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A STUDY OF PRODUCT DESIGNERS' EXPERIENCE WITH DESIGN PROCESSES AND TOOLS: OUTLOOK FOR DEVELOPING WEB-BASED DESIGN GUIDELINES

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KEYWORDS

Professional designers; design tools; product design guidelines

ABSTRACT

Industrial designers are increasingly challenged by the interdisciplinary nature, increasing complexity and time pressure in today's design projects. Understanding the product's environment, the user and recalling all design aspects in time places a great burden on the designer. The constant risk that the negligence of certain design aspects may result in inferior products, urges the need to develop systematic tools that support the designers in creating useful, usable and satisfying products. However, creating innovative tools that effectively support design practitioners require an understanding of designers' experience and actual use of systematic processes and tools. This paper presents the findings from an explorative study with professional industrial designers in New Zealand. It focuses on the designers' understanding of complexity in design, their design processes and use of design tools. In summary, it discusses the feasibility of developing web-based product design guidelines as a systematic tool to support design practitioners.

1. INTRODUCTION

Designing is a complex cognitive task and industrial designers have been increasingly challenged with the interdisciplinary nature, increasing product complexity and time pressure of modern design projects (Cross, 1994; Earl, Eckert, & Johnson, 2004; Freudenthal, 1999). The task of the industrial designer can generally be seen as a complex, creative and solution-focused problem solving process. This process is often characterised by a fuzzy front-end, an ill-defined problem (Cross, 2004) and the problem and solution co-evolving throughout the design process (Bezerra, 2000). The process of creating new products and systems is determined by the designer's understanding of the multiple levels of the user-product interaction, as illustrated in Figure. 1 These levels need to be holistically understood and addressed by the designers in order to create products and systems that are effective, efficient and satisfying (Hague, 2002; Jordan, 1999, 2000, 2002; Popovic, 2002).

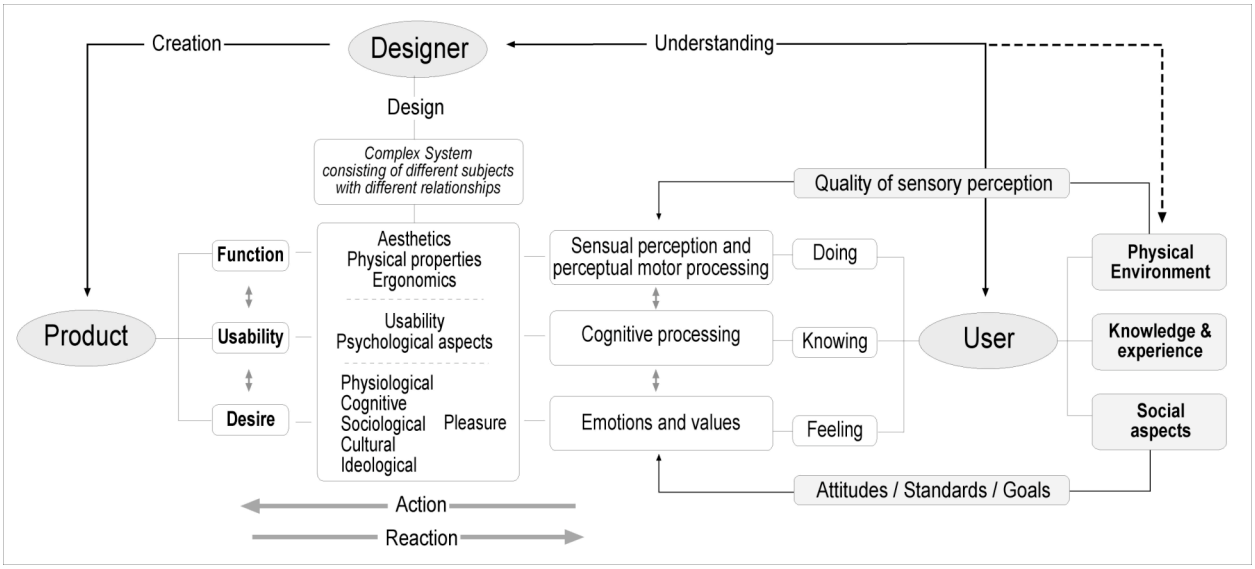


Figure 1: Multiple Levels of User-Product-Designer Interactions (Goellner, 2005)

The great number of different design aspects to be considered, such as the number of people involved in the design process, the aspirations of different users and the interactions of product parts make the whole a complex process (Reinmoeller, 2002; Sharma, 2000) and places a great cognitive burden onto the industrial designer. The risk thereby is that the negligence of considering all relevant aspects may lead to inferior products or increased costs.

2. BACKGROUND

In order to address all interrelated design aspect adequately and to overcome the issues of complexity industrial designers are strongly advised to follow a systematic approach in their projects (Pahl & Beitz, 1984; Roozenburg & Eekels, 1995). A great amount of different design approaches and techniques have been developed to assist designers in creating products and understanding the end-user, such as for example the *Product Design and Development Approach* (Ulrich & Eppinger, 1995), *Kansei Engineering* (Nagamachi, 1995), *four pleasures framework* (Jordan, 2000), *Sensorial Quality Assessment Method [SEQUAM]* (Bonapace, 2002) or the online *AGEtree Design Guide* (Baelus et al., 2007), to name a few.

As a special kind of a systematic tool amongst these techniques, design guidelines and checklists offer designers the possibility to manage the complexity issues in the design process not only during the specification design phase, but also throughout the whole design process (Freudenthal, 1999; Gardiner & Christie, 1987; Jones, 1980; Ponn, Baumberger, & Lindemann, 2004; Stanton & Young, 1999). Guidelines have been a traditional and well-proven tool in many disciplines. They offer many advantages (Gardiner & Christie, 1987; Ponn, Baumberger, & Lindemann, 2004; Stanton & Young, 1999; van Aken, 2005), such as:

- They are generally based on established knowledge.
- They need very little introduction.
- They are easily accessible.
- They cover all design aspects systematically.
- They can provide cross-disciplinary knowledge.
- They offer reference material.
- They can stimulate the designer's imagination.
- They can be applied at any point during the design process.
- They support designers in large design processes.

However, the main problem with systematic tools in design, such as guidelines, is that designers are continually confronted with a overwhelming amount of design tools making it difficult for them to locate the right ones (Bonner, 1998; Huang, Shi, & Mak, 2000). Moreover, the designers' incentive to use design tools is often compromised by time and cost constraints. Unless designers are required to employ these tools (for example by the company) or it is obvious that the benefit of using the tool is significantly higher than the cost and time invested [cost-benefit rule (Lidwell, Holden, & Butler, 2003)] the designers are unlikely to make use of them (Jones, 1980).

With regards to design guidelines, many are available to inquisitive designers, as shown in Table 1. However, most of them haven't been evaluated in terms of their usability, with exception of few guidelines and checklists (Freudenthal, 1999; Govindaraju, 1999; Huang, Shi, & Mak, 2000), which passed through limited evaluations. Hence, not much information about the usability of available guidelines for industrial designers is accessible.

	Reference	Title	Type	Medium
GENERIC	Archer (1964)	Systematic Method for Designers	Generic checklists and flow-diagrams	Book
	Jones (1980)	Design Methods: Seeds of Human Futures	Generic design evaluation checklists	Book
	Pahl and Beitz (1984)	Engineering Design	Generic specification and evaluation checklists	Book
	Pugh (1991)	Total Design: Integrated Methods for Successful Product Engineering	Generic specification checklist	Book
	Monterey Technologies Inc. (1996)	Resource Guide for Accessible Design of Consumer Electronics DRAFT	Generic information and guidelines on accessible design of consumer electronics	Online text
	Freudenthal (1999)	The Design of Home Appliances for Young and Old Consumers	Generic product design guidelines	Book (PhD Thesis)
	Govindaraju (1999)	Development of Generic Design Guidelines to Manufacture Usable Consumer Products	Generic usability evaluation checklists and engineering design guidelines	PhD Thesis
	Huang, Shi and Mak (2000)	Synchronised System for "Design for X" Guidelines over the WWW	Research paper about a protoype of web-based design guidelines database	Protype online database
	Lidwell, Holden & Butler (2003)	Universal Principles of Design	Generic and cross-disciplinary design principles and guidelines	Book
	Baelus, Van Gils, Hermans, Vranken, De Bruecker and Vanderschoot (D-Science Lab) (2007)	AGEtree Design Guide	Webbased generic checklists and guidelines for product design with focus on aging users	Online database
SPECIFIC	Gardiner and Christie (1987)	Applying Cognitive Psychology to User-Interface Design	Specific guidelines for user interface design	Book
	Pheasant (1987)	Ergonomics: Standards and Guidelines for Designers	Guidelines and information on ergonomics	Book
	Pirkl and Babic (1988)	Guidelines and strategies for creating trans-generational products	Specific guidelines and strategies for design for aging users	Book
	Mayhew (1992)	Principles and Guidelines in Software User Interface Design	Specific usability principles & guidelines for user interface design	Book
	Nielsen (1994)	Usability Inspection Methods	Small set of usability guidelines	Book
	Coleman (1997)	Interior Design Guidelines	Specific guidelines for layout of interior spaces	Book
	Daly-Jones, Bevan and Thomas (1999)	INUSE 6.2 - Handbook of User-Centred Design	Generic principles and activities of usability and user-centred design approaches	OnlineHandbook
	Gill (2004)	Guidelines for the Design of Accessible Information and Communication Technology Systems	Specific guidelines for inclusive design	Online text

Table 1: Commonly Available Design Guidelines and Checklists

More important than usability testing, one needs to understand the professional designers' experience and use of systematic tools before developing a new set of design guidelines. This understanding is vital to create a design tool that is tailored to suit design practitioners.

3. AIM AND SCOPE OF THE STUDY

This study aims to provide an in-depth understanding of the product designers' understanding of complexity in design, their background, design processes and use of design tools with a specific focus on design guidelines. The outcome provides a deeper understanding of the designers' needs, wishes and concerns with regards to design tools. This understanding will support the development of a new set of design guidelines that hopefully will not only be able to assist product design practitioners, but also increase their incentive to make use of them.

The findings are based on an explorative investigation conducted with seventeen product designers in New Zealand. New Zealand is a free-market economy that is known for its entrepreneurship with mostly small-scale companies compared by world standards. The level of design education is high compared to other countries worldwide (Darroch, 2002; Frederick, 2002; NationMaster.com, 2004; New Zealand Trade and Enterprise, 2004).

4. RESEARCH METHODOLOGY

4.1. PARTICIPANT SELECTION

Professional product designers that work in New Zealand were selected as a result of a comprehensive search in several resources such as the Internet, national design magazines (Prodesign, 2003; Urbis, 2003) and the New Zealand yellow pages (Yellow Pages New Zealand, 2003). Fifty-five professional product designers in New Zealand were identified and invited to the study by mail. Seventeen designers agreed to take part in the study, which equals a return rate of 30.9%.

4.2. RESEARCH TOOLS

In order to obtain comparable and in-depth information well-established research tools such as a questionnaires and semi-structured interviews were employed (Hague, 2002; Leedy & Ormrod, 2001). Using questionnaires provided the advantage of reaching the geographically dispersed designers. Two questionnaires each containing about 30-40 mainly fixed-response questions and five-point rating scales were used to provide an easy-to-use survey. In addition, open responses (i.e. "other") were used to allow for unexpected

answers of the participants. In order to establish a discussion, clarify ambiguous answers and to gain in-depth information a 45-minutes semi-structured face-to-face interview was conducted with each participant. The focus in this paper lies on the findings from the first questionnaire and partly from the interview. The second questionnaire focused on the evaluation of a prototype set of design guidelines (Goellner, 2004, 2005).

4.3. DATA ANALYSIS

Unfortunately, only twelve questionnaires could be retrieved, but all seventeen interviews were carried out. Due to the limited sample size all gathered data was considered to be of importance and is therefore presented with the actual number of responses always being stated. SPSS (Statistical Package for the Social Sciences) software (SPSS Inc., 2003) was used to calculate the frequencies of the responses, to compare findings by cross-tabulations and to carry out the corresponding statistical analyses of the data. The median and quartiles were used to accurately present the averages of the responses (Altman, 1991; Gorard, 2003). The open-ended interview responses were coded by identifying chunks of similar meaning and then grouped into categories by two analysts to assure accurate and meaningful categorisation (i.e. frequency counting method) (Carney, 1972; Hague, 2002; Kent, 2001; Miles & Huberman, 1994). In order to avoid loosing the in-depth information from the open-ended questions, some of the responses are presented as quotes.

5. RESULTS

5.1. PARTICIPANTS' BACKGROUND

The participants that took part in this study were mostly male (15/17) and consisted mainly of professional product designers (8/17), design managers (5/17) and a few academics (4/17) that were actively engaged in design practise. All of the participants had a very good educational background in design with a minimum of three years of study, such as a Bachelor (5/12), Masters (3/12) or Diploma (4/12). Two different age groups that were nearly equal in size could be identified: one group was younger between 26 and 35 years of age (5/11) and the other group was older between 41 and 50+ years of age (6/11). This finding was used for cross-tabulation analyses to detect difference in the participants' responses.

The study revealed that most participants used several sources to keep their design knowledge up-to-date, such as magazines (10/11), books (10/11), the Internet (11/11), academic journals (4/11), conferences (4/11) and contacts with colleagues (3/11). As most useful described were design magazines (9/11), interior

magazines (5/11) and academic books (4/11). These results indicate that the participants inform themselves by using highly visual and easily accessible sources, such as magazines and the Internet, but also perceive in-depth information from books or journals as useful.

In terms of their computer literacy most participants stated that they have an advanced to expert confidence (8/12) in using computers in design, with only few stated to be beginner (2/12) or intermediate user (2/12). Moreover, most participants (7/12) rated the use of Computer Aided Design (CAD) in their design processes as high, with the remaining ones applying CAD only in a low (3/12) to medium (2/12) intensity. This could be due to the high commitment of training and investment required for the use of CAD software, or due to the position of the participants (e.g. design managers). Overall, a high level of computer literacy is clearly indicated for the majority of designers.

Most participants had a great deal of experience in design. Nearly all participants (11/12) carried out more than five projects in industry and most of them (9/12) have been professionals for more then six years. Their projects dealt with a great variety of products, ranging from household/office (10/12), furniture/interior (9/12), outdoor/sports (10/12), medical/electro-technical (8/12) and engineering products (8/12). In terms of teamwork and collaborative design approaches, most participants (7/12) were used to work in smaller teams of two to three people, while some (4/12) had experience of working in medium-sized teams of four or more people. When asked about their personal design orientation (i.e. creative or technical focus), most participants described themselves as balanced (7/11), with the remainder expressing a creative focus (3/11).

5.2. PARTICIPANTS' UNDERSTANDING OF COMPLEXITY IN DESIGN

The participants perceived most frequently a complicated product architecture (17/17) as the driver of a product's complexity. Further mentioned were the amount of engineering/technical aspects (15/17), the involvement of many people (15/17) and a demanding design and management process (12/17). Only a few (2/11) addressed other aspects, such as aesthetics or usability aspects. Some quotes from the participants' understanding of complexity in design were as follows:

- "More than five parts working mechanically together in one chunk …"
- "Complexity has two levels: the product and the project."
- "When you have to deal with several people involved in the design process, … but also the product's physical aspects … "

Further cross-tabulation analysis of the participants' responses to the complexity factors with some of their distinguishing characteristics (i.e. age and position) showed no major differences. However, the cross-analysis

indicated that younger product designers that are less experienced (i.e. novice designers) are more likely to perceive technology and usability aspects as determining for a product's complexity, while more experienced designers that worked in larger teams perceived a demanding design management process and the involvement of many people as increasing a product's complexity. It is likely that this results from the product designer's changing role from a practical working designer to a design manager with growing expertise.

The participants' approaches to design a complex product include the formation of an experienced design team (13/17 designers) and a careful design management of the project (13/17 designers) (i.e. client communication, time and budget management). Further aspects that the participants mentioned were an analysis of the design situation (9/17), the decomposition of the design problem (8/17), the precise formulation of the design objectives in a brief (7/17), the facilitation of team work (7/17) and the conduction of testing and refinement (7/17). Some of their responses were as follows:

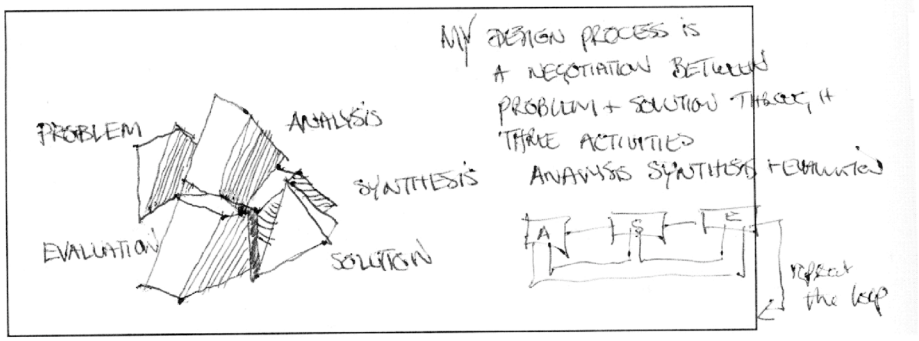
- "Get a clearly defined brief that outlines exactly what you have to do."
- "Break the design problem down in parts, identify the risk areas and isolate any problems. … Work on the most influential aspects first."

In summary, the responses indicate that two main areas seemed to be critical for understanding and designing a complex product. First, the number of parts and interactions (i.e. requiring an analysis of the product and the user to define the product's critical functions, parts, and interactions), and second the people and their interactions (i.e. requiring a thorough management of the design process, in terms of communication, team work and finances) need to be understood and handled by design professionals.

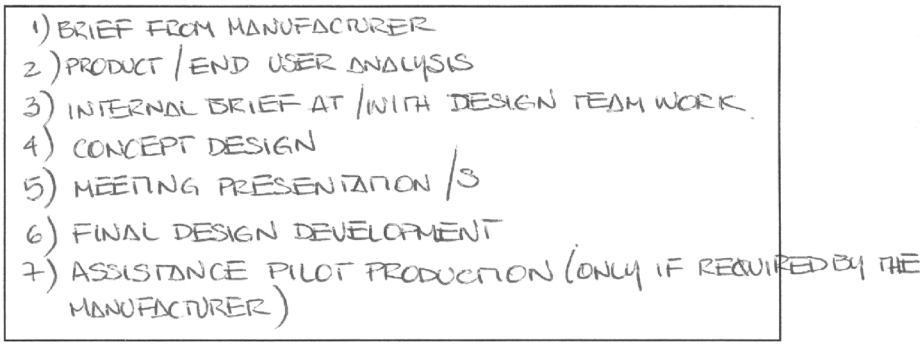
5.3. PARTICIPANTS' DESIGN PROCESSES

Most participants (9/12) usually follow a systematic design process, which was specified more precisely in only a few cases: internal company process, active data sheets or the Stage Gate™ process (Cooper, 1988). Any other processes were not stated, which suggests that they were not likely to be a standard design process model known from the literature. More insight was gained from the participants' sketches of their design process, as exemplary shown in Figure 2.

Design Process Sketch No.1



Design Process Sketch No.2



Design Process Sketch No.3

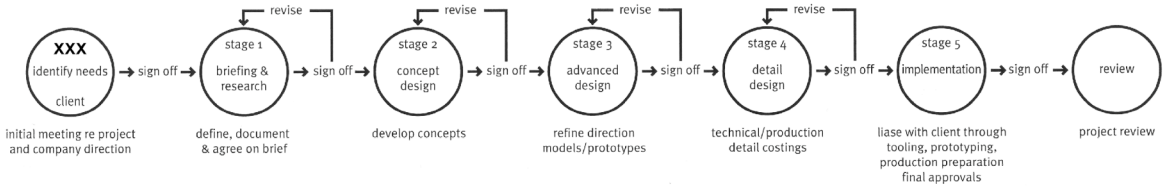


Figure 2: Examples of the Participants' Design Process Sketches

The analysis of the sketches showed that the participants use a great variety of different design processes. These processes included all major design stages as illustrated in Figure 3. Rarely mentioned were the idea development and post-launch activities stages (2/10), which indicates that most participants did not consider these stages as important part of their design work.

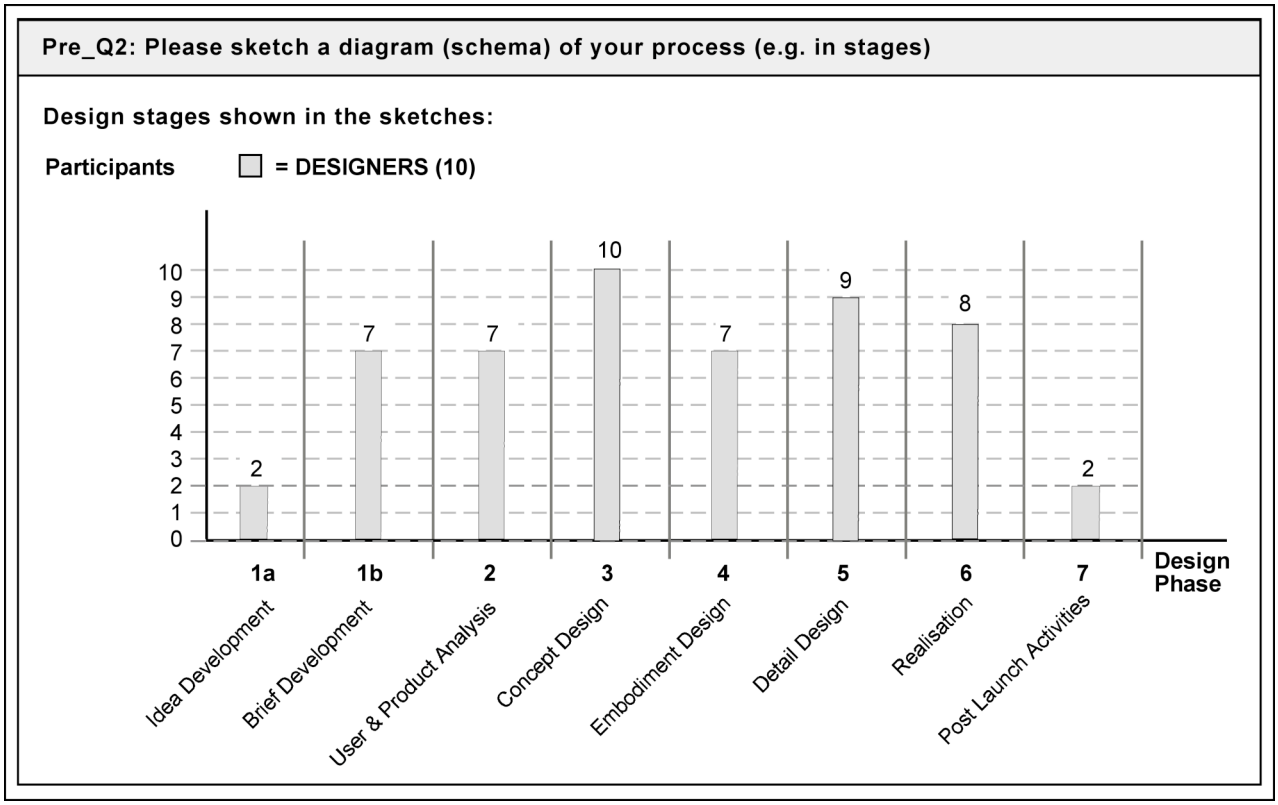


Figure 3: Identified Stages from the Participants' Design Process Sketches

It has been found that the participants (11/11) follow an iterative design process with design evaluations after every major design stage, such as the concept (11/12), refinement (10/12) and realisation stage (8/12). Most participants were either balanced (5/12) or user orientated (4/12) in their processes, with only a few being product orientated (3/12). Their preferred evaluation methods reflect this user-focus too: user trials (8/12), user focus groups (7/12), observations (6/12) and interviews (5/12). Interestingly, many participants also relied on expert investigations (10/12) to evaluate their design, which can be best explained by the designers or colleagues carrying these out themselves with little expense. Few participants (3/12) also carried out performance testing (e.g. accelerated life testing).

Next to the design evaluations, the participants also focused on the user during the initial information gathering of a project by direct investigations (8/12), such as interviews or focus groups. Further information from market research (6/12) and literature (9/12) was gathered too. Both provide the designers with a direct impression of the end-user's needs and wishes, and general information about the target group. However, only two participants (2/12) evaluated the analysis stage, which suggests that the gathered information was not critically reviewed.

The use of prototypes for design evaluations was high (12/12 participants) with a great variety of prototypes including drawings (8/12), low-resolution [card/foam] (10/12), medium-resolution [mock-ups] (10/12) and high-resolution [production/functional] prototypes (9/12 designers). On the basis of these results it can be reasonably assumed that the designers made use of the appropriate prototype depending on the design stage and the product to be designed.

5.4. PARTICIPANTS' EXPERIENCE WITH DESIGN TOOLS

Most of the participants (10/12) had previously used design tools during their projects, such as: ISO standards (8/10), anthropometrics lists (8/10), ergonomics lists (7/10) and engineering lists (6/10). Some also stated that they used academic literature (5/10) to support their design projects These results show that most designers were familiar with using some supportive design tools in their design projects, although these tools are rather of mandatory nature, which will be discussed later.

In terms of the participants' experience with using design guidelines as tools for their projects, the results were quite different. Most participants did not know any design guidelines (9/12). Only three mentioned they were familiar with some guidelines. These were identified as ergonomics guidelines (3/12), in-house guidelines (2/12) and product specific guidelines (2/12). Interestingly, when asked, whether the participants had ever used some guidelines, the results showed that more than half of them had used guidelines before (7/12). However, the participants did not specify these guidelines any further.

Further inquiry revealed the participants' perception of previously used design guidelines, as displayed in Figure 4.

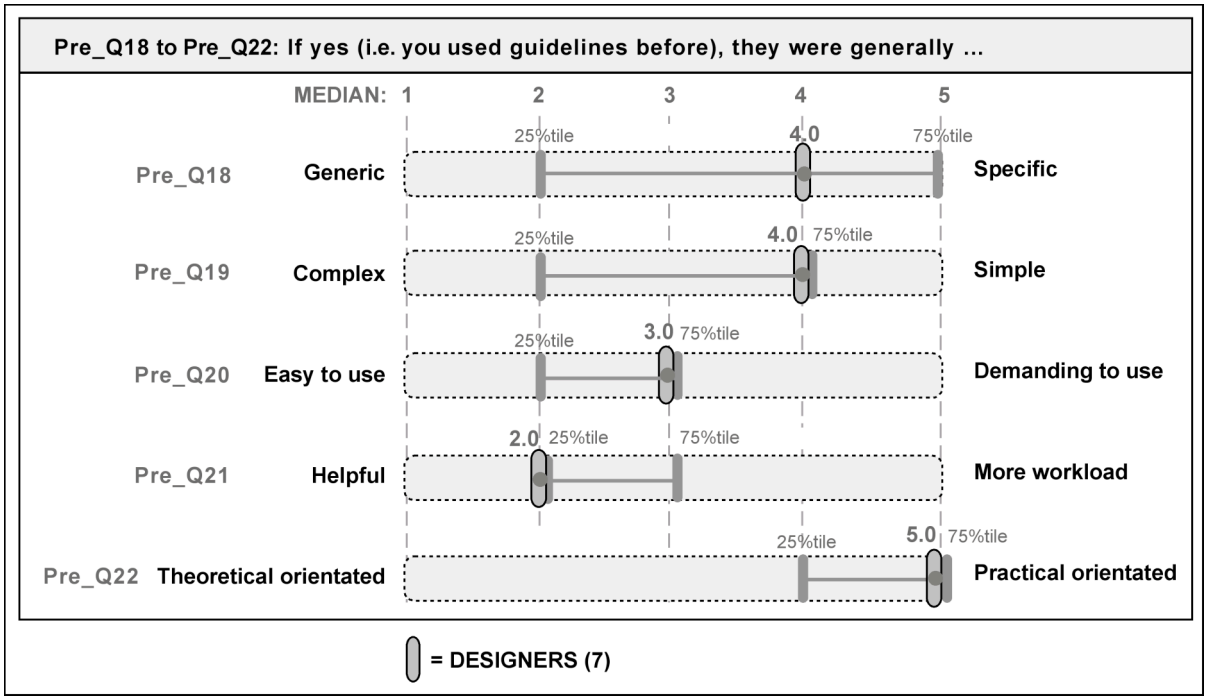


Figure 4: Participants' Rating of Previously Used Design Guidelines

The results show that the participants' perceived the guidelines on average as being quite specific. This is not surprising for the in-house or product-specific guidelines mentioned earlier. Furthermore, they rated the guidelines as relatively simple to understand, but only moderately easy to use. This indicates that the guidelines' usability was not well resolved. The guidelines were perceived as being quite helpful and very practical orientated. This shows that the guidelines were quite useful for the designers. It can be assumed that despite the low knowledge of design guidelines and their benefits, the experience of the designers with guidelines is generally positive in terms of their usefulness, support and simple applicability. However, concern needs to be raised in terms of their usability and coverage of a broad range of design aspects.

6. DISCUSSION: OUTLOOK FOR THE DEVELOPMENT OF GUIDELINES AS DESIGN TOOL

6.1. DESIGNER'S USE OF DESIGN TOOLS AND GUIDELINES

It has been found that the designers had little knowledge of any available design guidelines (see Table 1), but some experience with specific design guidelines. This finding implies that guidelines in product design practice are not much utilised by designers to support their design processes, despite their benefits especially for more

complex projects, as argued by Jones, Gardiner & Christie and Hunag et al. (Gardiner & Christie, 1987; Huang, Shi, & Mak, 2000; Jones, 1980). The reasons for this might be the designers' generally time constrained work situations and the difficult accessibility of most guidelines for design practitioners, as many guidelines are only available in costly books or academic articles.

The study also revealed that the few guidelines used by the designers were perceived as helpful, but quite specific and of low usability. These findings support the previous argument that guidelines currently available from the literature have not been adequately tested for their usability. Moreover, guidelines are often specifically designed for a subject area, such as engineering (Govindaraju, 1999) or aging related issues (Baelus et al., 2007), but do not holistically cover all aspects of the product design process.

With regard to using systematic tools in design, it has been found that the designers were quite familiar with using design tools. It can be argued that these tools are mandatory for many design projects, as the negligence of consulting these design tools could have severe implications for the quality of the design outcome (i.e. result in poorly functional or unusable products), explaining the designers' frequent use of these tools.

The designers' low knowledge of design guidelines indicate also that guidelines are not a recognised as design tool and moreover, that comprehensive product design guidelines seem to be difficult to access for design practitioners. It can be speculated that with the problematic access, the designers might have not develop an understanding of the potential benefits of design guidelines, as discussed in literature (Gardiner & Christie, 1987; Huang, Shi, & Mak, 2000; Jones, 1980). The chances of catching up with the knowledge of the design guidelines' benefits are limited too, especially with the difficult access and limited number of comprehensive and generic applicable design guidelines currently available (see Table 1). This leads to the question: "What medium is most suitable for the envisioned product design guidelines to transfer specialist knowledge to professional designers?"

6.2. VISUAL LAYOUT, ACCESS AND FORMAT OF THE GUIDELINE TOOL

The following indications for the development of the new guidelines were gained from the study. The designers' preferred information sources indicate a preference to highly visual media. Consequently, the layout of guidelines should make use of affective imagery and a highly aesthetic layout in order to be appealing at the first glance.

Another important factor was the participants' preference for easily accessible media and the frequent use of the Internet to obtain design related information. The ability of locating and accessing guidelines that are provided in the product design area is a challenge for many designers, as argued by Jones (1980). Taking the different media to transfer specific knowledge to professionals into account, such as print-published sources (i.e. books, journals, magazines, newspapers), conferences / meetings, education, software and online resources, it can be reasonably said that online publication is most likely the easiest and most cost-effective method for today's product designers to access information, provided that there are no costs involved in using the website. Moreover, the identified high computer literacy of most designers supports this choice of media.

In order to provide not only a highly visually appealing medium, but also in-depth information like from sound books (as most usefully perceived by the participants) web-based guidelines could be structured to provide both. An in-depth structured database would not only allow viewing the aesthetically presented guideline, but also provide further layers for the inquisitive designer to gain in-depth information, such as references, case studies or further images explaining detailed the use and background of each guideline.

6.3. CONSIDERATIONS FOR WEB-BASED DESIGN GUIDELINES

A well-designed web-based tool could also support several ways to access the guidelines: the access via a keyword search-function would allow the designers a direct access to the guidelines of their interest at the time required. This option would provide experienced designers with an on-demand database of guidelines. However, this option would need to be well designed to reduce the risk for the designer to neglect potentially important design aspects. A second access option via the familiar stages of a design process (as identified in Figure 3) would sequentially guide designers through the design process and provide the relevant information at the right time. This option would most likely be best suited for novice designers or even non-designers (e.g. managers or clients).

Huang, Shi & Mak (2000) advocate that the distribution via the Internet will provide the required ease of locating and accessing guidelines. In today's' environment the access to the Internet is widely provided, not only in a work environment, but also in a private setting. Consequently, a website as distribution method for the guidelines is advantageous to reach product designers worldwide. Taking the progress of wireless networks and mobile smart devices into account the accessibility of design guidelines via the Internet is likely to increase even further. However, one needs to remember that the ease of locating certain websites on the

Internet can be difficult within the vast amount of information. Appropriate location and advertising are vital to reach the target audience.

Further advantages and disadvantages of presenting the guidelines in the form of a website (in contrast to a paper-copy format) were derived from this study and a small-scale study done by Martyn (2004). The aspects listed in Table 2 need to be considered for the development of a web-based design tool.

Advantages	Disadvantages
+ Easy to access	- Difficult to locate on the Internet
+ Easy to distribute	- Lack of trust in reliability of information
+ Reach of a worldwide user base	- Availability of a computer for access
+ Internet is a frequently used information source	- Legibility on screen displays
+ Allows for demand-driven & sequential use	- Portability of the medium (i.e. computer)
+ In-depth structuring	- Problematic customisation (i.e. adding notes)
+ Improved user navigation (forward / backward)	- Copyright is less protected
+ Easy to add, change and update information	
+ Reduced loss of information (backup)	
+ Accessible worldwide	

Table 2: Advantages and Disadvantages of a Web-based Design Tool

Overall, the development of the guidelines into a web-based tool would provide a format that can offer not only a comprehensive coverage of all product design aspects (broad structure) in several layers (in-depth structure), but also different access methods (i.e. sequential and demand-driven) to cater for novice and experienced users.

In addition to the format, the structure and content of the guidelines play a crucial role for the usability of guidelines too (Goellner, 2005; Jones, 1980). A logical structure and designer-orientated content that supports their preferred navigation and use are essential for the guidelines' individual and collaborative usability. The following indications were gained from this study.

6.4. STRUCTURE AND CONTENT OF THE GUIDELINE TOOL

The generally systematic approaches of the participants, although mostly not specified, indicate that the envisioned guidelines need to be systematically structured to provide an easy navigation and guidance for the designers. The guidelines need to provide the right information at the right time to solve the problems of complexity in design, as described earlier. They need to address complexity aspects derived from the product (i.e. number of parts, interactions and technology) and the design process (i.e. number of people and interactions), as described by other authors too (Bezerra, 2000; Earl, Eckert, & Johnson, 2004; Friedman, 2002; Rodriguez-Toro, Jared, & Swift, 2004; Vicente, 1999). Support for the understanding of users, products and interactions, as well as the management of the design process (i.e. team work, communication and finance control) are essential.

As the designers were familiar with most stages of the product design process listed in Figure 3, it is suggested to structure the guidelines along these process stages in order to facilitate the navigation within the guidelines. The stages correspond with other design process models described in literature (Cross, 1994) and it can therefore be assumed that other designers worldwide will be familiar with those stages too. Although the early and late design stages, such as the idea development and post-launch activities stages were perceived as less important, the author believes that these stages should also be included in the guidelines, as the understanding of these stages is critical for a product to be successful: i.e. decision making in the fuzzy front-end, as well as marketing, advertising and branding issues towards the end of a project.

The largely iterative and evaluative approaches of the designers suggest that the guidelines need to provide evaluation methods at key design stages. Taking the often cost- and time-constraint every-day work of designers into account focus should be on easy and cost-effective evaluation methods. Moreover, the guidelines should also be linked at key stages with the guidelines of previous design stages, so that they could support the designer in their iterative processes. The study also indicates that the guidelines need to include aspects on the evaluation of the findings of the design analysis stage (i.e. design synthesis), as most participants were found to neglect an evaluation of these findings. It can be reasonably assumed that design practitioners often not conduct a critical evaluation of findings from the design analysis and consequently the resulting design specifications could be falsely interpreted. Despite the finding that the designers are likely to employ the appropriate prototype, the guidelines should also include suggestions for using different prototypes at key evaluation stages to support the designer's decision making.

Based on the identified focus of the participants on end-users and product aspects, the content of the guidelines should provide both user- and product-focus. This means that not only sufficient content on user-research methods, social-cultural aspects, cognitive aspects and desirability issues needs to be presented, but also the product related aspects, such as for example functional, aesthetic, material and manufacturing aspects. A special focus should be placed on providing methods for gathering specific in-depth information about the prospective end-users, which are practically feasible for design practitioners.

The indication that with growing design experience the perception of complexity in design seems to shift from understanding technical product related aspects (i.e. novice designer) to understanding the management of the process and people (i.e. design manager) implies for the creation of the guidelines that both needs to be addressed in order to provide usefulness for novice and experienced designers.

7. CONCLUSIONS

The study, despite its small scope, has provided valuable insights into the product designers' design processes and their understanding, requirements and concerns with regards to design tools, such as guidelines.

Following insights from the product designers were gained:

- They had generally experience with some design tools (such as ergonomics list), but these tools were of mandatory nature (i.e. negligence of consulting would be severe).
- The designers had little knowledge of available design guidelines.
- The designers had some experience with guidelines and perceived these on average as simple to use, helpful, very practical, but quite specific and only moderately usable.

Following indications for the development of a new set of comprehensive and sophisticated product web-based design guidelines were discovered:

- The guidelines need to provide affective imagery and an aesthetically appealing layout
- The guidelines should be a web-based tool (website) that can be accessed by the Internet and provides different access functions (i.e. sequential / demand-driven) to cater for novice and experienced designers.
- The guidelines need to provide a comprehensive content and a systematic structure that is practical and logical for designers.
- The guidelines need to provide both comprehensive (broad structure) and practically detailed (in-depth structure) information.

- The guidelines need to be structured along the stages of a design process to facilitate the designers' navigation and to provide a guiding systematic structure.
- The guidelines need to provide suggestions for evaluation methods and links to previous content at key evaluation stages.
- The guidelines need to provide aspects to holistically understand the users' and a complete list of all product-related considerations.

The envisioned web-based product design guidelines are currently under development, while a further study with an earlier paper-copy format of the guidelines (Goellner, 2005; Goellner, Wakes, & Shaw, 2004) is carried out with design students to discover further aspects about the use, usefulness, usability and satisfaction of such a systematic design tool.

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REFERENCES

Altman, D. G. (1991). *Practical statistics for medical research*. London: Chapman and Hall.

Archer, L. B. (1964). *Systematic method for designer*. London: H.M.S.O. for The Council of Industrial Design.

Baelus, C., Van Gils, M., Hermans, V., Vranken, S., De Bruecker, W., & Vanderschoot, B. (2007). AGEtree Design Guide. Retrieved April 2007, from http://www.d-sciencelab.be/agetree/index.htm

Bezerra, C. D. (2000). *Evolutionary structured planning*. Unpublished Unpublished PhD Thesis, Illinois Institute of Technology (IIT), Illinois, Chicago.

Bonapace, L. (2002). Linking Product Properties to Pleasure: Sensorial Quality Assessment Method (SEQUAM). In P. W. Jordan & W. S. Green (Eds.), *Pleasure with Products: Beyond Usability*. (pp. 189-218). London: Taylor & Francis.

Bonner, J. V. H. (1998). Towards Consumer Product Interface Design Guidelines. In N. Stanton (Ed.), *Human Factors in Consumer Products*. London: Taylor & Francis.

Carney, T. F. (1972). *Content analysis*. Winnipeg (Canada): University of Manitoba Press.

Coleman, R. (1997). *Design für die Zukunft*. Colonge: DuMont Buchverlag.

Cooper, R. G. (1988). The New Product Process: a Decision Guide for Managers. *Journal of Marketing Management, 3*(3), 238-255.

Cross, N. (1994). *Engineering design methods: Strategies for product design*. Chichester: Wiley & Sons.

Cross, N. (2004). Creative Thinking by Expert Designers. *The Journal of Design Research, Vol 4*(Issue 2).

Daly-Jones, O., Bevan, N., & Thomas, C. (1999). INUSE 6.2 Handbook of User-Centred Design. Version 1.2. Retrieved September 2002, from http://www.ejeisa.com/nectar/inuse/6.2/index.htm

Darroch, J. (2002). *Innovation and knowledge management.* Unpublished Unpublished PhD Thesis, University of Otago, Dunedin (New Zealand).

Earl, C., Eckert, C., & Johnson, J. (2004). *Proceedings of the 8th International Design Conference: Complexity models in design.* Paper presented at the International Design Conference - Design 2004, Dubrovnik (Croatia).

Frederick, H. H. (2002). The UNITEC global entrepreneurship monitor 2003/2004: Towards high growth enterprise in New Zealand: New Zealand Centre for Innovation & Entrepreneurship.

Freudenthal, A. (1999). *The design of home appliances for young and old consumers.* Delft: Delft University Press.

Friedman, K. (2002). Discussion: Complexity and Simplicity in Design. Retrieved September / October 2002, from http://www.jiscmail.ac.uk/lists/PHD-DESIGN.html

Gardiner, M. M., & Christie, B. (1987). *Applying cognitive psychology to user-interface design*. Chichester: Wiley & Sons.

Gill, J. (2004). Tiresias-International Information on Visual Disability: Guidelines for the Design of Accessible Information and Communication Technology Systems. Retrieved August 2004, 2004, from http://www.tiresias.org/guidelines/index.htm

Goellner, M. (2005). *Addressing Complexity in Product Design: Guidelines for Product Designers.* Unpublished PhD Thesis, University of Otago, Dunedin (New Zealand).

Goellner, M., Wakes, S., & Shaw, C. T. (2004). *Development of complex products: design guidelines for product designers.* Paper presented at the Futureground 2004: International Conference of the Design Research Society (DRS), Melbourne.

Gorard, S. (2003). *Quantitative methods in social science*. London: Continuum.

Govindaraju, M. (1999). *Development of generic design guidelines to manufacture usable consumer products.* Unpublished PhD Thesis, University of Cincinnati, Cincinnati.

Hague, P. (2002). *Market research: A guide to planning, methodology and evaluation*. London: Kogan Page Ltd.

Huang, G. Q., Shi, J., & Mak, K. L. (2000). Synchronized system for "design for x" guidelines over the www. *Journal of Materials Processing Technology, 107*, 71-78.

Jones, J. C. (1980). *Design methods: Seeds of human futures* (1980 Edition ed.). Chichester: Wiley & Sons.

Jordan, P. W. (1999). Inclusive Design. In W. S. Green & P. W. Jordan (Eds.), *Human Factors in Product Design: Current Practise and Future Trends* (pp. 171-181). London: Taylor & Francis.

Jordan, P. W. (2000). *Designing Pleasurable Products : An Introduction to the New Human Factors*. London: Taylor & Francis.

Jordan, P. W. (2002). The personalities of products. In W. J. Green & P. W. Jordan (Eds.), *Pleasure with products: beyond usability*. London: Taylor & Francis.

Kent, R. (2001). *Data construction and data analysis for survey research*. New York: Palgrave Macmillan.

Leedy, P. D., & Ormrod, J. E. (2001). *Practical research: planning and design.* Upper Saddle River (New Jersey): Prentice-Hall Inc.

Lidwell, W., Holden, K., & Butler, J. (2003). *Universal principles of design: 100 ways to enhance usability, influence perception, increase appeal, make better design decisions, and teach through design.* Gloucester, Mass.: Rockport Publishers.
Martyn, D. (2004). *Personal Audio - Urban Impacts and Design Guidelines.* Unpublished Final Year Honours Research Project, University of Otago (Department of Design Studies), Dunedin (New Zealand).

Mayhew, D. J. (1992). *Principles and Guidelines in Software User Interface Design*. Englewood Cliffs, N.J.: Prentice Hall.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: an expanded sourcebook*. Thousand Oaks (California): SAGE Publications Inc.

Monterey Technologies Inc. (Wright, M. C., Hartman, M. T., & Murphy, K. F.),. (1996). Resource Guide for Accessible Design of Consumer Electronics. Retrieved July 2004, from http://www.tiaonline.org/access/guide.html

Nagamachi, M. (1995). *The Story of Kansei Engineering*. Tokyo: Kaibunde Publishers.

NationMaster.com. (2004). New Zealand: Economy. November 2004, from http://www.nationmaster.com/country/nz/Economy

New Zealand Trade and Enterprise. (2004). Creative sector engagement strategy. February 2005, from http://www.nzte.govt.nz/common/files/ses-creative.pdf

Nielsen, J., & Mack, R. L. (1994). *Usability Inspection Methods*. New York: Wiley.

Pahl, G., & Beitz, W. (1984). *Engineering design* (K. Wallace, L. Blessing & F. Bauert, Trans.). London: The Design Council.

Pheasant, S. (1987). *Ergonomics - Standards and Guidelines for Designers*. London: British Standards Institution.

Pirkl, J. J., & Babic, A. I. (1988). *Guidelines and Strategies for Designing Transgenerational Products: A Resource Manual for Industrial Design Professionals*. Action MA (USA): Copley Publishing Group.

Ponn, J., Baumberger, C., & Lindemann, U. (2004). *Proceedings of the 8th international design conference - Design 2004: Guidelines for the development of individualized products*. Paper presented at the International Design Conference - Design 2004, Dubrovnik (Croatia).

Popovic, V. (2002). Activity and Designing Pleasurable Interaction with Everyday Artefacts. In W. S. Green & P. W. Jordan (Eds.), *Pleasure with Products: Beyond Usability.* (pp. 367-376). London: Taylor & Francis.

Prodesign. (2003). *Prodesign: The magazine for professional designers and their clients, Official Journal of the Designers Institute of New Zealand.* Auckland (NZ): AGM Publishing Ltd.

Pugh, S. (1991). *Total design: Integrated Methods for Successful Product Engineering*. Upper Saddle River (New Jersey): Prentice Hall

Reinmoeller, P. (2002). Emergence of Pleasure: Communities of Interest and New Luxury Products. In W. S. Green & P.

W. Jordan (Eds.), *Pleasure with Products: Beyond Usability.* (pp. 125-134). London: Taylor & Francis.

Rodriguez-Toro, C., Jared, G., & Swift, K. (2004). *Proceedings of the 8th International Design Conference DESIGN 2004: Product-Development Complexity Metrics - A Framework For Proactive-DFA Implementation.* Paper presented at the International Design Conference - Design 2004, Dubrovnik (Croatia).

Roozenburg, N. F. M., & Eekels, J. (1995). *Product Design: Fundamentals and Methods*. New York: John Wiley and Sons.

Sharma, P. (2000). The Importance of Mess. *The Design Management Journal, 11*(3).

SPSS Inc. (2003). SPSS (statistical package for the social sciences) version 11.0.2 for MAC OS X (Version Version 11.0.2 (Release 15/04/2003)). Chicago: SPSS Incorporation.

Stanton, N. A., & Young, M. (1999). *A guide to methodology in ergonomics*. New York: Taylor & Francis.

Ulrich, K. T., & Eppinger, S. D. (1995). *Product Design and Development* (2nd ed.). Boston: Irwin/McGraw-Hill.

Urbis. (2003). Urbis Design Magazine. Auckland (NZ): AGM Publishing Ltd.

van Aken, J. E. (2005). Valid knowledge for the professional design of large and complex design processes. *Design Studies, 26*(4), 379-404.

Vicente, K. J. (1999). *Cognitive work analysis: toward safe, productive, and healthy computer-based work*. Mahwah, N.J.: Lawrence Erlbaum Associates.

Yellow Pages New Zealand. (2003). The yellow pages online. Retrieved May 2003, from http://www.yellowpages.co.nz