nl/madeof	Y
2	Politecnico di Milano	Materialie Design	Italy	http://www.politeca.polimi.it/	Y
3	Six Swiss Institutions and Universities	Material Archiv	Switzerland	http://www.materialarchiv.ch/cms/	N
4	Royal Danish Academy of Fine Arts	Material Collection	Denmark	http://www.karch.dk/uk/Menu/About+The+School/Facilities/Material+Collection	Y
5	Harvard University Graduate School of Design	Materials Collection Frances Loeb Library	USA	http://materials.gsd.harvard.edu/materials/credits.html	Y
6	University of Texas at Austin	Materials Lab	USA	http://soa.utexas.edu/matlab/	Y
7	Anonymous 1	Anonymous 1	United Kingdom	-	Y
8	Rhode Island School of Design	Material Resource Center	USA	http://library.risd.edu/materialslibrary.html	Y
9	College for Creative Studies	Colors and Material Library	USA	http://www.collegeforcreativestudies.edu/student-resources/student-services-and-resources/library/colors-materials-library	N
10	The New England School of Arts and Design at Suffolk University	Materials & Resource Library	USA	http://www.suffolk.edu/nesad/17940_18105.htm	N
11	Virginia Commonwealth University	Materials Library	Qatar	http://www.qatar.vcu.edu/library/use-the-libraries/materials-library	Y
12	Kingston University	Rematerlalise Library	United Kingdom	http://extranet.kingston.ac.uk/rematerialise/links/index.htm	Y
13	Anonymous 2	Anonymous 2	USA	-	Y

Table 4-1 (continued)

14	Central Saint Martins College of Arts and Design	Materials & Products Collection	United Kingdom	http://www.arts.ac.uk/library/collections/csm/	N
15	London Metropolitan University	Materials and Products Collection	United Kingdom	http://www.londonmet.ac.uk/services/sas/library-services/commercial/materials-products.cfm	Y
16	Anonymous 3	Anonymous 3	Italy	-	Y
17	Materials and Design Exchange (MaDE)	MaDE Resource Centre	United Kingdom	https://connect.innovateuk.org/web/design-exchange	N
18	University College London	Institute of Making	United Kingdom	http://www.instituteofmaking.org.uk/materials-library	N
19	Materialbiblioteket	Materialbiblioteket	Sweden	http://materialbiblioteket.se/showroom/	Y
20	Materioteca	Materioteca	Italy	http://www.materioteca.com/materioteca/	Y
21	Matrec	Matrec	Italy	http://www.matrec.it/it/chi-siamo/il-gruppo-matrec	Y
22	Material Lab	Material Lab	United Kingdom	http://www.material-lab.co.uk/what-we-do/	N
23	MateriO	MateriO	France & Regional	http://www.materio.fr/en	Y
24	Materia	Material Inspiration Center	Netherlands	http://www.materia-ic.com/	N
25	Material ConneXion	Material ConneXion	USA & Regional	http://materialconnexion.com/Default.aspx	N
26	FCBA Institut Technologique	Innovatheque	France	http://www.innovatheque.fr/index.php	N
27	MaTech	MaTech	Italy	http://www.matech.it/index.asp?lang=en	Y
28	Materialsgate	Materialsgate	Germany	http://www.materialsgate.de/en/mcards/	N
29	Raumprobe	Raumprobe	Germany	http://www.raumprobe.de/ausstellung/uebersicht-ausstellung/	N
30	SCIN	SCIN	United Kingdom	http://www.scin.co.uk/index.php	N

4.2.1 Background Information about Material Libraries

Table 4-2 presents the background information for each participating library, such as its location, year of establishment and organization type. Most of the libraries are established in the 2000's (11), a few of them in the 1990's (4), whilst the material archive of The Royal Danish Academy, School of Architecture, was established in 1968. Three participants were from USA, one from Qatar and all others from Europe. Regarding the operational profile, ten participant libraries were educational, five commercial and two non-profit organizations.

Table 4-2: Background information about participating libraries

Participant Number	Short name	Location - city	Location - country	Establishment year	Parent organization	Parent organization
1	Materialbiblioteket	Stockholm	Sweden	2005	Stockholmsmässan	Commercial
2	KAAM	Copenhagen	Denmark	1968	The Royal Danish Academy of Fine Arts	Educational
3	Anonym 1	London	UK	2000	Anonym	Educational
4	-	PARIS	France	2001	-	Commercial
5	Anonym 2	San Francisco, CA	USA	1999	Anonym	Educational
6	-	Milan	Italy	1998	Plast Image (non profit association) and Plastic Consult s.r.l.	Non-Profit Organization
7	MATREC EcoLab	Milan and Florence	Italy	2002	Scuola Politecnica di Design, Corso di Laurea in Disegno Industriale dell'Universita' di Firenze	Commercial
8	MeD	Milan	Italy	1999	Politecnico di Milano	Educational
9	Rematerialise	Kingston, London	UK	1996	Kingston University	Educational/ Commercial/ Non-Profit Organization
10	Anonym 3	Torino	Italy	2005	Anonym	Commercial
11	-	London	UK	-	London Metropolitan University	Educational
12	Made Of..	Delft	Netherlands	2012	TU Delft	Educational
13	Materials Lab	Austin, TEXAS	USA	2001	University of Texas at Austin, School of Architecture (UTSoA)	Educational

Table 4-2 (continued)

14	-	Padova	Italy	2002	Parco Scientifico e Tecnologico Galileo	Commercial
15	None	Doha	Qatar	2011	Virginia Commonwealth University in Qatar	Educational
16	-	London	United Kingdom	2008	None	Educational
17	MRC	Providence	United States of America	2009	Rhode Island School of Design	Educational

4.2.2 Features of the Libraries

In this section, the findings the features of the participant libraries are presented. The features contain information about the libraries' space, number of samples in the library, its organization, target user group(s) and images of the library environment / general space.

4.2.2.1 Floor Space of the Libraries in m^2 (Question 9)

We can see in Figure 4-1 that the floor spaces of the libraries vary from 15 m^2 (Rematerialise Lab at the University of Kingston)to 456 m^2 (Materials Lab of the University of Texas at Austin, School of Architecture). The median floor space of the libraries is 75 m^2.

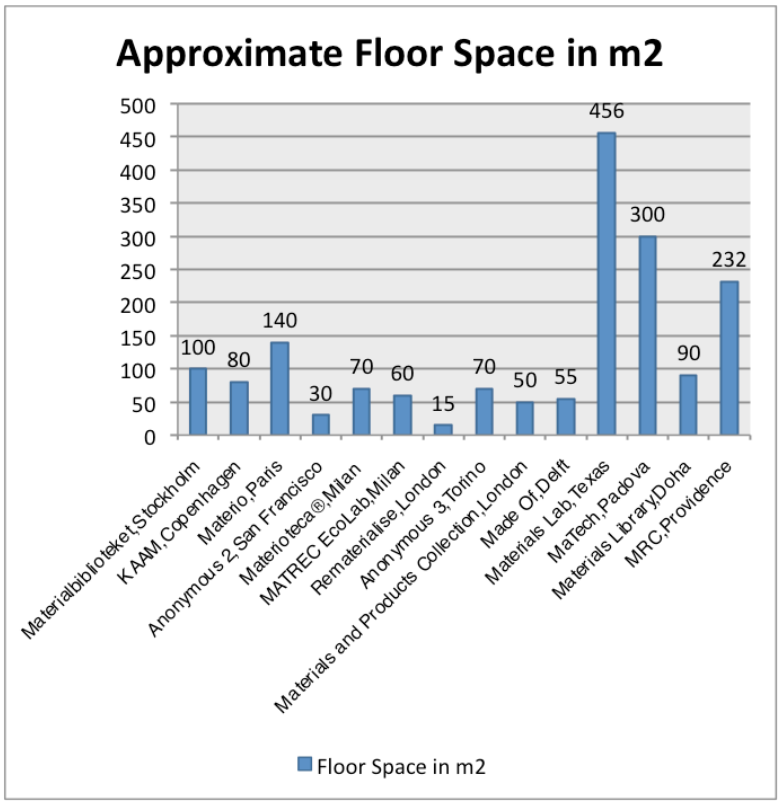


Figure 4-1 Floor space of material libraries

4.2.2.2 Target User of the Libraries (Question 13)

Appendix G contains information on the different libraries' target users. All 17 participants answered this question. Students are seen as the target group in 82% of libraries; in 59%, creative professionals are seen as the target group. Other audiences that are served by the material libraries are professors, companies and researchers. Only 11% of libraries see the public as a target audience.

4.2.2.3 Material Families in the Libraries (Question 15)

In Figure 4-2 it can be seen which different material families libraries include in their collections. All 17 libraries have plastics in their collection. Woods, wood derivatives and composites can be found in 16 libraries. It is obvious that nearly all libraries have all the mentioned material families in their collection. In some of the libraries, some more exotic materials can be found, including soils, technical fluids and treatment technologies. Some material libraries indicated that have examples of manufacturing methods, surface treatments, lighting devices, hybrid materials (e.g. collagene/plastic alloys), recycled materials, adhesives, technologies and technical fluids.

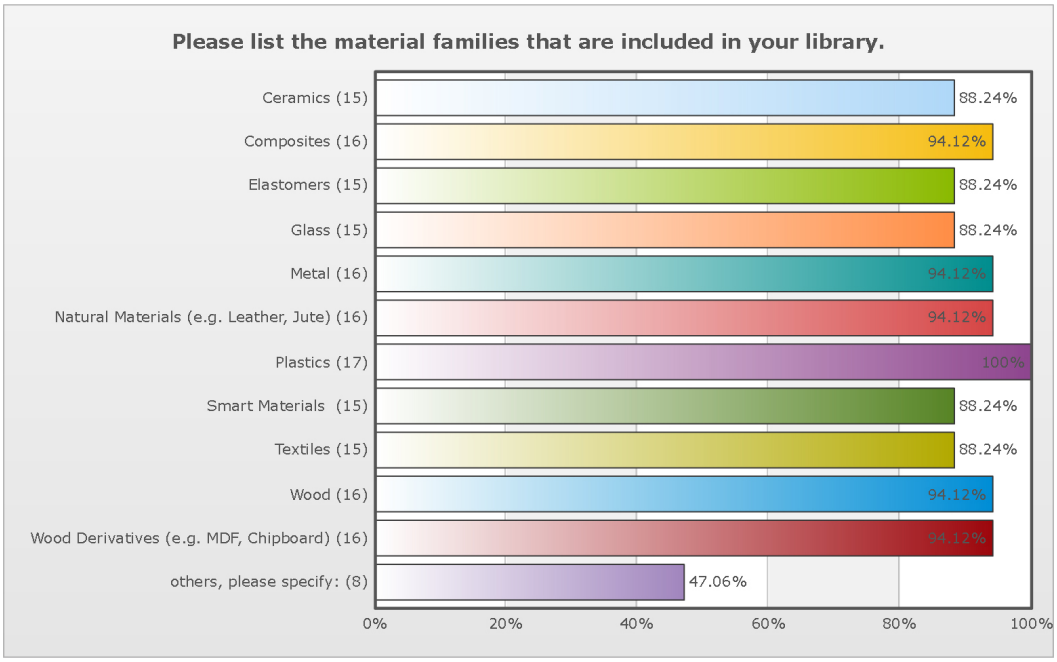


Figure 4-2 Material families included in libraries' collections

4.2.2.4 Number of Samples (Question 16)

The number of samples held at libraries ranges from 90 (Materials Library in Qatar) to 27500 (Materials Lab in Austin Texas). The median number of samples is 1750. Figure 4-3 gives details of the distribution of material sample quantities.

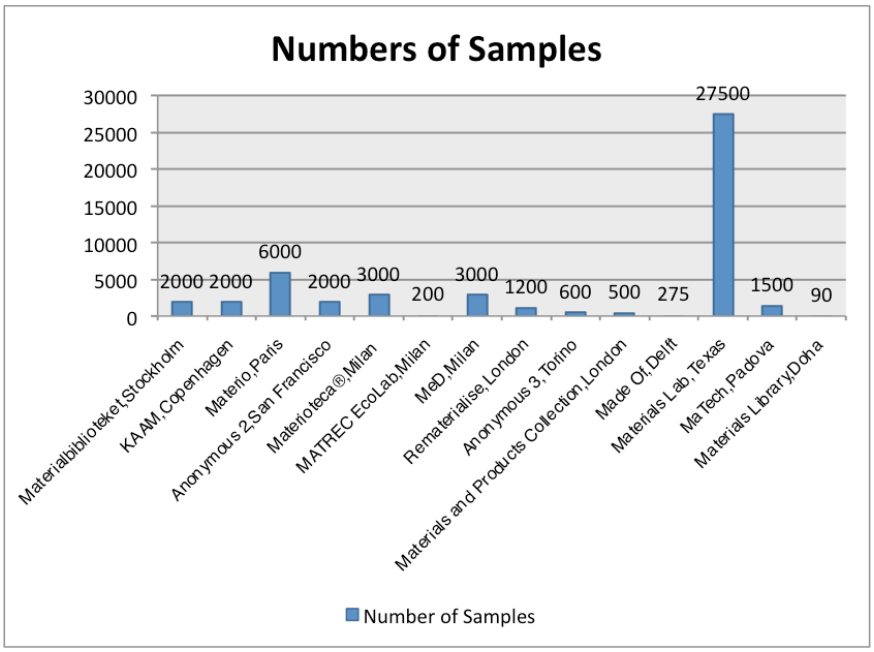


Figure 4-3 Number of samples held within libraries' collections

4.2.2.5 Percentage of Material and Product Samples in the Collections (Question 17)

In this section, participants were asked about the approximate percentage division of different kinds of samples in their collections – between material samples and product samples. Overall, material samples dominate (Figure 4-4). Some libraries even do not contain product samples. The Material Library at Central Saint Martins College consists of 50% product samples, half material samples.

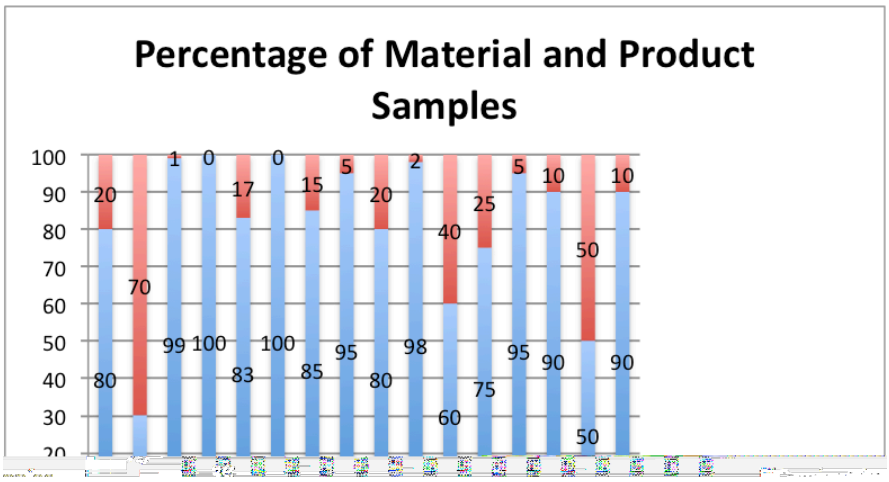


Figure 4-4 Distribution of material and product samples in libraries' collections

4.2.2.6 Emphasis on a Particular Design Branch (Question 18)

Libraries are asked on which design branch(es) they place an emphasis. In Figure 4-5 it can be seen that 87% of libraries have an emphasis on interior design. Also industrial design and architecture are particularly emphasized by the participant libraries. Only two libraries have special emphasis on graphic design. Some libraries indicated packaging design, electrical & electronics design, eco design, product design and landscape architecture as their special emphasis.

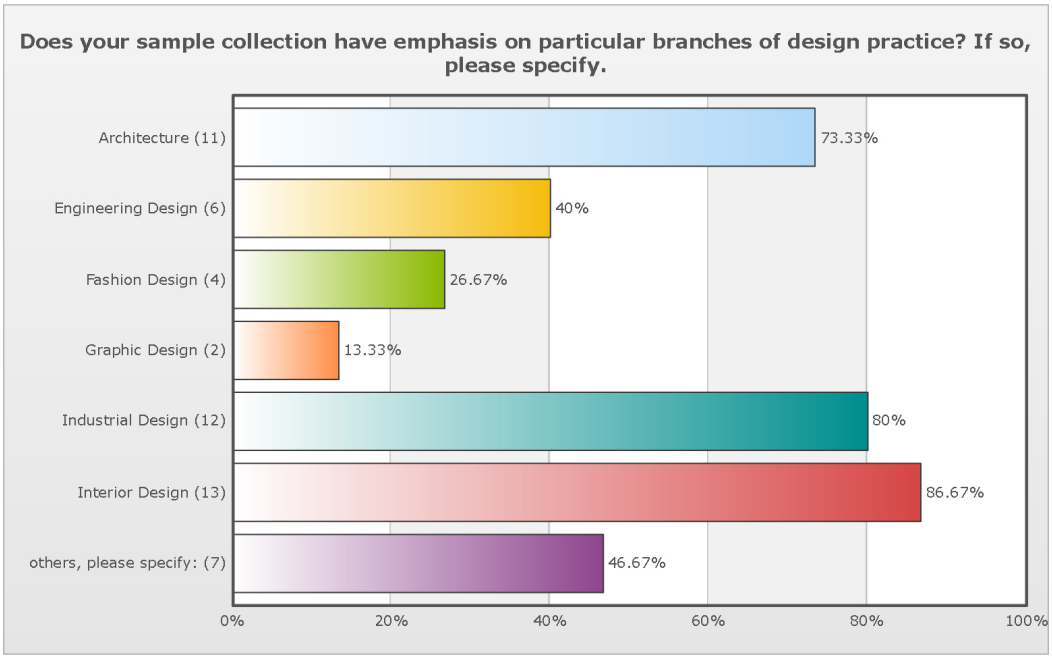


Figure 4-5 Emphasis of libraries regarding branches of design practice

4.2.2.7 Categorization Systems Used in Libraries (Question 19)

Most of the libraries categorize their samples according to material families (Figure 4-6). Other classification methods that are used can be listed as: Construction Specifications Institute's (CSI) Master Format, Ci/Sfb classification system, as recycled, natural, application, a self developed classification for plastics. And one library indicated that it was not organized and they didn't need to organize it.

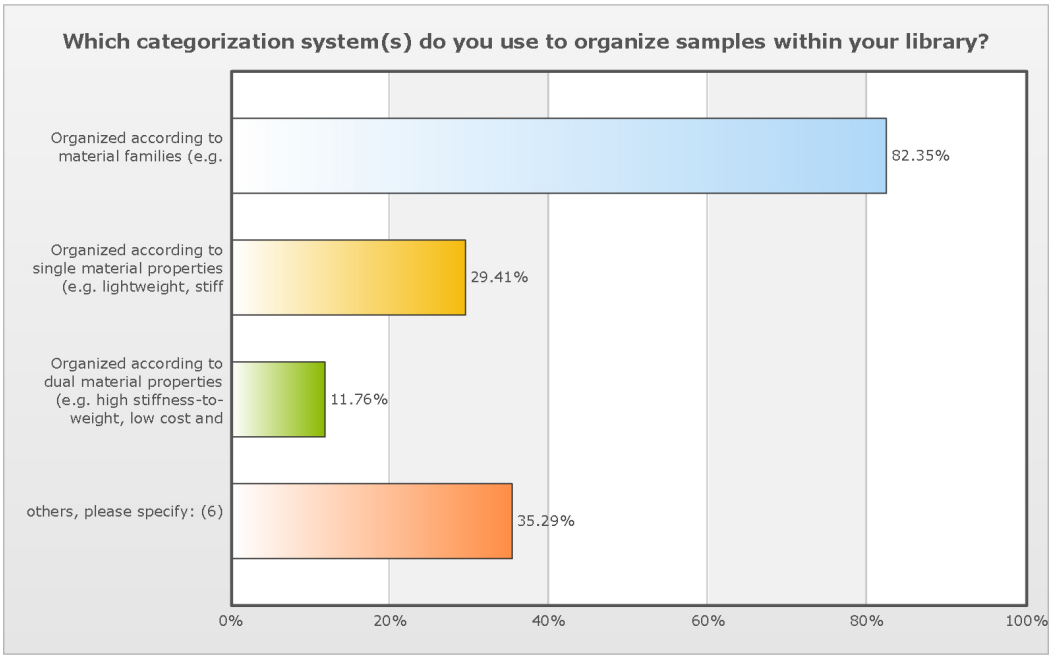


Figure 4-6 Categorization systems used in material libraries

4.2.2.8 Images of the Library Space Arrangements (Question 25)

Participants were asked to submit images showing the environment / work space of their libraries. These are collated in Figures 4-7 to 4-15, showing that every library has a distinctive space arrangement. It is also obvious that each has a different presentation method for samples. Some libraries are designed as a workplace (e.g. Figure 4-11), whereas others are closer to an interactive exhibition place (e.g. Figure 4-13). Some seem to be more like an 'sealed' archive (e.g. Figure 4-14).

Figure 4-7 Material Collection in Copenhagen © Ola Wedebrunn

Figure 4-8 Matério in Paris © matériO

Figure 4-9 Materioteca in Milan © Materioteca -Milan

Figure 4-10 MATREC Eco Materials Library in Florence © MATREC

Figure 4-11 Materials and Product Collection in London © London Metropolitan University

Figure 4-12 Materials and Product Collection in London © London Metropolitan University

Figure 4-13 Made of Materials Library in Delft © IO/TU Delft

Figure 4-14: Materials Lab in Austin © University Co-op Materials Resource Center, University of Texas at Austin School of Architecture

Figure 4-15 Matech in Padova © MaTech

4.2.2.9 Images of Library Sample Presentation Systems (Question 25)

Libraries present and store their samples in different ways. Some of them use walls and shelves, whilst others use specially made presentation units (Figures 4-16 to 4-21).

Figure 4-16 Materialbiblioteket in Stockholm © Materialbiblioteket

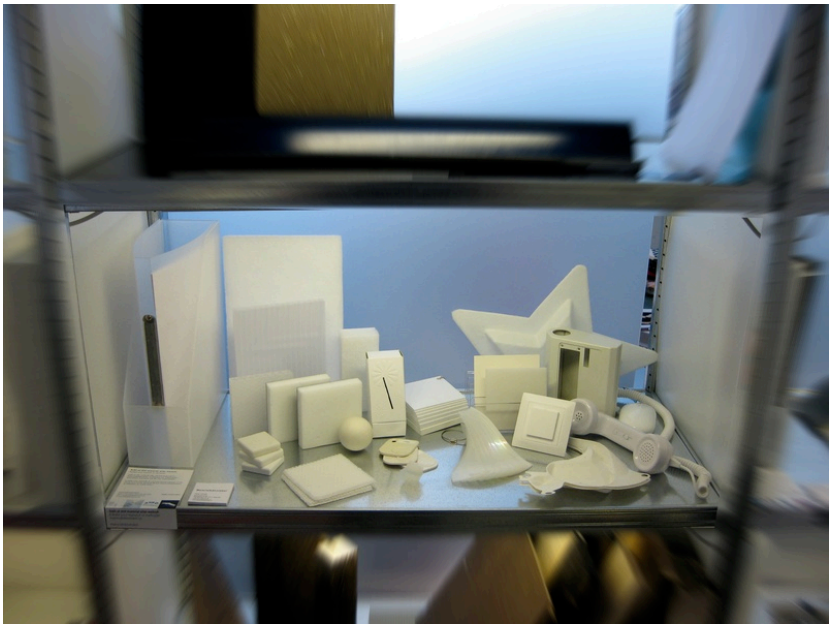


Figure 4-17 Materialbiblioteket in Stockholm © Materialbiblioteket

Figure 4-18 Matério in Paris © matériO

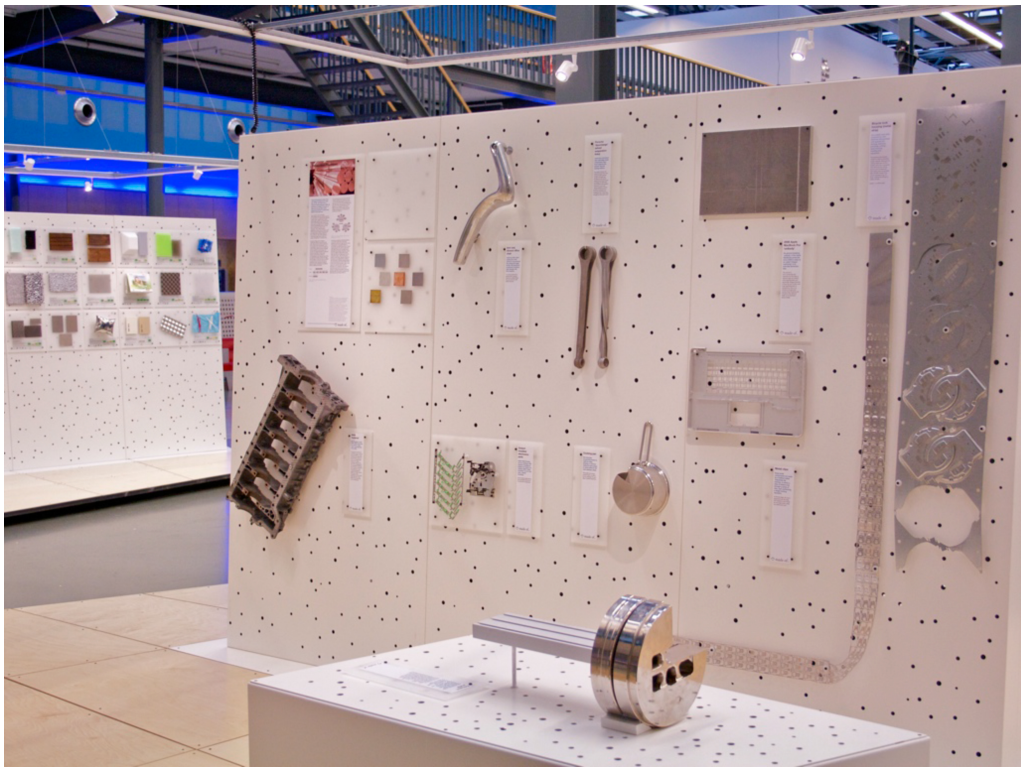


Figure 4-19 Made of Materials Library in Delft © IO/TU Delft

Figure 4-20 Materials Lab in Austin © University Co-op Materials Resource Center, University of Texas at Austin School of Architecture

Figure 4-21 Matech in Padova © MaTech

4.2.2.10 Images of library Sample Labelling (Question 25)

Some of the libraries also provided close-up images of samples in their collection, revealing how additional information in the form of tags or labels are attached (Figure 4-22 to 4-25). The images also reveal that libraries show different versions of a single material, for example showcasing different surface finishes.

Figure 4-22 Materioteca in Milan © Materioteca -Milan

Figure 4-23 MATREC Eco Materials Library in Florence © MATREC

Figure 4-24 Anonymous Library 3 © Owner

Figure 4-25 Materials Lab in Austin © University Co-op Materials Resource Center, University of Texas at Austin School of Architecture

4.2.3 Material Information Design of the Libraries

In this section, the material information systems of the libraries are investigated. The section is concerned with how the libraries provide information about materials and which resources they use to help designers develop knowledge about the samples in their collection.

4.2.3.1 Which Supplementary Resources are Used in the Libraries? (Question 21)

In Figure 4-26 it can be seen that the most used supplementary resources for samples are catalogues from suppliers and information attached to samples, through tagging or equivalent systems. Both of these resources were used by 65% of the libraries. Databases and material information sheets are popular, too. Other resources are the Internet links, posters, test results and magazines.

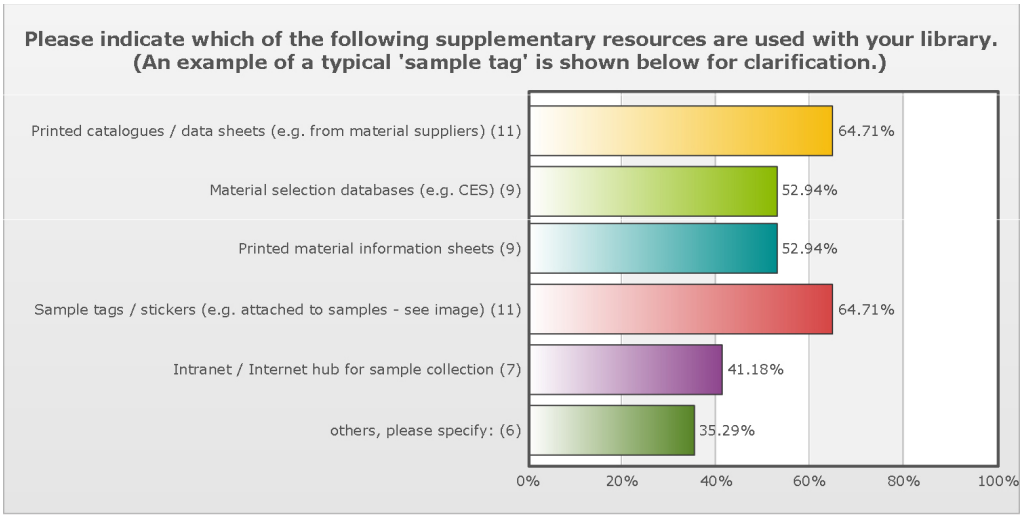


Figure 4-26 Presence of supplementary resources within material libraries

4.2.3.2 The kind of Information that Supplementary Resources Contain (Question 22)

Appendix H shows the kind of information that the supplementary resources contain. Material descriptions and technical properties are the most frequently used kind of information that material libraries provide in addition to samples (56%). Different applications of the material are also indicated by 44,4 percent of the material libraries. Other kinds of information contained in the material resources are: links to databases, environmental properties, pictures, and sensorial properties. Only one library provides videos about its sample collection.

4.2.4 Reflection on Material Libraries

For this section, the responsible people for the libraries were asked to reflect in volunteered descriptions their experiences of setting-up and running their own collections. They were asked how they judge their material library, questioned about the accessibility of samples, what they would change in their library if they had a chance to start over again, and how they see the establishment process of their library.

4.2.4.1 Main Reasons for Establishing the Library (Question 12)

Appendix I contains information on the reasons for establishing the material libraries. It can be seen that most libraries were established for educational reasons (71%). The other two popular answers to this question were: to connect material science and the design community (35%), and for research and development activities (35%). Other answers were: improving knowledge in materials, and promoting materials.

4.2.4.2 Features that Promote your Library (Question 14)

Each participant was asked to provide a strap line sentence that promotes their library (Appendix J). On analysing the phrases and keywords within the strap lines, 50% of the libraries were found to mention 'material samples' whilst 44% mentioned the activity of 'promoting materials'. Other emphasized subjects were: target user groups, material selection, education and material collection features.

4.2.4.3 Accessibility of Samples (Question 20)

An important issue among material libraries is the degree of accessibility to samples by visitors (Figure 4-27). One of the principle reasons for establishing a materials library is to allow people to explore samples by touching them. In this regard, 65% of libraries were reported to have samples that are accessible and available for picking-up and handling. Other methods of accessibility were: making an appointment with the librarian/curator to explore the samples, or viewing / accessing samples held in folders or display cases.

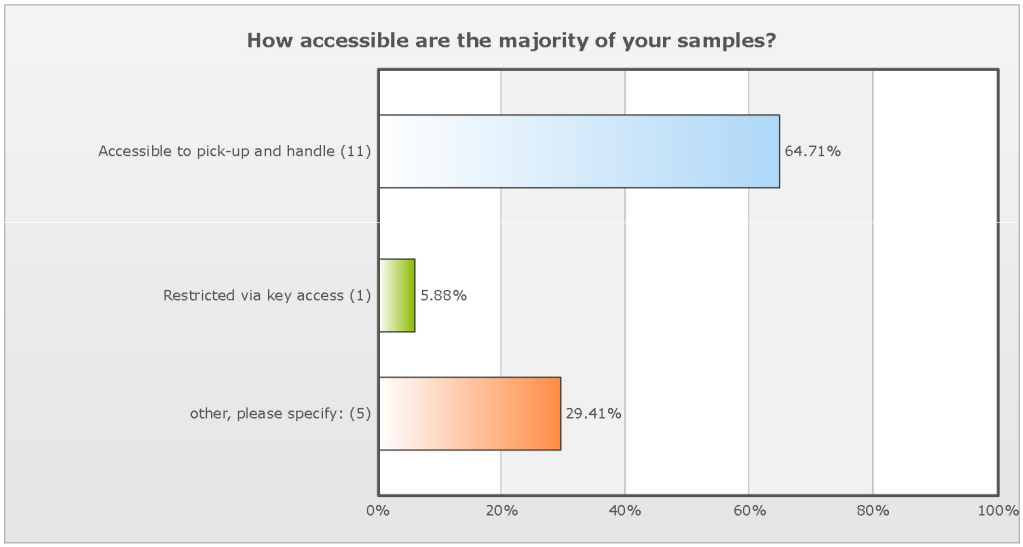


Figure 4-27 Accessibility of samples amongst libraries

4.2.4.4 Changes that Would Have Been Made in the Establishment Phase of the Library (Question 23)

When asked about what they would have changed if they have another chance to establish a material library, the most popular topic raised by the participants was the supplementary 'material information' issue (39%). Participants would have built a database or made special information resources to accompany the samples. Online presence, classification, hiring staff, and presentation were the other topics mentioned by 23% of participants. Having a

concept in the library, and physical equipment, were the least mentioned subjects (Appendix K).

4.2.4.5 Future Plans: (Question 24)

Appendix L contains information on the future plans of the libraries. A common point (36%) was that libraries intended to enlarge the number of samples in their collection. The second most mentioned answers were to make joint activities, involve technology, enlarge or develop material information systems, and open their library to new audiences. Only 14% of libraries intended to open new (satellite) branches.

4.3 Internet Research about Material libraries

In this final section, information about the 13 material libraries that did not participate in the online survey is presented. As the source of data for the information collected here is the Web, not all information is available or shared by each library. Also the variety of the information and level of detail provided is not equal amongst the library websites. For this reason, it was decided to present each of the libraries individually as cases.

4.3.1 Material Archiv, Switzerland

Images for this library can be found in Figures 4-28 to 4-35.

- Description: It is collective of six institutes in Switzerland. Some of them are educational; others are part of a museum. They use the same online database. Each sample is tagged with RFID, so samples can be put on the readers in the archive and information about them is generated through the website.
- Website: http://www.materialarchiv.ch/#/suche
- Number of Samples: 100 in the online-database
- Categorization methods: through material families
- Supplementary information about samples: online database
- What kind of information is available about samples: history, Boolean and numerical features, manufacturer, pictures
- Who can use the lab: everyone can use the online part, some of the physical libraries needs membership
- Aim: “creative professionals such as architects, designers and artists as well as students and apprentices can find an abundance of information on traditional and novel materials” (Material Archiv, n.d.)

Figure 4-28 Space Layout at Material Archiv in Switzerland, (Material Archiv, n.d.)

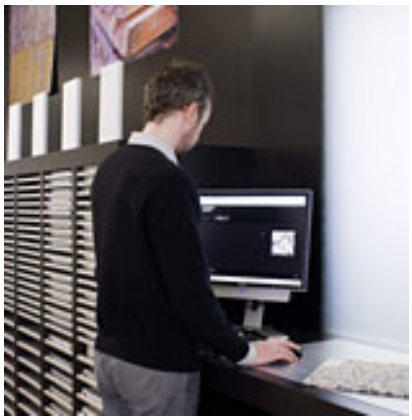


Figure 4-29 Information access at Material Archiv in Switzerland, (Material Archiv, n.d.)

Figure 4-30 Storage at Material Archiv in Switzerland, (Material Archiv, n.d.)

4.3.2 Materials Collection Frances Loeb Library, USA

- Description: The materials library of the Graduate School of Design in Harvard University.
- Website: http://materials.gsd.harvard.edu/materials/matlaunch.htm
- Categorization methods: according to Material's
  Name, Form, Composition, Vendor, Course information
- Supplementary information about samples: online database
- Who can use the lab: students and members of the faculty
- Aim: "By foregrounding material composition and functional traits, the collection allows users to rethink conventional applications and promote material experimentation in design practice" (Graduate School of Design, Harvard University, n. d.)

4.3.3 Colours and Materials Library, USA

- Description: The materials library of the College for Creative Studies in Detroit.
- Website: http://www.collegeforcreativestudies.edu/student-resources/student-services-and-resources/library/colors-materials-library
- Number of Samples: more than 1000
- Aim: "The purpose of the materials library is to inspire creativity as well as to introduce students to both new and traditional materials and the companies that produce them. Students in all disciplines at the college are encouraged to use the library's resources." (College for Creative Studies , n. d.)

4.3.4 Materials and Resource Library, UK

- Description: An educational resource for materials and information about them. The target is the interior design studentd of the faculty.
- Website: http://www.suffolk.edu/nesad/17940_18105.htm
- Categorization methods: Samples are categorized according to CSI Mater format. They have 17 divisions from which students can search for materials, which are coded with 6 digits. (Materials and Resource Library, n. d.)
- Supplementary information about samples: brochures and data sheets are available about materials.
- Who can use the lab: samples can be borrowed by the students

4.3.5 Materials and Design Exchange , UK

An image for this library can be found in Figure 4-31.

- Description: Materials and Design Exchange Resource is part of the Knowledge Transfer Network which is found by Royal Collage of Art, Institute of Making, Design Council, EEF's Organization of Manufacturers and Institution of Engineering Designers.
- Website: https://connect.innovateuk.org/web/design-exchange/design-exchange-resources
- Number of Samples: around 2000
- Who can use the lab: MADE members

- Aim: “The Materials and Design Exchange (MaDE) brings together the communities of design and materials technology in order to stimulate innovation, promote the transfer of materials knowledge and improve the competitiveness of UK business.” (Materials and Design Exchange, n. d.)

Figure 4-31: MaDe Resource in London, (Materials and Design Exchange, n. d.)

4.3.6 Materials Library, UK

An image for this library can be found in Figure 4-32.

- Description: The library is build by a research group for materials. They organize workshops and events around materials. The library mostly focuses on outstanding material samples.
- Website: http://www.instituteofmaking.org.uk/about
- Number of Samples: more than 800
- Who can use the lab: public
- Aim: The ideal of the library is to provide a intellectual and sensual intersection between the arts and sciences. We are not trying to create a comprehensive materials

collection; instead we are trying to create a thinking space for the Materials Research Group. (Institute of Making, n. d.)

Figure 4-32: Materials Library at the Institute of Making, (Institute of Making, n. d.)

4.3.7 Material Lab, UK

Images for this library can be found in Figures 4-33 and 4-34.

- Description: The library works as a show room for the tiles manufacturer Johnson, but they also have different kind of materials and the space can be used by designers as a meeting hub.
- Website: http://www.material-lab.co.uk/what-we-do/
- Number of Samples: over 650
- Who can use the lab: public/ free of charge
- Aim: "The Stoke-on-Trent based company created Material Lab purely to answer the needs of the architectural and design community, asking what sort of 'experience' they wanted in a design resource studio." (Material Lab, n. d.)

Figure 4-33: Ground floor at Materials Lab in London, (Materials Lab, n. d.)

Figure 4-34: Basement at Materials Lab in London, (Materials Lab, n. d.)

4.3.8 Materia Inspiration Centre, Netherlands

Images for this library can be found in Figures 4-35 and 4-36.

- Description: Materia Inspiration Center is opened by the owners of the website material.nl. The website is famous for featuring extraordinary materials. It is also a very useful database for material information and manufacturer.
- Website: http://www.materia-ic.com/
- Number of Samples: over 1500
- Exhibition methods: 40x40cm. Cut samples

- What kind of information is available about samples: “Form and colour variations are shown and each panel shows a label with the most relevant information about the material.” (Materia, n. d.)
- Who can use the lab: public
- Aim: “Materia functions as a platform between the creative professional and the manufacturer.” (Materia, n. d.)

Figure 4-35: Sample Displays at Materia Inspiration Centre in Amsterdam, (Materia, n. d.)

Figure 4-36: Space layout at Materia Inspiration Centre in Amsterdam, (Materia, n. d.)

4.3.9 Material Connexion

Images for this library can be found in Figures 4-37 to 4-39.

- Description: Material Connexion is the biggest network of libraries. The company has 11 libraries around the world. They also offer materials consultancy services.
- Website: http://www.materialconnexion.com
- Number of Samples: around 8000
- Supplementary information about samples: through database
- What kind of information is available about samples: "…images, detailed material descriptions, usage characteristics, and manufacturer and distributor contact information."(Material Connexion, n. d.)
- Who can use the lab: Subcribers
- Aim: "Material ConneXion is made up of an international team of multidisciplinary experts that bridge the gap between science and design to create practical manufacturing solutions." (Material Connexion, n. d.)

Figure 4-37: Sample Storage at Material Connexion, (Material Connexion, n. d.)

Figure 4-38: Exhibited samples at Material Connexion, (Material Connexion, n. d.)

Figure 4-39: Close up of samples at Material Connexion, (Material Connexion, n. d.)

4.3.10 Innovathèque, France

- Description: A commercial materials consultancy with a physical sample library in Paris.
- Website: http://www.innovatheque.fr/index.php
- Number of Samples: more than 2000
- Categorization methods: according to family (plastic,wood, metal...), form of presentation (textile, gel, block...), application sector (automobile, medical, furnishing...), visual appreance (opaque,shiny,dark ...), feel (hard,smooth...), ecology (recycled, natural...), technical characteristics (elastic,rigid...)
- Supplementary information about samples (see Figure 4-40).
- What kind of information is available about samples: electronic database and printed information
- Who can use the lab: everyone can use the library after paying the fees
- Aim: "The Innovathèque was established to meet the needs of professionals in furnishing and is a site in which creators searching for information on materials may exchange views with industrialists who are offering products and wish to make them known." (Innovathèque, n. d.)

Figure 4-40: Supplementary information for samples (Innovathèque, n. d.)

4.3.11 Materialsgate, Germany

An image for this library can be found in Figure 4-41.

- Description: A in Germany placed materials consultancy service with a private material collecion.
- Website: http://www.materialsgate.de/en/mcards/

- Number of Samples: over 4000
- Exhibition methods: not exhibited
- Who can use the lab: private
- Aim: “Materialsgate stands for high-quality consulting services and searches, competent information and target group-specific communication within the world of materials and material applications.” (Materialsgate, n. d.)

Figure 4-41: Materialsgate display an exhibition, (Materialsgate, n. d.)

4.3.12 Raumprobe, Germany

Images for this library can be found in Figures 4-42 and 4-43.

- Description: A material consultancy established by an interior designer and an architect in Stuttgart.
- Website: http://www.raumprobe.de/ausstellung/uebersicht-ausstellung/
- Number of Samples: 1.500
- Categorization methods: material families, according to themes, premium materials, metals
- exhibition methods: plain samples
- What kind of information is available about samples: descriptive paragraph, mechanical and sensorial properties, manufacturer information
- Who can use the lab: everyone
- Aim: A materials consultancy for planers by planers. (Raumprobe, n. d.)

Figure 4-42: Sample display at Raumprobe in Stuttgart, (Raumprobe, n. d.)

Figure 4-43: Sample storage at Raumprobe in Stuttgart, (Raumprobe, n. d.)

4.3.13 SCIN, UK

- Description: A material consultancy for architecture and interior design located in London.
- Website: http://www.scin.co.uk/index.php
- What kind of information is available about samples: “description, use, fire rating, price, installation, maintenance, lead in time any other relevant specifications and an image” (SCIN, n. d.)
- Who can use the lab: consumers, professionals, manufacturers
- Aim: “We source, advise, create and sell surfaces (finishes) and materials for every conceivable surface both inside and outside the building.” (SCIN, n. d.)

4.4 Conclusions

This chapter aimed to uncover the information provision within existing material libraries as well as general information about the facilities available at such libraries around the world. It was important to show the variety of collections and libraries. In the first section, detailed and insightful information about the libraries has been presented through the findings from the online survey. In the second part, those libraries not participating in the online survey have been showcased, through data gathered from the Web.

We can conclude that there exists quite a wide range of libraries with different focus points and very diverse methods of presenting material samples and supplementary information. Some libraries exist to teach materials to students. Others have the aim to act as a bridge between material scientists and designers. Still others are set-up to work on a commercial basis, through consultancy activities.

Most of the libraries are established in the last decade. They target quite a wide range of people such as researchers, students, companies as well as general public. There exist huge libraries with thousands of samples, but small libraries with smaller amount of samples exist, too. Some of the libraries put special emphasis on providing information about materials. Others’ collections work as an inspirational source without providing deep knowledge about materials.

CHAPTER 5

EVALUATION OF TEN MATERIAL INFORMATION SAMPLE TAGS

Before commencing the research on this subject, the author attended the ID 725 'Materials Experience' course, which is lectured by the advisor of this thesis Owain Pedgley. One of the aims is defined on the course handout as making students aware of the affect of the material choice to the relationship of products and users (Pedgley, 2012). This aim is related to the setting up a materials library in the Department of Industrial Design at METU. This library would enable students to experience materials by sensing them (METU ID, n. d.). At the end of the course, the 10 attending students were asked to develop a project where they would implement information into a materials library as an educational tool to make undergraduate students 'experience' materials in a better way. You can find the design brief on Appendix E. The project was formulated open ended so student see the design brief as a guidance and they were free to create their own content with the things they find necessary for such a material information system. The information systems developed by the graduate students had two layers of information. In the first layer, basic information was chosen to accompany material or product samples. In the second layer, concepts for a material library database/intranet were offered, allowing access to more detailed knowledge about the materials. The first layer of information with the aim of providing instant essential details about materials was in the form of tags. The research in this thesis takes forward the first layer of information, presented through the tag designs.

5.1 Informal Evaluation of the Tags

The first evaluation of the tags occurred during the lecture. In the final project presentation, the whole class criticized each tag. Notes were taken form the discussion and a document was made out of it (Appendix A). Later on the comments were categorized according to themes: information's link to material, layout, whether the information is understandable, pictures, whether the information is necessary. These categories were then used, later, as a first insight and for the planning stages of a specially devised detailed tag evaluation questionnaire.

5.2 Evaluation of the Connection Detail

The next evaluation of the sample tags was made on the connection detail of the tags to the material or product samples. As this connection detail is not part of the information design

and is more related to the production abilities of the materials library, the author undertook this evaluation personally and set evaluation criteria in discussion with the advisor of the thesis. The criteria were grouped into negative and positive attributes and each connection detail was judged according to them, to arrive at a 'final score'. Negative criteria were multiplied with -1 and positive criteria multiplied with +1. At the end the evaluation, the connection detail of tag 2 received 9 points, whist the next best solutions were tags 1 and 8 with 2 points (Table 5-1 and 5-2).

Table 5-1: the ten different connection details for sample tags

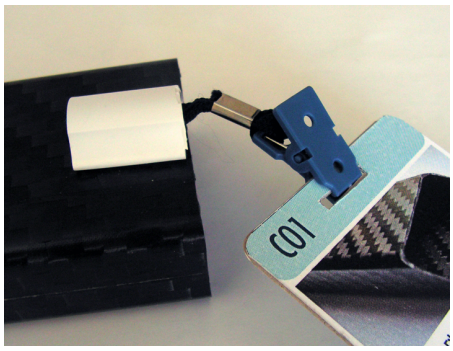
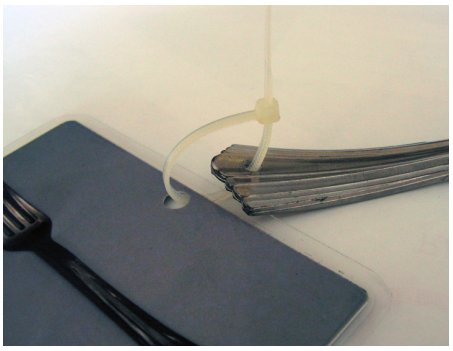
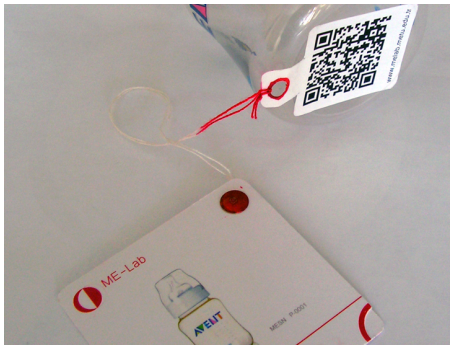
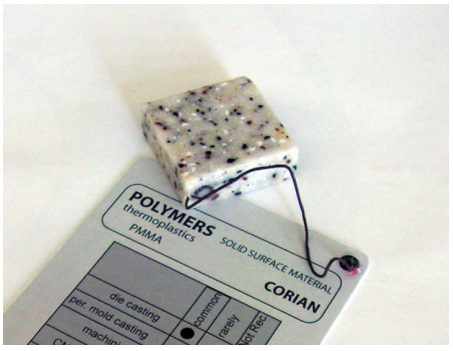
TAG 1 	TAG 2 
TAG 3 	TAG 4 
TAG 5 	TAG 6 

Table 5-1 (continued)

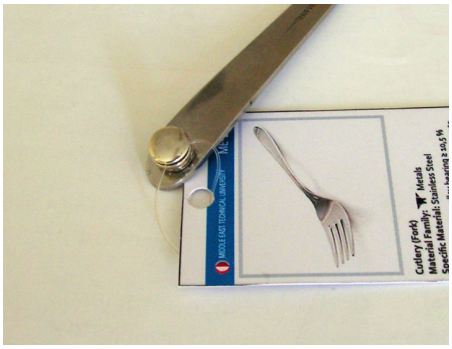
TAG 7 	TAG 8 
TAG 9 	TAG 10 

Table 5-2: Evaluation table of the connection details

POSITVES	1	2	3	4	5	6	7	8	9	10
cheap to produce/buy		x		x		x	x	x		
easy to replace		x		x			x			
needs no gluing		x		x			x	x		x
needs no hole/slit on the sample	x		x		x	x		x	x	
has one component		x		x		x	x			
is aesthetically pleasing	x	x			x					x
able to be disconnected and connected	x	x	x							x
safe geometry		x	x			x	x	x	x	x
strong enough	x	x		x				x		
reusable		x								
able to hold the sample safe	x	x	x	x				x		
NEGATIVES	1	2	3	4	5	6	7	8	9	10
expensive to produce	x		x							
hard to replace	x				x			x		x
needs gluing	x		x			x			x	
needs a hole/slit on the sample		x		x			x			x
has more than one component			x					x		x
is aesthetically unpleasing			x	x			x	x		
permanent connection				x	x	x	x	x		
unsafe geometry				x						
not strong enough					x	x			x	
not reusable				x			x			
able to be disconnected too easily										x
Positive score	5	10	4	6	2	4	5	6	2	4
Negative score	3	1	4	5	3	3	4	4	2	4
Overall score	2	9	0	1	-1	1	1	2	0	0

5.3 Evaluation Questionnaire with Undergraduates

The target group of the materials library is undergraduate students of METU's Department of Industrial Design. Therefore an evaluation of the sample tags with undergraduate students was considered an essential part of the research. Courses about materials and manufacturing are placed in the second year in the curriculum. The author was able to carry out a

questionnaire to let undergraduates evaluate the sample tags. At the end of the semester when 'ID236 Manufacturing Materials' course was finishing, students evaluated the tags.

The content of the questionnaire was planned to have both open-ended questions and grading. This approach purposefully led to quantitative and qualitative analyses. Accordingly, the questionnaire was designed with two parts, the first part being a Likert-grading, the second part posing open text questions.

In the first part of the questionnaire, students were asked to evaluate the sample tags according to five criteria: understandable, informative, relevant to students' needs, attractive graphics, and inspirational for material selection in industrial design. These criteria originated from the informal evaluation sessions made previously. With a 5-point Likert scale, students were asked to grade the tags.

In the second part of the questionnaire, two open-ended questions were asked: which part of the tag design they especially liked, and which they especially disliked? (Figure 5-1)

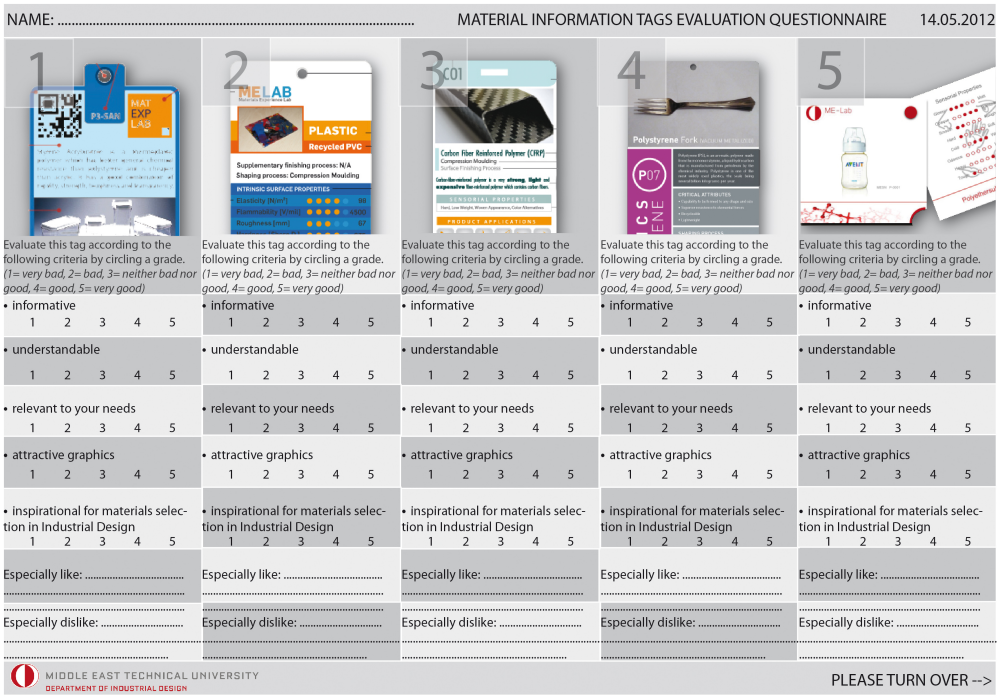


Figure 5-1: Questionnaire for the evaluation of the sample tags (showing tags 1 to 5, of 10)

In total, 38 students participated in and completed the questionnaire. As I mentioned in the methodology chapter, students discussed each tag in groups but completed the questionnaire form individually. The raw data from this questionnaire can be found on Appendix C.

The analysis of the questionnaire was completed over three steps. In the first step, the Likert-grading results were analysed. In the second step, participants' responses to open-ended text questions were evaluated quantitatively and qualitatively. At the end, a design recommendation list for 'best practice' in material tag design was created.

5.4 Quantitative Analysis

This Quantitative analysis section will consists two type of analysis of the results. First each tag's quantitative results will be analysed, later on each criteria will be explored in relation to the whole group of tags. At the end a criteria list will be presented from findings of this section.

5.4.1 Tag-Based Evaluation

The first part of the questionnaire analysis was undertaken to identify the best (highest) graded tag for each of the five previously mentioned criteria (understandable, informative, relevant to students' needs, attractive graphics, and inspirational for material selection in industrial design). Furthermore, answers were sought to the questions:

- Which tag was found most successful by the students?
- Which tag was favoured most?
- Were the sample tags as a group found successful?
- Were the sample tags satisfying for each criterion?

Amongst all tags, taking into account all criteria, Tag 7 received overall the highest mean score (4.35), whereas Tag 8 received overall the lowest mean score (2.13).

After making a paired t-test to determine whether there is a significant difference between the overall mean between 1st ranked and lower tags, as well as 10th ranked and higher tags, it was revealed that between the 1st and 3rd ranked tags (tag 7, tag 4, tag3) there was no significant difference. So the most successful tags can be defined as this tag group. As a result of the paired t-test the lower group was found as the last three ranked tags. We must reach the 7th ranked tag to find a statistically higher mean compared with the 10th ranked tag: the grades for the bottom three tags (tag 8, tag 5, tag 6) are not statistically different.

If we look at the tags from the perspective of individual criteria, the following results are found.

- Tag 7 was found the most informative tag (4.67), whereas Tag 8 was found the least for this criterion (1.86)

- Tag 7 was found the most understandable tag (4.75), whereas Tag 8 was found the least for this criterion (1.81)
- Tag 7 was found the relevant tag for the need of ID Students (4.50), whereas Tag 8 was found the least for this criterion (2.29)
- Tag 4 was found to have the most attractive graphic design (4.39), whereas Tag 9 was found the least for this criterion (2.47)
- Tag 7 was found as the most inspirational tag (4.22), whereas Tag 8 was found the least for this criterion (2.06)

As a collection of 10 individual designs graded against five criteria, the tags were found to be overall quite successful (3.55).

Although Tag 7 had the highest overall mean score, it was not the most 'favoured' tag by participants, if we consider the mean score assigned to tags by individual participants. Instead, from this complementary analysis, we see the following ranked result. The sum of the results (=51) is larger than the number of participants (=36) because some participants graded more than one tag as the highest.

- 1st = Tag 4 (19 participants' highest graded tag)
- 2nd = Tag 7 (17 participants' highest graded tag)
- 3rd = Tag 1 (7 participants' highest graded tag)
- 4th = Tag 3 (5 participants' highest graded tag)
- 5th = Tag 2 (2 participants' highest graded tag)
- 6th = Tag 10 (1 participants' highest graded tag)

5.4.2 Criteria – Based Evaluation

The rank order for criteria scores across all tags was as follows.

- 1st = being informative (3.74)
- 2nd = relevant for student's needs (3.66)
- 3rd = being understandable (3.59)
- 4th = being inspirational for material selection in industrial design (3.46)
- 5th = having attractive graphics. (3.29)

A 1-way ANOVA test was made to test the equality of samples by using variance. The test checked each possible pair combination of grading criteria per tag, with the intention of

revealing if any of the five criteria were graded significantly higher or lower than each other. The results were as follows:

- TAG 1. 5th ranked criterion (IV4 Attractive Graphics, 3.56) was significantly lower than all other criteria except the 4th ranked criterion (IV5 Inspirational for Materials Selection, 4.06).
- TAG 2. 5th ranked criterion (IV4 Attractive Graphics, 3.56) was significantly lower than only the 1st ranked criterion (IV1 Informative, 4.11).
- TAG 3. No significant differences found.
- TAG 4. No significant differences found.
- TAG 5. No significant differences found.
- TAG 6. 5th ranked criterion (IV4 Attractive Graphics, 2.50) was significantly lower than 2nd ranked criterion (IV3 Relevance to Needs, 3.42) and above. 1st ranked criterion (IV1 Informative, 3.64) was significantly higher than the 4th ranked criterion (IV2 Understandable, 2.75) and below.
- TAG 7. 5th ranked criterion (IV4 Attractive Graphics, 3.61) was significantly lower than all other criteria. 1st ranked criterion (IV2 Understandable, 4.75) was significantly higher than the 4th ranked criterion (IV5 Inspirational, 4.22) and below.
- TAG 8. 1st ranked criterion (IV4 Attractive Graphics, 2.66) was significantly higher than the 4th ranked criterion (IV1 Informative, 1.86) and below.
- TAG 9. 5th ranked criterion (IV4 Attractive Graphics, 2.47) was significantly lower than all other criteria.
- TAG 10. 1st ranked criterion (IV1 Informative, 4.39) was significantly higher than the 4th ranked criterion (IV5 Inspirational, 3.63) and below.

From these results it can be concluded different criteria as especially successful or especially unsuccessful, to help select the ‘right’ kinds of elements to be used in a new, finalized tag design (Table 5-3).

Table 5-3: Findings from 1-way ANOVA test

Tag	Especially Successful	Especially Unsuccessful
Tag 1		Attractive Graphics,
Tag 2	Informative	
Tag 6	Informative	Attractive Graphics
Tag 7	Understandable	Attractive Graphics
Tag 8	Attractive Graphics	Informative
Tag 9		Attractive Graphics
Tag 10	Informative	

5.4.3 Criteria List from Quantitative Test Results:

We can take tags 7, 4 and 3 as successful examples of information design as applied to material samples.

- Tag 7 can be a good example for an informative, inspirational, understandable and relevant tag for the needs of industrial design students.

- Tag 7 can be taken as a reference especially for understandability. But this tag cannot be taken as a reference for an attractive graphic design.

- Tag 4 can be taken as a good example of a tag with attractive graphics.

5.5 Qualitative Analysis

The next section of the questionnaire administered to the undergraduates collected their free comments. These comments were about what they especially liked and disliked on each tag. First these comments were grouped as negatives and positives. Then comments were categorized under a common headline (Appendix D). With this activity it was possible to create visuals with comments indicating discussed parts of the tags among students. On these visuals, if an issue is commented on only positively it is shown in green, if an issue is commented on only negatively it is shown in red, and those issues with mixed reactions are shown in grey. The number of students commenting negatively and/or positively for each

subject on the tag is indicated (Figure 5-2 to 5-11). These visuals helped to build the design recommendations for sample supplementary information.

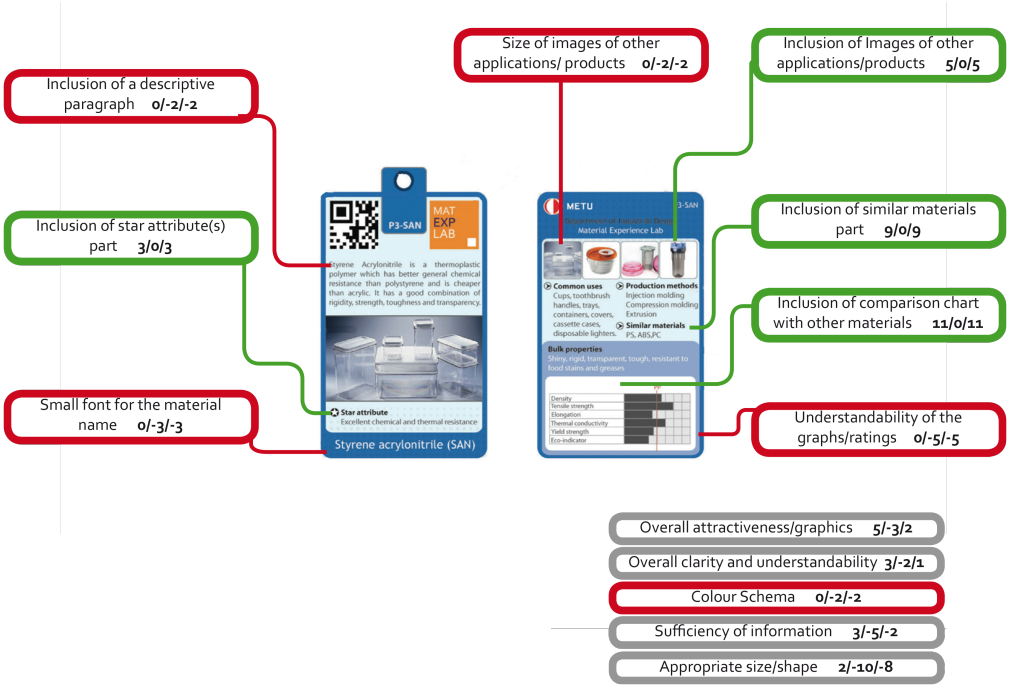


Figure 5-2: Students' comments on tag 1

Figure 5-3: Students' comments on tag 2

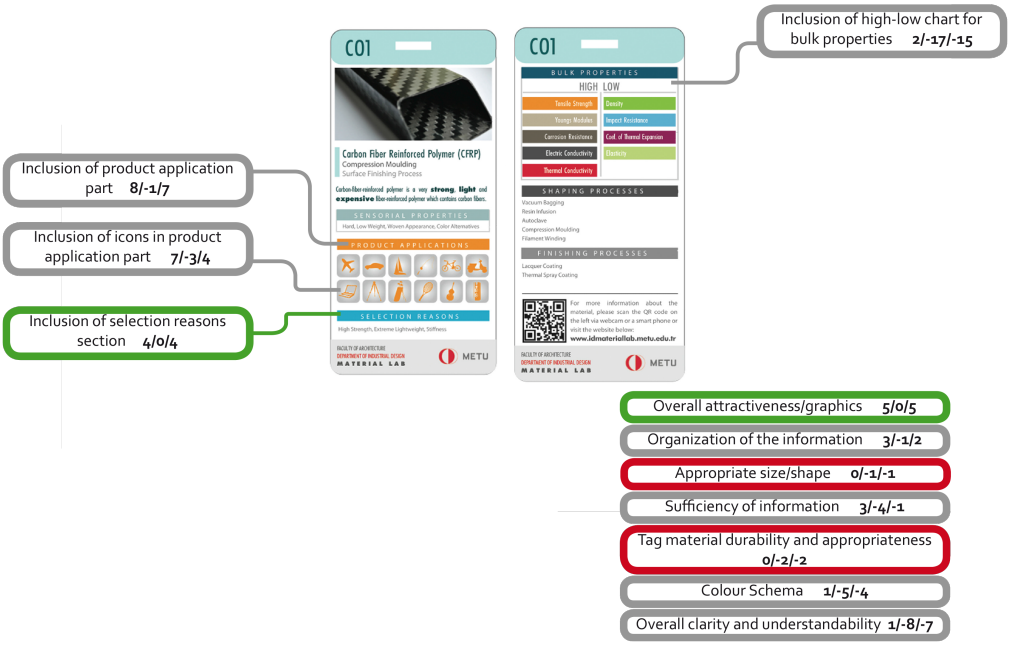


Figure 5-4: Students' comments on tag 3

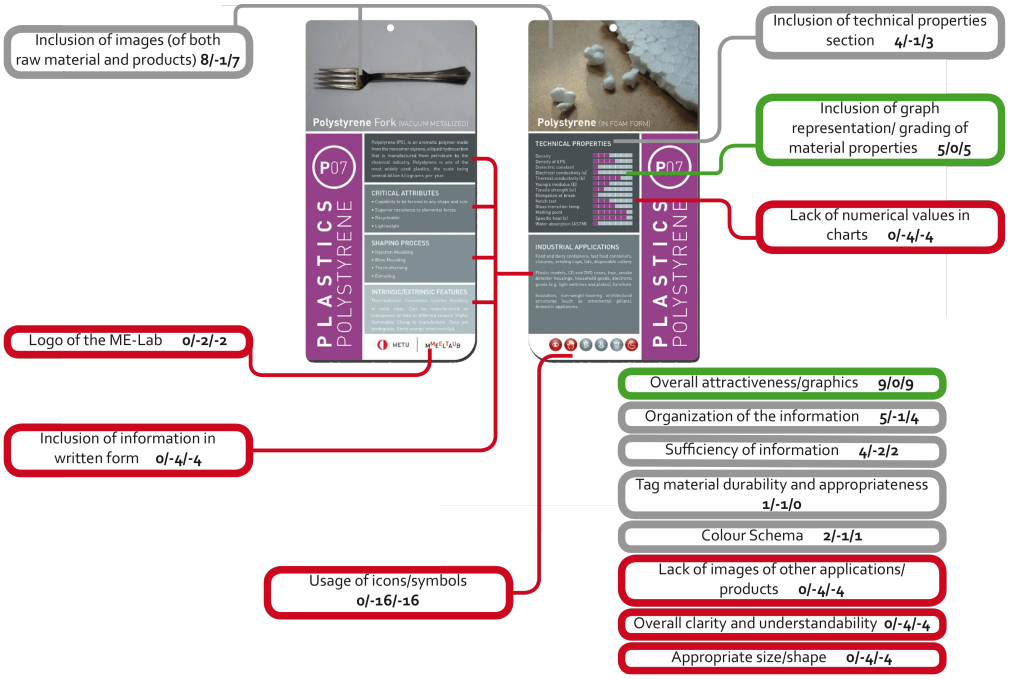


Figure 5-5: Students' comments on tag 4

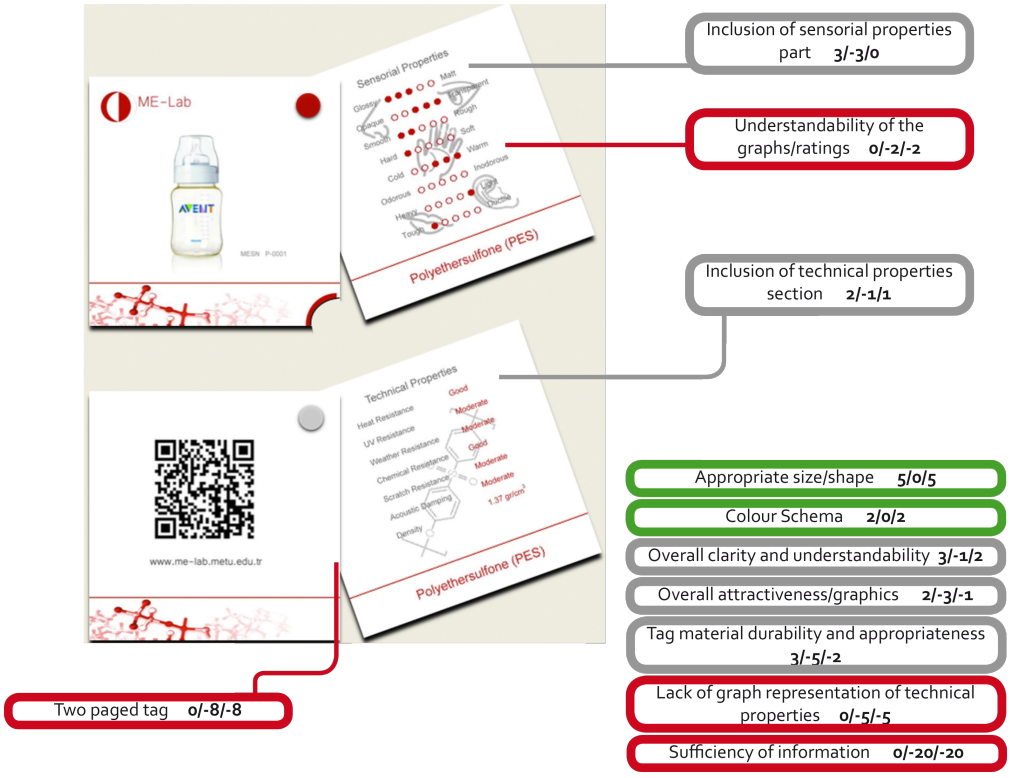


Figure 5-6: Students' comments on tag 5

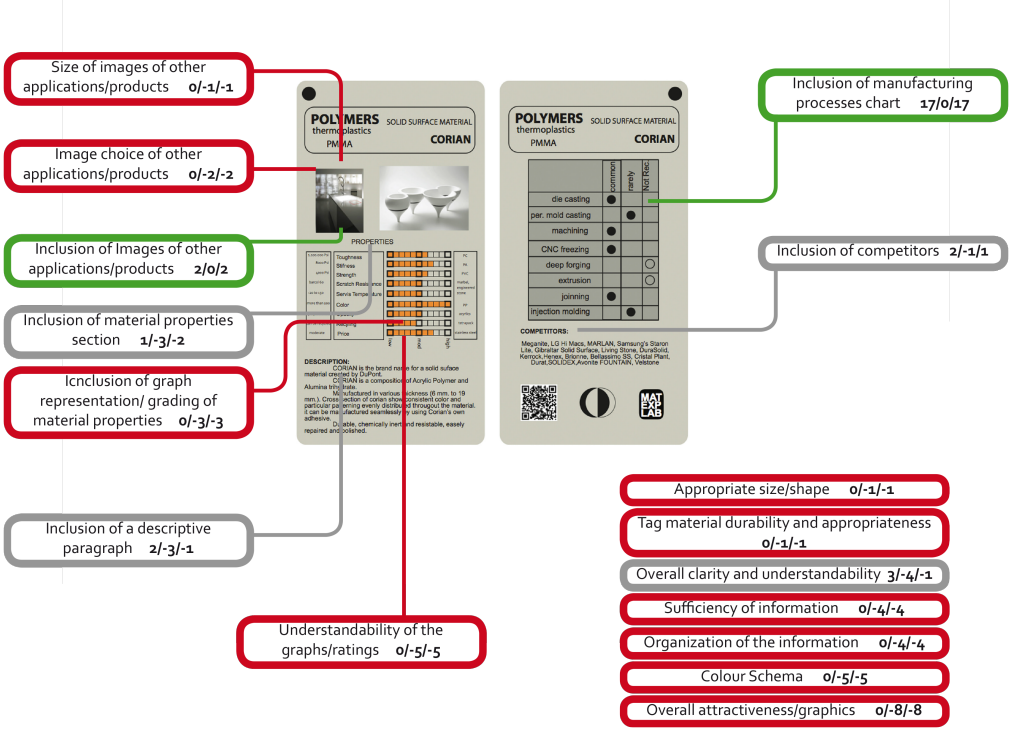


Figure 5-7: Students' comments on tag 6

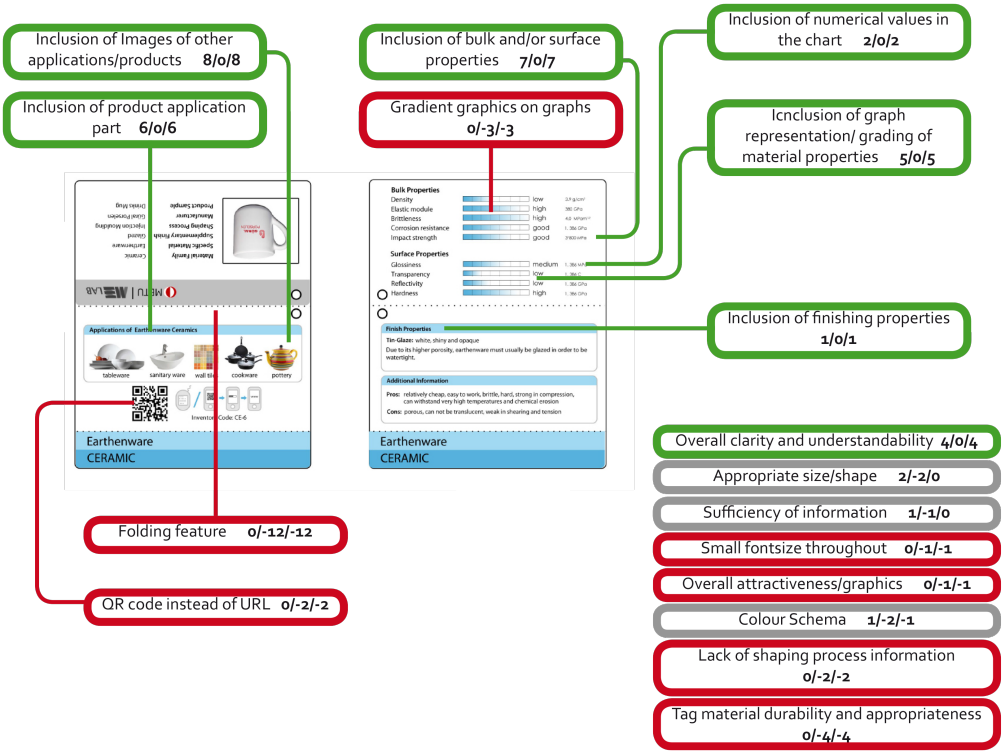


Figure 5-8: Students' comments on tag 7

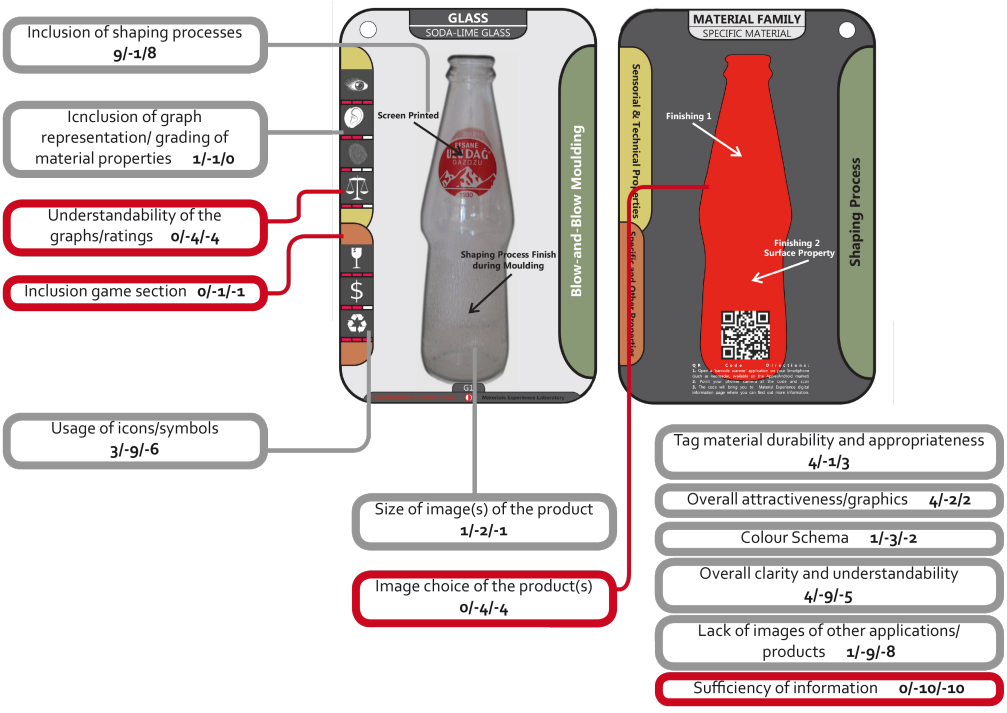


Figure 5-9 Students' comments on tag 8

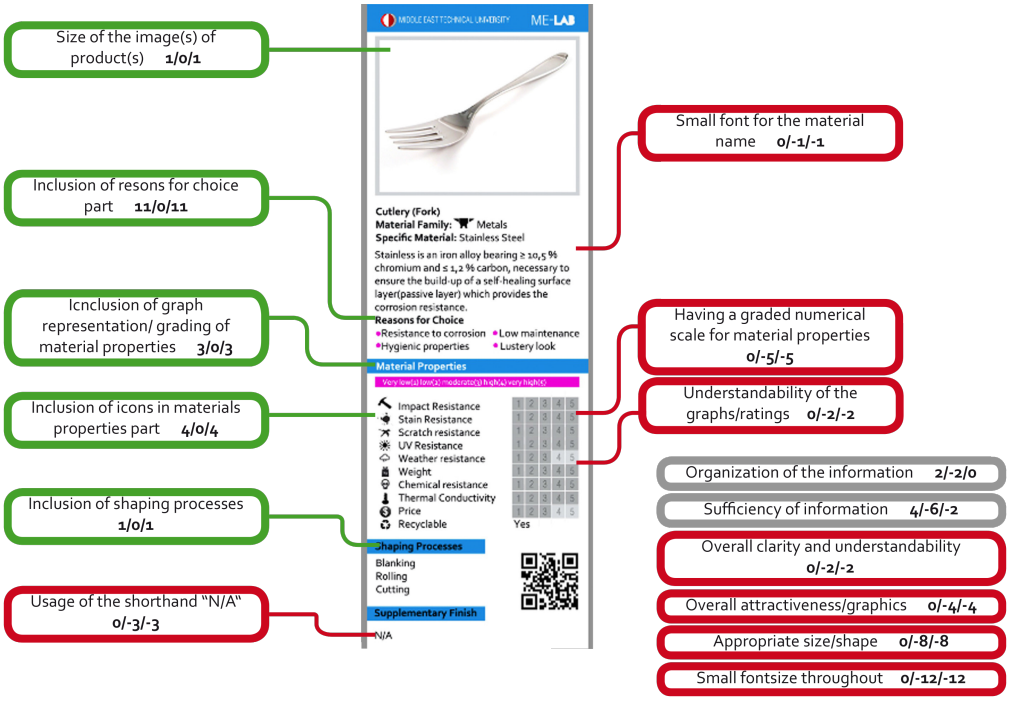


Figure 5-10 Students' comments on tag 9

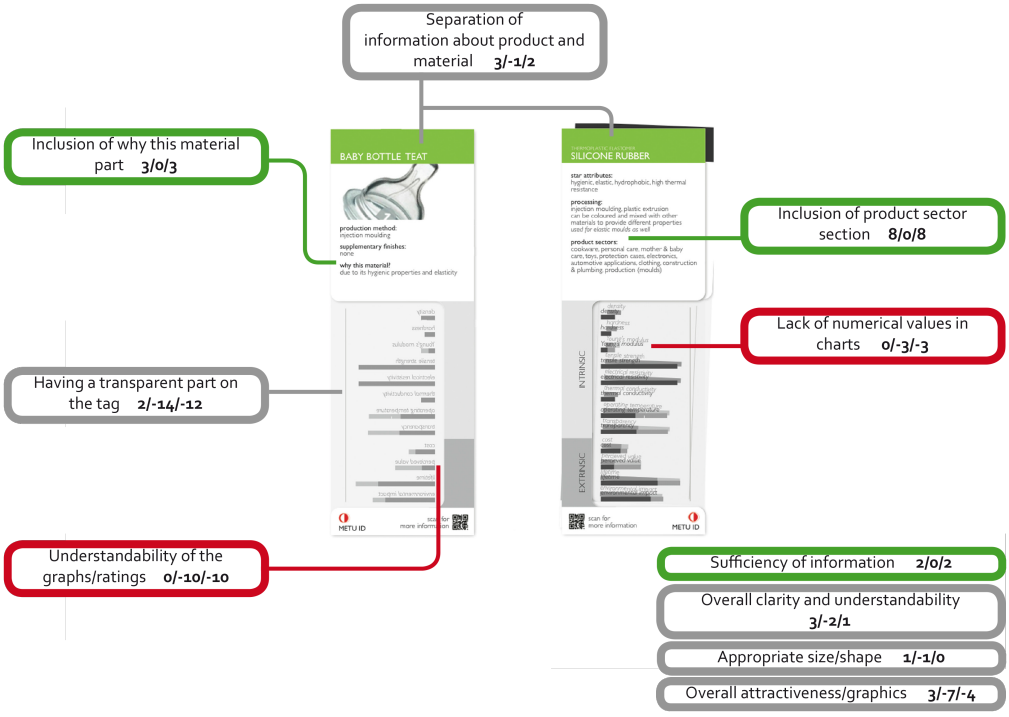


Figure 5-11 Students' comments on tag 10

The third part of the questionnaire analysis involved extracting quantitative results out of the free comments across all tags, rather than examining the tags on an individual basis. All

comments were combined into one spreadsheet (Appendix E). Three categories emerged during the analysis: comments could be classified as related to 'content', 'presentation' or 'materialization'. Accordingly, three separate spreadsheets were created, one for each classification (Appendix M).

5.5.1 Analysis Part A: Combined tag analysis

Only comments appearing for at least two tags (n≥2) were considered for this analysis.

5.5.1.1 Content:

Content was an important criteria for the students, especially the sufficiency of information (n=10, v=-28), which was mentioned for every tag. The other comments (2^{nd}-5^{th} rank) were not mentioned so much (n=3 to n=4). The reason for that is probably the variety of the content of the tags. Each tag had different information about materials. Although students were not satisfied with the 'sufficiency of information' provided in the tags, they liked the different kinds of information presented for the materials. It is interesting that all the most mentioned comments other than 'sufficiency of information' received high positive scores (v=26 to v=15). Except for tags 4, 5 and 8, all tags had at least one aspect of their content that satisfied the students, but none of the tags could combine all of these parts. When we look to the most mentioned and positive rated comments regarding tag content, we can say that they are about the usage of the material: example products, example applications and manufacturing methods.

5.5.1.2 Presentation:

The presentation of the tags received a variety of comments from the students as the tags had distinctive visual qualities. We can group the top mentioned comments (1^{st}-6^{th} rank) into two categories: 'aesthetic qualities' and 'functional qualities'. 'Color scheme' (n=8, v=-8) and 'overall attractiveness/graphics' (n=9, v=1) relate to aesthetic qualities of the presentation of tag information. The remaining comments relate to functional aspects of the presentation, concerning clarity and understandability. Another important point we can see from the top ranked presentation-related comments is that students liked the presence of a graph or visual rating of material properties (n=6, v=13), but did not find the offered solutions understandable (n=6, v=-28).

5.5.1.3 Materialization:

Students made considerable comments about the materialization properties of the tags, related to two specific issues: size/shape (n=9, v=-16) and the tag material durability/appropriateness (n=6, v=-6). The reason for this is the tags had similar physical

properties, printed on a thick paper. It is noticeable that both sets of comments about materialization received negative points, showing that overall the size, shape and durability were not considered satisfactory.

5.5.1.4 Priority Design Criteria

From the high-ranking and most commonly shared comments amongst tags, the following design criteria can be implied, in rank order.

- Content:
    1. The tag should contain sufficient information about the material and its applications.
    2. Specific attributes of the material should be mentioned on the tag.
    3. It should contain example usage of the material with pictures.
    4. Manufacturing information should be included.
- Presentation:
    1. The information on the tag should be well organized, presented clearly and be understandable.
    2. The tag should be aesthetically appealing in terms of graphics and colour.
    3. The tag should include a graph representation of material properties, but this should be easy to understand.
- Materialization:
    1. The tag should have an optimal size, not too big or too small.
    2. The tag should be made of a durable material and be well constructed.

5.5.2 Analysis Part B: Individual Tag Analysis

Of the full set of 47 comments, 23 comments were mentioned only one time. This is because every tag was quite different from the others in terms of presentation, materialization and content. So these singular comments cover all the differences between the tags.

The number of comments relevant to each tag was similar (n=11 to n=15), with tag 7 receiving the highest (n=17). From these data, it is not possible to identify tags that were 'particularly talked about' or 'particularly not talked about' relative to the full set of tag data.

The range of overall comment scores for tags was v=7 to v=-28 . The students overall graded the tags quite negatively, with little positive overall praise. Two tags (tag 1 and tag 7) received the highest positive overall score (v=7). On this basis, these tags can be considered the most successful. Two tags received noticeably low overall comment scores; tag 5 (v=-28) and tag 8 (v=-25). These tags can be considered the least successful.

5.5.3 Good Design Examples and Best Practices

In relation to the priority design criteria identified in the PART A analysis, we can identify 'good design examples' by highlighting those tags for which the comments made were high value positive-only or mixed valence. See below Table 5-4.

Table 5-4: Findings from qualitative analysis (good design examples)

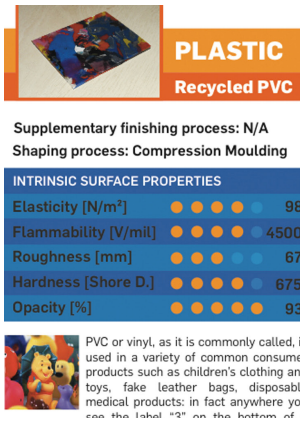
Priority Design Criteria	Best Example(s) from Tags 1-10
Content: 1. The tag should contain sufficient information about the material and its applications.	Tag 2, v=7 
Content: 2. Specific attributes of the material should be mentioned on the tag.	Tag 9, v=11 

Table 5-4 (continued)

<table>
<tr>
<td>Content:
3. It should contain example usage of the material with pictures</td>
<td>Tag 10, v=8
 

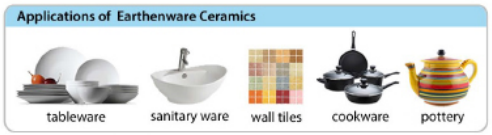
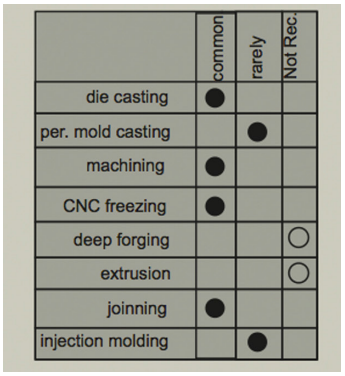
Tag 7, v=8
 
</td>
</tr>
<tr>
<td>Content:
4. Manufacturing information should be included</td>
<td>Tag 6, v=17
 
</td>
</tr>
</table>

Table 5-4 (continued)

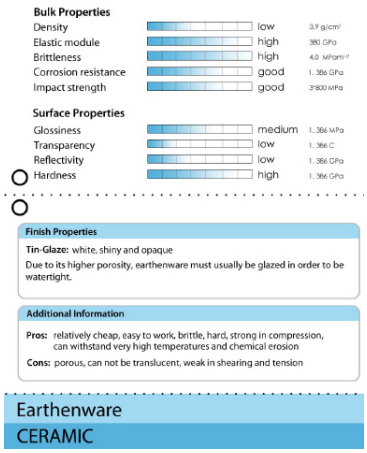
Presentation: 1. The information on the tag should be well organized, presented clearly and be understandable	Tag 4, v=4 (well organized)  Tag 7, v=4 (clear and understandable) 

Table 5-4 (continued)

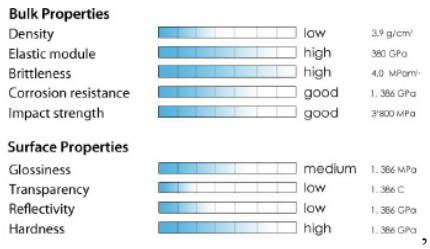
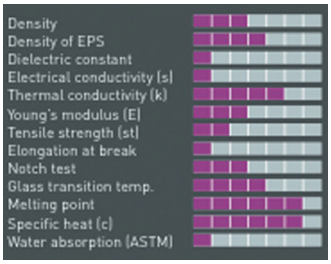
Presentation: 2. The tag should be aesthetically appealing in terms of graphics and colour.	Tag 4, v=9 (graphics)  Tag 2, v=3(colour) 
Presentation: 3. The tag should include a graph representation of material properties, but this should be easy to understand.	Tag 7, v=5  Tag 4, v=5 

Table 5-4 (continued)

Materialization: 1. The tag should have an optimal size, not too big or too small.	Tag 5, v=5 
Materialization: 2. The tag should be made of a durable material and be well constructed.	Tag 8, v=3 

Outside of the priority design criteria, we can identify other ‘best examples’ by highlighting those tags receiving low-mentioned or singular comments of high score with positive-only or mixed valence. By doing so, we can highlight unusual features that were specific to individual tags and highly appreciated by the students. See below Table 5-5.

Table 5-5: Findings from qualitative analysis (other best examples)

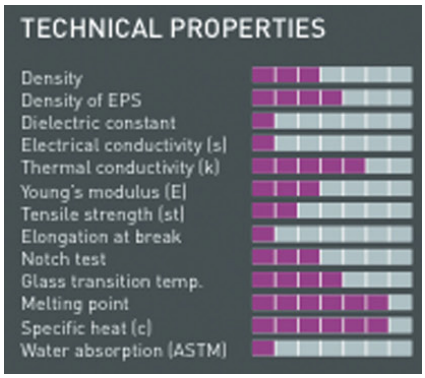
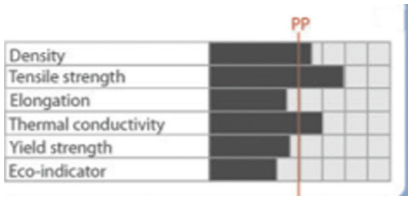
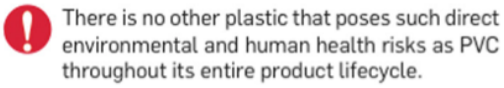
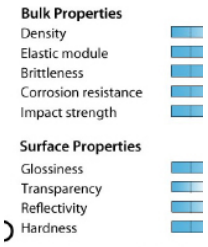
Other Design Criteria	Best Examples from Tags 1-10
Content: 1. Includes technical properties chart	Tag 4, v=3 
Content: 2. Includes numerical values for material properties	Tag 2, v=4 
Content: 3. Includes comparison chart with other materials	Tag 1, v=11 
Content: 4. Includes section on similar materials	Tag 1, v=9 
Content: 5. Includes a warning section	Tag 2, v=9 

Table 5-5 (Continued)

Content: 6. Includes images of both raw material and products	Tag 4, v=7 
Content: 7. Includes bulk and/or surface properties	Tag 7, v=7 
Presentation: 1. Includes icons within product application section.	Tag 3, v=4 
Presentation: 2. Includes icons for material properties section	Tag 9, v=4 

5.6 Conclusion

The findings from this chapter are used in the design process of a new materials tag. Some results pointed out the successful parts of the existing material tags, others revealed opinions of the students about the ideal material tag in their mind. In this evaluation phase it was important to make a requirements list for the next phase of the study. Through the analysis it was obvious which features should be put in the new design and which ones should be taken out.

From the evaluation of the existing material information systems it was found out that students tend to like tags with a wide range of information. It was also positively rated that tags have sections that are important for designers such as selection reason, negative affects of the material to the environment. Information about surface treatments and production techniques are also found necessary for the students. Applications of the material and the visual language of the tag affected the ratings of the students. Also physical properties of the material information tags were important for the students.

CHAPTER 6

DESIGN OF A SAMPLE TAG FOR THE MATERIALS EXPERIENCE LABORATORY AT METU DEPARTMENT OF INDUSTRIAL DESIGN

The final part of the research involved the design of a materials information tag. The findings from the literature review, questionnaire with students and the survey of material libraries were used as the basis of the tag specification, which will accompany material and product samples in the Materials Experience Laboratory.

6.1 Information from Literature

The findings from literature were more about a general knowledge, which designers should have on materials. Facts that were found from literature have been discussed in the second chapter. Therefore only a few points will be mentioned, which were helfull for the design process. In recent years sensorial and expressional properties of materials have been given greater prominence in industrial design education, complementing the technical information that has traditionally dominated (Pedgley, 2010b). Materials libraries, where students experience materials first hand, have been found an essential element for design education (Ward, 2008). People commonly want to access information about a sample without much effort. Therefore information systems for material collections should have a point of access that is connected to the material or product sample. Another important issue about materials information suitable for designers is the issue of multiple levels of detail. (Ramalhete et al., 2010; Karana et al., 2008; van Kesteren, 2008b; Ashby & Johnson, 2002). If designers are looking for materials as an inspiration source or in a very early development phase of project, they rarely need very detailed information. In the further phases of a project, especially during the finalization, greater levels of detail and very specific information are needed. Very easy-to-access first level information will be suggested that can be in a form of a tag, and the next level of the information can be a database, which is on the Internet or Intranet of an organization. In the limited time for this research, only on the first level of detail in information provision could be focused: a tag that would accompany samples in the library.

The form of the tag is influenced by implementation considerations. A computerized tag in a form of barcode or QR code was discussed but implementation of such a system would

require more resources and effort than could be allocated for the tag design performed here. Thus, monetary reasons and technological restrictions built the form of the first detail level information. Another reason why a tag is chosen is that material libraries emphasize the importance of materiality and experiencing samples in first hand not from pictures or online sources, so a materialized tag would fit better than an application to the theme of tangible interaction with materials. Using Smartphones or digital devices would add an extra layer between people and information; therefore a tag can be said as a more simplistic and straightforward solution.

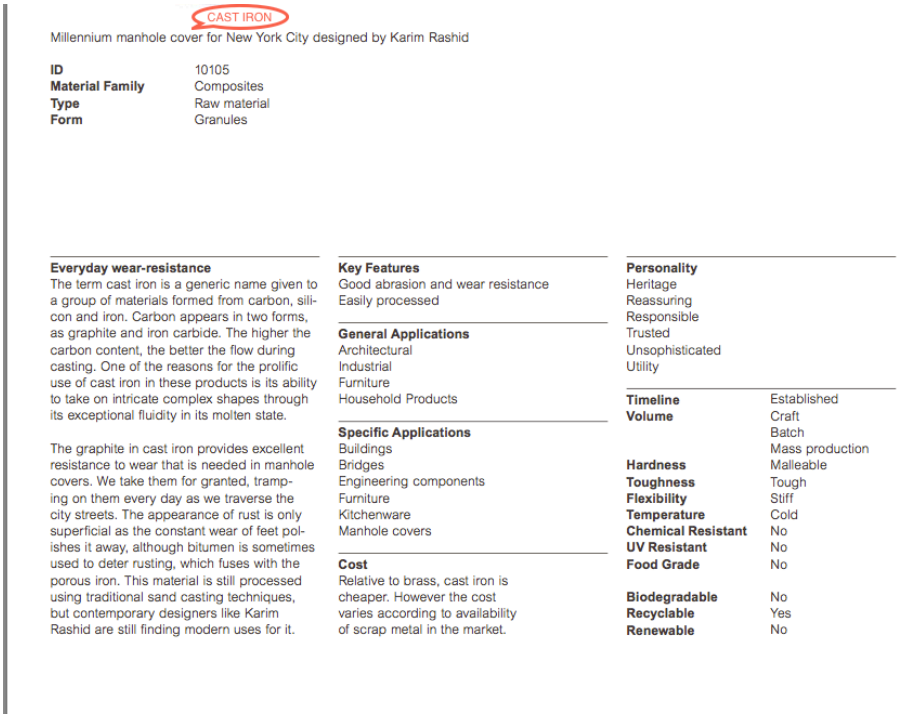
During the literature review, several information representations about materials for designers could be found. Some of those will be mentioned in the following paragraphs. Lefteri (2008, p.68) for example writes the following as a description for aluminium:

In little over a century, this relatively new addition to the family of metals has become one of the world's most widely used metals, second only to steel. With its winning combination of strength, low weight and resistance to corrosion, aluminium is the optimal metal for all kinds of transportation applications, including ocean liners, aircrafts and even space- ships. When ground into a powder form, aluminium is one of the few metals that retain a shiny appearance, which is why it is commonly found in paints and plastics to produce a metallic effect. However, the most remarkable property of this metal is that it can be 100% recycled. Incredibly, nearly 3 quarters of all aluminium ever made remains in use today!

In this description we can conclude that Lefteri mentions about special qualities of the material, its applications and some facts about environmental impact of the material. Another example from Lefteri (2009, p.32) concerns acrylic (PMMA). In the material description, Lefteri mentions the material's strengths and gives some example applications with it. He also makes a comparison with a similar material.

Polymethal Methacrylate (PMMA) is the chemical name for acrylic and is known as the top choice for high clarity. It's also a material with many incarnations, one of which is a household name: Perspex, which is its incarnation as a sheet material. PMMA is visually hard to distinguish from its slightly less clear relative PC, although it is less temperature resistant, but is in much the same region for pricing. It's much more of a high value material than PC; for example, think of some of those high gloss, glassy moulded parts that you might find in a pricey Alessi product.

In Figure 6-1 it can be seen that Lefteri provides information about a material's price, applications, strengths, meanings and expressions that the material conveys. He also gives information about some technical properties in a non-numerical way. Also a descriptive paragraph is written for the material.



CAST IRON

Millennium manhole cover for New York City designed by Karim Rashid

ID	10105
Material Family	Composites
Type	Raw material
Form	Granules

Everyday wear-resistance

The term cast iron is a generic name given to a group of materials formed from carbon, silicon and iron. Carbon appears in two forms, as graphite and iron carbide. The higher the carbon content, the better the flow during casting. One of the reasons for the prolific use of cast iron in these products is its ability to take on intricate complex shapes through its exceptional fluidity in its molten state.

The graphite in cast iron provides excellent resistance to wear that is needed in manhole covers. We take them for granted, tramping on them every day as we traverse the city streets. The appearance of rust is only superficial as the constant wear of feet polishes it away, although bitumen is sometimes used to deter rusting, which fuses with the porous iron. This material is still processed using traditional sand casting techniques, but contemporary designers like Karim Rashid are still finding modern uses for it.

Key Features

Good abrasion and wear resistance
Easily processed

General Applications

Architectural
Industrial
Furniture
Household Products

Specific Applications

Buildings
Bridges
Engineering components
Furniture
Kitchenware
Manhole covers

Cost

Relative to brass, cast iron is cheaper. However the cost varies according to availability of scrap metal in the market.

Personality

Heritage
Reassuring
Responsible
Trusted
Unsophisticated
Utility

Timeline	Established
Volume	Craft
	Batch
	Mass production
Hardness	Malleable
Toughness	Tough
Flexibility	Stiff
Temperature	Cold
Chemical Resistant	No
UV Resistant	No
Food Grade	No
Biodegradable	No
Recyclable	Yes
Renewable	No

Figure 6-1 Descriptive page about cast iron (Lefteri, 2009)

For the Exhibition '100% Materials' in 2009, Lefteri gave information about the properties, applications and manufacturer of materials for an exhibition involving material samples (Figure 6-2).

Figure 6-2: Example tag used for the exhibition '100% Materials' in 2009 (Lefteri, 2009)

The example tag from Material Lab (Zoe, 2010) shown in Figure 6-3 contains information about the material's durability, availability, manufacturer, standard sizes, fire rating and a brief description.

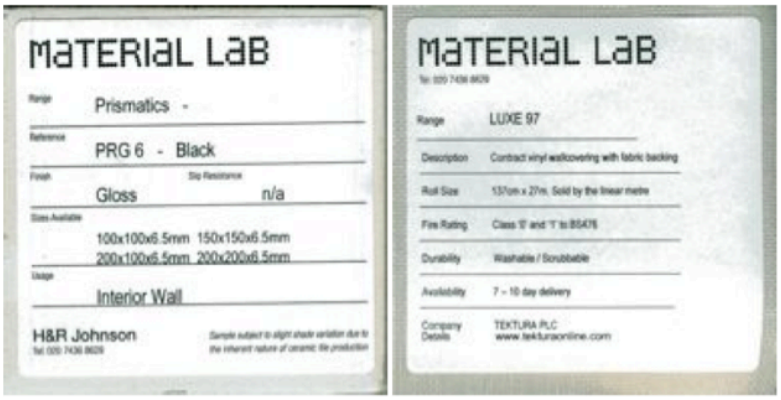
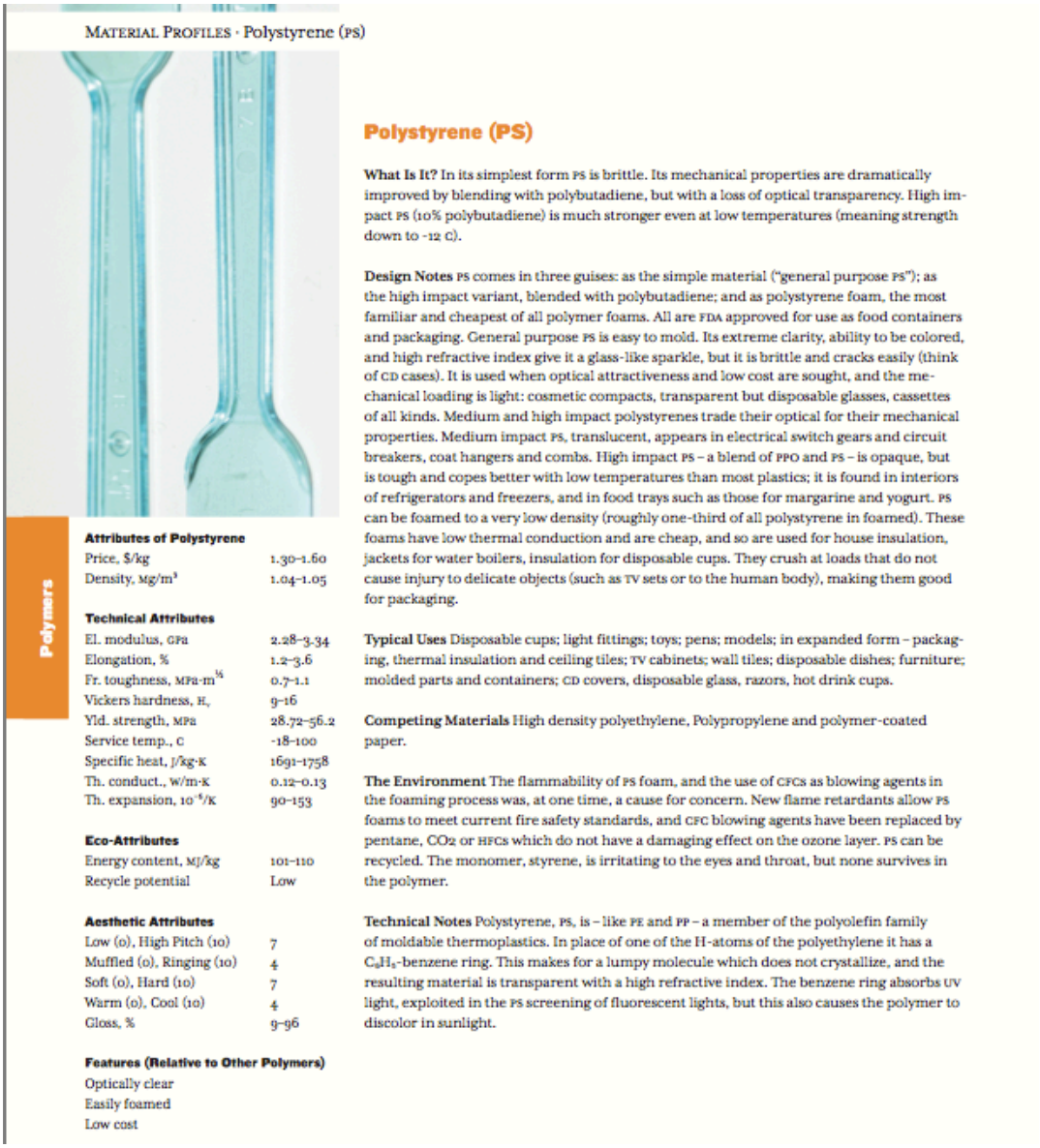


Figure 6-3 Material information label used in Material Lab. (Adapted from Zoe, 2010)

One of the core resources for designers is Ashby and Johnson's book 'Materials and Design' (2002), an extract of which appears in Figure 6-4. This book contains information about materials alongside current thinking on materials, the importance of materials for product design, selection methods for materials, and more. In this book, information about a material is provided within different headings: a short definition of the material, the importance of the material for designers (including special attributes and applications), similar materials, the environmental impact of it, and also technical properties expressed numerically and additional material properties such as price. Also sensorial properties of materials are mentioned. This book's information about materials can be categorized as a more detailed level than the tag design that will be proposed through the work in this chapter. But as a reference for materials information design appropriate for designers, it is a valuable example.



MATERIAL PROFILES · Polystyrene (PS)

Polymers

Polystyrene (PS)

What Is It? In its simplest form PS is brittle. Its mechanical properties are dramatically improved by blending with polybutadiene, but with a loss of optical transparency. High impact PS (10% polybutadiene) is much stronger even at low temperatures (meaning strength down to -12 C).

Design Notes PS comes in three guises: as the simple material ("general purpose PS"); as the high impact variant, blended with polybutadiene; and as polystyrene foam, the most familiar and cheapest of all polymer foams. All are FDA approved for use as food containers and packaging. General purpose PS is easy to mold. Its extreme clarity, ability to be colored, and high refractive index give it a glass-like sparkle, but it is brittle and cracks easily (think of CD cases). It is used when optical attractiveness and low cost are sought, and the mechanical loading is light: cosmetic compacts, transparent but disposable glasses, cassettes of all kinds. Medium and high impact polystyrenes trade their optical for their mechanical properties. Medium impact PS, translucent, appears in electrical switch gears and circuit breakers, coat hangers and combs. High impact PS – a blend of PPO and PS – is opaque, but is tough and copes better with low temperatures than most plastics; it is found in interiors of refrigerators and freezers, and in food trays such as those for margarine and yogurt. PS can be foamed to a very low density (roughly one-third of all polystyrene in foamed). These foams have low thermal conduction and are cheap, and so are used for house insulation, jackets for water boilers, insulation for disposable cups. They crush at loads that do not cause injury to delicate objects (such as TV sets or to the human body), making them good for packaging.

Typical Uses Disposable cups; light fittings; toys; pens; models; in expanded form – packaging, thermal insulation and ceiling tiles; TV cabinets; wall tiles; disposable dishes; furniture; molded parts and containers; CD covers, disposable glass, razors, hot drink cups.

Competing Materials High density polyethylene, Polypropylene and polymer-coated paper.

The Environment The flammability of PS foam, and the use of CFCs as blowing agents in the foaming process was, at one time, a cause for concern. New flame retardants allow PS foams to meet current fire safety standards, and CFC blowing agents have been replaced by pentane, CO_2 or HFCs which do not have a damaging effect on the ozone layer. PS can be recycled. The monomer, styrene, is irritating to the eyes and throat, but none survives in the polymer.

Technical Notes Polystyrene, PS, is – like PE and PP – a member of the polyolefin family of moldable thermoplastics. In place of one of the H-atoms of the polyethylene it has a C_6H_5-benzene ring. This makes for a lumpy molecule which does not crystallize, and the resulting material is transparent with a high refractive index. The benzene ring absorbs UV light, exploited in the PS screening of fluorescent lights, but this also causes the polymer to discolor in sunlight.

Attributes of Polystyrene

Price, $/kg	1.30–1.60
Density, Mg/m³	1.04–1.05
Technical Attributes	
El. modulus, GPa	2.28–3.34
Elongation, %	1.2–3.6
Fr. toughness, MPa-m$^{1/2}$	0.7–1.1
Vickers hardness, H,	9–16
Yld. strength, MPa	28.72–56.2
Service temp., C	-18–100
Specific heat, J/kg-K	1691–1758
Th. conduct., W/m-K	0.12–0.13
Th. expansion, 10^{-6}/K	90–153
Eco-Attributes	
Energy content, MJ/kg	101–110
Recycle potential	Low
Aesthetic Attributes	
Low (0), High Pitch (10)	7
Muffled (0), Ringing (10)	4
Soft (0), Hard (10)	7
Warm (0), Cool (10)	4
Gloss, %	9–96

Features (Relative to Other Polymers)
Optically clear
Easily foamed
Low cost

Figure 6-4: Extracted page describing Polystyrene (Ashby & Johnson, 2002)

6.2 Material Information Representations from existing Material Libraries

In the research about material libraries, a variety of information representations for material and product samples have been found. Some of them are presented in the following paragraphs. In Figure 6-5 we can see that the Made Of material library (Netherlands) provides information about material applications, properties, origin and its environmental impacts and ecological properties. Also a descriptive paragraph is added on the information resource.

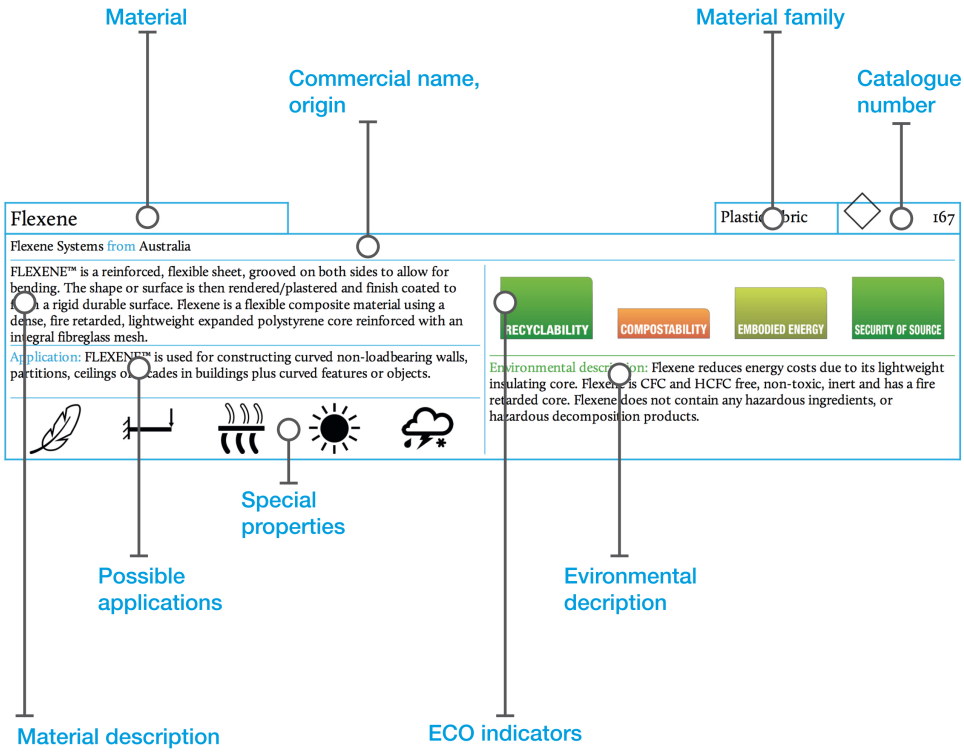


Figure 6-5: Accompanying information for samples in Made Of material library (TU Delft) © Karana/IO TU Delft

On the information label of Matech (Figure 6-6) we can see material's picture, application characteristics and a description in Italian.

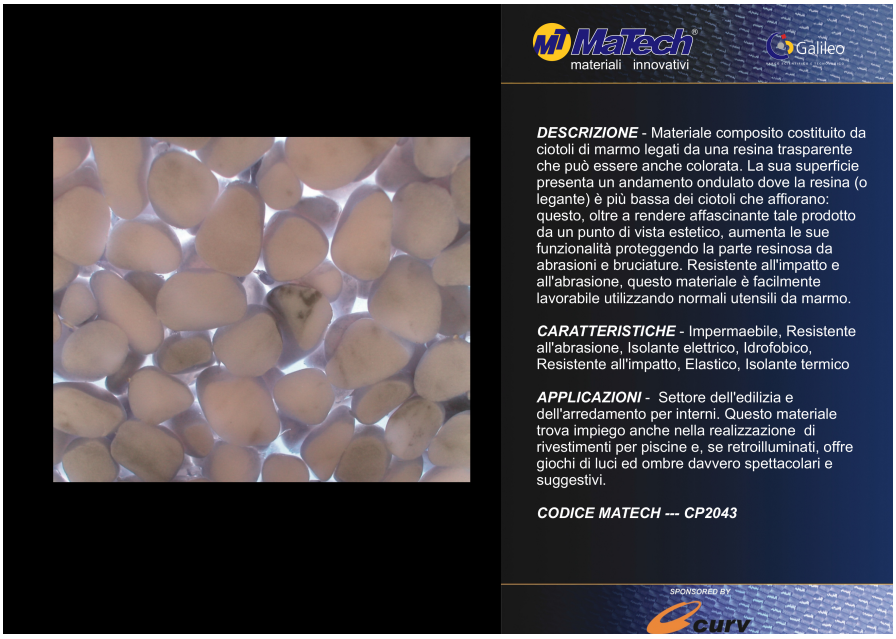


Figure 6-6: Accompanying information for samples in MaTEch's material library © MaTech

It can be seen in Figure 6-7 that London Metropolitan University's Material and Product Collection provides information about the material's manufacturer and its contact information, as well as a short description about the sample.

Anodised aluminium sheeting in a range of colours and textured finishes for lighting applications and decorative surfacing. Gauge range from 0.2 – 0.8mm with max sheet width from 500 – 1250mm

Company: Alanod Ltd

Product: Anodised aluminium sheets

URL: www.alanod.co.uk

CI/SfB: Yh4

London Metropolitan University	
14 June 2012	
Materials & Products Reference Only	**Yh4** Ala

Info and more samples at Yh4

Figure 6-7: Accompanying information for samples in London Metropolitan University's material library © London Metropolitan University

In Figure 6-8, showing the sample label from the Materioteca library, we can see provision for the material's manufacturer, applications, properties and shaping processes.

Figure 6-8: Accompanying information for samples in Materioteca, © Materioteca- Milan

The eco-materials Library Matrec attaches the tag shown in Figure 6-9 to their samples. The library provides a wide range of information such as shaping processes, manufacturer, applications and features.

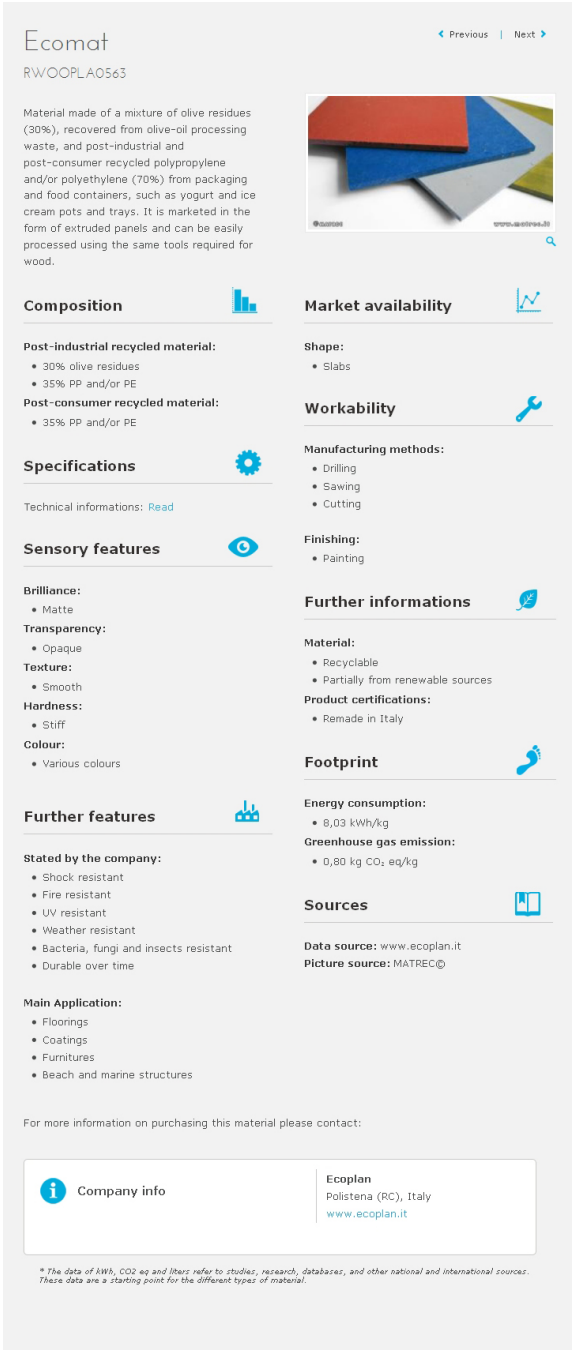


Figure 6-9: Accompanying information for samples in Matrec, © Matrec

At the University of Texas in Austin, the Co-Op Materials Resource Center material samples are labeled with barcodes (Figure 4-25). With the help of this barcode, more information can

be accessed via a website. Also the material manufacturer's name and its website can be seen on the label.

6.3 Design Specifications for the Tag

The information labels from different materials libraries and information representation in different books were a good starting point for the design process. But the core specifications which was used for the design of the tag came from the results of the questionnaire with undergraduates, reported in Chapter 5. The beginning of the process was to use the design recommendations from the questionnaire to make a requirements list. The results from the quantitative and qualitative analysis of the questionnaire were combined into one document. The results from the quantitative analysis, from the qualitative analysis and the results shown on visuals were placed onto a single page (Figure 6-10).

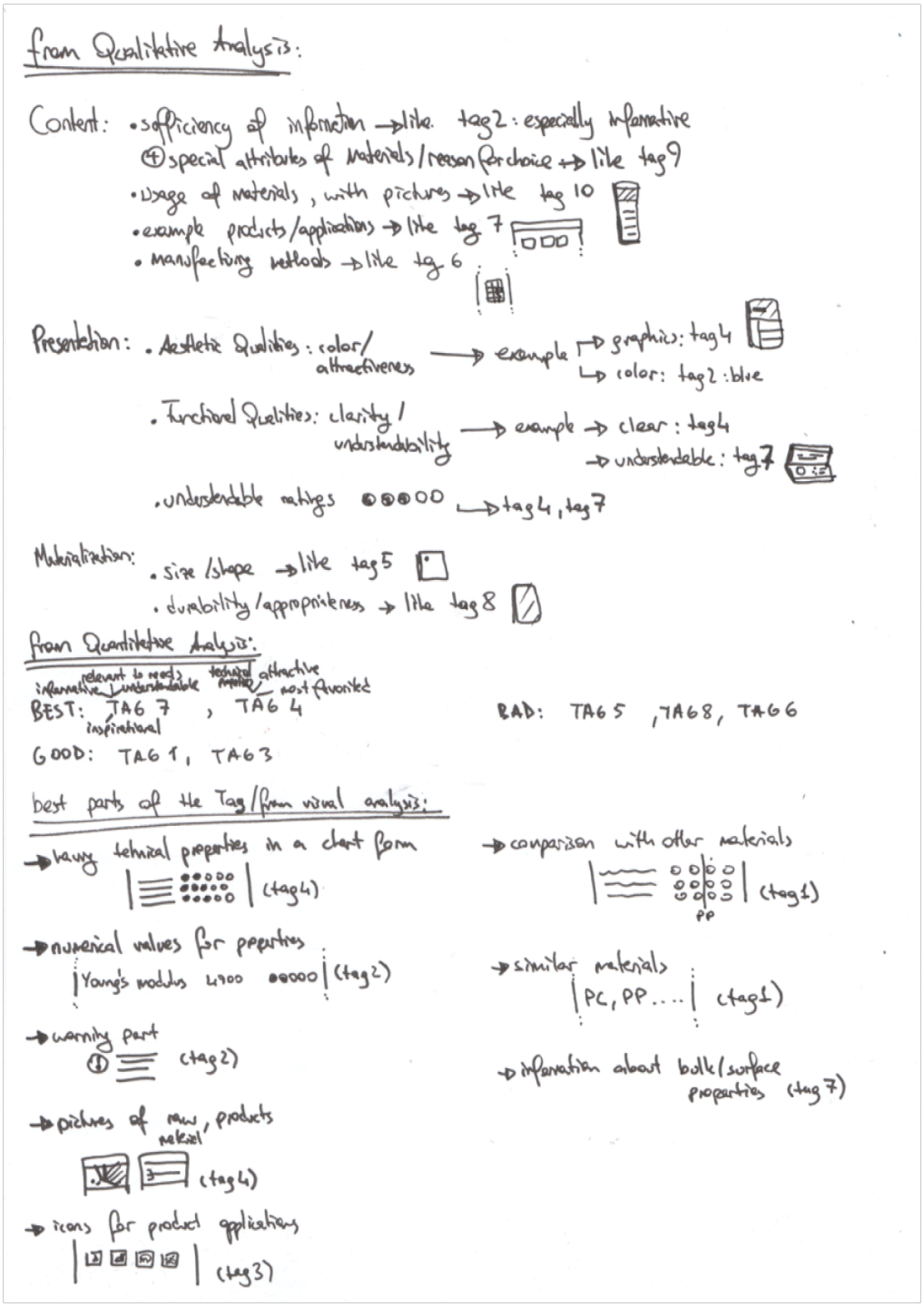


Figure 6-10 All design recommendation combined in one page

6.4 Initial Design Activity

With the help of the document, which was created, it was easy to extract the successful parts from each sample tag designed by the graduate students. Also the design recommendation list which was prepared from the findings of the questionnaire made it easier to understand which parts were important for undergraduate students in each tag. The only point it was not

used in the design was to utilize icons for the product application part. In the sample tags created by the graduate students, two tags used icons for the sensorial properties of materials (tag 8 and tag 4). The undergraduate students evaluating the tags were not sure about the meaning of the icons, and did not readily recognise them as representing five human senses. It is even harder to distinguish between icons used to represent different product sectors. So the uses of icons were omitted.

In different sample tags properties that distinguishes the material from other are mentioned on the parts which were named as star attribute (tag 1), selection reasons (tag 3), reason for choice (tag 9), why this material (tag 10). Those parts have very similar meanings on the new design those parts are combined under the positive sign. In tag 2 warning part was used for mentioning negative sides of the material such as health risks or environmental impact of the material. Those attributes are put under the negative sign in the new tag design.

During the design process, eight different wireframe designs were created. (Figure 6-11 and 6-12) The content of the different designs was similar, because it was built the requirements list previously created. So the majority of effort focused on presentation. For the graphics, tag 4 was taken as an example, since it was found the most attractive design. One (preferred) wireframe design was turned into an Illustrator file. (Figure 6-13)

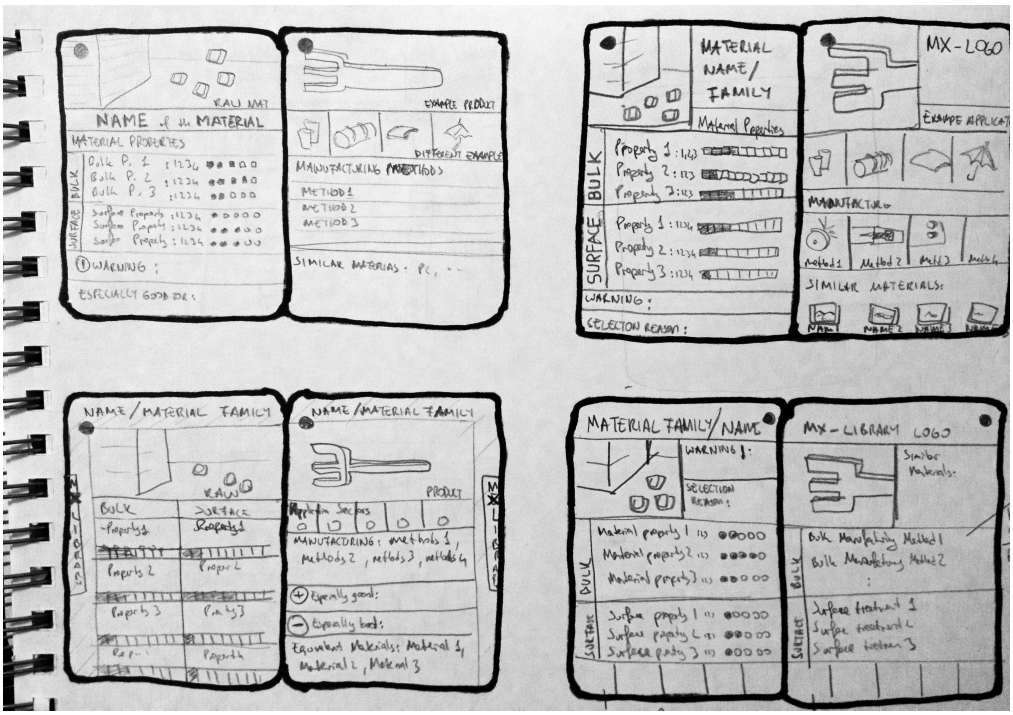


Figure 6-11 Wireframe designs (1 to 4 out of 8)

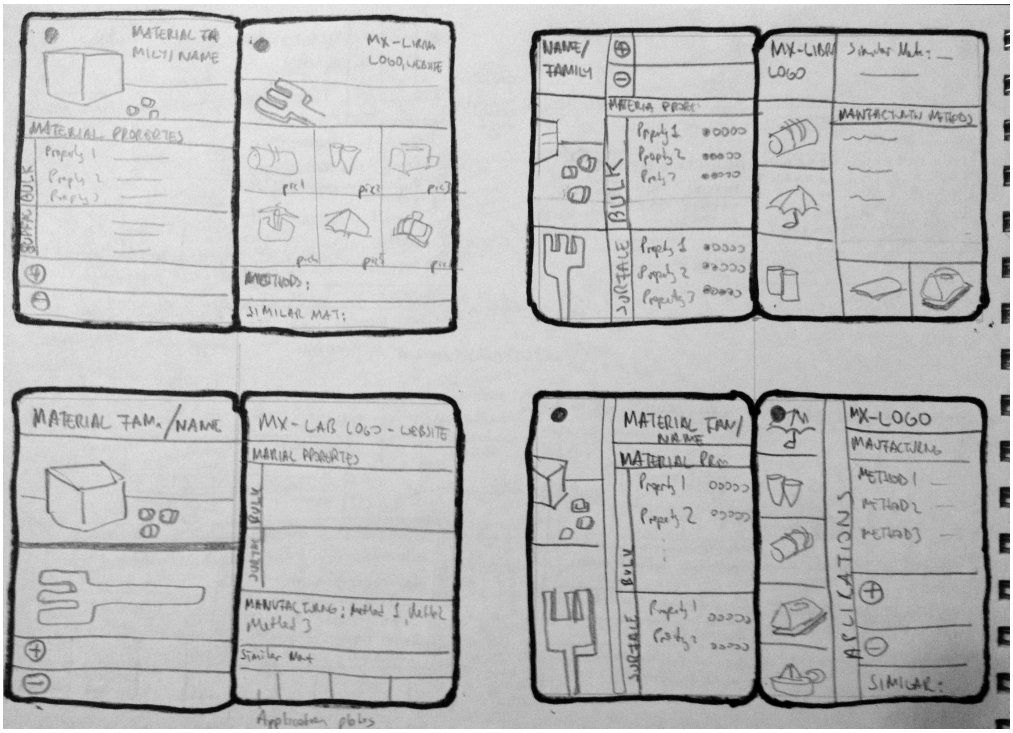


Figure 6-12 Wireframe designs (4 to 8 out of 8)

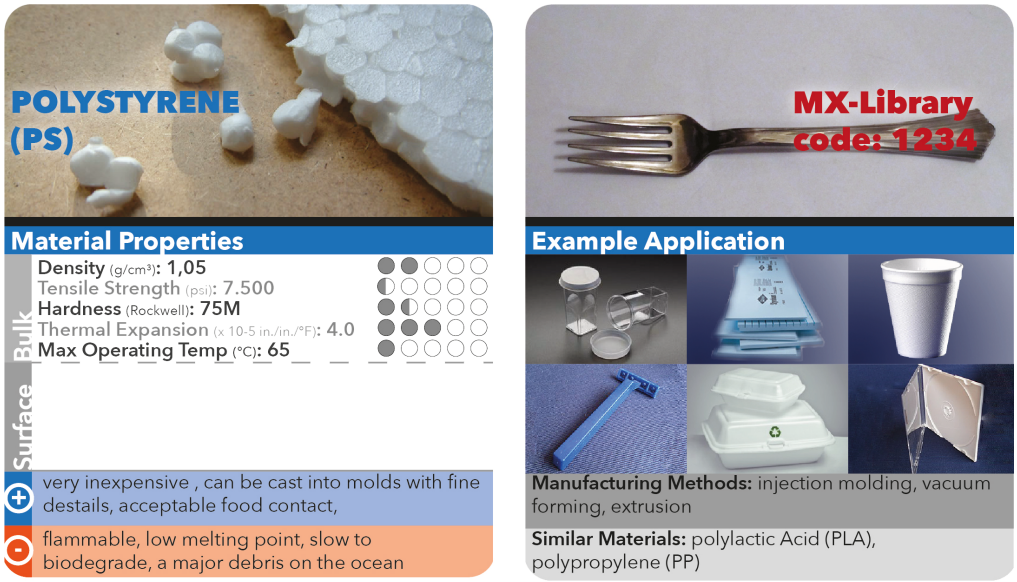


Figure 6-13 Preliminary tag design

6.5 First Iteration of the Design and Final Solution

The first tag design was discussed with the advisor of the thesis as an expert on this subject. The following points were discussed and accordingly drove changes in the design during its subsequent phase of development. (Figure 6-14)

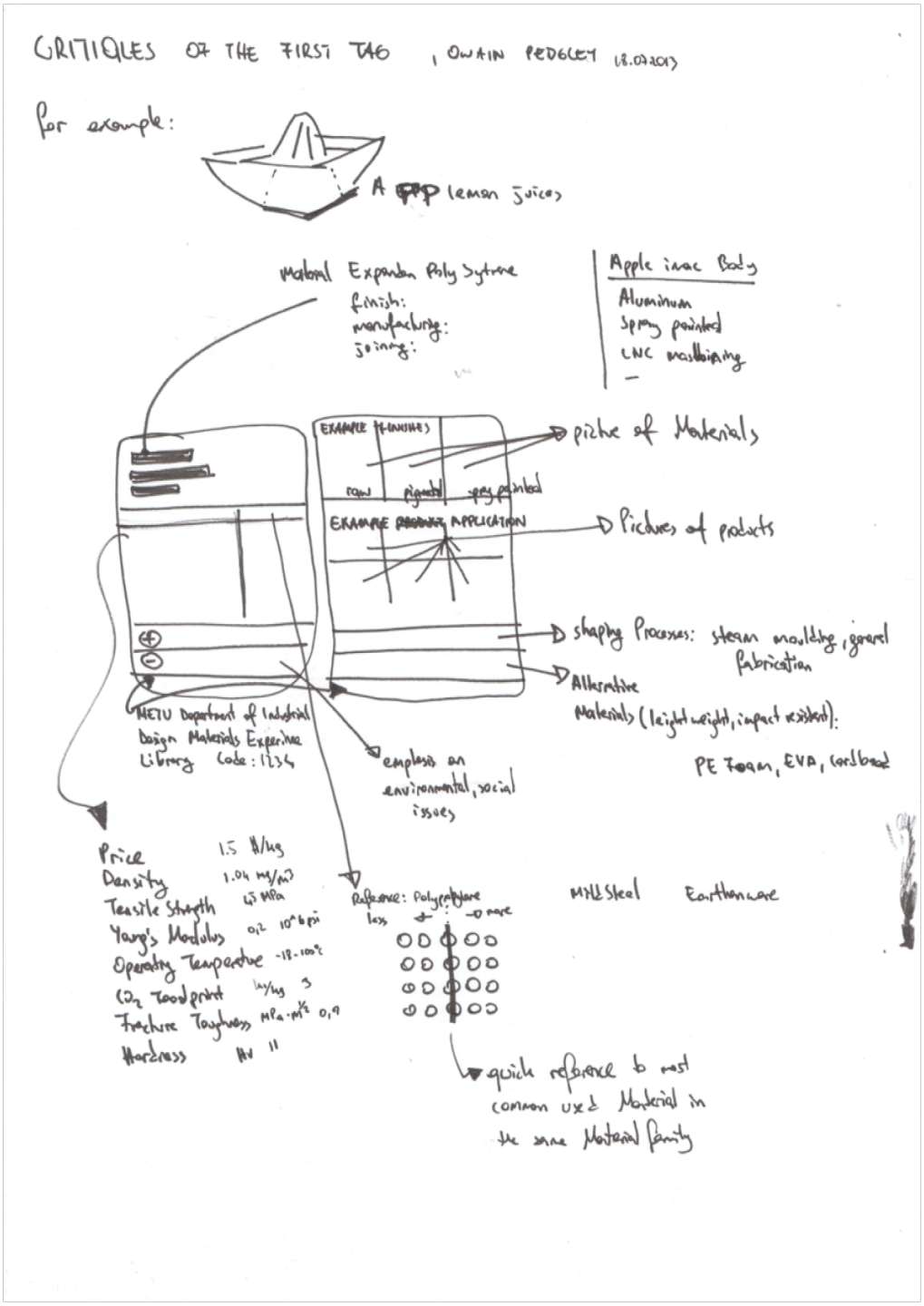


Figure 6-14 Expert interview notes about the preliminary design

- It is difficult to distinguish between surface properties and bulk properties. Surface properties are affected by different technical properties. Also, the sample itself is a rich information resource for surface properties, so there is no need to repeat information that is supposed to be gained tangibly through interaction with samples

in the material library. So we concluded that there is no need to have a special part for surface properties.

- It was also needed to have more information about the special features of the sample. So finishing, manufacturing and joining information were added.
- One of the important types of content the tag should have was pictures of raw materials and finished products. Pictures of different finishes were also added to the revised tag design.
- To compare the properties of the material with other (alternative) materials, a reference material has been added above the property grading section. The reference material was decided to be the most commonly used and low cost material within a specific material family (i.e. earthenware for ceramics; mild steel for metals; polypropylene for thermoplastics; soda-lime glass for glass; pine for softwoods etc.).
- The inclusion of a section on 'alternative materials' should be set according to some criteria (i.e. in what principle ways are the alternative choices similar but different?).

According these observations and critiques, a revision of the tag was made. Following finalization of the design (for ceramics), two additional sample tags were prepared demonstrating the layout and information provision (for metals and plastics). These three tags are shown in Figures 6-15, 6-16 and 6-17.

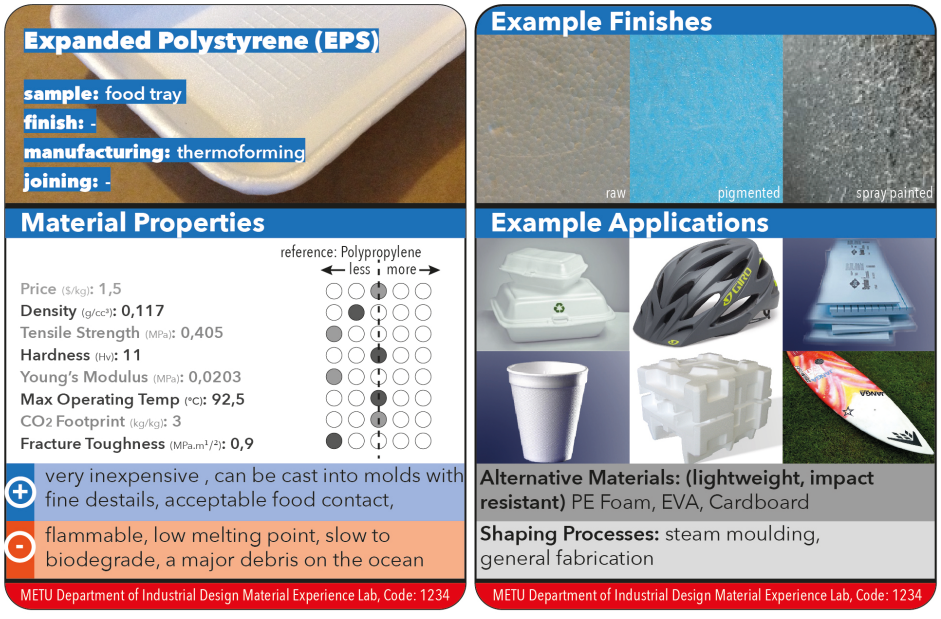


Figure 6-15 Finalized material information tag for expanded polystyrene

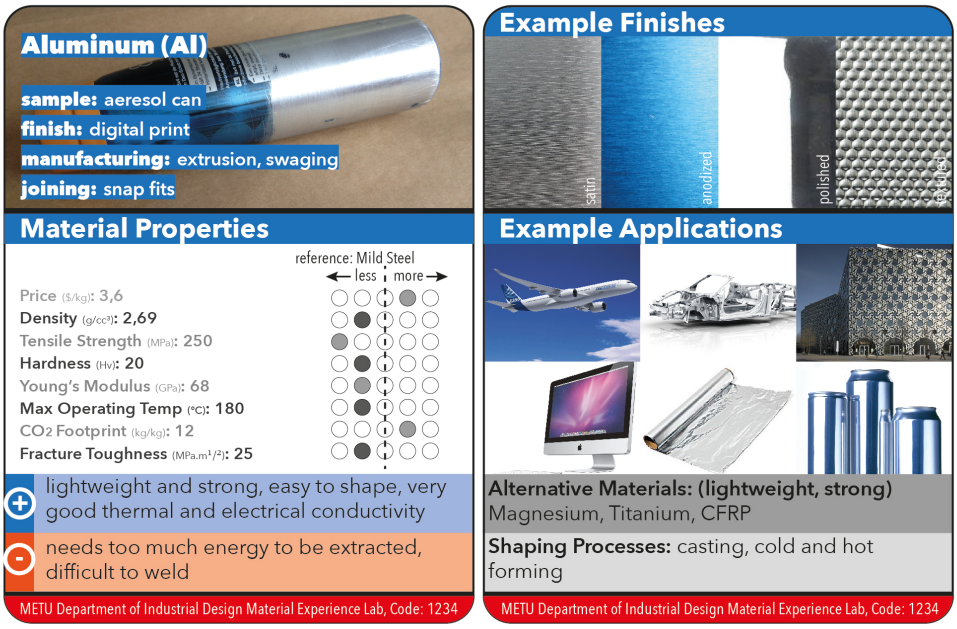


Figure 6-16 Finalized material information tag for aluminum

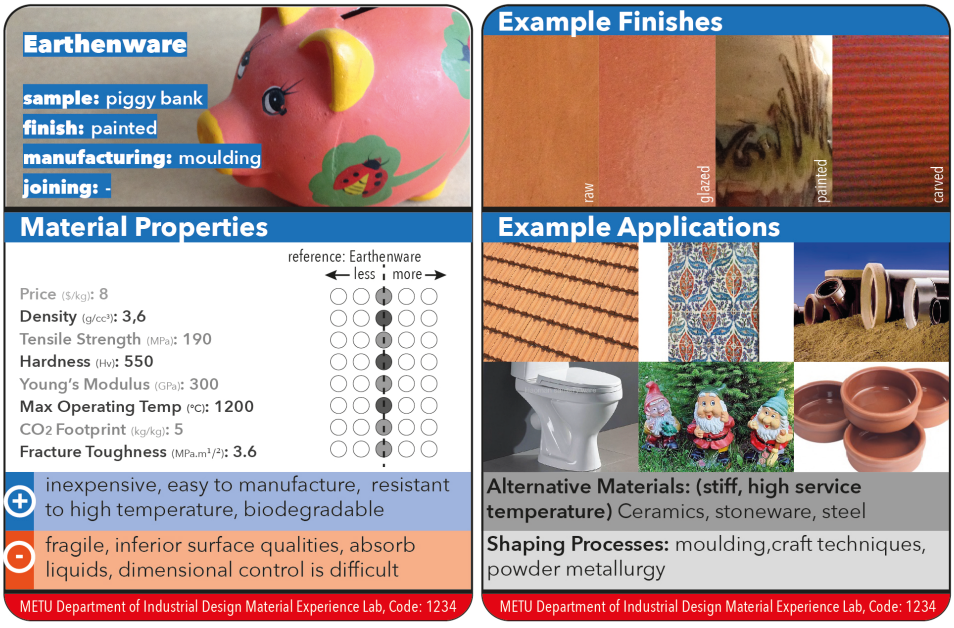


Figure 6-17 Finalized material information tag for earthenware

Figure 6-18 Expanded polystyrene information tag attached to product sample

Figure 6-19 Aluminum information tag attached to product sample

Figure 6-20 Earthenware information tag attached to product sample

6.6 Conclusion

In this chapter, information from literature, information from the findings of the tag evaluation session with undergraduate students, as well as results from the online survey of material libraries, were combined to inform the design of a new material information tag suitable for the Materials Experience Laboratory at METU Department of Industrial Design. The study was set up with a series of research steps to uncover information suitable for the design of an 'ideal' material sample tag to be used in an educational context. And, that the design specifications that were reached through this process allowed the author to design a new tag for METU's Department of Industrial Design's Material Experience Laboratory.

CHAPTER 7

CONCLUSIONS

This chapter concentrates on revisiting the research questions posed in the Introduction chapter to the thesis, and reflects on the achievements made through the conducted research. The findings from the research are interpreted as answers to the research questions. In the further parts of the chapter, limitations of the study and possible future research points will be discussed.

7.1 Revisiting Research Questions

The aim of the research was to investigate the material information needs of industrial designers. According to the findings, a first detail level material information system was designed for the prospective Materials Experience Laboratory to be hosted in METU's Department of Industrial Design.

Q1. Which material information is important for industrial designers?

During the literature review, more general information about the materials information needs of industrial designers was found out. In the questionnaire with the undergraduate students and the online survey with material libraries, my findings were more specific to the material information that could (or should) accompany the material or product samples within a library or collection.

The conclusions about the material information needs of industrial designers from the literature review can be summarized into the following points.

- A successful material selection depends on the knowledge of the designer about the field. Many different approaches to selection process exist such as analysis, synthesis, and inspiration. [from Literature]
- Information about a material's technical and sensorial properties are both important. [from Literature]
- The detail level of information varies according to the stage of the design process. In early stages information that is inspiring is needed but in the later stages more specific knowledge about a material's technical features is needed. [from Literature]

- Physical samples of a material, as well as information on its usage in a product form, are essential sources of material information for designers.
- Visual representations of information are valuable for designers.
- Although for a long time designers have been using material information sources from the engineering field, there exists a huge difference between engineers' need of information and designers' need of information. [from Literature]
- There exist also differences between design students' need of material information and design professionals' need of information. [from Literature]
- Material collections and libraries plan an essential role for designers in the field of material information provision.

My conclusions through the questionnaire with undergraduate students and the online survey of material libraries can be summarized with the following points.

- It is important that accompanying information to material samples contains enough information, it should be related to a designer's view of a material, and should have visual language with charts, pictures etc.
- The size and materialization of accompanying information to a material sample (e.g. a sample tag, information sticker) are important, too.
- Shaping methods, specific features of the material, advantages and disadvantages of the usage and applications of the material are considered the essential content of such an information representation.
- Using charts and numerical values for technical properties, making comparisons with similar materials, and putting emphasis on surface qualities of materials have been considered as good implementations for a material information tag.
- Most existing material libraries provide a special information tag attached to samples. But the content varies from library to library. Most do not include a large amount of information and the above-mentioned combinations of aspects are missing in their tags. This may be because their tags were not conceived to serve within a higher education context.

Q2. How do the information needs of designers and engineers differ?

- Engineers use analytical methods to select a material; designers use a more chaotic and less rationalized way, which includes also experimentation and synthesis. [from Literature]
- Engineers know a material from its measurable properties; designers tend to describe a material with its experiential characteristics. [from Literature]

- For engineers, technical properties of a material are paramount; for designers, sensorial aspects as well as meanings and experiences that the material conveys are important, too – perhaps more so. [from Literature]
- How engineers know things differs from the way that designers learn and know. [from Literature]
- In the engineering area, one can make calculations to predict things; in the design profession you often need to experiment and create physical models / mock-ups to verify the success (or not) of material choices. [from Literature]

Q3. How do the information needs of industrial design professionals and industrial design students differ?

- Design students need more general information about materials, regarding their capabilities and opportunities, whereas design professionals mostly need specific knowledge about specific materials. [from Literature]
- For design professionals, methodologies for selection are important; design students see methodologies as a limitation on their creativity. [from literature]
- In design education, limited time and resources cause students to have a foundation level knowledge about materials. In their professional life, designers should bridge this gap when their projects demand, as well as keeping abreast of new material developments. [from Literature]

Q4. What are the existing solutions of accompanying information for material samples in material collections and libraries around the world?

- Most of the material libraries provide the manufacturer's information and a short description of the material on their sample tags.
- Databases are a popular resource that libraries use for providing material information.
- Material libraries try to implement technological tools such as webpages, QR codes and digital databases into their collections.
- Some collections have an in-house expert on the subject, so visitors can arrange consultancy meetings with them.

Q5. What design specifications should a material information system have, so that it is effective for teaching and learning of material properties to industrial design students?

- An effective material information system should support students in different levels of the design process. [from Literature]

- The system should provide general information about materials.
- Design-related information such as sensorial properties, applications and environmental impact of the material should be mentioned on the system.
- The system should be designed with bearing in mind that designers as well as design students are visual oriented people. Well-designed graphs and pictures would enhance the usability of the system.
- Accessibility is important in such a system; an easily available information and samples would encourage student s to use them.
- Experiencing materials and getting instant information about them is essential for an effective learning. [from Literature]

7.2 Limitations of the Study

In different phases of the research different limitations can be pointed out. In the literature research phase, more on the recent articles were focused and thoughts about the material information needs of designers. Also historically important sources have been consulted. Only limited numbers of engineering sources were read. The limitation of time and the focus of the research made me to decide which sources had a larger impact on my study. A more detailed and wider scope literature review may reveal results that have been not been captured in the chapter about the information needs of designer. But the main issues are covered in the literature review, some subtleties could be revealed with further researches on the literature.

Examining different subjects such as infographics and information visualization could be useful for the design process of the tags but it won't be a contribution to the research part of the work. For enhancing the design of the tags which were designed at the end of this research those resources can be conducted and principles of information visualization can be applied for improvements.

The questionnaire with the undergraduate students consisted of quantitative and qualitative parts. Although the qualitative part revealed very valuable results for the study, an interview with each student could have been richer on what students want to learn when they encounter a material sample. The questionnaire was made with students from METU's Department of Industrial Design. A wider audience, involving students from different schools in Turkey and perhaps across the world, could be helpful to make more certain decisions about the requirements of a material information tag. But as the aim of this study was to design at the end of the research a material information tag for METU Department of Industrial Design,the focus was on the need of those students.

The questionnaire was the core element for my design decisions for the material information tag. The graphic design of it can be easily changed. existing tags were taken as a model for the design. At the end graphically it was similar to some of them. The content of the tag is build from essential parts that were mentioned during the evaluations. An interesting detail is that the more information a tag provides the more satisfied are the students with it. But there is an important limit for that, when the content gets too big that it is hard to understand then students doesn't like it. The content of my design is quite simplistic so some more details until a certain amount could make students more satisfied. In other words more types of technical properties or a higher number of applications' pictures may create also a successful tag.

The online survey, which was conducted with material libraries around the world, was an efficient way to collect information from distant facilities. Because of the distribution of material libraries around the world it was practically not possible to visit each library and make observations or investigations on place.

Regarding the design process of the material information tag, the usage of more technological solutions could be seen as advantageous. Because of the thought that my design can be implemented into the Materials Experience Lab at METU Department of Industrial Design, there were some requirements that came from the design brief linked to the design and specification of the laboratory. On that time of my study it was not planned to have an Intranet database that should be accessed within the library, so a QR code or a Smartphone Application that would serve the same as my tag design was not considered an efficient way to solve information problems. The usage of such technologies would increase the production and maintenance cost of the library. It is also arguable that technologies such as QR codes, RFID tags or Smartphone Apps would bring an additional value to the library by accessing updatable and mobile information. Adding these solutions requires greater research into the scenarios of information needs and use beyond the walls of the library, otherwise it could degenerate into provision just for the sake of technology and not for improved functionality and value.

During the research on existing solutions for material information tags, it was found out that icons on those tags were not understandable for most of the undergraduates. Therefore the usage of icons in the finalized design was omitted. It would need further iterations to find out acceptable solutions for icons that would be understandable. Then icons would enhance the functionality and ease of use of the tag.

Another limitation about the studies' design phase is the evaluation of the results. The findings for the design phase came from the evaluation session of sample tags that were

designed by graduate students. But the author was not able to test his own designs with a group of students. It would be good to discuss with them and determine the success (or otherwise) of the design, beyond the justification of the design based on the research findings. On the other hand the designs have been discussed with the advisor of the thesis, who holds expertise in this area. At the beginning of the research, the aim for the research was to develop a variety of contrasting designs for the tags. Then the most 'successful' of these designs was planned to be determined through student evaluations. But when the point come that all the findings have been collected to be implemented in the new designs, it was quite clear how the tag should be, based on the research findings. So there was no need to produce wide variations and select from amongst them.

7.3 Discussion and Potential for Further Research

In the beginning of the study, the aim was to design a whole material information system suitable for material libraries. Later it was realized that it would be a too big and ambitious project. So only the first level of a material information system could be designed. In other words if we think that during a product design process designers have different materials information needs, the proposed design is for the first level (or 'initial acquaintance') amongst those needs.

Another point is that the design and research is targeted to undergraduate students. Design professionals and graduate students would have different needs, which would lead to different material information provision. Thus, a route for further research would be to attend to the material information needs of design professionals and graduate students and design of a material information system (or tagging sub-system, at least) appropriate to them.

The secondary detail level of material information for students would be also another point to be researched. A database or intranet site with further information about the materials used in samples could be contemplated. Those websites would include information about other technical properties of the materials that were not mentioned on the tag. Also the amount of information could be increased through those websites such as more applications, more surface treatments and more negative and positive features of the material. This secondary level of information could include manufacturing details and videos, pictures of production process of the material or turning the material into products. Students could share their experiences and knowledge, perhaps through Pinterest boards or material blogs limited to the core intranet information. The tags that were designed could be connected to such a database through, for example, the application of QR codes or RFID tags. Also experts that are invited to the library would build third level material information. Very specific

information and hard to reach details about materials would be transferred through this activity.

The tag design proposed in Chapter 6 (Figure 6-18 to 6-20) will now be evaluated for adoption on all samples to be housed in the Materials Experience Laboratory at METU.

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APPENDIX A

INFORMAL EVALUATION DOCUMENT FOR TAGS

Negative Comments

Link between tag and material

-TAG5 Sensorial information like smooth/rough are not the property of the material

-TAG6 Relative properties to other plastic is something different

-TAG7 Surface finishes should be on the tag

-TAG7 The properties should be constant according to the material and should not change from product to product

-TAG8 Sensorial information are not constant they change from produt to product

Layout

-TAG1 QR code should not be on the first side

-TAG4 Too big, physically

Understandability of Information

-TAG1 The paragraph which explains the material is too long

-TAG2 The keywords can also be in lickert scale

-TAG3 Problematic to have high or low graphic sometimes high is good sometimes low is good

-TAG5 Not enough information

-TAG6 On the corian page there are other materials, it is confusing

-TAG9 Having bar graph for properties is not accurate and useful

Images

-TAG2 No need to have the picture of the sample product as it is attached to the product

-TAG8 We do not need to see the picture of the product on the tag

Unnecessary information

-TAG1 No other product samples are needed

-TAG1 Tactual qualities are needed

-TAG3 Too much information about manufacturing processes

-TAG4 Too much technical property

-TAG6 Instead of competitors there should be similar materials

-TAG6 We are not really in the need of manufacturing process

-TAG7 Some keywords would be enough for specific properties

Others

-TAG7 We can relate the materials to usage scenarios

-TAG6 Information about competitors will change dung the time

Positive Comments

Right information choice

+TAG10 Linking with the product is also good, the usage of material

+TAG1 Bar graphics are good to use for technical properties

+TAG2 Good to have design-related keywords like recycle, sustainability, dangerous

+TAG7 Good to have finish properties

+TAG9 Reasons for choice is good

+TAG1 Small pictures of other product samples are good to see different usages

+TAG6 Manufacturing processes are clear

Layout

+TAG4 Good to see the color of the category

+TAG7 Good to have products and the text below

Others

+TAG10 Good to compare physically

APPENDIX B

ONLINE SURVEY FOR MATERIAL LIBRARIES

WELCOME/INTRODUCTION

Hello. My name is Fazil Akin and I am a Masters student in Industrial Design at Middle East Technical University (METU), Turkey. I am working on the material information needs of industrial design students. The outcome of my thesis will be used to help improve materials and design education, as well as the establishment of a materials library at METU.

This questionnaire seeks information about your own materials library. It will take approximately 10 minutes to complete and consists of 5 sections covering:

- background
- samples
- supplementary information
- your experience
- images of the library and accompanying resources

If you find you do not have an answer to a particular question, please just skip that question and move to the next one.

The data collected from this questionnaire will be used in my MS thesis. A complimentary copy of the thesis chapter showing cross-comparison of material libraries around the world will be provided to you as an appreciation of your participation.

Please tick the box to indicate your acceptance to participate. [BOX – I accept]

Thank you very much for the valuable informatıon and insights you will give!

YOUR CONTACT DETAILS

Name and Surname (e.g. Owain Pedgley)

Position / Job Title (e.g. Director of METU MX-Lab)

E-mail (e.g. pedgley@metu.edu.tr)

Telephone including international code (e.g. +90 312 2106296)

SECTION 1 – BACKGROUND

This section asks about the background to your materials library and the contact person.

Full name of your materials library (e.g. Materials Experience Lab)

Short name or acronym of your materials library (e.g. MX-Lab)

Location - City (e.g. Ankara)

Location - Country (e.g. Turkey)

Year of Establishment (e.g. 2013)

Website (e.g. http://id.metu.edu.tr)

Approximate Floor space (e.g. 60m2)

Operational basis

Commercial

Non-Profit Organization

Educational

Other - explain

Parent organization (e.g. Institute of Materials; Middle East Technical University)

Who are the target users for your materials library? Who can use it?

What were the main aims or purposes for establishing your materials library?

Single sentence 'strap line' to promote your material library, e.g. 'The first academic resource in Turkey where industrial design students can learn about everyday and unusual materials and their potential for application in products, encouraged by a hands-on approach to materials exploration.'

SECTION 2 – SAMPLES

This section asks about the samples contained in your materials library.

Please list the material families that are included in your library (e.g. metals, ceramics, plastics, smart materials)

Approximately how many samples does your library contain? (e.g. 100, 2000, 5000)

Please indicate the approximate proportion of samples from the following two categories.

Material supplier samples, swatches etc. *xx%*

Product examples using specific materials *xx%*

Does your sample collection have emphasis on a particular branch of design practice? (e.g. architecture, interior, product, fashion)

What sort of categorization system do you use to organize the samples? (e.g. based on material family, based on material properties, based on themes such as low carbon footprint)

How accessible are samples to library visitors? (e.g. freely available to handle, mounted on a wall, inside locked cabinets)

SECTION 3 – SUPPLEMENTARY RESOURCES

Material samples allow visitors to directly experience material properties. But often it is necessary to access numerical data and other information about a material to fully understand its properties and uses. This section asks about the supplementary resources you provide.

Please indicate which of the following supplementary resources you include in your library.

Catalogues / data sheets (from material suppliers) *Yes/No*

Material description sheets / panels (produced in-house) *Yes/No*

Sample tags or stickers (produced in-house and physically attached to each sample) *Yes/No*

Searchable computer database of samples (produced in-house) *Yes/No*

Intranet / Internet hub for sample collection (produced in-house) *Yes/No*

Other - explain

If you produce supplementary resources in-house, please describe the kind of information that they contain and briefly explain the rationale for their design.

SECTION 4 – PARTICIPANTS' EXPERIENCE

With hindsight, if you think back upon your experiences in setting-up and running your materials library, can you identify anything that you would do differently now if you had a chance to start again?

Can you tell anything about your plans for developing your materials library in the coming years?

SECTION 5 – IMAGES OF YOUR MATERIALS LIBRARY

This section asks if you would kindly supply some high-resolution images of your materials library and its supplementary resources. The size limit per attachment is 5MB.

Please supply an image showing an interior overall view of your materials library. (ATTACH FILE NEEDED)

Please supply an image showing how you typically store or display your samples. (ATTACH FILE NEEDED)

If applicable, please supply an image (preferably PDF) showing your in-house material description sheets / panels. (ATTACH FILE NEEDED)

If applicable, please supply an image (preferably PDF) showing your in-house sample tagging system. (ATTACH FILE NEEDED)

This marks the end of the questionnaire. However, if you would like to volunteer any further information about your material library, or material libraries in general, please use the space below.

MANY THANKS FOR YOUR PARTICIPATION!

SUBMIT

CONFIRMATION PAGE

APPENDIX C

RAW DATA FROM THE QUESTIONNAIRE WITH STUDENTS

Table C 1 Rating of the students for tag 1

PARTICIPANT NUMBER	IV1: informative	IV2: understandable	IV3: relevant to you needs	IV4: attractive graphics	IV5: inspirational for mat. select. in
P 1	5	4	5	4	5
P 2	5	4	5	3	5
P 3	5	5	4	5	5
P 4	4	5	5	4	5
P 5	5	5	4	5	5
P 6	5	5	5	4	5
P 7	5	4	5	4	5
P 8	5	4	4	4	5
P 9	4	4	4	5	5
P 10	5	5	4	4	4
P 11	4	5	4	3	4
P 12	5	4	5	4	5
P 13	5	5	5	3	5
P 14	5	4	4	3	3
P 15	5	4	5	3	5
P 16	4	4	4	3	4
P 17	5	4	5	5	5
P 18	4	4	4	3	3
P 19	4	4	4	3	4
P 20	3	4	4	3	3
P 21	5	4	5	4	5
P 22	5	5	5	3	5
P 23	4	5	4	3	4
P 24	5	5	3	3	4
P 25	5	5	5	4	4
P 26	3	4	2	3	2
P 27	3	5	3	3	3
P 28	3	3	2	2	2
P 29	4	3	3	5	3
P 30	4	5	4	2	3
P 31	3	3	4	2	3
P 32	4	3	4	3	3
P 33	3	5	5	4	4
P 34	4	5	4	5	3
P 35	4	4	3	3	4
P 36	4	5	4	4	4
MEAN	**4.31**	**4.33**	**4.14**	**3.56**	**4.06**
STANDARD DEV	**0.75**	**0.68**	**0.83**	**0.88**	**0.95**
OVERALL MEAN					**4.08**

Table C 2 Rating of the students for tag 2

	TAG 2				
PARTICIPANT NUMBER	**IV1: informative**	**IV2: understandable**	**IV3: relevant to you needs**	**IV4: attractive graphics**	**IV5: inspirational for mat. Select. In ID**
P 1	4	3	4	2	5
P 2	4	4	4	3	4
P 3	5	5	4	5	4
P 4	3	4	4	4	3
P 5	4	5	5	3	4
P 6	5	5	5	4	5
P 7	3	3	3	4	4
P 8	3	3	3	4	4
P 9	3	3	3	3	3
P 10	4	2	2	3	2
P 11	3	3	3	4	3
P 12	4	4	3	4	4
P 13	4	3	4	3	3
P 14	5	4	4	3	3
P 15	5	5	5	5	5
P 16	5	5	4	5	4
P 17	5	5	5	4	4
P 18	4	4	4	3	4
P 19	5	3	4	3	4
P 20	4	4	5	4	4
P 21	5	4	4	3	4
P 22	4	4	4	4	4
P 23	4	4	4	4	5
P 24	4	4	4	5	5
P 25	4	4	3	3	4
P 26	3	2	3	2	2
P 27	4	4	5	4	3
P 28	4	4	4	3	3
P 29	4	3	4	4	3
P 30	4	4	3	3	4
P 31	5	5	5	3	5
P 32	4	4	4	4	4
P 33	4	4	5	3	3
P 34	5	4	4	4	3
P 35	4	5	4	3	4
P 36	4	4	4	3	4
MEAN	**4.11**	**3.89**	**3.94**	**3.56**	**3.78**
STANDARD DEV	**0.67**	**0.82**	**0.75**	**0.77**	**0.80**
OVERALL MEAN					**3.86**

Table C 3 Rating of the students for tag 3

	TAG 3				
PARTICIPANT NUMBER	**IV1: informative**	**IV2: understandable**	**IV3: relevant to you needs**	**IV4: attractive graphics**	**IV5: inspirational for mat. Select. In ID**
P 1	3	3	4	3	5
P 2	3	3	4	5	4
P 3	4	5	4	5	5
P 4	4	4	4	4	4
P 5	5	5	5	5	5
P 6	4	5	5	5	5
P 7	3	3	4	5	4
P 8	4	5	5	5	5
P 9	4	4	4	5	4
P 10	5	4	5	5	5
P 11	4	5	4	4	4
P 12	3	3	3	5	4
P 13	5	3	4	4	5
P 14	5	4	5	4	4
P 15	5	5	5	4	4
P 16	4	4	4	2	3
P 17	5	4	5	5	4
P 18	4	4	4	3	4
P 19	5	3	4	3	4
P 20	4	3	4	4	3
P 21	4	3	4	5	3
P 22	5	5	5	3	5
P 23	5	5	5	5	5
P 24	5	5	5	5	5
P 25	5	5	5	4	5
P 26	5	4	4	4	4
P 27	4	5	3	4	3
P 28	4	5	5	4	5
P 29	4	5	4	5	4
P 30	4	5	4	4	3
P 31	5	5	4	3	3
P 32	4	5	4	4	4
P 33	3	4	4	5	4
P 34	3	3	4	3	3
P 35	4	3	3	4	3
P 36	3	4	4	4	3
MEAN	**4.17**	**4.17**	**4.25**	**4.19**	**4.08**
STANDARD DEV	**0.74**	**0.85**	**0.60**	**0.82**	**0.77**
OVERALL MEAN					**4.17**

Table C 4 Rating of the students for tag 4

	TAG 4				
PARTICIPANT NUMBER	**IV1: informative**	**IV2: understandable**	**IV3: relevant to you needs**	**IV4: attractive graphics**	**IV5: inspirational for mat. Select. In ID**
P 1	5	5	5	5	5
P 2	5	5	5	5	5
P 3	5	4	4	5	5
P 4	4	4	4	5	4
P 5	5	5	4	5	4
P 6	3	3	5	5	5
P 7	5	5	5	5	5
P 8	4	5	5	5	5
P 9	5	5	5	5	5
P 10	5	5	5	5	5
P 11	4	5	4	4	4
P 12	5	5	5	5	5
P 13	4	4	4	4	4
P 14	4	4	5	5	5
P 15	4	3	3	3	4
P 16	4	1	4	1	1
P 17	5	5	5	4	5
P 18	4	3	4	5	3
P 19	4	3	4	3	3
P 20	5	5	5	3	4
P 21	4	2	3	5	4
P 22	5	5	5	5	5
P 23	5	4	5	5	4
P 24	5	5	4	5	4
P 25	5	4	5	5	4
P 26	5	3	3	4	3
P 27	4	2	2	2	3
P 28	5	5	5	5	4
P 29	4	3	4	2	2
P 30	5	4	5	5	4
P 31	5	4	4	4	4
P 32	5	4	3	5	4
P 33	5	4	5	4	5
P 34	5	4	5	5	3
P 35	4	5	5	5	5
P 36	5	4	5	5	4
MEAN	**4.58**	**4.06**	**4.39**	**4.39**	**4.11**
STANDARD DEV	**0.55**	**1.04**	**0.80**	**1.05**	**0.95**
OVERALL MEAN					**4.31**

Table C 5 Rating of the students for tag 5

	TAG 5				
PARTICIPANT NUMBER	**IV1: informative**	**IV2: understandable**	**IV3: relevant to you needs**	**IV4: attractive graphics**	**IV5: inspirational for mat. select. in ID**
P 1	2	1	2	1	5
P 2	1	1	1	5	1
P 3	3	4	3	3	3
P 4	2	1	2	3	2
P 5	2	4	3	2	2
P 6	2	3	2	3	2
P 7	1	1	2	1	3
P 8	2	2	2	2	2
P 9	2	3	2	1	2
P 10	2	1	1	1	1
P 11	3	5	3	3	2
P 12	1	1	2	1	2
P 13	1	2	1	3	1
P 14	2	2	2	5	3
P 15	2	4	2	2	2
P 16	1	3	2	3	2
P 17	2	4	2	3	2
P 18	3	3	4	3	3
P 19	3	3	4	4	4
P 20	4	3	4	4	4
P 21	3	4	4	4	4
P 22	3	5	3	1	2
P 23	3	5	3	4	5
P 24	3	4	3	2	2
P 25	3	3	3	2	3
P 26	1	3	2	1	1
P 27	2	4	3	5	4
P 28	3	2	3	2	2
P 29	1	2	2	1	1
P 30	2	2	1	1	2
P 31	1	1	1	2	1
P 32	2	1	3	1	2
P 33	1	2	2	1	1
P 34	2	1	1	1	1
P 35	2	2	2	2	1
P 36	2	2	2	1	1
MEAN	**2.08**	**2.61**	**2.33**	**2.33**	**2.25**
STANDARD DEV	**0.81**	**1.29**	**0.89**	**1.31**	**1.16**
OVERALL MEAN					**2.32**

Table C 6 Rating of the students for tag

	TAG 6				
PARTICIPANT NUMBER	**IV1: informative**	**IV2: understandable**	**IV3: relevant to you needs**	**IV4: attractive graphics**	**IV5: inspirational for mat. select. in ID**
P 1	2	1	3	1	5
P 2	3	4	3	5	3
P 3	3	3	3	3	3
P 4	3	2	3	3	2
P 5	3	2	3	2	3
P 6	3	3	3	2	3
P 7	3	2	3	2	4
P 8	4	4	3	3	3
P 9	4	4	3	3	4
P 10	4	3	3	2	3
P 11	4	3	3	4	3
P 12	3	2	3	1	3
P 13	3	5	3	4	3
P 14	3	2	3	3	3
P 15	5	3	4	2	3
P 16	4	2	3	1	1
P 17	4	4	3	2	1
P 18	5	5	5	2	5
P 19	5	5	5	3	4
P 20	5	5	5	3	4
P 21	5	5	5	2	4
P 22	5	3	5	4	5
P 23	4	1	4	5	5
P 24	4	1	4	2	3
P 25	4	2	4	3	5
P 26	4	1	3	3	3
P 27	4	3	4	5	4
P 28	2	1	2	1	2
P 29	3	1	3	3	3
P 30	3	3	3	3	2
P 31	3	2	2	1	1
P 32	4	2	4	2	5
P 33	4	2	4	2	2
P 34	3	2	3	1	1
P 35	3	3	3	1	2
P 36	3	3	3	1	2
MEAN	**3.64**	**2.75**	**3.42**	**2.50**	**3.11**
STANDARD DEV	**0.83**	**1.27**	**0.81**	**1.18**	**1.21**
OVERALL MEAN					**3.08**

Table C 7 Rating of the students for tag 7

	TAG 7				
PARTICIPANT NUMBER	**informative**	**understandable**	**relevant to you needs**	**attractive graphics**	**inspirational for mat. Select. In ID**
P 1	5	5	5	5	5
P 2	5	5	4	4	4
P 3	5	5	5	5	5
P 4	5	5	4	4	5
P 5	5	5	4	3	3
P 6	5	5	5	5	5
P 7	4	4	4	5	5
P 8	5	5	5	4	5
P 9	5	5	5	4	5
P 10	5	5	5	4	4
P 11	5	5	5	5	5
P 12	5	5	5	5	5
P 13	4	5	4	4	5
P 14	5	4	4	3	4
P 15	5	5	5	3	4
P 16	4	4	4	3	4
P 17	5	5	5	4	4
P 18	5	5	5	3	5
P 19	4	3	4	2	3
P 20	5	4	4	3	4
P 21	4	4	4	3	4
P 22	5	5	5	2	4
P 23	5	5	5	2	4
P 24	5	5	5	3	4
P 25	5	5	5	1	4
P 26	5	5	4	3	4
P 27	5	5	4	5	5
P 28	3	4	3	2	2
P 29	5	5	5	4	5
P 30	5	5	4	3	4
P 31	5	5	4	3	4
P 32	5	5	4	3	4
P 33	3	4	5	5	4
P 34	4	5	5	5	3
P 35	4	5	5	4	4
P 36	4	5	4	4	4
MEAN	**4.67**	**4.75**	**4.50**	**3.61**	**4.22**
STANDARD DEV	**0.59**	**0.50**	**0.56**	**1.08**	**0.72**
OVERALL MEAN					**4.35**

Table C 8 Rating of the students for tag

	TAG 8				
PARTICIPANT NUMBER	**informative**	**understandable**	**relevant to you needs**	**attractive graphics**	**inspirational for mat. select. in ID**
P 1	1	1	2	3	5
P 2	1	1	1	5	1
P 3	2	3	2	5	3
P 4	1	1	1	4	1
P 5	2	3	3	5	5
P 6	1	3	3	5	3
P 7	2	1	3	1	3
P 8	1	1	2	2	1
P 9	3	2	2	2	2
P 10	1	1	1	2	1
P 11	1	1	1	1	1
P 12	2	1	3	1	3
P 13	1	1	1	4	1
P 14	2	2	3	3	3
P 15	3	2	4	4	2
P 16	2	2	2	2	2
P 17	3	2	2	2	2
P 18	2	1	2	1	1
P 19	2	1	2	1	2
P 20	2	1	3	3	2
P 21	2	1	3	3	2
P 22	3	2	2	2	2
P 23	2	2	2	3	2
P 24	2	3	2	1	2
P 25	2	1	2	2	2
P 26	2	2	2	4	3
P 27	2	5	3	4	4
P 28	1	4	3	3	1
P 29	3	2	3	5	4
P 30	2	1	2	2	1
P 31	2	1			1
P 32	3	3	4	2	2
P 33	1	2	2	1	1
P 34	2	2	2	2	1
P 35	1	2	3	2	1
P 36	2	1	2	1	1
MEAN	**1.86**	**1.81**	**2.29**	**2.66**	**2.06**
STANDARD DEV	**0.68**	**0.98**	**0.79**	**1.37**	**1.15**
OVERALL MEAN					**2.13**

Table C 9 Rating of the students for tag 9

	TAG 9				
PARTICIPANT NUMBER	**informative**	**understandable**	**relevant to you needs**	**attractive graphics**	**inspirational for mat. select. in ID**
P 1	4	4	5	4	5
P 2	3	3	3	2	4
P 3	4	5	4	5	4
P 4	4	4	4	2	3
P 5	4	4	5	5	4
P 6	4	5	5	4	4
P 7	4	4	5	4	5
P 8	3	3	3	2	3
P 9	4	4	4	3	4
P 10	4	3	3	3	3
P 11	4	4	4	2	4
P 12	4	4	5	4	5
P 13	3	4	3	2	3
P 14	4	4	5	3	4
P 15	4	5	5	4	5
P 16	4	3	4	3	4
P 17	4	3	5	4	4
P 18	3	4		1	
P 19	4	4	4	3	3
P 20	4	4	4	1	5
P 21	4	4	4	2	3
P 22	5	5	5	2	5
P 23	3	4	4	1	2
P 24	4	4	3	3	4
P 25	5	4	5	1	4
P 26	2	3	2	2	2
P 27	3	3	3	2	3
P 28	3	2	1	1	1
P 29	3	2	3	2	2
P 30	4	4	4	2	3
P 31	4	4		2	2
P 32	4	4	4	2	3
P 33	2	2		3	1
P 34	2	2	2	1	1
P 35	2	2	2	1	1
P 36	3	2	3	1	2
MEAN	**3.58**	**3.58**	**3.79**	**2.47**	**3.29**
STANDARD DEV	**0.77**	**0.91**	**1.08**	**1.18**	**1.25**
OVERALL MEAN					**3.34**

Table C 10 Rating of the students for tag 10

	TAG 10				
PARTICIPANT NUMBER	**informative**	**understandable**	**relevant to you needs**	**attractive graphics**	**inspirational for mat. select. in ID**
P 1	5	5	5	2	5
P 2	4	4	5	5	5
P 3	4	4	4	5	4
P 4	4	4	4	4	4
P 5	5	3	5	5	4
P 6	4	4	3	4	3
P 7	5	5	4	2	4
P 8	4	5	4	4	4
P 9	5	5	4	4	4
P 10	5	4	4	5	4
P 11	4	4	5	5	4
P 12	5	5	4	2	4
P 13	5	5	5	3	5
P 14	5	2	4	4	4
P 15	5	2	3	2	2
P 16	4	2	2	2	2
P 17	5	3	5	4	4
P 18	3	5	3	5	4
P 19	4	3	4	4	4
P 20	4	3	4	3	3
P 21	4	4	4	5	4
P 22	5	3	3	2	3
P 23	5	3	4	3	5
P 24	4	3	3	2	3
P 25	5	3	4	5	5
P 26	5	5	3	2	
P 27	4	4	4	5	4
P 28	5	5	3	4	2
P 29	5	5	4	2	3
P 30	4	4	4	3	3
P 31	4	4	5	3	4
P 32	5	3	3	5	4
P 33	3	3	5	5	4
P 34	4	4	4	4	2
P 35	4	3	4	3	2
P 36	3	3	3	2	2
MEAN	**4.39**	**3.78**	**3.92**	**3.58**	**3.63**
STANDARD DEV	**0.64**	**0.96**	**0.77**	**1.20**	**0.94**
OVERALL MEAN					**3.86**

Table C 11 Mean grade of tags and favourite tag(s) of each participant

PARTICIPANT NUMBER	tag1 individual participant mean grade	tag2 individual participant mean grade	tag3 individual participant mean grade	tag4 individual participant mean grade	tag5 individual participant mean grade	tag6 individual participant mean grade	tag7 individual participant mean grade	tag8 individual participant mean grade	tag9 individual participant mean grade	tag10 individual participant mean grade	IDENTIFICATION OF FAVOURITE TAG(S)		
1	3.25	4.25	5	2.2	1.75	5	3	3.5	4.5	4.4	4	7	
2	3.25	4.5	5	1.8	3.75	4.25	2.5	2.5	3	4.6	4	7	
3	4.5	4.75	4.5	3.2	3	4.5	3.75	3.5	4.5	4.2	7		
4	3.75	4	4.25	2	2.75	4	2.75	2.5	3.25	4	1	7	
5	4.25	5	4.5	2.6	2.5	4.25	2.75	4.25	4.5	4.4	1		
6	4.5	4.5	4.5	2.4	2.75	4.5	3.5	3.75	4.5	3.6	7		
7	3.5	4.5	5	1.6	2.5	4	3.25	2.75	4.5	4	4		
8	4.25	4.75	5	2	3.5	4.5	2.75	2	2.75	4.2	3	4	7
9	3.5	4.5	5	2	3.5	4.75	3.5	2.5	3.75	4.4	7		
10	3.5	5	5	1.2	3	4.5	2.5	2	3	4.4	4		
11	4	4	4.25	3.2	3.5	4.5	3	1.75	3.5	4.4	7		
12	3.5	4.25	5	1.4	2.25	4.5	3.25	2.75	4.5	4	4	7	
13	3.5	4.25	4	1.6	3.75	4	2.75	2.25	3	4.6	1	10	
14	3.75	4.25	4.75	2.8	2.75	4	2.75	3.25	4	3.8	4		
15	5	4.25	3.25	2.4	3.5	4.5	3	3.5	4.75	2.8	3	9	
16	4.25	3.25	1.75	2.2	2.5	3.25	2.75	2.5	3.5	2.4	2		
17	4.25	4.75	4.75	2.6	3.25	4	3.25	2.5	4	4.2	1	4	
18	3.75	3.75	3.75	3.2	4.25	5	2.75	1.75	2.5	4	6		
19	3.75	3.75	3.25	3.6	4.5	3.75	2	2.25	3.5	3.8	7		
20	3.75	4	4.25	3.8	4.5	4.25	2.5	3	3.5	3.4	4	7	
21	3.5	4	3.5	3.8	4.25	4	2.5	3	3.25	4.2	1		
22	4.5	4.5	5	2.8	4.25	5	2.75	2.75	4.25	3.2	1	3	
23	4.75	5	4.5	4	3.5	5	2.5	2.5	2.75	4	4		
24	5	5	4.5	2.8	2.75	4.5	3	2.25	3.5	3	4		
25	4.25	4.75	4.5	2.8	3.25	5	2	2.75	3.5	4.4	1	4	
26	3.25	4.25	3.25	1.6	2.75	4.25	2.75	2.75	2.25	3.75	3	7	
27	4	3.5	2.25	3.6	4	4.5	4.25	3.5	2.75	4.2	7		
28	3.75	4.75	4.75	2.4	1.5	3	2.25	2.5	1.25	3.8	4		
29	4	4.25	2.75	1.4	2.5	4.5	3.5	3.75	2.25	3.8	7		
30	4	4	4.5	1.6	3	4	2.5	2.25	3.25	3.6	4		
31	4.5	3.75	4	1.2	2	3.75	2.5	2.5	2.67	4	2		
32	4.25	4.25	4	1.8	3	4.75	3.25	3	3.25	4	3	4	7
33	3.25	4.5	4.5	1.4	3	3.5	3	1.5	2	4	4		
34	3.25	3.75	4.25	1.2	2.25	3.75	3	1.75	1.5	3.6	4	7	
35	3.5	3.5	5	1.8	2.5	4	2.75	2	1.5	3.2	4		
36	3.5	4	4.5	1.6	2.5	3.75	2.75	1.75	2	2.6	4		
Mean	3.92	4.28	4.24	2.32	3.08	4.26	2.88	2.65	3.28	3.86			

Table C 12 Rank of tags

TEST 1.	**Define the Overall Rank Order of Tags**			
	Data sourced directly from spreadsheet.			
	Rank	**Tag ID**	**Overall Mean**	
	1st Rank	Tag 7	4.35	
	2nd Rank	Tag 4	4.31	
	3rd Rank	Tag 3	4.17	
	4th Rank	Tag 1	4.08	
	5th Rank	Tag 2	3.86	
	6th Rank	Tag 10	3.86	
	7th Rank	Tag 9	3.34	
	8th Rank	Tag 6	3.08	
	9th Rank	Tag 5	2.32	
	10th Rank	Tag 8	2.13	

Table C 13 Paired T-Test Results

TEST 2.	**Check for Significant Differences Between Tag Overall Means**			
	Paired T-Test			**alpha=0.05**
	Data sourced from spreadsheet, input into online tool: http://www.graphpad.com/quickcalcs/ttest2			
	Rank Pair	**Tags**	**p-value**	**Result**
	1st-2nd	Tag7-Tag4	p=0.8608	No significant difference
	1st-3rd	Tag7-Tag3	p=0.4357	No significant difference
	1st-4th	Tag7-Tag1	p=0.0186	Significant difference
	10th-9th	Tag8-Tag5	p=0.4949	No significant difference
	10th-8th	Tag8-Tag6	p=0.1061	No significant difference
	10th-7th	Tag8-Tag9	p=0.0290	Significant difference

Table C- 14 1-Way ANOVA and Post-Hoc Tukey HSD Results

TEST 3.	**Check for Significant Differences Between 5-Criteria Grading for Each Tag**			
	1-Way ANOVA and Post-Hoc Tukey HSD			**alpha=0.05**
	Data sourced from spreadsheet, input into online tool: http://vassarstats.net/anova1u.html			
	Source	**Groups**	**p-value**	**Result**
	Tag 1	IV1 - IV5	p=0.000529	Significant differences: IV1 vs IV4; IV2 vs IV4; IV3 vs IV4
	Tag 2	IV1 - IV5	p=0.036059	Significant differences: IV1 vs IV4
	Tag 3	IV1 - IV5	p=0.921265	No significant differences
	Tag 4	IV1 - IV5	p=0.079045	No significant differences
	Tag 5	IV1 - IV5	p=0.377911	No significant differences
	Tag 6	IV1 - IV5	p<0.0001	Significant differences: IV1 vs IV2; IV1 vs IV4; IV3 vs IV4
	Tag 7	IV1 - IV5	p<0.0001	Significant differences: IV1 vs IV4; IV2 vs IV4; IV2 vs IV5; IV3 vs IV4; IV4 vs IV5
	Tag 8	IV1 - IV5	p=0.003361	Significant differences: IV1 vs IV4; IV2 vs IV4
	Tag 9	IV1 - IV5	p<0.0001	Significant differences: IV1 vs IV4; IV2 vs IV4; IV3 vs IV4; IV4 vs IV5
	Tag 10	IV1 - IV5	p=0.002057	Significant differences: IV1 vs IV4; IV1 vs IV5

APPENDIX D

COMMENTS PART OF THE STUDENTS' QUESTIONNAIRE

Table D-1 Comments for tag 1

TAG 1		
TAG ATTRIBUTE	**LIKE**	**DISLIKE**
Inclusion of comparison chart with other materials *+ve = 11* *-ve = 0* ***overall = 11***	• Comparison with pp –p28 • Common uses, comparing chart –p25 • Comparing chart –p22 • comparison with other materials –p15 • That the material is compared with other similar materials/ production methods –p13 • seeing alternative materials is nice –p12 • The comparison with PP (it gives the designer a scale) –p6 • Comparison with other materials is very useable –p5 • comparison with other materials –p4 • Chart is very good about comparison –p3 • Bulk properties chart is very good –p24	
Inclusion of similar materials part *+ve = 9* *-ve = 0* ***overall = 9***	• Similar Materials part –p36 • Similar materials part –p35 • Similar materials –p34 –p33 • Similar materials (but in which way ?) –p31 • Similar materials are helpful –p19 • Similar materials part and common uses –p18 • Similar materials part and star attribute part –p1 • Similar materials –p15 • similar materials, -p4	
Inclusion of IMAGES of other applications / products *+ve = 5* *-ve = 0* ***overall = 5***	• Sample pictures –p20 • Different product examples –p16 • other applications, picture –p4 • different applications are shown on tag –p14 • Exhibiting alternative materials –p7	

Table D-1 (Continued)

Inclusion of star attribute section *+ve = 3* *-ve = 0* ***overall = 3***	• Star attribute part is nice –p12 • star attribute, -p4 • showing star attribute of the material –p7	
Overall attractiveness /graphics *+ve = 5* *-ve = -3* ***overall = 2***	• Look like ID card –p32 • Placement of logo and barcode-p14 • Design of the tag –p9 • The graphic star attribute –p8 • Its effectiveness despite being small, various images, the front –p17	• Layout –p4 • not attractive –p29 • Hard to read –p32
Overall clarity and understandability *+ve = 3* *-ve = -2* ***overall = 1***	• Simplicity –p29 • It's simplicity –p27 • Simple –p26 •	• It is not understandable because of organization and size –p14 • hard to understand –p16
Size of IMAGES of other applications / products *+ve = 0* *-ve = -2* ***overall = -2***		• Photos at the back too small –p2 • Photos are not useful as they are small –p18
Inclusion of a descriptive prargraph *+ve = 0* *-ve = -2* ***overall = -2***		• Paragraph part is not attractive as graph –p3 • The short paragraph, instead of it may be a nice graph –p6
Colour scheme *+ve = 0* *-ve = -2* ***overall = -2***		• the colour of the graphics are not good with each other –p13 • Colours –p23

Table D-1 (Continued)

Sufficiency of information *+ve = 3* *-ve = -5* ***overall = -2***	• Good general information about material –p21 • Compact include necessary information comparing –p2 • Production methods –p10	• There are not enough information –p27 • it should give information about price –p8 • We do not know anything about example product –p5 • more details are added relating to its cost compare to other materials such as PP –p9 • bulk properties values are inefficient, -p16
Fontsize of the Material's name *+ve = 0* *-ve = -3* ***overall = -3***		• The name of the material should be bigger –p34 • The name of the material must be on the top –p33 • Very small, the name of the material is not eye-catching at the bottom –p31
Understandiblity of the graphs/ratings *+ve = 0* *-ve = -5* ***overall = -5***		• the grading system (what does PP stand for?) –p17 • PP in the graphic is confusing and not easy to understand –p7 • I can't understand PP in the chart –p1 • "PP" in the graphics is not quite understandable –p12 • The rating scale is not clear –p15
Tag size /shape *+ve = 2* *-ve = -10* ***overall = -8***	• Size –p4 • Compact include necessary information comparing –p2	• The size of the tag is small –p36 • Too small -p35 • The card may be bigger –p34 • Very small size, card size –p28 • Size –p25 • Too small –p24 • Its being extremely small. –p17 • Too small –p29 • The card is a bit too small, -p13 • Too small-p16

Table D- 2 Comments for tag 2

TAG 2		
TAG ATTRIBUTE	**LIKE**	**DISLIKE**
Inclusion of warning part *+ve = 9* *-ve = 0* ***overall = 9***	• warnings part -p36 • Warning about material -p35 • The warning part -p18 • Warning parts -p14 • Warning about the health risk -p12 -p7 • Warning -p1 • The warning -p6 • Warning -p3 • warning part is good -p5	
Sufficiency of information *+ve = 8* *-ve = -1* ***overall = 7***	• showing the label "3" -p12 -p7 • Label 3 -p33 • Infos are very good, supplier info, price by kg/$ -p31 • the supplier -p18 • Wide range of information -p15 • Units are very informative -p5 • Common consumer product info -p2 • Supplier information -p25	• more product examples with bigger pictures -p16
Inclusion of numerical values in the charts *+ve = 4* *-ve = 0* ***overall = 4***	• numerical values and units given in the graphs -p6 • numerical values given in the graph are very good -p3 • The numerical showing of rating products -p20 • numerical rating -p18	
Inclusion of graph representation / grading of material properties *+ve = 3* *-ve = 0* ***overall = 3***	• rating system graphics -p14 • The grading system -p17 • Bulk properties chart -p27	
Colour scheme *+ve = 3* *-ve = 0* ***overall = 3***	• Contrast colours, colourfulness of card -p34 • Colourful graphics -p24 • Colours -p4	
Overall attractiveness /graphics *+ve = 3* *-ve = 0* ***overall = 3***	• the logo is good -p18 • graphics is so charming, distractive -p3 • Additional information is attractive -p19	

Table D-2 (continued)

Inclusion of common uses part *+ve = 1* *-ve = 0* ***overall = 1***	• Common-uses part -p36	
Overall clarity and understandability *+ve = 1* *-ve = 0* ***overall = 1***	• The organization of the tag, simplicity -p16	
Appropriate size/shape *+ve = 1* *-ve = 0* ***overall = 1***	• perfect size -p16	
Usage of the shortening "N/A" *+ve = 0* *-ve = -3* ***overall = -3***		• what is "N/A" -p12 • Supplementary finishing process is not easy to understand -p7 • what is N/A ? -p1
Organization of the information *+ve = 1* *-ve = -7* ***overall = -6***	• Properties are grouped -p21	• The hierarchy of the information -p36 • Hierarchy of list -p35 • Charts of bulk and surface properties -p29 • there are a lot of information but they are not that understandable because of the long sentences -p13 • Confused, intrinsic, classification of information is not decent to understand -p9 • application could have written under a new title why this material -p4 • Suppliers and addresses are not very necessary. It could be smaller and at the bottom -p34

Table D-2 (continued)

Readability of the text *+ve = 0* *-ve = -19* ***overall = -19***		• In properties part the black text cannot be read. -p34 • Hierarchy of info and colors of the text is difficult to read -p33 • Blue colour makes it hard to read -p32 • Text and font colours (hard to read) -p28 • Text and font colours, suitability black letters on dark blue -p27 • Text and font colours -p26 • Black font in dark blue background -p21 • Properties written in black is hard to read -p19 • Black fonts in dark blue -p18 • The black coloured font on dark background, -p16 • Because of the color choice it is not easy to read -p15 • The writing could not be read because of the colour selection, -p13 • Wrong colour choice in graphic, -p12 • wrong colour choice in the graphics. -p7 • blue tones of graphics are so dark, it makes hard to differentiate the texts. -p6 • blackwriting on the blue surface is not understandable -p5 • black on blue background is unreadable -p4 • black letters on blue background -p2 • graphic background is too dark, -p1

Table D- 3 Comments for tag 3

TAG 3		
TAG ATTRIBUTE	**LIKE**	**DISLIKE**
Inclusion of product application part *+ve = 8* *-ve = -1* ***overall = 7***	• Product application -p25 • Product application chart is very good -p24 • Product applications are helpful -p19 • Product applications section -p17 • Product applications chart -p16 • Product applications -p10 • Product applications part is very attractive -p5 • Product application graph is very good -p3	• That it indicates where to use it. Labels should not guide where to use it -p27
Overall attractiveness /graphics *+ve = 5* *-ve = 0* ***overall = 5***	• layout -p23 • Graphic design -p29 • Images in graphic, -p12 • Images in graphic, -p7 • Visual usage place -p26	
Inclusion of selection reasons section *+ve = 4* *-ve = 0* ***overall = 4***	• Selection reasons -p18 • Selection reasons -p2 • selection reasons -p12 • selection reasons -p7	
Inclusion of ICONS in product application part *+ve = 7* *-ve = -3* ***overall = 4***	• The icons of product application -p32 • icons -p23 • More product applications are enabled to be shown because of used graphics -p21 • The icons that shows product application -p15 • Graphics in product applications part -p14 • The template and product applications graph -p6 • Images in production applications -p8	• icons are not good idea in applications -p18 • Product application symbols not clear, -p2 • Product applications icons are not clear. -p33
Organisation of the information *+ve = 3* *-ve = -1* ***overall = 2***	• Categorization -p36 • Categorize the properties -p35 • Order of the information is useful -p31	• Processes should be at the middle. Right side is blank. -p34
Appropriate size/shape *+ve = 0* *-ve = -1* ***overall = -1***		• small paper size -p28

Table D-3 (continued)

Sufficiency of information *+ve = 3* *-ve = -4* ***overall = -1***	• That it shows other manufacturing/finishing methods shows strong and weak sides separately -p13 • Selection reasons, product applications, general shaping/finishing processes -p4	• Lack of info about price -p32 • There is not enough info about price of the material and where it can be found generally , -p31 • Product applications should be more informative -p30 • Some information should be added such as thermal resistance… -p9
Tag material durability and appropriateness *+ve = 0* *-ve = -2* ***overall = -2***		• material is not durable -p33 • Small paper size, -p29
Colour scheme *+ve = 1* *-ve = -5* ***overall = -4***	• Colours -p23	• Colors are used unnecessarily. Processes should be at the middle. Right side is blank. -p34 • Bulk properties are so colorfull, -p33 • The colour coding -p17 • bulk properties' colors doesn't look like o.k. -p31 • Colours do not mean anything in bulk properties part -p14
Overall clarity and understandability *+ve = 1* *-ve = -8* ***overall = -7***	• Easy to understand/product application section -p28	• High-low graphics are not separated well -p26 • it is sometimes not easy to understand which shapes define which product on applications parts -p13 • Colour codes are confusing, -p12 • there is written "surface finish process" but no processes written below on the front page -p12 • Colours in bulk properties is confusing and it can not explain the surface finishing processes even if it show -p7 • some pictures need extra explanation -p4 • colours are confusing. -p1 • In graphics I can't understand the material used part of the product -p1

Table D-3 (continued)

Inclusion of High-Low chart for Bulk Properties *+ve = 2* *-ve = -17* ***overall = -15***	• High-low chart -p27 • High or low bulk properties are new, clearly showed when compared others -p22	• Degree of high and low -p35 • It cannot be informed how high or low the bulk properties are -p21 • High and low part in bulk properties (should be rate), -p18 • There is no rating grade -p15 • It say high and low but does not show how much, -p13 • High /low separation is not enough to understand where t stands, -p4 • Bulk properties part -p36 • Bulk properties are not informative enough -p8 • The absence of numerical values in the bulk properties. -p6 • Bulk properties part is not totally informative -p5 • The absence of numerical values in the bulk properties -p3 • lack of ranking in bulk properties -p2 • high-low part confusing -p29 • In bulk properties part it should use more clear comparison -p20 • Bulk properties are hard to compare with each other -p19 • Bulk properties are not easy to understand, -p1 • Bulk properties chart, too many without meaning is used -p16

Table D- 4 Comments for tag 4

TAG 4		
TAG ATTRIBUTE	**LIKE**	**DISLIKE**
Overall attractiveness /graphics *+ve = 9* *-ve = 0* ***overall = 9***	• Graphics are very attractive -p5 • Graphics -p1 • Graphics -p12 • The graphics -p10 • Graphics -p23 • Layout size and colours -p22 • Graphics are very good, colours can be better -p18 • Layout -p25 • Attractiveness, -p33	
Inclusion of IMAGES (of both raw material and the product) *+ve = 8* *-ve = -1* ***overall = 7***	• There are pictures of the material and the product at the same time -p29 • easy to see photographs -p28 • Image of the raw form of the material -p16 • Pictures are bigger and clear -p15 • Including both product image and raw material image -p14 • The photographs before the shaping and after the shaping -p6 • Photographs and template are good -p3 • the images of both the product and raw material -p17	• Unnecessary big photo -p2
Inclusion of graph representation / grading of material properties *+ve = 5* *-ve = 0* ***overall = 5***	• The grading -p17 • Technical properties chart -p24 • Technical properties charts -p33 • Technical properties chart -p27 • Graphics give more information about technical properties. -p7	
Organisation of the information *+ve = 5* *-ve = -1* ***overall = 4***	• and categorization -p31 • Orders of text, -p28 • Parts are grouped well -p21 • Properties are good grouped -p19 • Design of it is very understandable and informative -p9	• The organization, hard to process the information -p16
Inclusion of technical properties section *+ve = 4* *-ve = -1* ***overall = 3***	• Technical properties -p36 • Technical properties -p35 • Technical properties part -p29 • Technical properties part -p26	• technical properties is not too much comparable, -p31

Table D-4 (continued)

Sufficiency of information *+ve = 4* *-ve = -2* ***overall = 2***	• Detailed information -p2 • It has more useful information -p20 • That it tells all the manufacturing techniques -p13 • Applications, general shaping process -p4	• There is no finishing properties part -p1 • Price is not included, -p31
Tag material durability and appropriateness *+ve = 1* *-ve = -1* ***overall = 0***	• Material of the card -p34	• The material of the card is not durable. -p34
Colour scheme *+ve = 2* *-ve = -1* ***overall = -1***	• Colours -p31 • the colour choice -p17	• The icons and hierarchy of colours, -p17
Logo of the ME-LAB *+ve = 0* *-ve = -2* ***overall = -2***		• Logo is not good -p18 • Logo, -p4
Appropriate size/shape *+ve = 0* *-ve = -4* ***overall = -4***		• tag is too much bigger for small products -p31 • lack of being large -p17 • Too big -p11 • big, -p4
Inclusion of information in a paragraph form *+ve = 0* *-ve = -4* ***overall = -4***		• too much text -p26 • Too much text and small font size -p29 • Too much text small size hard to read -p28 • Too much text and small fonts -p27
Inclusion of numerical values in the charts *+ve = 0* *-ve = -4* ***overall = -4***		• Values of properties are not given -p21 • Values of technical properties are not given -p19 • Not numerical values for technical properties, -p3

Table D-4 (continued)

Inclusion of IMAGES of other applications / products *+ve = 0* *-ve = -4* ***overall = -4***		• There is no other photos of other products where such materials are used -p10 • May be added a few product sample images -p9 • The pictures are unnecessary, instead of them, the possible applications could be showed. Possible applications can also be divided according to their manufacturing methods. So we can see how to manufacture different kind of products -p13 • no pictures of other uses -p4
Overall clarity and understandability *+ve = 0* *-ve = -4* ***overall = -4***		• Images below the label not clear. It is written "6" on the fork, but written P07 on the label? -p12 • Images below are not clear -p7 • There should be a warning icon near to the 4 icons -p6 • Warnings are not so understandable -p5
Usage of icons/ Symbols *+ve = 0* *-ve = -16* ***overall = -16***		• The meaning of symbols -p36 • Meaning of symbols is not clear -p35 • The symbols at the bottom of the card are not understandable. -p34 • Symbols below are not clear enough-p33 • I couldn't understand the icons at the bottom of industrial application -p32 • at the bottom it is not easy to understand the symbols , -p31 • There are icons at the bottom and they are not understandable -p30 • Red, green organs (symbols) are not understandable, -p26 • Icons which are on the bottom are not understandable -p25 • Icons are not understandable -p24 • Symbols which are placed at the bottom of the back side are not understandable. -p22 • The icons are not easy to understand -p15 • Graphics on the bottom are not understandable -p14 • explanation of small icons are missing, -p4 • icons are not exactly understandable -p3 • The icons -p17

Table D- 5 Comments for tag 5

TAG 5		
TAG ATTRIBUTE	**LIKE**	**DISLIKE**
Appropriate size/shape of the tag *+ve = 5* *-ve = 0* ***overall = 5***	• Its being small -p17 • Creative paper size -p28 • Being small, -p3 • Compact -p2 • Square shape, -p23	
Colour scheme *+ve = 2* *-ve = 0* ***overall = 2***	• colours -p23 • Colours -p4	
Inclusion of technical properties part *+ve = 2* *-ve = -1* ***overall = 1***	• Technical properties considered are good selected -p21 • Considered properties are good and helpful -p19	• Technical properties -p26
Overall clarity and understandability *+ve = 3* *-ve = -3* ***overall = 0***	• Simple and fresh -p18 • Graphs distinction about sensorial and technical properties are good -p3 • Simplicity -p15	• name of the material is not at the top. -p33
Inclusion of sensorial properties part *+ve = 3* *-ve = -3* ***overall = 0***	• Sensorial properties chart is very clear -p22 • Sensorial properties chart -p24 • Information about the surface properties like glossy -p6	• Sensorial properties chart -p33 • Sensorial properties seem a little bit confusing -p18 • Not understandable evaluation for sensorial properties -p1
Overall attractiveness /graphics *+ve = 2* *-ve = -3* ***overall = -1***	• The background of tag in properties parts -p20 • Graphics in a unity with METU logo -p14	• graphics are not sufficient -p30 • Graphics -p24 • Poor graphics, -p12
Understandiblity of the graphs/ratings *+ve = 0* *-ve = -2* ***overall = -2***		• Graphics are not understandable, -p7 • graphics are unclear -p35

Table D-5 (continued)

Tag material durability and appropriateness *+ve = 3* *-ve = -5* ***overall = -2***	• Current choice of product and paper -p29 • Movable papers design -p27 • Paper for product suitable -p26	• The material and form of the tag -p36 • Material of tag is not durable, -p35 • The material of card and it is very small. -p34 • material of the tag (not durable), -p33 • being two part, -p33
Lack of graph representation of technical properties part *+ve = 0* *-ve = -4* ***overall = -4***		• Density with numbers doesn't mean much. -p31 • Technical properties should had been shown in graphics. -p13 • technical properties not useful -p12 • Not understandable evaluation for technical properties -p1
Two paged Tag *+ve = 0* *-ve = -8* ***overall = -8***		• joining at two papers is not useful, -p30 • It shouldn't be two part it may be ripped off. -p25 • The two page tag is hard to use and it isn't functional -p16 • The template two-pieces form is not userfriendly and technical properties info -p6 • consisting two paper make it hard to understand -p14 • confusing to use, -p4 • ,confusing open -p2 • The material of the product cannot be seen at first glance, you should turn over the card. -p34

Table D-5 (continued)

Sufficiency of information *+ve = 0* *-ve = -20* ***overall = -20***		• There is not enough information. -p31 • First page with only baby bottle picture doesn't give any sense, very bad ! -p31 • There isn't enough info, -p30 • Lack of information -p29 -p28 • Information is not detailed -p27 • It does not show any type of shaping or finishing processes -p22 • Sensorial properties are not enough informative -p21 • Lack of information -p15 • Not informative-p14 • There is no applications part. No shaping methods -p13 • There is no enough information -p11 • No information -p10 • There is no informative information out of a basic and insufficient graphic -p9 • technical properties are not informative -p7 • It includes very few information -p5 • No application, no name of the material at the front page, confusing to use, no shaping processes -p4 • Information is not enough in general -p3 • Lack of information, shaping processes ,confusing open -p2 • Sliding pages its lacking relevant information -p17

Table D- 6 Comments for tag 6

TAG 6		
TAG ATTRIBUTE	**LIKE**	**DISLIKE**
Inclusion of manufacturing processes chart *+ve = 17* *-ve = 0* ***overall = 17***	• The chart that explains how it is produced -p22 • Manufacturing processes description, properties are very good -p18 • Rating scale is good, process chart is very informative -p15 • The processing part, but it can be showed the reasons/ why rare, why common? -p13 • Various shaping methods -p4 • Shaping processes scheme -p2 • The chart which explains how it is produced -p25 • Shaping processes -p36 • Chart at the backside -p28 • Process chart -p26 • The part of common, rare, not recog. In the shaping process-p34 • Common-rarely part is beneficial, thinking about price is good -p31 • The chart that explains how it is produced was inspirational -p24 • Manufacturing processes are rated -p19 • Manufacturing processes are shown in the card -p21 • In shaping process chart it is good to be three criteria -p30 • Nice chart of processes and competitors -p29	
Inclusion of IMAGES of other applications / products *+ve = 2* *-ve = 0* ***overall = 2***	• The graphics of applied products -p32 • Photos -p10	
Inclusion of competitors *+ve = 2* *-ve = -1* ***overall = 1***	• competitors -p27 • Nice chart … and competitors -p29	• Competition info -p2

Table D-6 (Continued)

Size of IMAGES of other applications / products *+ve = 0* *-ve = -1* ***overall = -1***		• The pictures are small –p19
Inclusion of a descriptive paragraph *+ve = 2* *-ve = -3* ***overall = -1***	• Description part is very informative -p23 • Description -p27	• Design of the text -p33 • No need to write competitors, -p4 • Design of the description section is not so good -p9
Tag material durability and appropriateness *+ve = 0* *-ve = -1* ***overall = -1***		• Form of tag (not durable) -p35
Appropriate size/shape of the tag *+ve = 0* *-ve = -1* ***overall = -1***		• very big -p4
Overall clarity and understandability *+ve = 3* *-ve = -4* ***overall = -1***	• Understandable -p35 • Understandable info about production -p8 • Simplicity -p14	• Confusing information -p29 • I cannot understand graphs and it is hard to follow the information -p3 • Hard to understand -p6 • Very confusing -p5
Inclusion material properties part *+ve = 1* *-ve = -3* ***overall = -2***	• properties are very good -p18	• Properties part and description part-p34 • properties part is not understandable, -p31 • Properties part is not clear. -p13
IMAGE choice of other applications / products *+ve = 0* *-ve = -2* ***overall = -2***		• The pictures are not understandable -p21 • The pictures are hard to understand -p19

Table D-6 (Continued)

Understandiblity of the graphs/ratings *+ve = 0* *-ve = -3* ***overall = -3***		• Properties chart isn't understandable->applications? -p30 • Properties chart is not understandable -p22 • what PC, PA, PVC column stand for is not understandable , -p4 • Info charts which are hard to understand, what is it for -p27 • Some graphic are not easily understandable -p11
Sufficiency of information *+ve = 0* *-ve = -4* ***overall = -4***		• no info about where it is used -p31 • not usage example -p26 • No possible applications are showed -p13 • no other applications, -p4
Organisation of the information *+ve = 0* *-ve = -4* ***overall = -4***		• The whole organization -p16 • Disorganized -p15 • Disorganized -p14 • The lack of organization -p17
Colour scheme *+ve = 0* *-ve = -5* ***overall = -5***		• colours -p17 • colours -p16 • The colours -p32 • Tags colours, -p31 • Colour , -p26
Inclusion of graph representation / grading of material properties *+ve =0* *-ve = -6* ***overall = -6***		• Properties chart -p25 • The properties chart -p24 • Properties graphics -p8

Table D-6 (Continued)

Overall attractiveness /graphics *+ve = 0* *-ve = -8* ***overall = -8***		• Poor graphics -p7 • Poor graphics -p12 • Graphics -p10 • Poor graphics -p1 • Graphics are really bad (photos are not clear, colours are bad, graphics can be much more attractive) -p18 • The design of the tag and graphics -p36 • Design of the texts and graphics -p35 • The circles in not recommended part which is don't need to be different -p20

Table D- 7 Comments for tag 7

TAG 7		
TAG ATTRIBUTE	**LIKE**	**DISLIKE**
Inclusion of IMAGES of other applications / products *+ve = +8* *-ve = 0* ***overall = +8***	• Picture of another applications, -p4 • Application graphs (graphics?) are very good -p5 • Images in graphic (attractive images in application of ceramic) -p7 • Support with images -p8 • Images, -p12 • The images which show the possible applications of the material -p13 • The images –p17 • The samples on the back of tag are informative -p20	
Inclusion of bulk and/or surface properties *+ve = +7* *-ve = 0* ***overall =+7***	• Bulk properties and surface properties -p10 • Charts that show bulk and surface properties. -p22 • It gives information of bulk and surface properties -p24 • Bulk properties -p26 • Properties charts are so understandable and informative -p30 • Properties are very good -p31 • Bulk and surface properties -p36	
Inclusion of other applications / products *+ve = +6* *-ve = 0* ***overall = +6***	• Applications part -p14 • The wide range of application -p15 • Info about where it's applied -p17 • Other product and cams examples are very useful, -p18 • Given examples are helpful -p19 • Good examples of products in which this material used -p21	

Table D-7 (continued)

Inclusion of graph representation / grading of material properties *+ve = +5* *-ve = 0* ***overall = +5***	• Graphs for explanation are good – p3 • Showing properties in a scale -p4 • Understandable chart -p29 • Properties charts are so understandable and informative - p30 • Grading of properties -p32	
Overall clarity and understandability *+ve = +4* *-ve = 0* ***overall = +4***	• clear graphics -p12 • Easy to read -p28 • simplicity -p33 • It is not complicated at first sight. It is very simple -p34	
Inclusion of property data *+ve = +2* *-ve = 0* ***overall = +2***	• Numerical values for explanation are good -p3 • That bulk properties has data. -p27	
Inclusion of finishing properties *+ve = +1* *-ve = 0* ***overall = +1***	• finishing properties part is good - p18	
Appropriate size / shape *+ve = +2* *-ve = -2* ***overall = 0***	• It looks compact –p2 • size -p4	• Shape of the tag –p31 • The form of the tag -p36
Sufficiency of information *+ve = +1* *-ve = -1* ***overall = 0***	• It has enough information -p2	• Additional information is not enough -p21
Small font size *+ve = 0* *-ve = -1* ***overall = -1***		• small fonts -p31
Overall attractiveness /graphics *+ve = 2* *-ve = -3* ***overall = -1***	• The template -p6 • Graphics -p1	• There are not any attractive graphics. -p22 • Graphics were bad -p24 • Graphic design -p14
Colour scheme (blue) *+ve = 1* *-ve = -2* ***overall = -1***	• The colours – p17	• Using the same colour -p15 • The colour that used too much blue -p16

Table D-7 (continued)

Extensiveness of shaping process information *+ve = 0* *-ve = -2* ***overall = -2***		• no other shaping processes -p4 • Other possible shaping processes could be mentioned. -p13
QR code instead of URL *+ve = 0* *-ve = -2* ***overall = -2***		• QR code is useless numeric labels can be used manually without specialized device, -p4 • The webpage could be written in case somebody has an old fashioned telephone -p13
Gradient graphics on graphs *+ve = 0* *-ve = -3* ***overall = -3***		• Gradient in rating -p18 • Gradient is confusing -p19 • It should not use highlight in rating that is confusing -p20
Tag material durability and appropriateness *+ve = 0* *-ve = -4* ***overall = -4***		• Form of paper -p26 • The material –p31 • Not durable -p33 • The card should be harder -p34
Folding feature *+ve = 0* *-ve = -12* ***overall = -12***		• It is not necessary to be folded -p1 • Folding can decrease the lifetime -p3 • Folding system is not effective -p5 • The action to fold the paper, it may cause to decrease the lifetime of the tag -p6 • The dots showing the user where to fold. And I don't like that it's folded and punched in the middle -p17 • Folding and being 2 paged -p23 • The layout it would better if it didn't folded -p25 • That it folds, because it is not durable -p27 • Folding -p28 • Folding paper -p29 • It is not practical due its shape and material-folding -p30 • Hard to open the tag -p32

Table D- 8 Comments for tag 8

TAG 8		
TAG ATTRIBUTE	**LIKE**	**DISLIKE**
Inclusion of shaping processes (showing with arrow) *+ve = 9* *-ve = -1* ***overall = 8***	• Showing processes in images -p31 • Using arrows is good -p30 • Process representation on product -p26 • Writing and showing processes by arrow on the picture of the product -p20 • Finishing processes are shown by arrows -p19 • Showing photo info on photo with arrow -p18 • the fact that the processes are shown by arrows -p17 • Processes are shown by arrows -p14 • Pointing the exact place, -p2	• Shaping processes place is awfull, -p31
Tag material durability and appropriateness *+ve = 4* *-ve = -1* ***overall = 3***	• Dimensions, -p17 • The size -p16 • Material of the card -p4 • texture of card -p2	• Paper is easy to dissolve, paper selection -p28
Overall attractiveness /graphics *+ve = 4* *-ve = -2* ***overall = 2***	• Graphics -p29 • Attractiveness, very high-tech graphics -p5 • Attractive graphics -p3 • Graphics, -p13	• Not attractive -p32 • Graphics and icons -p18
Inclusion of graph representation / grading of material properties *+ve = 1* *-ve = -1* ***overall = 0***	• The graph (but it is not informative and understandable) -p6	• Charts -p25
Inclusion of game section *+ve = 0* *-ve = -1* ***overall = -1***		• I think no one use the card for predicting game. It is unnecessary -p34
Colour scheme *+ve = 1* *-ve = -3* ***overall = -2***	• Color selection-p28	• Colours no hierarchy of colour no organization! -p17 • Colours -p23 • colours are irritating -p33

Table D-8 (continued)

Not inclusion of IMAGES of other applications / products *+ve = 0* *-ve = -2* ***overall = -2***		• no other application -p13 • no other applications -p4
Size of IMAGES of other applications / products *+ve = 1* *-ve = -3* ***overall = -2***	• big images, -p13	• Size of photos unnecessary -p35 • Image size is very big -p33 • too big picture -p27
Understandiblity of the graphs/ratings *+ve = 0* *-ve = -4* ***overall = -4***		• These graphics are so confusing and not enough to understand what this want to say -p20 • The graph (but it is not informative and understandable) -p6 • Unnecessary graphics and games (not understandable) -p36 • Graphics are hard to understand -p19
IMAGE choice of other applications / products *+ve = 0* *-ve = -4* ***overall = -4***		• Images are not informative, it is hard to understand finishing processes -p12 • Images are not informative -p7 • Images are not informative, poor evaluation of properties -p1 • Not understandable images -p29
Overall clarity and understandability *+ve = 4* *-ve = -9* ***overall = -5***	• Simplicity -p27 • few words -p28 • Design layout and simplicity -p11 • Graphics are simple to see every part of the card -p21	• These graphics are so confusing and not enough to understand what this want to say -p20 • lack of organization -p16 • Disorganized -p15 • Titles are on the backside; so the relation could not be easily understood. -p14 • product properties are not clear. -p9 • it's hard to understand the finishing process -p7 • How the information is given -p6 • Not understandable -p10 • Design is not understandable,p9

Table D-8 (continued)

Usage of icons/ Symbols *+ve = 3* *-ve = -9* ***overall = -6***	• Icons -p24 • Icons -p23 • Icons -p15	• There is no explanation for the symbols, -p4 • Symbols are not clear -p2 • The icons don't explain themselves very limited info -p30 • Organs (symbols) are not understandable -p26 • Icons used to express properties are hard to understand -p21 • The interface icons are inefficient, -p16 • I could not understand the meaning of the symbols, -p13 • icons are very bad, -p31 • and bulk properties' symbols are not readable, -p27
Sufficiency of information *+ve = 0* *-ve = -10* ***overall = -10***		• They don't give proper info -p24 • infos are limited, Very Bad!! -p31 • very limited info -p30 • That it is less informative -p27 • It does not include information -p5 • Information is not enough, I expect more information -p3 • not enough information -p2 • There is no information about finishing properties and other material properties -p9 • infos are limited, Very Bad!! -p31 • That it is less informative-p27

Table D- 9 Comments for tag 9

TAG 9		
TAG ATTRIBUTE	**LIKE**	**DISLIKE**
Inclusion of reasons for choice part *+ve = 11* *-ve = 0* ***overall = 11***	• Reasons for choice part was useful, materials properties part is nice -p13 • Reasons for choice -p12 • Reasons for choice -p7 • Ranking material properties -p2 • Reasons for choice part -p1 • Reasons for choice part -p21 • Reasons for choice, -p18 • reasons for choice -p17 • Reasons for choice part -p14 • Reasons for choice, relevant properties -p4 • Reasons for choice feature -p16	

Table D-9 (continued)

Inclusion of graph representation / grading of material properties *+ve = 3* *-ve = 0* ***overall = 3***	• Material properties chart - p22 • material properties chart - p16 • The existence of the material properties graphic - p6	
Inclusion of icons in material properties part *+ve = 4* *-ve = 0* ***overall = 4***	• Material properties' icons - p23 • Material properties graphics is very good -p3 • Material properties has understandable graphics - p19 • Ranking scale informative icons -p15	
Size of the product image *+ve = 1* *-ve = 0* ***overall = 1***	• the image size -p17	
Inclusion of shaping processes *+ve = 1* *-ve = 0* ***overall = 1***	• shaping processes -p18	•
Organisation of the information *+ve = 2* *-ve = -2* ***overall = 0***	• The organization-p17 • Coherence of context -p32	• Materials properties graph should be before the short paragraph -p6 • Space usage, layout, name of the material is not visible at first sight, -p4
Overall clarity and understandability *+ve = 0* *-ve = -2* ***overall = -2***		• Images are not quite understandable, -p12 • Too small and confusing -p29
Understandability of grpahs/ratings *+ve = 0* *-ve = -2* ***overall = -2***		• Graphic are not understandable, -p7 • Graphics are not understandable-p1

Table D-9 (continued)

Sufficiency of information *+ve = 4* *-ve = -6* ***overall = -2***	• Information -p25 • Information -p24 • Informative chart is very effective -p5 • It include information the basic properties clearly -p9	• no applied example -p32 • Not mentioning using areas -p31 • There is no applications, 2 sides at the tag should be used -p30 • No other application, -p13 • There is no exact price -p5 • no other applications, texture -p4
Usage of the shortening "N/A" *+ve = 0* *-ve = -3* ***overall = -3***		• N/A ? -p12 • N/A ? -p7 • what is N/A ? -p1
Overall attractiveness /graphics *+ve = 0* *-ve = -4* ***overall = -4***		• The graphics and layout -p25 • The graphics -p24 • Graphics -p22 • Graphics -p15
having a graded numerical scale for material properties *+ve = 0* *-ve = -5* ***overall = -5***		• Material property charts numbers are unnecessary and chart is not clear. -p33 • The numbers in properties part is too unnecessary. -p34 • Material property charts numbers are unnecessary and chart is not clear. -p33 • Numbers in rating boxes (not needed) -p18 • Visualization of material properties rating system -p14
Appropriate size/shape of the tag *+ve = 0* *-ve = -8* ***overall = -8***		• Tag is so narrow -p33 • One side printed, -p32 • the blank side can be used tag's material is not so good, its like bookmarker -p31 • Too small and confusing -p29 • Too small -p26 • Some information move behind the card -p9 • Not appealing, not rounded corners -p28 • the use of space is poor. The back part of the paper could be used so the length could be shorter. -p13

Table D-9 (continued)

Readability of the text (Small font throughout + small font Material's name) *+ve = 0* *-ve = -13* ***overall = -13***		• There is too much text on the tag , font is small -p16 • The graphics and the size of the font (very small and complicated) -p36 • Very small size of text and numbers -p35 • small fonts -p34 • Font size is small. -p33 • Small fonts -p27 • Small fonts -p23 • The grading system of material properties it resembles sudoku. The font size may be problematic -p17 • font is small -p16 • Titles can be more noticeable -p3 • Letters are little and hard to read -p2 • font, -p4 • The material should have been written bigger as title. -p13

Table D- 10 Comments for tag 10

TAG 10		
TAG ATTRIBUTE	**LIKE**	**DISLIKE**
Inclusion of product sector section *+ve = 8* *-ve = 0* ***overall = 8***	• Product sectors, good image -p31 • It is good to see the sectors of a specific product -p12 • "product sector" title is very informative -p5 • product sector information -p2 • product sectors part is good to learn that. -p1 • It can be seen which products are produced with this material-p7 • product sectors -p18 • other application part -p4	
Inclusion of why this material part *+ve = 3* *-ve = 0* ***overall = 3***	• Why this material for baby bottle part -p26 • Really like front of the page is for the material, why this material? Part, -p18 • why this material, p4	

Table D-10 (continued)

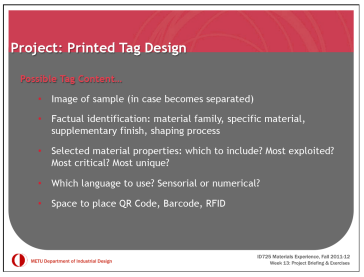
Separation of information about product and material *+ve = 3* *-ve = -1* ***overall = 2***	• Product properties and material properties are separately showed -p21 • There are separated information about product and material -p19 • Processing methods used for silicone rubber and the method used for the baby bottle was written separately -p13	• Focusing on products rather than material, -p28
Sufficiency of information *+ve = 2* *-ve = 0* ***overall = 2***	• It's being informative -p15 • It includes enough information but title is reviewed -p9	
Overall clarity and understandability *+ve = 3* *-ve = -2* ***overall = 1***	• Simplicity -p16 • Font size and chart are understandable due its graphics -p33 • explanation parts are not include long paragraphs -p3	• Hard to understand -p32 • Hard to understand two sides -p23
Appropriate size/shape of the tag *+ve = 1* *-ve = -1* ***overall = 0***	• Interesting type of tagging -p32	• Paper is too long -p13
Lack of numbers in material properties chart *+ve = 0* *-ve = -3* ***overall = -3***		• There are no exact values of properties -p21 • The values of properties are not given -p19 • the properties values -p16
Overall attractiveness /graphics *+ve = 3* *-ve = -7* ***overall = -4***	• good image -p31 • Text size easy to read -p28 • Layout -p25 • The template, the first information part -p6	• Image is placed wrong side -p24 • Layout -p22 • The graphics could be more attractive. -p13 • No consistency in graphics and all light gray lines gray lines should be at the same light as they represent the maximum value -p12 -p7 • Graphics -p10 • Graphics don't have same length -p1

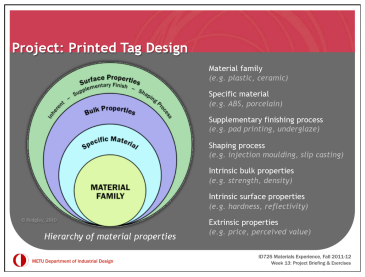
Table D-10 (continued)

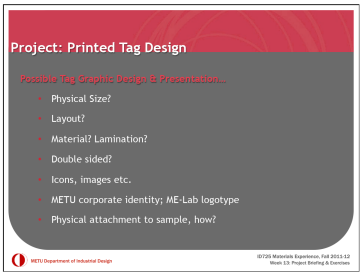
Understandability of the charts on the transparent part *+ve = 0* *-ve = -10* ***overall = -10***		• Transparency is unnecessary and that part is not understandable -p34 • Charts different lengths confused me, -p33 • Understandablity of transparent chart-p25 • Rating graphics should be more understandable and could be divided to parts. -p20 • Transparent section grading system is confusing, the categorization, why two pages? -p17 • Rating is not clear and comparable -p15 • Rating scale of the properties is not understandable. They do not take reference from each other -p14 • The graphic about intrinsic properties. It is hard to read and evaluate -p6 • Chart is not totally understandable -p5 • Chart is not totally understandable -p3
Having a transparent part on the tag *+ve = 2* *-ve = -14* ***overall = -12***	• Transparency of paper -p24 • Transparent part -p23	• It is unnecessary to use transparent materials for the tag it is useless -p36 • It should not be transparent -p35 • Transparency is unnecessary and that part is not understandable -p34 • transparent part is not appropriate to use -p33 • Material used for tag -p31 • Two materials for this tag is irrelevant -p30 • Transparent paper -p29 • unnecessary use of transparency -p28 • Its translucent part, because its useless -p27 • The transparent part-p16 • One side can be used due to transparent part, big, material of transparent part is weak -p4 • Transparent part causes unnecessary place at back, not compact -p2 • Transparent part is unnecessary and I can't read when I lift up, Graphics don't have same length -p1 • Not dislike but transparent part is not needed because back of it is not used, there can be extra infos back of it -p18

APPENDIX E

PROJECT BRIEF OF THE SAMPLE TAGS







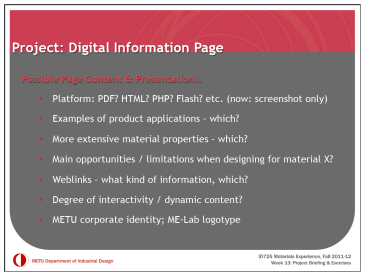


Figure E- 1 Project Brief

APPENDIX F

CATEGORIZED COMMENTS FROM THE QUESTIONNAIRE

Table F- 1 Categorized comments about sample tags (green=only positive valence comments, grey= mixed valence comments, red=only negative valence comments)

Comment No.	Category: C, P, M	Overall clarity and understandability		clear and understandable
1	P	Comment		**implied design criteria**
		Tag 1	1	
		Tag 2	1	
		Tag 3	-7	
		Tag 4	-4	
		Tag 5	2	
		Tag 6	-1	
		Tag 7	4	
		Tag 8	-5	
		Tag 9	-2	
		Tag 10	1	
		count (only positive valence comments)	2	
		count (mixed valence comments)	6	
		count (only negative valence comments)	2	
		Overall comment score	**-10**	**10** **comment mentions (out of 10)**

Table F-1 (continued)

2	C	Sufficiency of information	-2	7	-1	2	-20	-4	0	-10	-2	2	1	6	3	**-28**	**10**	sufficient information
3	P	Overall attractiveness/graphics	2	3	5	9	-1	-8	-1		-4	-4	3	3	3	**1**	**9**	attractive graphics
4	M	Appropriate size/shape	-8	1	-1	-4	5	-1	0		-8	0	2	3	4	**-16**	**9**	optimal size
5	P	Colour scheme	-2	3	-4	1	2	-5	-1	-2			2	4	2	**-8**	**8**	attractive colours
6	M	Tag material durability and appropriateness			-2	0	-2	-1	-4	3				2	4	**-6**	**6**	durable material and construction
7	P	Inclusion of graph representation / grading of material properties		3		5		-3	5	0	3		4	1	1	**13**	**6**	includes graphic representation of material properties
8	P	Understandiblity of the graphs / ratings	-5				-2	-5		-4	-2	-10			6	**-28**	**6**	easy to understand graphs / ratings
9	P	Organization of the information		-6	2	4		-4			0			4	1	**-4**	**5**	well organized information
10	C	Inclusion of selection reasons section / Inclusion of reasons for choice part / Inclusion of why this material / star attribute(s) part	3		4						11	3	4			**21**	**4**	includes selection reasons / key features / star attribute(s) of the material

Table F-1 (continued)

11	P	Size of images of other applications / products	-2					-1		-2	1		2	1	1	**-4**	**4**	large enough images to be understood
12	C	Inclusion of product application / products part / common uses part /product sector section		1	7				6			8	3	1		**22**	**4**	includes product application / common uses part
13	C	Inclusion of images of other applications / products	5					2	8				3			**15**	**3**	includes images of example products / applications
14	P	Inclusion of a descriptive paragraph / information in written form	-2			-4		-1						1	2	**-7**	**3**	excludes information in paragraph form
15	C	Inclusion of manufacturing processes chart / Inclusion of shaping processes						17		8	1		2	1		**26**	**3**	includes manufacturing information
16	C	Inclusion of technical/material properties section				3	1	-2						3		**2**	**3**	includes technical properties/ properties chart

Table F-1 (continued)

17	C	Lack of numerical values in charts /				-4						-3			2	**-7**	**2**	includes numerical values for material properties
18	C	Inclusion of numerical values in the charts		4					2				2			**6**	**2**	includes numerical values for material properties
19	C	Lack of images of other applications / products				-4				-2					2	**-6**	**2**	includes images of example products / applications
20	C	image choice of other applications / products						-2		-4					2	**-6**	**2**	includes understandable and informative images
21	P	Usage of the shorthand “N/A”		-3							-3				2	**-6**	**2**	excludes use of the "N/A" shorthand
22	P	Usage of icons / symbols				-16				-6				1	1	**-22**	**2**	excludes use of symbols
23	P	Small font for material name	-3								-1				2	**-4**	**2**	use suficiently large fonts
24	P	Small font size throughout							-1		-12				2	**-13**	**2**	use suficiently large fonts
25	C	Inclusion of comparison chart with other materials	11										1			**11**	**1**	includes comparison chart with other materials

Table F-1 (continued)

26	P	Lack of graph representation of technical properties part					-5								1	**-5**	**1**	includes graphs for technical properties section
27	C	Inclusion of similar materials part	9										1			**9**	**1**	includes section on similar materials
28	C	Inclusion of warning part		9									1			**9**	**1**	includes a warning section
29	P	Contrast of the text with background		-19											1	**-19**	**1**	choose a good contrast background color
30	P	Inclusion of icons in product application part			4									1		**4**	**1**	includes icons within product application section
31	P	Inclusion of high-low chart for bulk properties			-15									1		**-15**	**1**	excludes high-low chart for material properties
32	C	Inclusion of images (of both raw material and products)				7								1		**7**	**1**	includes images of both raw material and products
33	P	Logo of the ME-LAB				-2									1	**-2**	**1**	attractive logo for MX-Lab
34	C	Inclusion of sensorial properties part					0							1		**0**	**1**	consider including sensorial properties section
35	M	Two paged tag					-8								1	**-8**	**1**	do not create multiple page tags

Table F-1 (continued)

36	C	Inclusion of competitors						1						1		**1**	**1**	consider including competitors section
37	C	Inclusion of bulk and/or surface properties							7				1			**7**	**1**	includes bulk and/or surface properties
38	C	Inclusion of finishing properties							1				1			**1**	**1**	includes finishing properties
39	C	Lack of of shaping process information							-2						1	**-2**	**1**	includes reasonable quantity of shaping process information
40	P	QR code instead of URL							-2						1	**-2**	**1**	includes URL as well as QR code
41	P	Gradient graphics on graphs							-3						1	**-3**	**1**	do not use gradients in graphs
42	M	Folding feature							-12						1	**-12**	**1**	do not make the tag foldable
43	C	Inclusion of game section								-1					1	**-1**	**1**	excludes any 'game' section
44	P	Inclusion of icons in material properties part									4		1			**4**	**1**	includes icons for material properties section
45	P	having a graded numerical scale for material properties									-5				1	**-5**	**1**	exclude numbers on the likert scale

Table F-1 (continued)

46	P	Separation of information about product and material										2		1		**2**	**1**	includes seperate information for material and product applications
47	M	Having a transparent part on the tag										-12		1		**-12**	**1**	do not make the tag transparent
		count (positive valence comments)	4	8	2	2	2	2	7	0	5	3						
		count (mixed valence comments)	4	2	7	5	5	4	3	7	2	5						
		count (negative valence comments)	5	2	2	8	4	9	7	5	8	2						
		overall comment score	7	4	-8	-7	-28	-18	7	-25	-19	-13						
		comment mentions (out of 47)	13	12	11	15	11	15	17	12	15	10						
		only positive valence comments																
		mixed valence comments																
		only negative valence comments																

Table F-1 (continued)

	C	Content of Tag Information														
	P	Presentation of Tag Information														
	M	Materialization of Tag														

APPENDIX G

SURVEY QUESTION 13

Table G- 1 Question 13, Target user of the libraries

	Materialbibliotheket, Stockholm	KAAM, Copenhagen	Anonymous 1	Materio, Paris	Anonymous 2	Materioteca®, Milan	MATREC EcoLab, Milan	MeD, Milan	Rematerialise, London	Anonymous 3	Materials and Products Collection, London	Made Of, Delft	Materials Lab, Texas	MaTech, Padova	Materials Library, Doha	Material Library, London	MRC, Providence	Percentage
Creative Professionals	x			x		x	x	x	x		x		x			x	x	58.8
Companies	x					x	x		x	x						x		35.4
Researcher									x	x				x		x	x	29.5
Professors			x		x			x	x			x	x		x	x	x	53.1
Students		x	x		x		x	x	x	x	x	x	x	x	x	x	x	82.3
Public															x	x		10.8

APPENDIX H

SURVEY QUESTION 22

Table H- 1 Question 22, The kind of information that supplementary resources contain

	Anonymous 1	Materio, Paris	Rematerialise, London	Anonymous 3	Materials and Products Collection, London	Made Of, Delft	Materials Lab, Texas	MaTech, Padova	Materials Library, Doha	Percentage
Description		x	x		x	x		x		55,5
Link to online database/ information resource	x				x		x			33,3
Manufacturer					x					
Technical Properties		x		x		x		x	x	55,5
Sensorial Properties				x		x				22,2
Environmental Properties				x	x	x				33,3
Applications				x	x	x		x		44,4
Pictures		x	x	x						33,3
Videos				x						11,1

APPENDIX I

SURVEY QUESTION 12

Table I- 2 Question 12, Main reasons for establishing the library

	Materialbibliotekет, Stockholm	KAAM, Copenhagen	Anonymous 1	Materio, Paris	Anonymous 2	Materioteca®, Milan	MATREC EcoLab, Milan	MeD, Milan	Rematerialise, London	Anonymous 3	Materials and Products Collection, London	Made Of, Delft	Materials Lab, Texas	MaTech, Padova	Materials Library, Doha	Material Library, London	MRC, Providence	Percentage
for education		x	x		x			x	x	x		x	x	x	x		x	70,6
for connecting materials science and design community	x			x			x		x		x					x		35,4
for improving knowledge in materials						x			x				x			x		21.6
for R&D activities		x					x				x		x				x	35,4
for promoting materials		x		x		x												16.7

APPENDIX J

SURVEY QUESTION 14

Table J- 1 : Question 14, Features that promote the libraries

	Materialbibliotheket, Stockholm	KAAM, Copenhagen	Materio, Paris	Anonymous 2	Materioteca®, Milan	MATREC EcoLab, Milan	MeD, Milan	Rematerialise, London	Anonymous 3	Materials and Products Collection, London	Made Of, Delft	Materials Lab, Texas	MaTech, Padova	Materials Library, Doha	Material Library, London	MRC, Providence	Percentage
Promotion of Materials				x	x	x		x		x			x		x		43,8
Target group	x				x	x				x	x	x					37,5
Material Samples		x		x	x	x		x		x		x				x	50
Material Selection			x		x	x			x				x				37,5
Education							x		x		x			x		x	25
Collection's Features								x									6,3

APPENDIX K

SURVEY QUESTION 23

Table K- 1 Question 23, Changes that would have been made in the establishment phase of the Library

	KAAM, Copenhagen	Anonymous 1	Materio, Paris	Materioteca®, Milan	MATREC EcoLab, Milan	MeD, Milan	Rematerialise, London	Materials and Products Collection, London	Made Of, Delft	Materials Lab, Texas	Materials Library, Doha	Material Library, London	MRC, Providence	Percentage
online presence	x				x		x							23,1
material information			x			x			x		x		x	38,5
staff		x					x				x			23,1
presentation			x	x	x									23,1
concept						x								7,7
classification								x			x	x		23,1
equipment										x				7,7

APPENDIX L

SURVEY QUESTION 24

Table L- 1 Question 24, Future Plans

	KAAM, Copenhagen	Anonymous 1	Materio, Paris	Materioteca®, Milan	MATRÉC EcoLab, Milan	Rematerialise, London	Anonymous 3	Materials and Products Collection, London	Made Of, Delft	Materials Lab, Texas	MaTech, Padova	Materials Library, Doha	Material Library, London	MRC, Providence	Percentage
involve technology/web	x											x		x	28,6
enlarge number of materials					x		x	x	x		x				35,7
make joint activities with companies/researchers/ users		x		x						x			x		28,6
opening new libraries			x			x									14,3
enlarging/ developing material information					x							x	x	x	28,6
Opening the library to new audiences			x			x	x			x					28,6

APPENDIX M

COMMENTS LIST CATEGORIZED ACCORDING TO MATERIALIZATION, PRESENTATION, CONTENT

Table M- 1 Categorized comments about materialization of sample tags (green=only positive valence comments, grey= mixed valence comments, red=only negative valence comments)

	Comment No.	Category: C, P, M	Comment	Tag 1	Tag 2	Tag 3	Tag 4	Tag 5	Tag 6	Tag 7	Tag 8	Tag 9	Tag 10	count (only positive valence comments)	count (mixed valence comments)	count (only negative valence comments)	**Overall comment score**	**comment mentions (out of 10)**	**implied design criteria**
1	4	M	Appropriate size/shape	-8	1	-1	-4	5	-1	0		-8	0	2	3	4	**-16**	**9**	optimal size

Table M-1 (continued)

2	6	M	Tag material durability and appropriateness			-2	0	-2	-1	-4	3				2	4	**-6**	**6**	durable material and construction
			count (positive valence comments)	4	8	2	2	2	1	7	0	5	3						
			count (mixed valence comments)	4	2	7	5	5	5	3	7	3	5						
			count (negative valence comments)	5	2	2	7	2	6	7	2	6	2						
			score (count +ve minus -ve valence comments)	**-1**	**6**	**0**	**-5**	**0**	**-5**	**0**	**-2**	**-1**	**1**						
			comment mentions (out of 44)	13	12	11	14	9	12	17	9	14	10						

Table M-1 (continued)

			only positive valence comments																
			mixed valence comments																
			only negative valence comments																
		C	Content of Tag Information																
		P	Presentation of Tag Information																
		M	Materialization of Tag																

Table M- 2 Categorized comments about presentation of sample tags (green=only positive valence comments, grey= mixed valence comments, red=only negative valence comments)

	Comment No.	Category: C, P, M	Comment	Tag 1	Tag 2	Tag 3	Tag 4	Tag 5	Tag 6	Tag 7	Tag 8	Tag 9	Tag 10	count (only positive valence comments)	count (mixed valence comments)	count (only negative valence comments)	**Overall comment score**	**comment mentions (out of 10)**	**implied design criteria**
1	1	P	Overall clarity and understandability	1	1	-7	-4	2	-1	4	-5	-2	1	2	6	2	**-10**	**10**	clear and understandable
2	3	P	Overall attractiveness/graphics	2	3	5	9	-1	-8	-1		-4	-4	3	3	3	**1**	**9**	attractive graphics

Table M-2 (continued)

3	5	P	Colour scheme	-2	3	-4	1	2	-5	-1	-2			2	4	2	**-8**	**8**	attractive colours
4	7	P	Inclusion of graph representation / grading of material properties		3		5		-3	5	0	3		4	1	1	**13**	**6**	includes graphic representation of material properties
5	8	P	Understandiblity of the graphs / ratings	-5				-2	-5		-4	-2	-10			6	**-28**	**6**	easy to understand graphs / ratings
6	9	P	Organization of the information		-6	2	4		-4			0			4	1	**-4**	**5**	well organized information
7	11	P	Size of images of other applications / products	-2					-1		-2	1		2	1	1	**-4**	**4**	large enough images to be understood
8	14	P	Inclusion of a descriptive paragraph / information in written form	-2			-4		-1						1	2	**-7**	**3**	excludes information in paragraph form
9	21	P	Usage of the shorthand “N/A”		-3							-3				2	**-6**	**2**	excludes use of the “N/A” shorthand
10	22	P	Usage of icons / symbols				-16				-6				1	1	**-22**	**2**	excludes use of symbols

Table M-2 (continued)

11	23	P	Small font for material name	-3								-1				2	**-4**	**2**	use 200ufficiently large fonts
12	24	P	Small font size throughout							-1		-12				2	**-13**	**2**	use 200ufficiently large fonts
			count (positive valence comments)	4	8	2	2	2	1	7	0	5	3						
			count (mixed valence comments)	4	2	7	5	5	5	3	7	3	5						
			count (negative valence comments)	5	2	2	7	2	6	7	2	6	2						
			score (count +ve minus –ve valence comments)	**-1**	**6**	**0**	**-5**	**0**	**-5**	**0**	**-2**	**-1**	**1**						
			comment mentions (out of 44)	13	12	11	14	9	12	17	9	14	10						
			only positive valence comments																
			mixed valence comments																
			only negative valence comments																

Table M-2 (continued)

		C	Content of Tag Information																		
		P	Presentation of Tag Information																		
		M	Materialization of Tag																		

Table M- 3 Categorized comments about content of sample tags (green=only positive valence comments, grey= mixed valence comments, red=only negative valence comments)

		sufficient information	**10**
		implied design criteria	**comment mentions (out of 10)**
1	2	Comment No.	**Overall comment score**	**-28**	3
	C	Category: C, P, M	count (only negative valence comments)		6
		Sufficiency of information	Comment	count (mixed valence comments)		9
			Tag 1	-2	count (only positive valence comments)		1
			Tag 2	7	Tag 10		2
			Tag 3	-1	Tag 9		-2
			Tag 4	2	Tag 8		-10
			Tag 5	-20	Tag 7		0
			Tag 6	-4	Tag 6		-4
			Tag 7	0	Tag 5		-20
			Tag 8	-10	Tag 4		2
			Tag 9	-2	Tag 3		-1
			Tag 10	2	Tag 2		7
			count (only positive valence comments)	1	Tag 1		-2
			count (mixed valence comments)	6			
			count (only negative valence comments)	3			
			Overall comment score	**-28**			
			comment mentions (out of 10)	**10**			
			implied design criteria	sufficient information			

Table M-3 (continued)

2	10	C	Inclusion of selection reasons section / Inclusion of reasons for choice part / Inclusion of why this material / star attribute(s) part	3		4						11	3	4			**21**	**4**	includes selection reasons / key features / star attribute(s) of the material
3	12	C	Inclusion of product application / products part / common uses part /product sector section		1	7				6			8	3	1		**22**	**4**	includes product application / common uses part
4	13	C	Inclusion of images of other applications / products	5					2	8				3			**15**	**3**	includes images of example products / applications
5	15	C	Inclusion of manufacturing processes chart / Inclusion of shaping processes						17		8	1		2	1		**26**	**3**	includes manufacturing information

Table M-3 (continued)

6	16	C	Inclusion of technical/material properties section				3	1	-2						3		**2**	**3**	includes technical properties/ properties chart
7	17	C	Lack of numerical values in charts /				-4						-3			2	**-7**	**2**	includes numerical values for material properties
8	18	C	Inclusion of numerical values in the charts		4					2				2			**6**	**2**	includes numerical values for material properties
9	19	C	Lack of images of other applications / products				-4				-2					2	**-6**	**2**	includes images of example products / applications
10	20	C	image choice of other applications / products						-2		-4					2	**-6**	**2**	includes understandable and informative images

Table M-3 (continued)

			count (positive valence comments)	4	8	2	2	2	1	7	0	5	3						
			count (mixed valence comments)	4	2	7	5	5	5	3	7	3	5						
			count (negative valence comments)	5	2	2	7	2	6	7	2	6	2						
			score (count +ve minus -ve valence comments)	**-1**	**6**	**0**	**-5**	**0**	**-5**	**0**	**-2**	**-1**	**1**						
			comment mentions (out of 44)	13	12	11	14	9	12	17	9	14	10						
			only positive valence comments																
			mixed valence comments																
			only negative valence comments																

Table M-3 (continued)

		C	Content of Tag Information															
		P	Presentation of Tag Information															
		M	Materialization of Tag															