Experience, Context-of-use and the Design of Product Usability

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Dedication

To Leonardo.

Abstract

This study argues that including aspects of user experience relevant to the user's knowledge of a product's context-of-use in the early stages of product design can enhance the design of product usability. To explore these issues, research was undertaken to respond to three research questions: (i) What aspects of user experience influence people's understanding of product usability? (ii) What is the nature of the differences between users' and designers' understandings of product usability? (iii) How can context-of-use and human experience enhance the design of product usability?

Findings from the study have shown that experience, context-of-use and knowledge about a product's usability are interrelated. Conceptual principles and design principles were established based on findings to explain (i) the relationships between aspects of experience and areas of product usability and (ii) differences between designers' and users' concepts of product usability. These principles responded to the first two research questions. Causal relationships found between experience and product usability suggested the need to implement them in an accessible manner for a product design process. A design tool — named the Experience and Context Enquiry Design Tool (ECEDT) — was devised to exemplify the implementation of findings. A trial run verified that the type of information that ECEDT brings to designers could assist them to address usability and experience issues during the early stages of the design process. This result responded to the third research question of the study.

This study's conceptual principles and design principles contribute new knowledge to design theory and practice. This knowledge contributes to design theory in providing greater detail about the differences between designers and users than that

addressed by existing theory; it contributes to design practice as it informs designers about the aspects of human experience that prompt users' understanding of a product's use. In doing so, it can potentially assist in the design of products that embed new technological applications, and support the design of product usability.

Keywords

Experience

Context-of-use

Usability

Design of product usability

User–product interaction

Visual representation of concepts

Product design

User concept

Designer concept

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Statement of original authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Marianella Chamorro-Koc
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Chapter 1:

Introduction

In our daily life we often encounter products that are difficult to use or understand. For example, selecting different options on the washing machine at home, or using the different settings of the photocopy machine at the office. As stated in several studies (Norman, 1988; Jordan, 1988; Kahmann and Henze, 2002), these types of difficulties are usability problems that arise from diverse issues that have not been addressed in the design of the product's user–artefact interaction. The user–artefact interaction, or the way the user interacts with the product and vice versa, has been largely studied in Human Computer Interaction (HCI) and Design. However, most of these studies have mainly focused on the final stages of a design process, delivering usability assessment methods that can assist designers to evaluate only the final product design or to redesign some of its features. These types of approaches do not support the early stages (or conceptualisation stages) of the design process.

As emerging technologies constantly change the way people interact with products and their physical environment, recent studies have started looking at human experience as a source to generate products or systems that engage the user. Nevertheless, while these approaches have explored ways to access the users' experience, they have not provided guidance to designers on how this information could also contribute to enhancing the design of product usability.

This thesis states that designing products without considering the human experience related to a product's context-of-use is one of the causes of usability problems. It also states that human experience is related to the user's understanding about the use of a

product, which is based on his or her experience of using it in a particular context-of-use. The thesis statements can be illustrated with the example of travellers trying to operate commonly known products or devices in hotel rooms. This is the case of shower knobs that operate differently in different contexts-of-use. In this type of product, the colour coding, the layout of the knobs, or the way they are turned on and off sometimes reflect they way things are understood in that particular context-of-use. These differences confuse the user and lead him or her to operational mistakes when trying to accomplish the intended activity (e.g. failure to set the water temperature). This simple observation is confirmed by previous studies indicating that 'products of design engage humans through their utility as well as their cultural location' (Plowman, 2003:30–31), and that designed artefacts are integrated into people's lives in multiple ways of interaction. Such studies indicate that through this experience, users create understanding (Weiser, 1993; Hall, 1976; Norman, 1998).

This study investigates those aspects of human experience that influence users' and designers' understandings of a product's use and its context-of-use, and it argues that including these aspects in a design process can support the design of product usability. Although the topics of experience and context-of-use have been studied in research design, previous studies have not investigated these topics in relation to the design of product usability.

1.1 Problem statement

This study is concerned with the difficulties that a broad range of users encounter when using products during activities in their daily life. These difficulties arise from issues not considered in the design of the user–product interaction, such as the user's knowledge and experience, and from the relationship of that knowledge and experience with the design of product usability. Essentially, the problem statement can be presented as:

> *Product designs that do not relate to the users' experience and their understanding of a product's context-of-use can create usability difficulties to the users.*

1.2 Context of the research problem and theoretical foundation

The need to study usability problems in user–product interactions has been acknowledged in previous studies in the HCI and Design fields, where arguments mainly pointed out that language, cultural differences and the emergence of new technology make products difficult to use (Del Galdo, 1996; Kahman and Henze, 2002). Those studies overlooked the fact that as technology progresses, it changes the way users experience everyday products, and as experiences result from the user's knowledge and interaction with the world, different users in different places might use the same product in different ways. This can be illustrated by the researcher's observations of artefacts for public use in international settings, where these artefacts impose usability problems to international travellers. Although travellers were able to read instructions labelled on the artefacts, they were unable to follow such instructions or understand the artefacts' feedback, and became confused on how to interact and operate the artefacts' features. In these types of artefacts, language limitation is considered a common usability problem (Del Galdo, 1996); but it is not the only one (Neulip, 2000): the user's prior knowledge of similar artefacts can also affect his or her understanding of a product's usability.

Figure 1 shows that users interact with the same artefact according to their previous knowledge, their personal characteristics (physical and cognitive capabilities), and within a particular emotional and cultural framework. Different users' characteristics generate different types of user–product interaction (interaction A, interaction B) with the same artefact. This interaction might also be different for other users in different contexts-of-use. For example, tourists from different countries vary in how they expect to operate petrol pumps at petrol stations. In some countries, the drivers interact directly with the petrol pump; in other countries drivers must wait for the station's employees to do it for them. These different experiences with the same type of device establish different forms of knowledge and understanding of it. Theoretical support for this statement is found in Norman's (1988) definition of 'mental models', which states that different people might have different understandings of the user–product interaction. This also influences the differences existing between designers' and users' mental models of everyday objects. In this illustration (Figure 1) the dark area represents the product's usability, in which the product's characteristics, the

user–product interaction, the product's context-of-use, and the user's experience are considered.

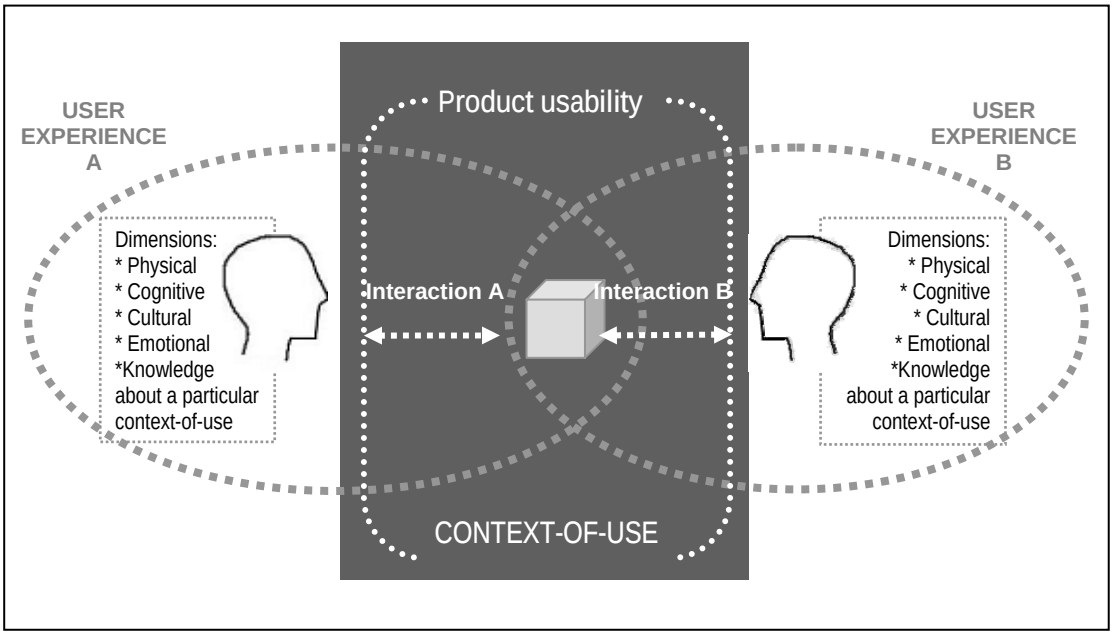


Figure 1: Research problem

This argument is consistent with previous studies in which a product's use, or the user–product interaction, is considered to be an event that takes place in a larger context comprising social, cultural, experiential and other possible contextual factors that influence how people relate to products (Hekkert and van Dijk, 2001). Although existing design research has addressed these factors, a gap still exists with regard to how the user's experience influences his or her understanding of product usability.

User experience, context-of-use and product usability have been associated in various disciplines. In computer science fields, the emergence of the microcomputer prompted the user study and context-of-use analysis as part of usability trials and usability evaluation of end products. In the design domain these issues were transferred by usability experts, whose research and methods initially aimed to help in translating usability information to designers (Kahmann and Henze, 2002; Green and Jordan, 2002; Maguire, 2001), and to guide usability assessment of product designs (Jordan, 1998). Most of this work has been related to the final stage of product design; nevertheless, recent studies show that an increasing interest in enhancing people's interactions with products has prompted design research about

the user's experience and contextual information to inspire and inform the early phases of a design process (Overbekee, 2002; Sleeswijk Visser et al., 2005; Hekkert and van Dijk, 2001; Grudin and Pruitt, 2002). Although these studies aimed to include experience and context-of-use issues, their approaches focussed mainly on identifying characteristics of the contexts in which products 'are' or 'will be' used (Sleeswijk Visser et al., 2005). In these studies, methods and techniques employed to explore the user experience have extended the conventional user-study techniques and included a Participatory Design framework. In that framework, verbal protocols, observations and the process of 'making artefacts' such as drawings, collages and 3D models (Sanders, 1992; Sleeswijk Visser et al., 2005) have been used to model archetypical users (Personas) and to develop possible scenarios of use to establish design criteria and guide the design process. These techniques, which are useful to elicit information from users and to communicate it to a design team, have been applied to large-scale projects, involving cross-disciplinary teams and extensive analysis processes (Sleeswijk Visser et al., 2005). Within the application of these techniques, the use of visuals has been explored as a source for the analysis of human experience; results point out that visuals can reveal a person's perception of reality, his or her past experiences, and ideas from imagination and concepts (Tovey, 1989; Goldschmidt, 1991; Schon, 1995).

All these research efforts have placed emphasis on eliciting information that could assist designers to enhance the user–product relationship in diverse situations of use. Nevertheless, current methods and techniques in Design have not addressed the aspects of user experience and contextual information that trigger a user's understanding of a product's use.

As design methods are based largely on user research, two points from previous studies about the design activity must be also considered: that designers interpret users' needs to predict user behaviour from their own experience and knowledge (Lorenz, 1990; Rassam, 1995; Popovic, 2002), and that design errors arise from the differences between designers' and users' mental models of everyday products (Norman, 1988). If human experience and people's interaction with products of everyday life limit or broaden their understanding of products and the surrounding

environment, the differences between users' and designers' concepts might also be at the core of the problems in the design of product usability.

From the previous work in this area, four key assumptions emerge as the basis of this study:

1. In product design, knowledge about usability issues has been adopted from the HCI field, where trends on usability research evolved from the assessment of end products (final stages of design), towards user-research that involves experience and context-of-use as components of usability (at the initial stages of design).
2. Context-of-use and human experience are related in the design of product usability; experience influences the user–product relationship and broadens people's understanding of a product's context-of-use. In user-research, users' sketches have been used to explore experience, as a source that depicts the users' representations of reality.
3. In a design activity, designers determine the context-of-use of new product designs. Usability problems of everyday products seem to arise from lack of information about context-of-use and experience issues in the design process, in which designers design and interpret users' needs from their own experience, without considering that their mental models of the usability of everyday products can be very different from those of the users.
4. Current design methods assist designers to access user experience by focusing on engaging designers with users' needs, and on identifying users' profiles and the product's context-of-use. However, they do not provide guidelines on how to incorporate this information to enhance the design of product usability, which requires extensive analysis involving teamwork.

1.3 Aim and scope of the study

This research aims to identify the aspects of human experience and context-of-use that influence the users' understanding of everyday products, to gain a greater understanding of the differences between designers' and users' concepts of a product use, and to explore how this knowledge can be made accessible to designers and applicable to the design process. The objective of the study is to establish a conceptual and methodological approach that includes these issues to support the

design of product usability in the initial stages of the design process. This study is limited to the area of everyday products that are of public or domestic use, and which are designed for a broad range of users.

For this purpose, the study investigates two components of the problem: aspects of human experience that influence the user's and the designer's understandings of product usability, and differences between designers' and users' concepts or knowledge of a product's use. The first component can inform the design process about particular aspects of human experience that prompt people's understanding of a product's use. This can be thought of as the user's experience within a particular social, cultural and physical context-of-use that determines how a product is used. The second component describes the aspects of experience and context-of-use issues that designers assume about users' concepts, and which influence their decisions during the design of product usability. This can be referred to as the differences between the designer's and the user's concepts or ideas about a product's use and its context-of-use, which influence the designer's knowledge about a product's use and its usability. In this study it is argued that addressing these issues in the initial stages of the design process can potentially support the design of product usability; consequently, the study also explores how the two components of the aforementioned problem could be included at the initial stages of the design of product usability.

1.4 Research questions

The inquiry of this study is: *How does experience influence people's understanding of product usability?* This question has been broken down into the following three sub-questions that lead this study.

Research Question 1:	*What aspects of the users' experience influence their understanding of product usability?*
Research Question 2:	*What is the nature of the differences between users' and designers' understandings of product usability?*
Research Question 3:	*How can context-of-use and human experience enhance the design of product usability?*

1.5 Research design

An empirical study was conducted to verify and explore the initial assumptions. The research approach employed visual representation of concepts to elicit users' and designers' concepts of a product's use, and to understand how their concepts are influenced by their individual experiences. Visual representations of concepts and verbal protocols helped to identify those aspects of context-of-use and human experience that are relevant to the design of product usability, and also to aid the interpretation process. Relationships that emerged from the iterative process of data analysis became the links between data and the emerging concepts that respond to the Research Questions of this study.

1.6 Outline of the Thesis

Chapters 2, 3 and 4 explore the key assumptions of this study. Chapter 2 looks into the notion of usability, the research done into product usability, and the involvement of context-of-use and human experience. It identifies the aspects that have been considered within the design of product usability, as well as past and current methods involved in the study of usability and user–product interaction. It points out that there is little evidence of previous studies that look at the design of product usability in the initial stages of a design process, and that context-of-use and human experience are issues in relation to the design of product usability that have been overlooked in those studies.

Chapter 3 examines the design activity and the differences between designers and users. It delves into previous studies on design process and thinking, and stresses that in the design domain, user research is still based on the designers' own ideas, knowledge and experience. Chapter 4 explores research methods employed in user research for data analysis that can help to access the user's experience and knowledge.

Chapter 5 presents the research design methodology devised to elicit knowledge and experience from the study's participants: product designers and product users. It proposes the use of visual representation of concepts as a means to access

experiential data from users, and the use of verbal protocols to assist in the interpretation of data and avoid the researcher's bias. In this chapter are presented the experiment design, a pilot study, the system of categories for interpretation of data, and the data analysis process. Chapter 6 presents the experiment results, the conceptual principles identified from overall findings, and the causal relationships describing particular links between aspects of experience and aspects of product usability. The conceptual principles involve five aspects of human experience influencing user's understanding of particular areas of a product's use, and eight types of similarities and differences between users' and designers' concepts of product usability.

Chapter 7 presents the discussion and implications of the findings. It addresses the significance of the relationships found between experience and product usability with regard to three aspects: (i) the relevance of experience and context in the design of product usability, (ii) the influence of differences between designers' and users' concepts of everyday products in their understandings of product usability and (iii) the methods employed to uncover aspects of experience related to product usability. The significance of findings and their implications for the design theory and practice are presented along with the contributions of this study to the Design field. This chapter suggests that a methodological approach — a design tool — is needed in order to make these findings accessible for designers and suitable for the design process. In this regard, Chapter 8 presents the Experience and Context Enquiry Design Tool (ECEDT), a research application prototype devised as an example of how findings could be implemented as a tool to assist designers addressing usability, context and experience issues at the early stages of the design of product usability. This chapter revises context-related tools currently employed in design activities; it presents the conceptualisation of ECEDT, and discusses its potential contribution based on a trial that was implemented to verify findings from this study. Conclusions are drawn, and future directions for further research are identified in Chapter 9.

1.7 Contributions

This study can potentially contribute to the design of products from emerging technologies that often challenge people's experiences and interactions. It addresses

the needs of an increasing number of international travellers who are permanently challenged by designs that are difficult to use in different contexts; it addresses the lack of information about the interrelations between experience, context-of-use and product usability that currently exists in design knowledge; in doing so, it also addresses the needs of the international design community to design products usable for global markets.

As designers have searched for the perfect 'fit' between users and products, they have been led to think about, and to design, products in relation to how they will be experienced by the users. This shift in the design of the product–user relationship has been supported by new concepts and methods emerging from diverse studies in design research (Sanders, 1999; Dandavate, 2000; Overbekee, 2002; Sengers, 2003). This study provides an alternative perspective; it aspires to contribute to the design of better and more usable products by providing new knowledge and by suggesting a means of how to implement this new knowledge in the design process.

Chapter 2:

Usability, Experience and Context-of-use

The study of usability emerged from diverse fields related to computer sciences and especially to Human Computer Interaction (HCI). It evolved from technology-centred issues to culture-related concepts that illustrate variables influencing human involvement with interactive systems in daily life. This knowledge was subsequently transferred from HCI to the Design domain. Traditional usability research has mostly focused on the evaluation of usability of artefacts and systems at the final stage of product/system development. Recent studies have shown that usability research in HCI and Design is increasingly concerned with the study of the user's individual needs. This has prompted the emergence of various methods that aim to better understand and represent the prospective user, and engage designers with users' experience. However, the few methods that focus on the initial stages of the design aim mostly to assist the user-research process and to trigger design creativity. Current literature does not refer to methods that take account of experience and context-of-use (a) in the initial stages of the design process and (b) in relation to the design of product usability.

This section explores what has been done in usability research, from traditional studies on HCI to issues being considered in current trends about the user–product relationship. It presents methods employed in usability research and in the design of human–artefact interactions. The connections between product usability and the issues of human experience and context-of-use are also explained.

At this point, a distinction must be made about the reference to HCI in this study. HCI has been considered due to the extensive body of knowledge that comes from that domain and which has been applied in product design. Computer sciences, Software engineering, Social sciences and Psychology are the four other domains from which information regarding usability research has been drawn in connection with human–artefact interaction, experience and context-of-use.

Regarding the term 'human–artefact interaction', it must be explained that this term has been most used in Sciences and Engineering, and in this study, it carries a very similar connotation to the term 'user–product interaction' used in the Design domain. The notion of human–artefact interaction in HCI refers to the use and design of 'human–computer interfaces' and has been widely used in usability research in the study of how users interact with computer technology and its applications in everyday artefacts. The study of human–computer interfaces has led to 'user interface design' representing a discipline focused on the design of digital artefacts. In Design, the notion of user–product interaction is used to refer to all the possible ways in which a user interacts or relates to a product during its use. The study of user–product interactions for the design of intelligent devices conduced to 'interaction design', a design-oriented discipline that focuses on human interaction and communication mediated by artefacts (Ehn, 2003). The term 'artefact' has been variously defined in different disciplines according to the area of domain. Artefacts are generally defined as human-made objects, with specific purposes (Lindquist and Westerlund, 2006). In HCI and computer sciences related fields, artefacts are objects 'enhanced with sensing, computing and communication capability' (Mavrommati and Kameas, 2001). This notion has also been used in Design, and in Participatory design activities it has been extended to any object that is used or created during a design process (Lindquist and Westerlund, 2006). In this study, the preferred term is 'product', in order to make reference to the 'user–product interaction' when referring to the design of product usability.

2.1 Approaches to product usability: from HCI to product design

The evolution of computer sciences and trends in HCI provided a foundation for the emergence of the study of product usability in design. As it was considered that the

usability of complex products is based on simple user mental models about how things work, and that the elements interacting with the user are the product's attributes and the user interface, the human–artefact interaction emerged as a core problem in usability research (Wiklund, 1994).

The most formal definition of usability is presented in the ISO standard 9241–11 (ISO, 1988): 'the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction, in a specified context of use' (UsabilityNet, 2003). The scope of this standard applies to office works with visual display terminals and other situations where a user is interacting with a product to achieve goals (ISO, 1994). Nevertheless, the use of the term 'usability' dates to a decade before ISO 9241–11. According to Bevan et al. (1991) the term 'usability' was used in diverse studies to replace the term 'user friendly', conveying connotations from various views that reveal the evolution of usability research. Three of these views are: (i) a product-oriented view that relates usability to ergonomic attributes, (ii) a user-oriented view that focuses on the mental effort of the user, and (iii) a user-performance view in which usability refers to the ease-of-use during human–artefact interaction. All three views demonstrate that the focus of earlier usability studies was placed mostly on the physical and cognitive aspects of the human–artefact interaction.

Since then, the study of usability has evolved towards interaction issues that relate to different types of human needs. Maxwell (2002:191) views HCI as a discipline that evolved towards the purpose of supporting people's needs with regard to the use of computing technology in their everyday life. His perspective about the evolution of HCI is connected to usability issues in computing technology, as he describes three levels of progression of HCI, from basic usability needs to higher-level human needs (2002:192). These are: (i) the basic usability (past), (ii) the collaborative-organisational and role-based interaction level (present), and (iii) the individualised and holistic interaction level (future). The move of computers into daily life environments (homes and offices) prompted research to support people's needs relating to ease-of-use and ease-of-learning. The use and development of Graphic User Interfaces (GUI), and research on design standards to enhance interaction issues also characterised the basic usability level. The collaborative, organisational and

role-based interaction level focuses on the sociological and cultural impact of collaborative technologies in organisational structures. At this level, a role-based approach is adopted to enhance customisation of processes, which requires a move towards aspects of interaction that can be tailored according to the users' role in an organisation. The study of interactive environments and individual issues such as motivation, personal growth, emotions, and individual differences will be the focus of the holistic interaction level, where computing environments are ubiquitous, integrated, interconnected and mobile. Maxwell's description shows that HCI research on usability is evolving towards an increasing concern with interaction, focussed on meeting higher-level human needs and human individuality.

Those descriptions agree with other studies in Design in which usability is defined as the interaction between the user and the product 'mainly focused on how people use the product' (Kahmann and Henze, 2002:297). These studies reveal usability research in product development that is focussed on the design of user-friendly products. The study of how well people are able to use a product supported a definition of usability as the 'quality of use in context', which reflects the experience of somebody 'doing something somewhere to accomplish a goal' (Wilson, 2002). Within this view, usability of product design focuses on the relationship of product–user–task within a particular scenario of use.

In HCI and in Design, the increasing interest in designing mobile devices that could respond to changing environments of use prompted the design of user interfaces that included emotions and pleasure as design issues. In this regard, Blythe and Wright (2003) explained that the increasing involvement of home tasks with information devices and computers challenges HCI, as traditional usability approaches are limited to whether the product does or does not frustrate the user. Sengers (2003) referred to the role of technology in everyday products, which allows exploring new ways to experience the world — thus underpinning the view that the design of technological artefacts for everyday use must focus on creating opportunities for thinking and engaging in different experiences. In the Design domain, the consideration of the user's experience, emotions and the issue of enjoyment in the design of user–product interactions evolved towards Experience design and Interaction design.

Experience design emerged from design studies that showed an increasing interest in designing 'beyond the object', and on how 'use and users' were considered in existing design processes (Redstrom, 2006:123). This interest can be seen in the study of Overbekee et al. (2003), whose work on human–product interaction stressed the importance of engaging the user in fun and beautiful experiences, as opposed to a technological or cognitive approach. Overbekee et al. acknowledged that ease-of-use has been the focus of usability improvement, but stressed that conveying contexts for experience and aesthetics of interaction in the design of products would contribute to an overall experience.

Interaction design, according to Ehn (2003), emerged from the participation of software and information technology into design. Interaction design focuses on designing user interfaces that facilitate and enhance designs that bring computational technology and ubiquitous computing into the design of people's interaction with artefacts. Ehn referred to the role of computers and information technology in our everyday life, by stating that computing has become more tangible and social, and that as a result their use is embodied in our experience of our everyday environment.

Previous studies show that usability research has evolved from an object-centric approach that considered ergonomics, cognitive and product attributes as core issues, to a user-centred approach that focussed on mental models, collaborative teamwork and individual differences. Moreover, studies about usability of the user–product interaction have extended their focus from a traditional usability approach to the inclusion of other aspects such as human experience and emotion. From this it can be said that there is an increasing interest towards the inclusion of aspects of user experience that look at the quality of use in context as core issues for the design of user–product interaction.

2.1.1 Involvement of human experience and context-of-use issues in usability research

As usability research evolved, it conveyed the study of human activity and the study of user experience in relation to context issues. For instance, Suchman (1987) stressed that understanding how human actions are informed by situations and how these become productive interactions are relevant to the design of interactive devices.

Her research about purposeful action in the design of interactive devices introduced the term ‘situated action’, which establishes that human action is situated within culture, a particular context, experience and activity. Her concept of situated action has been applied in HCI and Design, serving as a platform for emerging concepts, and contributing to other human–machine interaction studies in which human experience has been related to context-of-use issues. The ISO standard 9421–11 (ISO, 1994) definition of usability reflects the influence of Suchman’s concepts by stating that user, task, and physical and social environments of a product’s use are related. Within this definition it is considered that context depends on culture and that culture impacts on all aspects of usability.

Culture is a crucial variable in the study of context in usability research. In Hall’s (1976) study of the influence of culture on the act of thinking and perceiving, he explains that context carries meaning from the outside world by providing the codes to understand the messages that are received. In his view, language is not the only code that provides meaning to the information perceived from the context; that is, language provides only part of the message. Hall’s definitions about context involve a relationship between past experience in relation to a situation or environment of use that allows the human to perceive and adjust everything in terms of context. According to Neuliep (2000) cultural context is a dimension that involves all the other contexts. The environmental context is created within people’s own culture, showing the projection of how people see the world; context, therefore, is an active ingredient in human experience. It is influenced by culture and it affects and changes natural patterns of human behaviour and communication. Neuliep explained that cultural, environmental and perceptual contexts are interdependent, and that context comes within a perceptual frame of reference that influences our interactions with others. He agreed with Hall (1976) in defining context as culture-dependent. For Neuliep, context has an important role because it impacts on intercultural communication; it is more influential than language or personal abilities (physical and cognitive capabilities) in understanding messages.

Issues related to context-of-use were introduced into usability research after usability was defined in relation to the user, task and environment of a product’s use. Context is an ingredient in human experience. It is related to culture as it projects people’s

understandings of the world, and it is related to the physical and social situations of a product's use.

Human–product interaction and experience issues were connected in Johnson's (1997) study of interface culture, which found a relationship between technological evolution and culture. In relation to 'interface design', Johnson argued that culture and technology are interrelated concepts, and the fusion of technology and culture has always been part of human experience. Aligned with this view, the concept of artefacts as mediators of human experience was used in other studies to stress that the focus of the design process must change from objects to human experience (Wilson, 2002). For instance, Frascara considered experience and culture as the dimensions of design that indicate a shift of focus from objects, materials and manufacturing issues, to the contexts in which a designed product operates, and to the influence of such designs on people (2002:38). In Frascara's views, addressing the contexts in which product designs operate opens the possibility to examine a broader set of human needs. Such needs respond to three areas he identifies with regard to the design practice: (i) design that works to make life possible, which he related to designs that keep more people alive and safe, as in his work on traffic safety communications, (ii) design that makes life easier, which refers to the design of tools or systems that aim to extend our body abilities, and (iii) design that works to make life better, which addresses a higher dimension of human needs related to enjoyment, feelings and cultural sensitivity. Whilst he addressed the role of the social sciences in the design field and exemplified this through the aforementioned issues, he also stressed the notion of efficiency, which he deemed central to the design activity. His notion of efficiency in design relates to designs that facilitate the satisfaction of human needs. Frascara brought together the notion of designing from a user-advocate perspective by addressing user needs that emerge from experience in the context of interaction.

Plowman (2002) stated that the products of design engage people through their interaction in particular locations. His view, founded in an ethnographic approach to material culture, illustrates that people's behaviour, feelings, thoughts and understanding of things derive from their experience of everyday activities with everyday objects in a cultural location. Based on this view, Plowman established the

notion of ‘situatedness’, which explains that people’s experience with the multiple ways in which they integrate products (objects) designed through interaction, creates understanding about such products (2003:30–31). In this sense, the context in which a product is used (situatedness) and experienced lies at the core of people’s knowledge.

The notion of experience has been observed in relation to technology and culture. Experience has a connection with context issues because it takes place within particular situations, through which people’s experience of their interaction with product designs creates an understanding of the world. These studies show that issues of usability have been connected to human experience as part of the studies of the user–product interaction.

2.2 Usability research and the design of human–artefact interaction

In HCI and in Design, the design of human–artefact interaction has always been concerned about producing devices and systems that are efficient to interact with in terms of practical functionality and unambiguous communication or user experiences (Redstrom, 2006). Thus, several studies have indicated that the design process must focus on bridging the gap between people and products, and to do this, designers need to better understand users in order to model their activities and tasks during the early stages of design (Popovic, 2002).

The issue of activities and persons acting in particular contexts has been analysed from different perspectives. Some of these referred to Activity Theory, which places the emphasis on ‘artefacts’ as mediators of human expertise (Nardi, 1996:14). Nardi (1995) stated that Activity Theory contributed to the HCI field in the understanding of ‘context’, ‘situation’, and ‘practice’ by offering a set of perspectives and concepts for describing human activity. However, Bannon and Bodker’s (1991) study about the use of Activity Theory and information processing tasks to guide the design of HCI artefacts concluded that decomposition or descriptions of tasks were not enough to address contextual issues.

Kahmann and Henze (2002) explored the user–product relationship and argued that new technology makes difficult-to-use products; therefore, they considered that usability issues have become more important in the design process and that it is crucial for designers to study the user experience. In line with this, Overbeeke et al. (2002) stated that designers must create context for experience and enjoyment instead of just products, and emphasised that conveying 'contexts-for-experience' and 'aesthetics of interaction' in product design would contribute to designing an overall experience (p.12). Such studies stressed the importance of creating experiences that enhance the human–artefact interaction, rather than assessing product usability.

The literature shows that in usability research the design the of human–artefact interaction has taken account of several issues in areas related to the design process; such as the study of human activity, the focus on user experience, and the design of contexts for experience.

2.3 Methods used in usability research in HCI and Design

Diverse methods have been used in usability research. Most of them have focused on the usability evaluation of products and systems, while some have partially addressed the design process of product usability. However, methods to incorporate context and experience issues in the design process have received very little attention.

The role of 'scenarios' in user-centred designs has evolved from just providing context for usability testing of prototypes; now, scenarios have become an integral part of the design process. This has required providing feedback to designers and including the active participation of user representatives (Bodker, 2000). Scenarios have been defined as 'stories' within a setting, actors with goals, and a plot or sequence of actions and events (Carroll, 2000); and as 'constructions' made with the purpose of situating solutions, illustrating alternative solutions, and identifying potential problems (Bodker, 2000). The use of scenarios in HCI has enabled designers and analysts to be aware of assumptions about people and tasks considered in design (Carroll, 2000). Scenarios have also helped users explore a product's current and future use, helped prompt design decisions, and facilitated

communication between participants (Bodker, 2000). Scenarios are generated in concept-design activities, preceding interaction design and prototyping (Iacucci and Kutti, 2002) and are used 'in place of real data' during a design process to represent real-life practices (Grudin and Pruitt, 2002). This view has been used in product design, where scenarios describe the context of a user's experience with products (Lim and Sato, 2005:57). Scenario development in design assists the study and analysis of a situation through multiple aspects of the user's experience. Scenario development also guides design solutions by supporting the generation of design requirements and criteria at early stages of the design process (Lim and Sato, 2005), and by providing timely feedback to designers during the design process within a participatory design approach (Iacucci and Kutti, 2002).

Khong (2000) noted, in considering product usability, that product design practitioners have mostly employed methods that initially focus only on ergonomics, and physical usability issues that are mostly based on human factors. He employed a Product Design Process (PDP) model to illustrate that ergonomic methods can play a holistic role for identifying and satisfying user/customer requirements, and to ensure performance, usability, comfort, safety, and satisfaction. Khong's study emphasised that the use of ergonomic methods in PDP relies mostly on individual experience and knowledge of the product designer.

The studies cited above have followed HCI's traditional approach to usability, focusing mostly on the physical and cognitive aspects of a product and on usability assessment at the final stage of the design process. A shift in the design activity that aimed to include the user in the design process prompted the need to understand the user through methods that allow access to the user's experiential world. For instance, a study by Dandavate et al. (2000) used a participatory collaborative research project with multidisciplinary teams for the creation of new products for the office industry, in which a strategy named 'Postdesign' was employed as the main approach to understanding the experience of people who work away from a traditional office space. Postdesign, an information collection process that helps designers internalise the user's experience, is defined by Sanders as 'the domain of collective generativity' practiced as an ongoing activity in a design process (Sanders, 1999). This strategy was devised after employing an ethnographic approach, which led researchers to

realise that experience cannot be ‘observed’. To discover users’ emotional and cognitive experiences, a Generative Research method and a Participatory Design approach were applied. These involved four types of activities:

1. A participatory work session within the work environment,
2. An individual experience with the use of a workbook given to each participant to answer and represent open-ended questions,
3. A participatory technique based on a collage made about their experiences and their thoughts about their current experiences at work, aspirations and products,
4. A concept formulation with a specific set of words given to the participants that represented products, functions and context-of-use.

This approach allowed Dandavate et al. (2000) to develop an experiential model that depicts the user experience. The design process continued with an ideation workshop that was set up to create user scenarios. This was organised around six steps: using inspiration boards, creating a day-in-the-life narrative of users, producing product and marketing ideas for use in such scenarios, employing a narrowing-down process, brainstorming sessions and ideation workshops. The project helped to compare the benefits of participatory research with an observational type of research. The first is a means to learn from users and communicate this learning in a design team; the second reveals activities that users are not aware of, but which are complimentary.

The study by Dandavate et al. was one of the first to report a detailed exploration of user experience and context information as part of the design process. The origin of these techniques can be traced back to the research done independently by Sanders (1993) and Gaver et al. (1999) in the exploration of human experience and enhancement of the user experience in the design of the human–artefact interaction. Sanders’ studies developed Generative Research Techniques, where the main idea is to enable people (user representatives) to access and express their experience. This would introduce them to a creative process that makes them aware of their own experiences so that they can share these in design sessions. This facilitates the collection of information in a form that can later be analysed and used in the design process. Techniques evolved from methods with an ethnographic approach that were associated with what people say, do, and make, to generative sessions employing various types of toolkits that allow participants to express how they feel and dream

through stories represented in bi-dimensional (drawings, collages) and tri-dimensional (Velcro toolkit) objects (Sleeswijk Visser et al., 2005). Similarly, Gaver et al. (1999) developed the Cultural Probes Technique that aims to elicit diverse information from users through a specially designed package of different tasks and questions about their lives, thoughts, likes and dislikes. The package aims to provide a means for self-reflection and documentation (Mattelmaki and Battarbee, 2001). Cultural probes are used in a design process mainly to help designers empathise with the user, to understand the context in which a product is used, and to generate new design ideas. In design, cultural probes have been adopted to explore and uncover people's pursuits, emotional issues and latent needs, and have been employed in cross-disciplinary projects investigating the family group in domestic settings and the elderly and disabled group of users in care settings (Horst et al., 2004; Westerlund, 2003; Crabtree et al., 2003).

Generative Research and Cultural Probes are two different techniques. Generative Research is employed as the first stage in a user research process; it is carried out within design teams that follow a Participatory Design approach. On the other hand, the Cultural Probe technique provides fragmentary insights into participants' lives, and constitutes the main source of information in a design process where the designer is the interpreter of the probes.

Understanding and learning from the user have led to a method that facilitates the designer's engagement with the user for whom they design. The method is called 'Persona', a design tool that supports the use of scenarios and relies on generative techniques to access people's characteristics and behaviours. Personas are defined as fictional people, based on behaviours and motivations of real people (Cooper, 2003); Personas are 'user archetypes' that depict user profiles including names, social networks, gender, ethnicity, stories, aspirations, etc. (Cooper, 1999). The use of Personas in interaction design shows the increasing interest of the usability community in understanding the users' goals in specific contexts. Cooper explained that Personas are discovered during the research phase of a design project, and they are formalised during the modelling phase. According to his view, Personas are powerful tools that support understanding of user needs, help to differentiate between types of users, and assist prioritisation of the user type that is more important to

target in the design. User representation through Personas is closely related to users in context, as they are built from specific observations of users interacting with specific products in specific contexts (2003:59). According to Grudin and Pruitt (2002), Personas assist designers to develop partial knowledge about prospective users into a full description of a Persona profile and project it into new contexts for interaction. Persona design provides the foundation for scenario design, and is commonly used in a participatory design approach.

Approaching the user's experience and designing products that fit the user's latent needs evolved towards a design approach that aims to design for engagement and experience through interaction. This was the approach of Overbekee et al. (2002) in their study about usability problems in electronic products. Their study found that creating a context for experience and enjoyment could enrich the user–product interaction. Overbekee et al. (2000) presented a proposal of ten design rules to augment fun and beauty in interaction design. These are:

1. Don't think products, think experiences.
2. Don't think beauty in appearance, think beauty in interaction.
3. Don't think ease of use, think enjoyment of the experience.
4. Don't think buttons, think rich actions.
5. Don't think labels, think expressiveness and identity.
6. Metaphor sucks.
7. Don't hide, don't represent; show.
8. Don't think affordances, think irresistibles.
9. Hit me, touch me, and I know how you feel.
10. Don't think thinking, just do doing.

Aligned with this concept, Kahmann and Henze's (2002) study on the user–product relationship discussed the importance of including the 'context of experience' in design to enhance product usability. They presented three methods that would lead to a better understanding of the user–product relationship so that information provided to designers would help them to design products that can be better experienced by their owners. These methods are the:

- Usability Intervention Model — a schematic idea of design teamwork and the iterative process operating among the object of study, the intervention and the outcome;
- Use Scan Approach — presents three phases of the design process: exploration, evaluation, and verification; in this approach the designer receives information and does not generate data;
- Affection Scan — emphasises the user's wants or expectations about the product, and measures the affection and emotional aspects involved.

Kahman and Henze (2002) considered that usability professionals are needed in the design process to translate usability information from users to designers; consequently, their methods aim to help the 'intervention' in the design process. These methods are mostly concerned with the interaction between the product and the user, as they consider that usability is focused mainly on how people use the product.

In line with the Generative Research Techniques, Shneiderman (2002) discussed the study of creativity in the field of information technology, and the development of tools to support innovation. He stated that it is necessary to analyse HCI experts' understanding of creativity, their process of generating ideas (design), and the techniques associated with the generation of ideas to enhance the design of innovative user interfaces. These views are the foundation of the Genex Framework (generator of excellence framework), which consists of a set of activities that aim to support creativity. The Genex Framework is a four-phase integrated framework: (i) collect: learn from previous works, (ii) relate: consult with peers at various stages of the project, (iii) create: explore and evaluate possible solutions, and (iv) donate: disseminate results and contribute to existing resources. Shneiderman adopted a service-oriented approach to the design of user–interface tools, which illustrates a different perspective on the role of the design of user interfaces in HCI. Emphasising creativity to support learning and learning to support creativity, the Genex Framework was devised to contribute throughout the design process from the early stages of design.

The literature shows that adding context and experience in the design of the user–artefact interaction has been approached in various fields in different ways. Initially, a traditional HCI approach applied an empirical validation of models and usability trials. Recent trends in HCI and Design comprise methods and strategies that focus on understanding the users' experiences, behaviour, expectations and emotional engagement during the realisation of activities. These methods have been applied in a Participatory Design approach and have led to the development of user profiles (Personas) and context-of-use development (Scenarios) at the initial stages of the design process to assist designers to establish design requirements and criteria. This approach in current design activities aims to generate products as contexts for experiences.

2.3.1 Assessing usability and context issues in HCI

Methods used for usability assessment in HCI represent the most traditional approach to usability studies. Bevan et al. (1991) stated that usable products must meet specified usability criteria. They considered that those criteria depend on specific requirements from the user, task and environment of use. Based on this, the usability of products could be measured in terms of effectiveness, efficiency and satisfaction; these measurements provide an overall assessment of the user–artefact interaction. According to Bevan et al., the assessment of product usability facilitates making comparisons between different product–system performances, and assists in establishing ergonomic requirements and guidelines. They stated that in this way the use of agreed standards such as ISO 9241–11 (Guidance on Usability Specification and Measures) gained acceptance for usability assessment in industry.

Nielsen (1993) described another methodology called 'Discount Usability Engineering' based on four techniques that help usability assessment focused on the user: (i) user and task observation, (ii) scenarios, (iii) simplified thinking aloud and (iv) heuristic evaluation. Nielsen emphasises the point that usability is one category in the 'System Acceptability Scheme'. This scheme is divided into two large areas: social acceptability and practical acceptability. Nielsen stressed the importance of considering the user's real situation and highlighted that user testing is fundamental in usability evaluations (for interface design). He also addressed usability test measurements and described a usability evaluation model in which the goal

(usability) comprises ‘components’ that describe the sub-issues to be tested. The type of quantification, method and techniques are presented as sub-parts of the components. According to Nielsen, these techniques form the basis of the empirical methods.

Mack and Nielsen (1994) referred to usability inspection methods and processes that are applied to the existing user interface design at the engineering cycle stage. They report eight methods that are used for this purpose: (i) Heuristic evaluation, (ii) Guideline review, (iii) Pluralistic walkthrough, (iv) Consistency inspections, (v) Standards inspection, (vi) Cognitive walkthrough, (vii) Formal usability inspection and (viii) Feature inspection. Some of these methods are empirical and others are non-empirical, but most of them rely on user testing. According to Mack and Nielsen (1994), usability inspection refers to a set of methods that are based on the participation of inspectors who evaluate products according to specific criteria.

Del Galdo and Nielsen (1996) approached the topic of international usability based on the participation of usability experts from multiple countries in the evaluation of user interfaces. One of the methods addressed by Del Galdo and Nielsen is the International User Testing that is employed in the computer media communication (CMC) field, which uses real users and tasks as components of usability assessment.

Assessing context as a part of usability has focused mostly on task oriented tests. Abowd and Mynatt (2002) described some case studies that examined the usability of ubiquitous computing services/devices. They emphasised that usability laboratories are not suitable for deeper evaluation, and that an authentic setting in the environment of expected use is required. One of the evaluations performed referred to a system that aimed to capture the living experience in the classroom for further references for teachers and students. In that case, the design of the ubiquitous computing device was focused on the ‘experience’ of a daily life activity. Abowd and Mynatt argued that usability tests in laboratories are applied to fixed tasks but this does not accommodate usability evaluation for ubiquitous computing devices, as it might not be appropriate to capture everyday operations in a real context-of-use. Methods used in this case were prototyping, content-based retrieval, and a playback of experience.

Maguire (2002) described a study about an evaluation of digital TV services, in which he used a user-task evaluation focusing on the family use of this service in home settings. In order to address context-of-use issues to improve the design of product usability, Maguire presented a usability evaluation model called 'components of context of use analysis'. Within this model, he explained five stages in 'performing a usability-context-analysis'. These are: (i) describe the product, (ii) identify users, (iii) describe the context-of-use, (iv) identify usability factors and (v) document the test conditions. Maguire's results from this evaluation are framed into design considerations for future evaluation of this service; however, he reported that new methods in product assessment are needed to address the study of context-of-use issues in design.

Assessing usability and context issues has involved the following assessments: (a) a traditional usability assessment view focused on measuring the product's efficiency, effectiveness and satisfaction, (b) a usability assessment focused on the user in laboratories or in real situations and (c) a usability assessment focused on user activity that includes contextual information and user experience.

2.3.2 Assessing usability and experience issues in design

Methods employed to address usability issues in Design typically have two perspectives: one that involves usability experts in the design process, and another that highlights the lack of methods for designers to include experience and context in a design process. Although methods that deal with usability issues have traditionally focussed on assessments at the final stage, more recent work has seen the focus changing towards other stages of design. For instance, a study from Van Viannen et al. (1996) discussed usability evaluation issues in product development processes, and demonstrated it by referring to the methods, and test organisation, of the Product Creation Process (PCP) at Philips Electronics Inc. Van Viannen et al. conducted a project at Philips Electronics that resulted in a set of guidelines for the usability evaluation of products. The use of scenarios for testing was part of the procedures included in the guidelines. However, the project did not provide orientation for the design process, and the question about how designers can ensure a real scenario for the PCP to ensure international understanding of products remained unanswered.

Smit's (1996) statements indicate that usability evaluations take place at a very late phase in product development, so its results are not fully implemented in the product. According to Smit, usability is applied as a separate stage of the usability engineering cycle, and the understanding of clients and developers about usability goals is not necessarily the same as those addressed at the usability evaluation stage. Smit described a case study that shows the application of a method to help clients and developers detect whether they have different or similar ideas about the aim of the usability project. In this method, through discussion in which all views are expressed, a common ground is reached to determine the usability goals of the project. Making the client's situation the starting point of the approach is the main difference that Smit addresses with regard to 'traditional' usability evaluation. This provides a 'recognisable context' for the usability project. Smit highlighted the idea that 'trying to understand the context of the application development is almost a precondition for good results' (1996:27).

To include usability concepts and methods in the Design, Jordan (1998) developed a five-component model named 'components of usability' based on the ISO 9241–11 definition of usability. The model deals with the three usability measures outlined in the ISO definition — effectiveness, efficiency and satisfaction — and aims to reflect the level of performance of a user–product interaction during the realisation of specific tasks, during first-time use and after an extended period of non-use (1998:11). Jordan's five components are (i) guessability, (ii) learnability, (iii) experienced user performance, (iv) system potential and (v) re-usability. The application of usability concepts and methods followed the HCI tradition, and focused on assessing final product designs with regard to the physical ergonomics and the cognitive aspects of the user–product interaction.

Usability evaluation methods have also included observation techniques. Bouma (2000) defined observation as a qualitative research technique that is conducted by watching what happens. The observation technique is guided by specific research questions that aim to help the researcher to focus on particular features, and it is mostly used to observe processes, and activities related to the task observed. Using and positioning cameras for different views to aid the observation would allow

researchers to access data in great detail. Baber and Stanton (2004) stated that this technique could help analyse people's reactions while they interacted with products, yet it needs to be coupled with some other technique to access any unobservable information.

Blackler et al. (2004) used observation methods to record the intuitive use of products. She focused on analysing how users relate to individual product features based on their prior experience. To observe users in great detail, Blackler et al. employed observation techniques combined with a Think Aloud protocol, and found that combining these methods eliminated the possibility of the user forgetting details of the activities performed during the experiment. At the same time, combining Observation and Think Aloud protocols allowed the user to recall past experiences. Blackler considered that using a Retrospective protocol would have limited the user's recollection of activities. The Noldus Observer — specialist software that manages and analyses observational data — was used in this experiment, and helped the researchers to apply a coding system and to categorise the observations into observable behavioural classes that were investigated in their study. By using the observation technique with the aid of two cameras, the researchers were able to access results concerning features of the artefact tested and also to features related to the participants' performance. Observations and verbal reports allowed measurements with regard to time, technology, familiarity, and intuitive uses of features. In this study, both techniques allowed access to rich and complex data.

The literature indicates that in Design, methods involving usability have focused mostly on the evaluation of products at the very late phases of design — measuring product performance and task performance and using methodologies from the HCI tradition. The users' experience has been approached through user-trials, focus groups, interviews and other methods that aim to access and depict human experience. While these methods can assist designers to understand the experiential world of the user, they do not assist in understanding the connections between aspects of user experience and product usability characteristics.

2.4 Context-of-use and human experience in the design of product usability

In this section are discussed the conceptual issues related to human experience and context-of-use that emerge from existing research design, and which are relevant for the design of product usability.

2.4.1 Product usability and the concept of context-of-use

Various approaches to the concept of 'context' and its application to the design of product usability are related to whether a product can be understood or not. Context-of-use has been defined by ISO standard 9241–11 (1988) as 'users, goals, tasks, equipment (hardware, software and materials), and the physical and social environments in which a product is used'. It focuses mainly on the activity and the physical aspects of the human–artefact relationship (ISO, 1998) that specifically describe users, equipment, environment, goals and tasks in relation to the usability framework.

From the perspective of product semantics in design, Krippendorf (2000) examined design activity and the meaning of products, pointing out that products take meaning within a context. In regard to how users and designers perceive the meaning of products, Krippendorf (2000:159) suggested that 'objects are always seen in a context (of other things, situations and users, including the observing self)'. He explained that the perception of the purpose of an object places the object in a context of intended use, and perceiving who will use it places the object in a social context. For Krippendorf, the relationship between object and context are cognitive constructions that are meaningful for users; therefore, he stated that an object's meaning is the 'sum of the total of its imaginable contexts'. Krippendorf's theory of the meaning of products demonstrates the importance of context in product design activities.

In attempting to study usability issues that can improve the design process and provide better design outcomes, Maguire (2001) stressed that context is an important concept in daily life activities; he explained that the use of every product takes place within a particular context and a particular characteristic of use that defines the product's context-of-use. He stated that the inclusion of the study of context-of-use in the product design process benefits the understanding of user needs and the

identification of user requirements; it addresses usability and provides validity for evaluation. Although Maguire's study addresses the importance of context in design, and contributed to the evaluation of product usability, it did not indicate how this could be included in the early stages of the design process.

The study of context in product design is prominent in Hekkert and Van Dijk's study, which uses a 'context-driven view on designing' (2001:2). They argued that context comprises all the factors that a designer considers in his or her design by influencing his or her views and design decisions, and therefore the 'design of context' should be the first step in every design project. According to this view, context is defined as all factors related to the human–product interaction (social, cultural, experiential and environmental) that a designer chooses to consider when setting the parameters of product design. In that sense, the designer creates the context of a product's design. Hekkert and Van Dijk defined four types of 'context factors': (i) 'states' that reflect stable conditions, (ii) 'development' that is a changing state, (iii) 'trends' that reflect tendencies in behaviour, values, and preferences and (iv) 'principles' that reflect immutable laws or patterns found in human beings or nature. Hekkert and Van Dijk applied their theoretical view in the development of the Vision in Product design approach (ViP) — a context and interaction-driven design method that supports designers finding and setting parameters during the design of their products. The application of ViP to design projects shows effectiveness in aiding designers to drive their concept designs by considering the particular contextual information for the specific user–product interaction designed for the project.

In Pullman's (2002) study about the design process for creating engaging products and systems, it is considered that context is a key issue for the design of the activity, and that context provides meaning to the experience. Pullman (2002) defined context as the physical setting and arrangement of products, rules and procedures for social interaction with customers and service facilitators; that is, context provides meaning to the experience. For Pullman, context is a key issue in the design of the activity that is to be supported by a product or system. In her view, context and experience are connected in the design and creation of engaging products.

Mills and Sholtz's (2002) concept of context refers to something that changes in response to external influences. They agreed with the ISO's (1998) concept of context, explaining that it can be inferred from the user, the location and the task descriptions; they further explain that contexts change continuously due to new demands in work environments, and that much of the information that users produce is context-dependent. In line with this thought, from the social perspective, Frascara (2002) explained that designers are no longer concerned with products, but with the context in which products are used by people. In his view, context includes the particular situation, and not only the activity, as part of the interface. According to Frascara every object affects the behaviour of people; in public spaces it conveys a cultural impact as well.

In a study that brings context issues into design practice, Sato's study addressed the concept of context as a critical component of the design information in order to enhance the human-centred design practice (2004: 277). From various definitions in diverse fields, Sato explains that there are *external* and *internal* conditions that converge into the definition of context and suggest that it has four characteristics (2004:278):

1. aspects of context are based on the nature of actions and conditions,
2. description depends on the focus of the viewpoints,
3. contextual changes are triggered from different elements of the domain,
4. context evolves over the time, some aspects change fast others change slow.

From this, Sato defined context as a mental model or a pattern of one's memory triggered by elements in the situation, where situation is a collective condition at the scene of interaction composed of relations among variables of conditions (2004:278). He employed this concept to describe the influence of contexts in people's interactions and system performance and vice versa.

Aligned with this view, Sleeswijk Visser et al. (2005) pointed out that an increasing need to study the 'context of people's interactions with products' originated from new processes of product development that aim to 'fit products into the lives of people who will use them' (2005:119). In complementing the definition of context as 'the environment of human–computer interaction' that refer only to what is 'outside

the product' (2005:121), Sleeswijk Visser et al. provided a definition of context as 'all factors that influence the experience of a product's use arising from an activity (2005:121). They stressed the importance of 'redefining context for every design problem' — that the study of context allows designers to understand users and so avoid a priori assumptions. Employing this view, they applied a generative research approach to elicit information from prospective users about the context of a product's use, and developed a Contextmapping technique to apply outcomes from the generative research to the early phases of product design. Their approach focussed on creating and defining new concepts about how a product can be experienced.

The concept of context and its role in design has been the topic of a recent on-line discussion between Design Research Society (DRS) members who contribute to the PhD-Design List (JISC, 2006), which includes design researchers and practitioners. There, context has been described in two different types of models: static and dynamic. However, context has also been referred to in terms of the context of a design and the context in which the designer works. In the static sense, context is considered as a theoretical model, particular to a design, and part of the user study (Chow, 2005). Similarly, another definition refers to the notion of context as 'the situation or the operating environment into which designers add some artefact, for the sake of causing a change in that environment' (Salustri, 2005). These definitions present context as a static model of a situation that receives the action of design, leading to the use of the word 'situation' instead of 'context'. However, as indicated above, context can also be viewed dynamically. The dynamic model is defined as 'not a theoretical object but a living, evolving environment' (Disalvo, 2005). Considering both dynamic and static definitions of context, it can be suggested that in the design process, designing a product for a specific context-of-use is to presume that a design would fit into a static model of an operating environment.

From a different perspective, two other definitions of context present the notions of the 'designer's context' and the 'design context' (Sless, 2005). The designer's context relates to the context in which designers work, and depends on the designer's individual point of view, sophistication, social environment and economic sensitivity or awareness. The design context refers to the designs that designers create and that exist in a particular 'context'. These definitions suggest that the way designers

perceive the ‘context’ for their ‘design’ can be attributed to the context in which that design is used.

In this study, product usability is defined as the dimension of the user–product interaction that is affected by the product’s context of interaction and the user’s experience. Cultural issues, human experience and the characteristics of the environment where the user–task relationship takes place are components of the context of a product’s use, from which interpretation and understanding of the external world and interactions are inferred. Considering definitions from previous studies, the definition of context in this research refers to the relationship between use–activity–task–situation that takes place during people’s interactions with products, and which provides users with an understanding of the product. Context is thus viewed as a dynamic entity that changes according to the user’s experience and culture.

2.4.2 Product usability and the concept of human experience

In product design, research relating to usability, context and experience has been influenced by Norman’s (1988) definition of conceptual models, which refers to the ideas people have about how things work. His view about people’s understanding of the material world emphasises that experience is a determining factor for the construction of knowledge. In Norman’s conceptual model, designers design the products we use in our daily lives according to their own conceptual models, expecting the product design to match the users’ conceptual models. This leads to mismatches in the relationships between the system’s components (designer–product/system–user) and gives rise to errors in the human–artefact interaction. Norman’s concept has been important in prompting the study of experience issues in product design.

New conceptual approaches emerged from the study of experience as part of the design process. Sanders (2001) defined experience as a ‘subjective event’ occurring in the ‘context of time’, including ‘memories from experiences already lived, experiences from the present moment, and dreams about future or imagined experiences’. This definition established the experience domain as an event comprehended only by the person who lives the experience. Grupta and Vajic’s

(2000) study about service providers defines experience within context as ‘something that occurs when a customer has any sensation or knowledge acquisition resulting from some level of interaction with different elements of a context created by a service provider’. These approaches indicate that experience refers to more than a past time, and that it involves acquisition of knowledge.

Studying experience and the ways to access it has been an evolving process. According to Sanders (2002), traditional methods in design research have used observation techniques and market research techniques such as focus groups, questionnaires and interviews. She explains that new tools to access and understand users’ experiences are focused on what people create and express about their thoughts, feelings and dreams (the ‘do-say-make technique’).

These concepts have been employed in various design studies that aim to enhance people’s experience during the user–product interaction. For example, to emphasise the importance of user engagement in fun and beautiful experiences in the design of the user–product interactions, Overbeeke et al. (2003) devised ten design rules that aspired to create enjoyment of experiences (p.18). Sleeswijk Visser et al. (2005) adopted Sander’s definition of experience (2001) and explained that it has been applied to several consumer product design projects in which other conventional user study techniques were only able to uncover people’s views on current and past experiences; such techniques provided no access to their dreams or aspirations (future contexts and experiences). Those studies, conducted by employing Generative Research and Contextmapping, have extended the application of Participatory Design techniques and user scenario formulation by including aspects of context and experience in the design process. In these projects, Contextmapping was used to elicit contextual information from user’s experiences in a form that helped designers generate human-centred designs of consumer products within a Participatory Design approach. In both studies, authors stressed that context and experience are closely related.

To explain the design of pleasurable interaction, Popovic (2002) discussed an approach that involves understanding and modelling the user, activities and tasks in order to support the design of everyday artefacts. She explained that in current design

processes, designers apply their own knowledge and expertise to predict human behaviour with an artefact, but that designers are increasingly considering the user's viewpoint. However, she argued that this is still insufficient to address the user needs and viewpoints and that understanding the process that occurs behind the activity must be a key issue for designers. As pleasure cannot be defined by rules, she pointed out that achieving pleasurable interaction in the design of artefacts should involve the following process: (a) research into the scenario–user's concept formulation, (b) design and application of relevant research findings and (c) design development and production.

Approaches that address the design of product usability and which include the user's views and experiences range from (a) intervention models that facilitate collaboration between usability professionals with designers, through (b) methods that assist designers to access people's thoughts and feelings through participatory techniques, to (c) design processes that focus on initiating the design with a user and scenario formulation.

Taking all these approaches into consideration, experience, in this study, is defined as the comprehension and perception of life events that underlie understanding of the world, and upon which individual knowledge is constructed. In this sense, it can be said that the user's experience reflects particular moments (episodes) that result from some level of interaction with products and surroundings, and within different aspects of a particular situation.

2.5 Summary

The previous definitions have addressed existing research related to usability, context and experience. Seminal work in HCI and in Design has been discussed to show how concepts have evolved from an object-centric perspective in HCI to a more 'user involvement' view in Design, where new dimensions of design are studied and included in the design process. Among these, context, experience and culture are considered. This section summarises the main issues from the literature.

The relationship of usability to issues of human–product interaction and experience emerged from HCI research that evolved into more contextual issues. This can be seen in studies connecting the design of human–product interaction to human experience as a means to improve the design of usability (Wiklund, 1994; Johnson, 1997; Wilson, 2002). The study of usability in the design of artefacts, both in HCI and in Design, seems to have arrived at the same conclusion; that is, that human experience impacts on whether an artefact can be used or not by a diverse range of users. Usability conveys not only the individual experience of users, but also aspects of culture. Experience is therefore a component of the system of interaction that affects the usability of any artefact. Methods employed in HCI and in Design evolved from assessing product usability at the final stages of design process, to studying, understanding and engaging the users' experiential knowledge at the initial stages of design. In Design, methods involving user research support the design of user profiles or Personas and the definition of contextual information for Scenario development. Although modelling users, activities and possible contexts-of-use has helped designers generate products as 'contexts for experience', these methods do not provide information about the aspects of human experience that can support the design of product usability.

Considering the existing literature and the problem statement, the following definitions of product usability, context and experience will be used:

- Product usability is defined as the dimension of the user–product interaction that is affected by the product's context of interaction and the user experience.
- Context is defined as the relationship between use–activity–task–situation that takes place during people's interaction with products, and that provides users with an understanding of a product. It is a dynamic entity that changes according to user experience and culture. In this relationship *use* relates to a product's user-product interaction, *activity* refers to the actions related to that interaction, *task* refers to the specific purpose for which the interaction is produced, and *situation* refers to the circumstances and characteristics of the social and physical environment in which the interaction happens.
- Experience is defined as people's comprehension and perception of the life events that underlie their understanding of the world, and upon which individual knowledge is constructed. This results from some level of interaction with

products and surroundings, and happens within different aspects of a particular situation.

It is clear that context-of-use and experience are important when user–product interactions are being considered in the design process. Some studies that focus on the initial stages of design employ methods that help access and depict human experience and help designers generate more engaging products. However, these methods do not aim to explore how aspects of experience would influence the user's understanding of product usability; consequently, they fail to address how this information could be included in the design process. A more comprehensive reference to the design is needed in order to explore this. The design domain and related issues will be discussed in Chapter 3.

Chapter 3:

Approaches to user research in Product Design

Within the Design domain, designing has always been characterised by the pursuit of product designs that address users' needs — practical, functional, cognitive, interpretative and emotional. As technology progresses and pervades almost every daily life activity, many everyday products become difficult to use. Therefore, addressing user needs in product design has become a more complex process, moving away from the ergonomics approach to the adoption of HCI usability methods, and later to the adoption of an ethnographic research approach.

In Design practice, designers primarily frame the design of the user–product interaction of everyday products based on their knowledge and experience, and on their interpretation of the users' needs (Rassam, 1995; Lorenz, 1990; Popovic, 2002, Redstrom, 2006). The study of users' needs and characteristics is a core activity in Design, and in general it has been approached in two different ways: through the study of the physical and cognitive characteristics of the intended user (Khong, 2000), and through user-research that seeks to elicit knowledge and experiential information from prospective users through a participatory design approach. While the first way corresponds to a more traditional object-centred approach, the second responds to current design trends that aim to design the user experience (Redstrom, 2006). Context-of-use and experience have been studied as part of user research and Participatory Design approaches that tried to reduce the distance between users' and designers' ideas of experiencing a product's use. This topic requires the consideration of other aspects of the design domain, such as the design activity and process, design thinking and knowledge in design.

To understand the ways in which designers have addressed users' needs with regard to the design of a product's use, this chapter will look at the design activity, the issues that inform the design process, and the possible causes that lead to product designs that do not fit with users' needs and expectations.

3.1 Research about the design activity

Design has been defined in several ways. One definition states that design is a 'process by which designers devise courses of action that aim at changing existing situations into preferred ones' (Friedman, 2003:509). Design evolved from 'designing the use of objects' that includes ways of use and living, to 'design as communication' that expresses the functionality and intended use of the object. More recently it has evolved towards a focus on the user's experience of the object. According to Redstrom (2006), the latter indicates a 'shift' in the notion of design, from object to user; from designing 'things to be used', to designing the 'use' or the 'user experience'. In this sense, he stressed that 'design has become a matter of process rather than product' (2006:136).

Cross et al. (1996:1) defined design activity as the process that 'encompasses some of the highest cognitive abilities of human beings, including creativity, synthesis and problem solving'. According to Friedman, designers move from thought to action, identifying problems, selecting goals, and realising solutions (2003:511). He suggested that most definitions share three attributes: (i) process, (ii) goal-orientation, and (iii) problem-solving. The main design goal of any design activity is to design objects and/or systems that satisfy user and producer requirements. To accomplish this, the design process encompasses various activities that have been studied and categorised in various ways. A very broad description of the design process presents it in two stages: designers as 'black boxes', and designers as 'glass boxes' (Jones, 1970). The first corresponds to the creative or initial stage, and the second to the product development stages. The second can be described in terms of three sub-stages: exploration, generation and selection (Cross, 1975). The literature indicates that research about the design activity has been conducted mostly with a focus on the first stage of the design process.

The study of design activity has been approached from diverse perspectives, and a variety of methods have been applied to study it. Methods employed range from philosophical types of reflection, to empirical investigations, and to explorations of the design process and design thinking. Verbal reports and the analysis of sketches produced during a design activity are two of the methods most used; these two methods have been used together to complement results.

Verbal Protocol Analysis is regarded as the method that is most helpful in revealing the designers' cognitive abilities that are difficult to discover by other methods. According to Cross et al. (1996), concurrent verbal accounts (Think Aloud Protocol) might not reveal what is happening in the designer's head, but do reveal what they believe they are thinking. One drawback of this method is the possible subject's change of behaviour during a verbal protocol, which can affect his or her cognitive performance and lead to irrelevant accounts of thoughts during the task. These are pointed out as disadvantages of protocol analysis in Design, where external verbalisations of thought processes are fundamental to understanding the design activity. Given the limitations of the sole use of verbal protocols to elicit knowledge about the design process, the study of sketches produced during the early stages of design was also employed to approach and understand design thinking. For example, Schon and Wiggins (1992) focussed on studying the role of freehand sketches in design activities, and stated that designers use sketches as a medium to engage in reflective conversation with their own ideas. They employed Protocol Analysis to examine the cognitive processes happening while sketching in design and found that sketches have two different roles: as a medium to re-interpret ideas, and as a medium for unexpected discovery. Those concepts were later found in other research studies relating to the investigation of design thinking, and became the point of departure for new approaches relevant to the study of visual thinking.

A study by Suwa et al. (1998) looked into the sketching process at the early stages of the design activity in order to interpret the designer's cognitive actions while sketching, and to understand how those actions contribute to forming key design ideas. Using systematic coding to interpret designers' actions from video and audio protocols, they found that designers interact with their own ideas through sketches,

and that designers do not always interpret their own depictions with the same connotation but could also associate them with a new concept or meaning. Their study concurred with Goldschmidt's (1991) concept of 'seeing-as' and Goel's (1995) concept of 'lateral transformation' and stated that those concepts in design are the 'driving force for the exploration of new design ideas' (Suwa et al., 1998:457). The coding scheme was devised as a general taxonomy of the designer's cognitive processes, distinguishing visual information (depictions) and non-visual information (knowledge and thought). The Suwa et al. study shows that the use of sketches is a useful source of information for understanding the creation process in design.

In those studies, Protocol Analysis was also used to access and reveal current actions during a design task. Schon and Wiggins (1992) and Suwa et al. (1998) used Protocol Analysis to examine the cognitive processes taking place during design activity. Dorst and Dijhuis (1995) studied the use of this technique in research design and proposed that protocol analysis methods fall into two categories: (i) process-oriented protocols and (ii) a content-oriented approach. The first category is relevant to the organisation of taxonomies for problem solving, problem statements, plans, goals, or strategies that occur in a design process. The second category applies to the designer's interaction with his or her own sketches; but according to Dorst and Dijhuis (1996) the lack of a general taxonomy of designers' actions has been the drawback of content-oriented protocols; without this taxonomy the possibility of comparing outcomes from different designers is limited.

Gero and McNeill (1998) studied the use of the Think Aloud method to understand how designers design. They state that protocol data are rich but unstructured, and that detailed understanding of design process requires projecting the data onto a framework (1998:23). In their study, a coding scheme was developed as a framework to analyse data; this framework was derived from direct observation of the designer's interaction with the problem domain and from models of design reasoning. Design tasks selected for designers to perform in their normal place of work were videotaped and designers were asked to verbalise their thoughts during design episodes. The use of Think Aloud methods in this case was instrumental in accessing the design thinking that took place during the different design episodes; further, the coding scheme was useful for understanding the different design processes occurring in the

design activity. Verbal protocols and techniques to analyse them are further explained in Chapter 4.

Sketches, as an externalisation of design, have been a useful medium to investigate the design thinking and design process, and have also been employed to study the design activity from other perspectives. For example, sketch production in design tasks has been studied in relation to the influence of functional knowledge (of objects and their parts) on sketching and its role in visual reasoning. A study by Tseng et al. (2002) explored this with novice designers, who were asked to observe and then to draw three chairs from memory. This process is referred to as the 'object-recall paradigm'. Prior research had identified two modes of drawing: part-by-part (each part is drawn completely before moving to another), and non-part-by-part (elements of parts are drawn as they come to mind). This study revealed that novice designers draw sketches in a part-by-part manner; most of the process of recalling and drawing objects from memory occurred this way. The study concluded that in the case of novice designers, representation of an artefact's concept is influenced by their knowledge about objects.

Knowledge in design has been investigated with regard to the extent to which it could be organised into some sort of typology, and accessed during a design activity. Muller and Pasman (1996) proposed a design information model to aid designers during the form-creation process, as a way of organising design knowledge that can be extracted from existing form concepts. Their model, 'The Image Database Project', contained a collection of existing designed products and provided references to behavioural (use) and semantic (form) aspects of the products. The database demonstrates that prior knowledge and experience play an important role in designing.

The design activity has evolved to become a matter of process rather than product, and thus it has prompted the study and analysis of the design process and design thinking. The literature reports that studies about the design activity have focussed mainly on the analysis of the initial stages (creative stage) of design. The methods most used in these studies have been verbal reports and sketch analyses. Outcomes from previous studies indicated that sketches are a medium that designers use to

reflect on their designs, to re-interpret ideas with different connotations, and to discover new ones. Verbal protocols have been used in connection with sketches to analyse and understand the designer's thinking process and reveal design actions, for which coding schemes have been used to interpret data from audio and video sources. Sketches have also been related to the study of knowledge in design and design expertise as important aspects of a design activity, for both novice and expert designers. The following sections discuss this in more detail.

3.1.1 Design knowledge: design thinking, visual thinking and the study of sketches

Design research has focussed not only on design thinking and design knowledge involved in a design process, but also on the issue of knowledge elicitation in Design. One of the forms of analysing design knowledge is visual thinking, which focuses on analysing sketches and drawings as the expression of cognitive activities in a design process.

Goldschmidt's (1991) seminal study of sketching as a means to analyse design thinking focussed on understanding the kind of reasoning involved in sketching as part of the design process. Her observations of architects performing design activities revealed the complexity of design reasoning where there does not seem to be a linear or logical sequence in design decisions. Protocol collected from experiment sessions revealed that visual thinking is not only a representational task but also a process for conceptualising and organising ideas. Protocol also revealed that designers elaborate and re-interpret each time they see and do a sketch. Goldschmidt identified two concepts or modes of visual thinking that take place during the design process: 'seeing as' and 'seeing that'. The first refers to the sketch–thinking process and the second to the concept representation in the sketch. Goldschmidt's study provides a significant theoretical platform for several aspects of the visual thinking that occurs during the early stages of design.

Research in visual thinking focussed then on categorising sketches. According to Ferguson (1992), sketches in the engineering field can be categorised as the thinking sketch (nonverbal thinking), the prescriptive sketch (providing directions), and the talking sketch (exchanging ideas or clarifying ideas with others). The thinking sketch would be related to the process of eliciting knowledge during design thinking.

Similarly, Schon (1995) stated that drawings are a ‘medium of reflection-in-action’ and representations of a virtual world, allowing designers to quickly ‘try out’ a new idea on paper.

Extending Schon’s and Ferguson’s concepts, McGown and Green (1988) investigated the sketching activity of engineering students in the process of conceptual design thinking; they focussed on observing the pattern of information flow in the conceptual sketching activity. Their study confirms that freehand sketching is prevalent in the conceptual phase of design, and that freehand sketches convey three modes of sketching functions: lateral transformation, vertical transformation and duplication.

Tovey (1989) further researched the functions of sketching in a study that compared conventional design drawings and computer aided designs (CAD drawings) in the car industry. Tovey considered drawings and three-dimensional models to be essential components of the design activity, as they provide a physical manifestation of visual thinking (1989:24). In Tovey’s study, visual thinking uses three kinds of visual imagery: things we see, things we imagine in our minds and things we create by drawing (1989:25). His study indicated that designers’ drawings convey ideas from imagination as well as from experience, and that all these are an externalisation of the design process in which concepts are being formed (early stages of design).

Clancey’s (1997:250) study of knowledge distinguished between ‘concepts’ (what people know), ‘descriptions’ (representations people create and interpret to guide their work), and ‘social activity’ (how work and points of view are coordinated). His views, grounded in Artificial Intelligence, associate the concept of knowledge to human experience and the context in which such knowledge is built. Clancey defined knowledge in relation to expertise and stated that professional expertise is contextualised as it reflects knowledge about a community’s activities, values and interpretation of theories (1997:255).

The study reported by Van der Lugt (2002) explored the functions of sketches that can be identified in ‘design idea generation meetings’. The study found that three functions of sketching in the design activity concur with some aspects of the findings

from previous studies. Similar to Goldschmidt's concepts of 'seeing as' and 'seeing that', the first function refers to a re-interpretive cycle in the designer's idea generation process in which sketches facilitate the transition from general descriptive knowledge to specific depiction (2002:73). The second function is about the capability of sketches to act as stimulus to re-interpret the designer's ideas. This was consistent with Tang's study (1991), in which sketches allow the re-interpretation of a drawing's information, enabling other information not conveyed in sketches. The third function states that sketching stimulates the use of earlier ideas by enhancing accessibility to them; in other words, sketches are easier to recognise than words because sketches provide distinctive features of the referred object.

Do's (2005) study into design sketches as design tools established the notion of drawing as 'the freehand diagrams and sketches designers draw and use in their early design stages'. Do stated that designers' drawings help them discover and explore ideas. She considered that drawing is an iterative and interactive act that includes both seeing and thinking, and involves recording and distinguishing functions and meanings. Based on this, Do stated that visual thinking conveys a relationship between drawing and previous experience.

During visual thinking, sketches and drawings are analysed as expressions of cognitive activities in the design process; visual thinking thus reveals the non-linear process of design decisions. Sketches are the externalisation of the design process and provide a medium for reflection in action. In a design process, sketches not only represent, but also aid the conceptualisation and organisation of ideas. There is a relationship between drawing and experience: drawing is an iterative act that involves seeing and thinking; therefore, knowledge in visual thinking has been associated with human experience and is contextualised. This will be explored in the following section.

3.1.2 The study of visuals as representations of human experience

Petterson (1989) stated that using visuals for communication has always been a natural way for people to express themselves. In his dissertation about visual languages, Petterson explained that visual languages attempt equivalence with reality, they are iconic, and they normally resemble the thing they represent.

However, Petterson pointed out that visual languages have varying levels of meaning and, as in verbal languages, 'reading' or understanding the content of visuals as language requires prior experience and contextual information. In this regard, Petterson's arguments are consistent with those of other researchers who state that the content of an image can be recognised in 2–3 seconds (Pavio, 1979; Postman, 1979). To read a verbal description of the same image might take 20–30 seconds (Lawson, 1968; Ekwall, 1977), and 60–90 seconds to read it aloud (Sinatra, 1986).

Various approaches to visual thinking have focussed on the study of visuals and on how they represent human experience. An interdisciplinary research in Health and Social Sciences conducted by Kosslyn, investigated people's visualisation of 'objects and scenes' when asked about properties of objects (2003:122). For Kosslyn, visual mental imagery is 'seeing' in the absence of an immediate sensory input, and imagery is 'the perceiving of patterns that arise from memory'. His study concluded that people's mental imagery results from a process of evaluating properties of the objects being recalled; a type of memory that associates objects to spatial and sensorial information stores these properties. In this regard, Kosslyn established that mental imagery is related to human experience, in which memory comprises not only an image or an event, but also information about the sensorial context of the thing remembered.

The issue of visuals and their relation to human experience has recently been discussed in the design domain at the Design Research Society (DRS) on-line discussion group (JISC, 2006). Here, mental images have been described as representations relevant to the way people construct mental imagery (Kueh, 2005), which are always constructed from a mixture of previous visual experience (Salisbury, 2005). The issues of meaning and understanding embedded in visuals were related to the expression of human experience in the following argument: 'to be able to give an explanation or demonstration of the meaning of something, it is also necessary to demonstrate one's understanding of it' (Mathews, 2005).

Visuals represent reality and depict human experience, conveying formal, physical and sensorial properties of the thing represented. However, as visuals embed experience and contextual information, explaining a visual also requires an

understanding of it based on prior knowledge. These statements support the notion that people store visual references about their experience in the world.

3.2 Design knowledge and expertise

In Design research, human expertise has been explored in relation to knowledge and the differences between expert and novice designers' thinking processes during a design activity.

Goker (1997) investigated the influence of experience in design problem solving; he carried out an experiment in which novice and expert designers were asked to solve a simple design task with the use of a computer program named 'The Incredible Machine'. A Think Aloud method was employed to access the designers' thinking during the problem-solving task. Outcomes were transcribed into a task list (goals and related actions) and a solution tree (graphical representation of the problem decomposition). Goker's experiment concluded that expert designers create knowledge from previous experience, and showed that experience generates the main differences between novice and expert designers in the early phases of design.

In contrast, Posner (1988) related expert performance to 'the ability of people to perform exceptional feats of memory'. He pointed out that expertise lies more in people's capability to store information resulting from coding and chunking than in a general reasoning process. Chi et al. (1988) carried out a study with a special interest in superior human performance. Their study discovered key characteristics of expert performance, some of which can be used to understand differences between designers and users. One of these characteristics established that experts excel mainly in their own domain; they have an excellent domain of knowledge in a particular area. This would suggest that one of the main differences between designers and users in relation to their concept of a product would be related to their knowledge domain.

To study the progression from novice to expert designer, Popovic (2004) investigated the modelling of design expertise through design visuals produced during problem solving in the conceptual stage of a product's design. She considered visual language

as a means to represent the knowledge domain. Popovic compared sketches from novice, intermediate and expert designers, focusing on identifying different types of strategies and knowledge. Her study found that the level of expertise influences problem representation and shows that (i) novices applied trial-and-error processes by making assumptions during design activity, (ii) intermediate designers were more skilled at accessing information and they used a goal-limited strategy that helped them to accomplish the task and (iii) expert designers used strategies that allowed them to form abstract concepts without doing detailed representations.

Oxman (2002) studied the nature and organisation of design knowledge in Information Technology (IT). Her work focussed on the phenomenon of creativity and its role in knowledge based design systems. Her study approached the nature of design knowledge by exploring designer's thinking processes and the relationship between prior design knowledge and experience. She stressed that the nature of design knowledge is context-dependant, and that it relies on precedents and past experience. For Oxman, design knowledge constitutes the embodiment of the designer's experience; it is typified in the form of design concepts, descriptions and principles that lead to 'solution types' (prototypes). Her statements suggest that concepts used in design processes are based on designers' past experience, and built upon episodic experience.

A study by Visser (1995) addressed the role of episodic knowledge in design problem solving, and established a relationship between knowledge and episodic data. According to Visser, designers' use of knowledge from particular experiences is related to a particular episode from their experiential source (1995:173). Visser's study demonstrated that designers' use of information for design problem solving is based on episodic data from internal and external sources. Thus, her study indicates that during a design process, designers use their own knowledge to resolve design problems and that this knowledge is based on their own experience.

Muller and Pasman's (1996) work on design knowledge is consistent with the previous studies, confirming that design knowledge is based on prior experience. They added that the application of such knowledge in new design situations is a complex process, and as every design problem is unique, the transfer of previous

knowledge should be based on case-based presentations. They proposed ‘The Image Database Project’ as a model for describing and decomposing the design knowledge that can be extracted from existing form concepts. It is based on the assumption that typological concepts (products) can be represented by typical features, and on how users interact with products. For Muller and Pasman, conventions between form and function provide clues to users about the intended use of products. Their model presents a large collection of images of previously designed products (precedents) to allow designers to visualise a product’s characteristics within its context-of-use by considering aspects such as behaviour-use type and form-function type. Muller and Pasman’s proposal aimed to assist the creation-stage process of a product design by taking into consideration designers’ episodic knowledge.

From a cognitive perspective, Goker (1997) investigated the influence of experience in design problem solving with the aim of understanding how new experiences are created, learned, indexed and recalled, and how experience influences problem understanding and the approach to the problem solution. The experiment conducted by Goker indicated that in design problem solving tasks, novice designers rely on deductive reasoning while expert designers apply their experience. His investigation employed Observation and Think Aloud protocols to identify the actions performed to achieve a design goal. The experiment revealed that the designer used her prior experience to identify the solution to the design problem. Goker emphasised that expert designers create knowledge from previous experience; in this way, Goker established a relationship between design knowledge, experience and expertise in design.

From these studies, it can be said that the body of knowledge regarding the design process and thinking has confirmed that designers draw their concepts from their own experience; knowledge and expertise are also connected to human experience, and in the field of design this knowledge could be typified and contextualised. Studies also indicate that when confronting the design of a new human–artefact interaction, novice designers will relate first to reasoning by deduction rather than to experience.

3.3 Designers versus users

The issue of the differences between users' and designers' understandings of the material world has been addressed by Norman (1988) in his concept of 'mental models', which he described as the 'model that people have of themselves, others, and the environments and the things they interact with' (Norman, 1988:17). Norman interpreted human–artefact interaction as a 'conceptual model' formed by the design model, the user's mental model, and the system image. He concurred with other researchers as he emphasised that life experience is a determining factor for the construction of knowledge. Norman explained that the designer expects the system model to match the user's model, but their different life experiences lead to mismatches in the relationship between the system components, giving rise to errors in the human–artefact interaction. Norman's views highlight 'experience' as the basis for constructing knowledge about the world; it indicates that designers and users formulate conceptual models about themselves and their environment in the same way, using their own experience as a source of reference.

The meaning of form and its influence on the understanding of a product's context-of-use are addressed in Krippendorf's (2000) theory of product semantics. Here, the term 'product semantics' relates to the study of the symbolic qualities of man-made forms in the cognitive and social contexts of their use (2000:157), and deals with the issue of users 'making sense of' artefacts within the artefact's context-of-use and the user's everyday experiences. People's understanding of things is widely different and depends on their experience and the context in which they built that experience with the artefact. To support this, Krippendorf referred to an experiment in which people perceived objects not as things, but as meanings. Krippendorf's views concur with Norman's concept of mental model. Depending on their individual experience, designers and users therefore have different understandings of the meaning of an artefact. Krippendorf (2000:169) addresses the differences between designers and users by stating that any form given by designers is professional sense-making and not ordinary sense-making. Again this is consistent with Norman's system model representation concept. Therefore, he argued that in a design process, industrial products must address people's cultural, sensory and cognitive differences allowing visual, tactile, acoustic and verbal indicators or clues to different interpretations of forms to exist side by side.

There are limited references with regard to the differences between users and designers when products are being conceptualised. Kavakli et al. (1999) emphasised the differences with regard to the sketching process and the cognitive process behind it. Their study investigated the visual reasoning differences between a novice and an expert designer during a conceptual activity. Kavakli et al. considered that if visual reasoning were an essential part of the design process, expert performance would highlight the differences of the particular visual reasoning processes that allow expert performance. Their investigation demonstrated that given a design task and the same time to accomplish it, expert designers produce three times the number of design alternatives and number of actions involved in the process that novices do. Kavakli et al. concluded that visual reasoning is associated with expert performance, and that experts revise, modify and discover new relationships in their existing depictions while novices draw on new ones.

The differences between designers and users have been researched mostly from the cognitive viewpoint, where studies have concentrated on distinguishing the thought processes that expert and novice designers carry out in a design task. This can be connected to a study by Chi et al. (1988) about human expertise. In this study they explained that experts see and represent a problem in their domain at a more principled level (semantically) than novices, while novices tend to represent a problem at a superficial level (surface-feature oriented). The latter indicates that concepts about artefacts produced by designers might be principle-based (explaining concepts of use) while novices' concepts would be more representative (features related).

3.4 Design methods: the design of the user–product interaction and product usability

Designing a successful user–product interaction can be understood as designing products that fit with users' needs. In this regard Redstrom stated that optimising design based on knowledge about the user has evolved from usability or utility aspects to include aspects of interpretation, understanding and experience (2006:127–128). According to this, in Design, methods employed to design the user–

product interaction evolved from ergonomics-driven methods to a user-centred approach that involves consideration of the user experience and the product's context-of-use. This section illustrates this move through the work of Jordan, Sanders, Hekkert and van Dijk, and Sleeswijk Visser et al.

Jordan's (1998) approach to the design of product usability is based on the ISO definition of usability. His views on product usability focus on user performance with a product and in relation to a particular task. To include usability throughout a design process, Jordan proposed ten principles of usable design in relation to five aspects of a user-centred approach for usability evaluation. However, this work is based mainly on the aspect of 'use' and the measurement of task performance during specific activities in a specific context-of-use. This approach follows the traditional HCI tradition.

Sanders' work on user-research evolved towards the topic of products that can be experienced and enjoyed. She stressed that experience cannot be designed as the act of experiencing lies within people (2001); thereby her studies aim to enhance the design for experience through diverse methods called Generative Research. These methods facilitate knowledge and experience elicitation from users and support designers' engagement with users' experiences and dreams. They also support creative thinking and collective creativity during the early phases of the design process, involving designers and non-designers (users). Generative Research methods are focussed mostly on the user-research stage of product design. Various researchers reporting the use of these methods in design activities have stated that results inspire new design concepts throughout the design process (Sleeswijk Visser et al., 2005); nevertheless, those reports do not clarify to what extent those designs would also address usability requirements.

Hekkert and Van Dijk (2001) claimed that the nature of human–product interaction relies on their notion that a user–product relationship does not take place in isolation but as part of a context; such context consists of social, technical, cultural and other factors that influence how people relate to products. From this perspective, they presented a context-driven view of design in which context parameters are predetermined and created by the designer. Hekker and Van Dijt developed a design

approach they called Vision in Product design (ViP), a six-stage method where the designer could use a guideline to set product parameters about the factors that will influence the design of the user–product relationship. The ViP method assists designers to identify and make explicit the context factors to take account of in their designs; these would otherwise be implied in the designers' work, underlying their design decisions without being acknowledged.

With a similar interest in identifying the context of a product's use, Sleeswijk Visser et al. (2005) built on Sanders' Generative Research methods and presented Contextmapping as an emerging discipline in which contextual information is elicited through generative techniques. The aim of Contextmapping is to bring useful information to guide the design process by revealing the new design's opportunities and limitations. Sleeswijk Visser et al. illustrated Contextmapping with a number of projects, and point out that product designs resulting from this approach unite experiences of users and the contexts in which the product is or will be used (2005:135). Although Sleeswijk Visser et al. presented a thorough explanation of most of the user-research processes embedded in Contextmapping; their statements do not include an indication of how this information is translated to the product development stages.

Methods aiming to enhance the design of the user–product relationship have either covered the ergonomic aspects of product performance during the realisation of a task, or have covered the identification of present and current contexts of a product's use through people's dreams and experiences. Nevertheless, previous research — in which experience is the basis of people's understanding of the world with which they interact — has not explored the areas of experience that relate to product usability.

3.5 Summary

The previous section presented current approaches to the study of the design domain and design thinking, and to the use of sketches as methods to elicit knowledge. In regard to design knowledge, several authors have stated that design knowledge uses precedents, and is typified and relies on prior experiences; and that functional experience is a better source to recall images from memory. As an example of this, several studies highlight the observation that expert designers use experience as a

source of knowledge more often than novice designers, who prefer a deductive method for problem solving in design activities.

Research into design thinking and the design process has included visual thinking and the analysis of visuals. Various studies demonstrate that visual thinking is associated with human experience, and that visuals represent prior knowledge and contextualised information. The analysis of visuals (coding of sketches) has helped to uncover aspects of the thinking process and their relationship with the production of design ideas. In such studies, using verbal protocols allowed the interpretation of sketches and revealed aspects of the design thinking process. Likewise, the use of protocol analysis to interpret designers' actions or cognitive activities during a design process has been possible through the classification of groups and subgroups of categories describing those activities.

Differences between users and designers have been investigated in various studies, and it has been found that their different life experiences influence the way designers and users perceive the meaning of things. Such differences lead to errors in the design of the user–product interaction. To overcome limitations in understanding users and interpreting their needs, various studies have developed methods to elicit knowledge from users. Such methods have either focussed on identifying new design opportunities or on creating future contexts of a product's use.

The following chapter, Visual and Verbal Data Analysis, examines protocols employed to analyse human experience, and focuses on the methods and techniques available to analyse visual data and verbal reports. It presents the extent to which other studies have employed these methods with regard to the study of experience and product usability.

Chapter 4:

Visual and Verbal Data Analysis

Previous studies on the design activity have stated that visual thinking conveys a relationship between drawing and previous experience that involves contextualised knowledge. The previous chapter demonstrated that the use of visuals and verbal protocols has provided a useful medium to investigate issues about design thinking and design process, and has contributed to knowledge elicitation in the study of the design process. As this investigation includes an experiment to elicit conceptual information from participants' experience, this chapter delves into methods related to the analysis of visual data and verbal protocols. References to previous studies in which these methods have been employed are presented in order to illustrate the extent of their application.

4.1 Visual data analysis

Loizos (2000) affirmed that visual data are no more than representations of past actions, and as visual data are two-dimensional, such representations can only be secondary and reduced simplifications of reality. He emphasised that images must also be corroborated, and indicated that perceptual variations of this medium make the visual data an ambiguous record: 'the information may be in the photograph but not everyone is equipped to recover it in full' (Loizos, 2000:96). This suggests that visual data also need further corroboration with testimonies or other means to 'uncover' ambiguous interpretations. His conclusions are in accord with those studies in which sketches were used along with verbal protocols in order to access greater detail of the design process.

Understanding the meaning of images has been approached through content analysis, visual anthropology, cultural studies, semiotics and iconography, psychoanalytical image analysis, and social semiotic visual analysis. Van Leeuwen and Jewitt (2001) explained that some studies take existing images as a resource, while others base the study on images produced for research purposes. There are two approaches in the study of images produced during research: (i) the image as representative of who, where, and what of reality and (ii) the image as evidence of how its maker or makers have (re-) constructed reality. The second is common in cultural studies, semiotic analysis, and ethno-methodological research, which document the process of re-constructing the reality from images. According to Van Leeuwen and Jewitt, visual anthropology and cultural studies seem to be the approaches helpful to the understanding of descriptions of past and present, and of socio-cultural relationships with regard to a phenomenon. Their study seems to support the use of visuals in the study of context related to a product's use.

Ball and Smith (1992) argued that content analysis can be applied to investigate the content of visual representations. They considered visual representations as documentary data that range from photographs and films to sketches. Ball and Smith (1992:20) explained that it is an unobtrusive-objective-systematic and quantitative method. Its objective is to devise precisely and clearly defined categories to apply with explicit rules of procedures. The method's reliability is based on the rules of procedures that would provide identical results, and it can process large amounts of data covering long time spans. Nevertheless, an important disadvantage of the method is the exclusion of 'latent meaning' that emerges from raw data; this disadvantage is generated from the coding operation in which content is matched to pre-defined categories.

With regard to the strategy for the method, Ball and Smith (1992) enumerated six steps to use content analysis of visual representations:

1. Select a topic and determine a research problem,
2. Select a documentary source,
3. Devise a set of analytic categories,

4. Formulate an explicit set of instructions for using the categories to code the material,
5. Establish a principled basis for sampling documents,
6. Count the frequency of a given category or theme in the document sampled.

Ball and Smith (1992) considered that the coding process of content analysis has limitations, as the resulting data fragmentation might not fairly represent the participant's message. They stated that categories that are pre-defined by the analyst fragment and decontextualise the content of the message; such categories may not correspond to the categories that members of society use to communicate their message (Ball and Smith, 1992:27). It can be inferred from this that a grounded theory approach to the analysis of data would allow better interpretation of contents, as key issues emerge from the original data.

According to Emmison and Smith (2000), the sources of data that are utilised in visual research can be categorised in three groups: (i) advertisements, which can be viewed as 'texts' and can be subject to semiotic or cultural interpretation, (ii) sketches (diagrams, maps and signs) that are studied by the ethno-methodological tradition and (iii) documentary photographs, which are regarded as 'raw materials' or visual accompaniments for traditional anthropological ethnography. The authors indicated that some experts consider that visual data correspond to a qualitative type of study, while for others it corresponds to quantitative study as such data can also be quantified by content analysis procedures. One of the approaches to the analysis of visuals referred by Emmison and Smith (2000) is the 'analysis of practices of visualisation'. This approach includes the analysis of sketches and diagrams that have been used mostly in physical and life sciences to represent the natural world (2000:51). According to Emmison and Smith, the analysis of practices of visualisation is shifting its focus towards cultural studies concerned with deconstruction of scientific communication; however, the literature does not indicate how this is being applied.

A study by Psathas (1979), explored the way in which practical reasoning is embedded in the making of maps drawn by laypersons, and how this can provide directions to a particular location. His study examined the features of the map that

make it recognisable, readable and interpretable. He detected that people drew maps with specific details (paths) on how to get to the specified location, highlighting the features (landmarks) that would allow the reader of the map to follow it. In this sense, the use of maps in Psathas' study demonstrates that visuals (sketch of a map) can demonstrate (i) the person's solution to the question 'draw a map to our place' and (ii) the person's knowledge (concept) of the world known (location) based on his or her experience.

Collier (2001) explained that visual records are a source for the 'analysis of human experience' in which 'pattern' and 'meaning' are explored. He considered that all elements of an image may be important sources of knowledge through analysis, where the challenge is to properly identify the many aspects of the image, acknowledging that meaning and significance extracted from this analysis only produce few viewpoints on human circumstances (Collier, 2001:35–36). According to Collier (2001), two different types of interpretation can be made from the analysis of visual records of human experience: (i) examination of the content of images as data and (ii) interpretation of images as vehicles to elicit information not present in the image.

Collier also examined the importance of contextual information to understanding the meaning of the image, and explained the use of 'direct' and 'indirect' analyses. Context for analysis must be established before one engages in direct analysis. Collier (2001:39) explained that the process of 'direct analysis of visual data' searches for (a) information about the subjects seen in the image and (b) understanding about the making of the image, its functions, and the perspectives of its maker. He presented a model for direct analysis in four stages (Collier, 2001:39). These are:

1. Observe data as a whole, detect overtones and subtleties, discover connecting contrasting patterns, and take note of your personal impressions and questions during the observation,
2. Make an inventory or record of all images, and design the inventory around categories that reflect and assist research goals,

3. Structure the analysis and go through evidence with specific questions (measure, distance, count, compare). The statistics can be presented in graphs; this part must be described in detail,
4 Search for meaning and significance by completing a visual record that can be placed in a context that defines its significance. Re-establish context and write conclusions.

In regard to the 'indirect analysis of visual data', Collier explained that it is the form of analysis in which images are used as vehicles to knowledge and understanding through photo elicitation sessions (Collier, 2001:46). In this type of analysis, photographs give birth to stories, which are important sources of information and data; in this case excessive detail is of limited value if it is not articulated to meaningful conclusions. Collier's views do not address the issue of drawings or sketches as sources of knowledge.

The use of visual data as a means to understanding a research problem has been used to uncover information about particular aspects of reality. Visual data have also been studied with regard to its type of content; that is, the visuals are produced for a specific purpose under specific conditions (laboratory). The second type of study has focussed mostly on the cognitive aspects revealed by the process of making the visual data (sketch).

The practices of 'visualisation approach', which can generate visuals (sketches, diagrams) about an individual's concept of a particular reality, seem suitable for the purpose of this study; however, studies undertaken under this approach have been oriented towards the analysis of the reasoning process embedded in these visuals, and no evidence has been found about how to analyse them with regard to the human experience as a source of concept representation. Loizos (2000) stressed that visual data are reduced simplifications of reality, and that such data need testimonies to corroborate ambiguous interpretations; however, this study applies Collier's (2001) definition of visual records as a source for analysing human experience from which meaning and knowledge can be extracted, and from which contextual information in relation to the image can be identified.

4.2 Verbal protocol analysis

According to Ericsson and Simon (1993), verbal reports can be a problem solver's account of his or her own mental processing. Therefore, verbal reports can be an account of one's belief about how to resolve a problem, a concurrent account of the problem solving process, or a retrospective account of the problem-solving task. These different types of verbal reports take the names of 'concurrent verbal protocols' (that reflect ongoing cognitive activities) and 'retrospective reports' (that attempt to describe a cognitive process that has been completed and can no longer be changed) (Hannu and Pallab, 2000:390–391).

Concurrent verbal protocols, also referred to as Think Aloud protocols, elicit a great deal of 'what' content, along with some 'why' and 'how' content (Hannu and Pallab, 2000). Think Aloud protocols are widely used as a method for the usability testing of software, interfaces, websites and instructional documents (Van den Haak et al., 2003:339). Retrospective reports are accounts of the actions and thoughts remembered from a cognitive activity; that is, a verbalised account that follows that activity. Another name given to this type of verbal protocol is Retrospective Debriefing (Ericsson and Simon, 1993:413).

Hannu and Pallab (2000) explained that verbal protocol analysis is one of the most widely used methods for tracing processes or procedures; for example, it has been used to study the design activity as presented in Chapter 3. Verbal protocol analysis usually focuses on the sequence of cognitive events occurring between the introduction of an information stimulus and the decision outcome. Verbal protocol analysis, as a process-tracing procedure, aids in focusing on the strategies used by people to arrive at decisions and by tracing the steps that lead to those decisions. It illuminates the pre-decisional behaviour of situation analysis. Its main use has been as a tool to study decision-making processes and consumer judgement. The premise of verbal protocols is that verbalisation registered during an information–evaluation–decision process can be later analysed to uncover the cognitive elements of such processes. The main advantage of using verbal protocols is that they provide their own interpretation because verbal protocols not only trace thoughts but explain what is going on (Hannu and Pallab, 2000:388).

With regard to the differences between the Think Aloud protocol and Retrospective protocol, both methods present advantages and disadvantages that can affect the quality and validity of the report. The basic principle of the Think Aloud method consists of asking potential users to complete a set of tasks with the artefact being tested, while constantly verbalising their thoughts as they work on the tasks. The method has high validity, as data collected reflect the actual use of an artefact and not the participants' judgements about its usability. The research paradigm behind the method is that it reveals people's cognitive processes during the execution of a variety of tasks. There is evidence from other research studies pointing out that the drawback of this method is that it affects the way participants handle tasks and the time it takes for them to complete tasks (Van den Haak et al., 2003). With regard to Retrospective protocols, Van den Haak et al. (2003) explained that one of the benefits of using retrospectives is that it decreases 'reactivity' from participants. This means that it does not affect the way participants execute a task because they can focus on the task only. Another benefit is the reduction in the time taken to perform a task, as retrospectives are done after the task is completed. A third advantage is that participants can reflect on the process, highlighting important events. The fourth advantage is that it makes it easier for participants to verbalise their thoughts in a foreign language after their task has been performed (Van den Haak, 2003:341). Problems associated with retrospectives relate to their validity. This is because they can lead participants to mix past and present experiences, as subjects have different abilities to remember and verbalise things.

The procedure employed to collect protocol data is an important consideration as it affects the richness and reliability of the data. Hannu and Pallab (2000) explained that the procedure to elicit verbal protocols from participants might vary depending on whether those verbal protocols are collected by instructing participants to Think Aloud during or after their decision-making. The thoughts revealed are tape-recorded, then transcribed into a sequence of task-relevant statements (protocol segments), and then content-analysed using a code scheme. The thoughts produced correspond to short-term-memory (STM) processing. The protocol segments represent different aspects of the elementary information processes.

A study by Van den Haak et al. (2003) reported an experiment that compared concurrent and retrospective reports used in a particular usability test case. Within the theoretical framework of their study, Think Aloud and Retrospective protocols were compared as equal alternatives in various studies. From the literature and from their experience they reported that retrospectives used as 'aided' and 'unaided' accounts of a process had different results, and that unaided accounts were to be avoided as they caused distortions and gaps in the protocols. This confirmed a previous study in which Taylor and Dionne (2000) explored the problem-solving strategy knowledge that can be accessed by verbal protocols. According to Taylor and Dionne, the collection of retrospective debriefings may be a collection of records facilitated by retrieval cues such as videotapes or specific questions. This means that Retrospective protocols require a pre-determined guide to elicit the desired type of response from the users, to avoid gaps and to focus on the type of information required for the study.

In terms of the validity and reliability of Retrospective protocol data, Taylor and Dionne (2000) provided recommendations that emphasised three aspects of data collection and its analysis:

1. Eliciting the report — retrospectives should be elicited as soon as possible following a task to optimise the retrieval of memories of a specific episode,
2. Probing during retrospective debriefing data collection — the use of retrospective accounts allows the researcher to probe more deeply into specific aspects of the research; using questions and references to specific moments in the preceding process can serve as retrieval cues that enhance the richness and veridicality of data. Emphasis must be placed on 'what' or 'which' types of questions rather than 'why',
3. Retrospective debriefing — sets of data can be analysed by their internal consistency. This can be done by counting perceptions of researcher bias against the proportion of participant-initiated responses relative to responses prompted by the researcher. This can provide the degree to which data were influenced by the researcher.

Thus, a verbal protocol can be collected in the form of concurrent or retrospective reports, and it can be analysed in different ways according to the aim of the study.

The literature referred to in this section suggests the use of a coding scheme to content-analyse the data collected. Nevertheless, the literature also reports that analysis of verbal reports in some cases requires the code to emerge from raw data instead of from predefined categories.

In relation to methods used to content-analyse verbal protocols, Bauer presented the following three basic steps (Bauer, 2000:136):

1. Sampling the test units, which means selecting part of the text (recording units) to work with rather than the whole,
2. Defining a coding frame or category system as a systematic way of comparing the recording units; each code has a finite number of values,
3. Carrying out the coding process and interpretation, done with paper and pencil or with a computer program. The output from a manually or computerised coding process will be interpreted statistically. Codes are independent of each other, and mixing categories is to be avoided (i.e. red and small are from different categories).

Bauer (2000) explained that content analysis has two dimensions: syntax and semantics. The first provides the means for the data, and the second provides the data's meaning. He used Krippendorf's (in: Bauer, 2000:135) distinction of four different research strategies for constructing a text-corpus through text analysis: picking up trends and changing patterns, finding comparisons that reveal differences, constructing indexes (signs that relate to some other phenomenon), and reconstructing maps of knowledge embodied in text.

Bauer (2000) enumerated six types of content analysis design research. Starting from the simplest, they are:

1. Descriptive studies — count the frequency of all the coded features of the text,
2. Normative analyses — make comparisons with standards (of 'objective' or 'unbiased'),
3. Cross-sectional analyses — make empirical comparisons of texts from different contexts about the same topic; for example, newspapers,

4. Longitudinal analyses — make comparisons that span the same context over a longer period to detect fluctuations in content, and to infer related changes in the context,
5. Cultural indicators — take account of several contexts over many years,
6. Parallel designs — involve longitudinal analyses in combination with other longitudinal data such as opinion polls.

These different types of content analysis provide a broad approach to analysing text data that can be adjusted to suit diverse materials, not only to analyse newsprint, but also transcripts from interviews.

Thematic analysis has also been employed to analyse verbal protocols. According to Boyatzis (1998), thematic analysis is a 'way of seeing' a perceived pattern or theme in seemingly random information. It is a process for encoding qualitative information, and it can transform that information into quantitative data. Thematic analysis undergoes three inquiry phases:

1. Recognizing important moments (perceiving a pattern),
2. Encoding the moments,
3. Interpreting the moments.

Boyatzis (1998) emphasised that thematic analysis is a process for encoding qualitative information and that this requires an explicit code. A code might be a list of themes, a model with indicators and qualifications that are causally related, or something in between. A theme is a pattern found in the information that at minimum describes and organises the possible observations, and at maximum interprets aspects of the phenomenon. It can be identified at a manifest (observable) level or from a latent level (underlying the phenomenon). Themes might be generated inductively from raw information, or generated deductively from theory and prior research. The integration of a number of codes is termed a 'codebook' (Boyatzis, 1998:4). Manifest content analysis is the analysis of the visible or apparent content of something; latent content analysis is more interpretive than manifest content analysis. Thematic analysis allows the researcher to use both at the same time, and might help to overcome the limitations of the fragmented data that can be generated by a content analysis process.

From the literature it can be inferred that retrospective reports can be used as a recollection of ‘concepts’ represented in drawings. For this study, the cue can be provided by the drawing itself and by a simple question that prompts the elements conveyed in the drawing. The use of retrospective reports presents a good choice for this research study as it allows data to be elicited from participants without affecting the way and manner in which they perform their first task (drawing). This allows the participants to talk about the meaning of the drawing and perhaps highlight some aspects that could not be conveyed in the drawing, making it easier for those participants for whom English is a second language to verbalise their thoughts. The drawbacks enumerated by previous research would have no effect on the desired outcomes, as participants are not to be asked to record an entire mental process, and bias would be avoided, as their account would be requested in relation to the meaning of the drawing and the elements conveyed in the drawing. Time does not count as a drawback as it is not an aspect measured in any way in this study. Furthermore, this study will use retrospectives immediately after drawing, so that information from short-term memory (STM) will be accessed easily, thus avoiding omissions or misinterpretations.

4.3 Summary

Experts who have undertaken qualitative studies have mostly included content analysis methods to analyse and interpret texts and visuals. Different approaches have been reported with regard to the study of visuals: semiotic analysis, analysis of practices of visualisation, and visual anthropology to elicit knowledge from visual sources. The approach that applies the analysis of practices of visualisation (sketches) has been found suitable for this study, although there are no references on how to analyse such visuals with regard to the human experience conveyed in them. While photographs are the source most employed by social researchers, other sources such as images and sketches produced by the observed participant, and texts that are derived from conversations or interviews, are less reported.

The literature shows that visual analysis has been used to uncover particular information about the observed reality (the research problem). Related methods have

been applied, depending on whether the analysis is focussed on the content of the image or the cognitive aspects revealed by the process of making the image. In this study, visual records are used as a source to reveal the human experience behind the concepts drawn, and to extract meaning and any contextual information related to it. The literature also shows that verbal reports can reveal important information about the processes undertaken in a problem-solving task, and that such reports can be concurrent or retrospective. Retrospective reports are applied in this study to aid the recollection of concepts represented in the drawings, in which the retrospective is cued by the drawing itself, and by a simple question that prompts the user to report on the elements conveyed in the drawing. Using retrospectives in this way conforms to the recommendations made in previous studies by allowing participants to talk about the meaning of the drawing without interrupting the drawing task, making it easier for international participants to verbalise thoughts, and avoiding misinterpretations due to the researcher's bias. Observation in combination with other techniques (e.g. interviews, Think Aloud protocols) has been used to access unobserved information, entailing perspectives from both the observed and the observer. This technique is used here as a complement to verbal reports in order to access data that support the interpretation of visuals and verbal reports. All these are conveyed in the research design of this study, and presented in Chapter 5: Research Design.

The literature also reveals that methods employed to study the design domain and design processes have not addressed the question of what aspects of knowledge or experience influence people's concepts about the world. Nevertheless, methods discussed here from diverse studies in the design domain can be used, as described, to elicit knowledge from users and designers, and to explore the differences between their concepts. Methods and techniques reported by this literature review help address Research Questions 1 and 2. Through this exploration, it is expected that aspects of human experience and context relating to artefact usability that are relevant for a design process would be identified.

Chapter 5:

Research Design

In the previous chapters, the literature review demonstrated that the design of the user–product interaction and product usability is associated with experience and context-of-use issues. The review also highlighted the role of experience in the people's understanding of the world that surrounds them. Problems arising from people's experiences with products that are difficult to use have also been related to designers' permanent aspirations to design for efficiency (functional, cognitive, emotional), and to the designers' intentions to create designs that fit with people's lives, needs and dreams. However, 'design intentions' very frequently do not match the real use (Redstrom, 2006). In this study it has been stated that some of the causes of these problems relate to the differences between designers' and users' concepts of products or systems (Norman, 1988), and to design processes in which designers interpret users' ideas and needs primarily from their personal knowledge and experience (Rassam, 1995; Popovic, 2002). With this theoretical background in mind, our research inquiry is stated as: *How does experience influence the user's understanding of product usability?*

This study looks into the issues of human experience and context-of-use that are embedded in everyday user–product interactions, which influence people's understanding of a products' usability. The concepts of context, experience and usability were defined in Chapter 2. In this study, context is presented as the relationship between use–activity–task–situation that takes place during the user–product interaction. Experience refers to people's comprehension of live events — comprehension that supports their knowledge and that results from their interaction

with products and surroundings. Hence, usability is defined as a dimension of the user–product interaction influenced by experience and the product's context of interaction. From these definitions it can be stated that identifying aspects of the user experience that influences people's knowledge of a product's use has the potential to inform the design process about the particular contextual clues (or factors) that trigger the user's understanding when interacting with products. Likewise, identifying differences and similarities between users' and designers' concepts about product usability can inform designers about the ways in which their concepts are different from the users' — thus having the potential to enable designers to address users' concepts of a product's use. Therefore, this study investigates the thesis that identifying aspects of the users' experience, and the differences between users' and designers' concepts of product usability, can support the design of product usability and assist designers in the early stages of the design process.

To explore these issues and to address this study's inquiry, the Research Design addresses two research sub-questions:

1. What aspects of the users' experience influence their understanding of product usability?
2. What is the nature of the differences between users' and designers' understandings of product usability?

The third research question of this study — *How can context-of-use and human experience enhance the design of product usability?* — is addressed in Chapter 8. This chapter (Chapter 5) presents the Research Design undertaken to conduct this study, the experiment design, and the data analysis process.

As part of the study, an experiment was conducted to explore the concepts of context-of-use and user experience as components of the users' and designers' understandings about a product's use. The method of data collection employed visual representation of concepts, retrospective verbal reports and interviews. The experiment elicited the participants' references to their individual experience with regards to a product's use, and their concepts about a product's context-of-use. The data analysis process interpreted visuals and verbal reports (a) by focussing on the aspects of human experience that influence people's understanding of a product's

usability and their knowledge of a product's context-of-use, and (b) by identifying similarities and differences between users' and designers' concepts.

5.1 Research plan and approach

This is a qualitative study that aims to explore issues about human experience and the product's context-of-use in relation to people's understanding of product usability. The research plan consists of:

- An experiment,
- A qualitative interpretation of outcomes,
- A definition of conceptual principles.

The research approach employed visual representation of concepts as means to elicit particular information from the participants. The qualitative interpretation of outcomes was based on an inductive approach that focused on identifying relationships between experience, context and usability. This was done in order to establish conceptual principles that could answer the study's research questions. The boundaries of this research were limited to the study of relationships referring to the concepts of context-of-use and user experience, and to how both are interrelated in the user's understanding of a product's usage. The research design and the process of interpreting the experiment's outcomes are presented in this chapter, whilst the definition of conceptual principles is presented in Chapter 6.

5.1.1 Methods and techniques

Four methods were employed: observation, visual representation of concepts, retrospective verbal report and interview. These methods were used to elicit the participants' concepts of everyday products in relation to their experience, and to explore how these influence their understanding of product usability.

Visual representation of concepts was employed to elicit the participants' concepts of a product's use, as in this study it was considered that visuals provide an adequate means to reveal aspects of human experience with regard to product usability. This is supported by previous studies (Oxman, 1990; Rosch, 2002; Tang, 2002; Dahl, 2001) that used visuals to study human experience and knowledge in different ways. In

design research, drawings have been used as one of the generative techniques to elicit people's past experience and dreams of the future, and to express people's thoughts about a product's scenario of use (Sleeswijk Visser et al., 2005).

In this study it was also considered that the interpretation of any kind of representation from a person's own experience must be done by the person himself or herself, as previous studies have found that experience is a subjective event comprehended only by the person who experiences it (Sanders, 2001). Consequently, retrospective reports were employed in this study to (a) allow participants to explain the product and the experience represented in their drawings, (b) allow participants to point out any aspects that they could not convey in their drawings, and (c) enable the drawing to be understood as seen through the participants' eyes. Using retrospective reports immediately after visual representation of concepts facilitated the verbalisation of thoughts and concepts for those participants for whom English is a second language, without distracting them while working on the visuals (Hannu and Pallab, 2000; Van Den Haak et al., 2003; Taylor and Dionne, 2000). This also diminished the risk of participants forgetting aspects of the information embedded in their drawings, and the risk of the researcher misinterpreting the visuals. The use of visuals supported by retrospective verbal protocols allowed the researcher to explore the data while avoiding her bias, and ensured that the interpretation of visuals represented the participants' perspectives.

Interviews were employed to gain further insights into what the participants 'say' and 'think' (Sanders, 2002) about the concepts revealed in visuals and retrospectives. This provided an opportunity for participants to expand their previous responses and to provide more detail. Interviews allowed the researcher to explore each participant's knowledge of a product's use and context-of-use, through complementary questions on particular aspects that the participant mentioned during the interview. Observations were used as a complementary technique, along with verbal reports, in order to access data that could help to interpret information conveyed in the visual representation of concepts. The observations focussed on capturing the participant's responses to the experiment's questions, and were not aimed to capture behavioural, cognitive or emotional aspects of the participant's

activities during the session. Observations were video- and audio-taped to support the interpretation of concepts, and to simplify note taking during the sessions.

Analysis of the outcomes from visuals and verbal protocols was assisted with ATLAS.ti, a software-based qualitative analysis package for data management. In this study, the process of data analysis comprised (a) an iterative process of transcribing the data collected and (b) an interpretation process. The iterative process of transcribing data led to the identification of categories emerging from it in relation to aspects of context-of-use and human experience; this was done in order to generate a system of categories for the interpretation of data. The interpretation process was based on the application of the system of categories to code visuals and transcripts from verbal reports. From the interpretation, a number of relationships between the categories were identified. The data analysis process is further explained in Section 5.4. Findings of this study were established from the interpretation of those relationships and in the form of statements that responded to the research questions. This is explained in Chapter 6.

5.1.2 Experiment design

The experiment investigated (a) the nature of the differences between users' and designers' concepts and (b) the relationships between the users' experience and their understanding of product usability. It gathered responses from two types of participants — product users and product designers — having regard to their knowledge about the use and context-of-use of everyday products. Table 1 summarises the research experiment.

Table 1: Experiment summary

Exp. aspects	Description
Objective	To investigate the: - Aspects of human experience that influence people's understanding of product usability - Differences and similarities between users' and designers' concepts
Participants	- Product users: adult population representing a range of differences of gender, age, cultural background and expertise - Product designers: professional designers, who are currently practicing industrial designers
Products	Products from different contexts-of-use: - Domestic - Transportation - Leisure - Sports - Public
Data collection methods	- Visual representation of concepts - Retrospective verbal reports - Interviews - Observation (as back-up material for the analysis stage)
Setting	Human-Centred Design and Usability Research Laboratory of the Faculty of Built Environment and Engineering at QUT
Time	There is no time limit

For every product selected in the experiment, random sampling was employed to convey a representative sample of a larger group of users. As this research aims to understand the nature of differences between designers and users, the participants were divided into two groups: twenty product users and five product designers. To involve a broad range of users, the user group was selected to represent differences in cultural background, age, gender, and level of expertise. In the case of the designer's group, it was considered that the designers must be currently practicing industrial designers.

Products chosen for the experiment represented diverse contexts-of-use. Emphasis was placed on products of everyday use; some of these products are of general public use. A list of all the products proposed for the experiment is presented in Table 2.

Table 2: Contexts-of-use and product types

Context-of-use	**Product type**
Domestic	Pruning/garden shears, grass shears, grill, kettle, alarm clock, blender
Transportation	Scooter, portable GPS for street navigation
Leisure – outdoors	Sports utility knife, sports watch, water sport camera
Sports	Treadmill
Public	Public trash bin

References to any specific model or brand of a product were avoided in this experiment, as it was considered that this could limit or influence the responses of the participants. During the experiment, the participants were given a name referring to a product category (e.g. water sport camera) so that they could choose to refer to the product model and/or brand of their choice (e.g. digital water sport camera, disposable water sports camera). This consideration was also applied with regard to the product's technological complexity. Considering that everyday products have different levels of technological complexity that influence their operation and functionality (e.g. door handle versus universal remote control), and considering that the research design aimed to represent a wide range of users representing diverse demographics values, technological complexity was not emphasised in the experiment design.

A screening process was employed to select participants and allocate specific products to them for each session. This was done through a questionnaire that was sent to all the participants invited to take part in the experiment. The questionnaire addressed each participant's demographic information, and his or her knowledge of the products proposed for the experiment. To be able to explore human experience issues that are part of the participants' concepts of a product's use, it was a precondition that participants have some knowledge about the type of product they were going to be asked about, or that they were first-time users who knew the

product's main functionalities. This precondition was relevant to the use of visual representation of concepts as a method to elicit the participant's concept of a product. Two other conditions were imposed on the selection of participants: the user-group representatives could not include product designers, and the designer group representatives were not required to have expertise in the design of the products proposed. As a result of the screening process, some of the products proposed were not employed in the experiment. The screening questionnaire is presented in Appendix A.

The experiment's structure and the questions put to participants were the same for both the users and the designers. The experiment consisted of one-to-one (researcher–participant) sessions and each participant was asked about one product only. Visual representation of concepts, retrospective protocol and the interview were applied independently; this marked three different steps in each session. Table 3 presents the aims and instructions given at each step.

Table 3: Aims and instructions at each step of the experiment's sessions

Exp. steps	Aim and instructions
Step 1: Drawing	Aim: To elicit the participant's knowledge about a particular product. Instructions: Please provide a drawing(s) about the product mentioned above. Include in the drawing enough information to explain what the product is, and any other information regarding its use.
Step 2: Retrospective verbal report	Aim: To obtain the participant's description and interpretation of the elements represented in his or her drawings. Instructions: Please explain what you have represented in the drawing (describe all the information you tried to represent). In this part of the test, exchange of comments between the interviewer and the participant is not permitted, as this exchange can influence your answer to this question.
Step 3: Interview	Aim: To discover other references to the participants' experience and knowledge in relation to the usability of a particular product. Instructions: Please try to explain what this product is used for? When and how do you think it is used? For what purpose or occasions? In this part of the test, comments between the interviewer and the participant to extend the answer will be permitted. But, no comments that could influence in any way the answer to this question should take place.

The setting for the experiment was the Human-Centred Design Research and Usability Laboratory of the Faculty of Built Environment and Engineering at QUT.

5.2 Pilot experiment and the interpretation of data into a system of categories

A pilot experiment was conducted to test the experiment design, to evaluate the criteria for the selection of participants and type of product, and to identify the categories emerging from the data.

Figure 2 illustrates outcomes from the pilot experiment at each step of the experiment's sessions. Outcomes from the visual representation of concepts showed that the users draw from memory while designers draw from their knowledge domain. Retrospective reports revealed that users' concepts about a product's use are

drawn from their experience, but designers' concepts focus on aspects related to product usability. Interviews showed that while users' concepts derive from their experience with the product, designers' concepts of a product use could be invented.

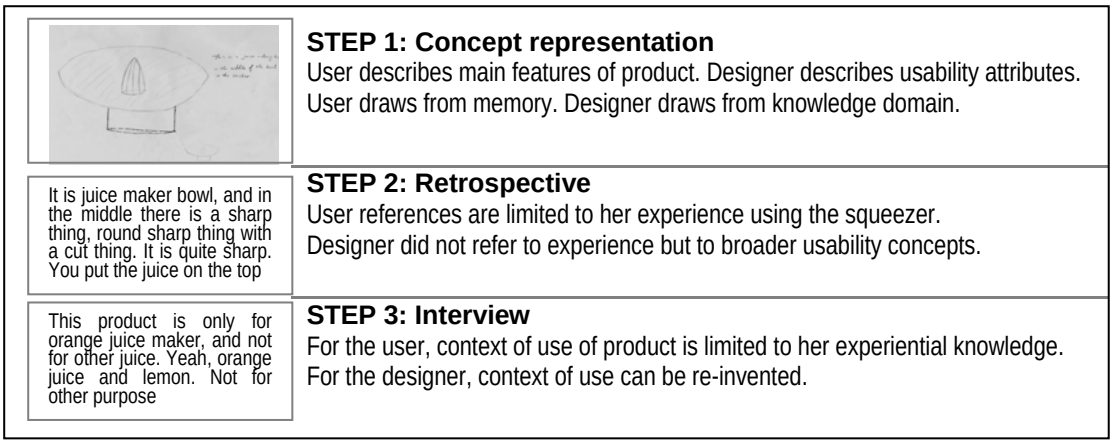


Figure 2: Outcomes from the pilot experiment

Outcomes from the pilot experiment were translated into the following statement:

> *Human experience is a powerful source that drives concept formulation about products and their context-of-use, where the main differences between users' and designers' concepts refer to their knowledge domain, which is influenced by their own cultural background.*

This statement was helpful at a later stage of the study, as it supports the relationships found during data analysis and the interpretation process.

The evaluation of the criteria for selecting participants and the type of product for each session was based on a comparison of the participants' outcomes in each product category. This comparison was organised to take account of differences of age, cultural background, expertise, and gender. Overall comparison shows that including participants who represent multiple user profiles can benefit the study, as outcomes from the pilot study identified concepts that revealed a diverse number of human experience related issues. This comparison is presented in Appendix B.

From the data collected, it was possible to identify and organise a 'system of categories'. This system conveyed all categories that informed the study about the participants' experience and their concepts about a product's use and its context-of-

use. Visuals and transcriptions from verbal reports were coded and interpreted according to these categories. The process of interpretation was iterative, and this helped to make corrections to the emerging system of categories. Terminology used for the definition of categories and for the interpretation of outcomes is presented in Table 4.

Table 4: Terminology used in the interpretation of outcomes

Terminology	Definition
User experience	A person's cognisance of how a product is used based on previous interaction with the product. This could refer to procedures of use, the intended activity or occasions in which the product was used.
Knowledge	The extent to which a product's use and characteristics are demonstrably comprehended and displayed.
Context-of-use	Relationships between a use–activity–task–situation that takes place during people's interaction with products. It reveals aspects of the product's environment of use and of its intended activity.
User's concept of a product's use	A person's particular definition or notion about a product's features (e.g. shape), procedures of use, purpose and functionality.
Situation	Particular circumstances, characteristics of the settings or social environments in which the product's intended use and intended activity take place.
Design domain	Concepts, thinking processes, behaviour and type of activities that characterise the Design field.
User domain	Information, behaviour and type of activities that characterise the way any individual relates to the use of products in his or her everyday life.
Expert domain	Theories, behaviours, processes and activities that characterise a professional field.
Familiarity	Understanding of a product's use and of its characteristics based on similar products a person has seen or used before.
Usability	Dimension of the user–product interaction that is perceived from the way the product performs its intended use.

The researcher's perspective for interpreting the data into a system of categories included:

- Taking into account every detail that could provide hints or insights about the participant's idea of a product's context-of-use, and considering the participant's knowledge that derives from his or her experience with regard to a particular everyday object, regardless of whether the participant was a designer or a user,

- Gaining an in-depth understanding of the nature of the differences between a user's and designer's knowledge or concept formulation about an everyday object.

The data collected (visuals and transcriptions from retrospectives and interviews) were organised into three groups of categories: (i) experience, (ii) knowledge and (iii) context. Subcategories focussing on specific aspects of each category emerged from the data. The designation of categories was based on multiple perspectives as they conveyed and represented the views and perspectives of the user group, the designer group and the researcher. Evidence of this is grounded in interviews, annotations from the drawings, and the researcher's observations. The following subcategories were identified: features with indication of context-of-use, individual experience within context, episodic data, principle-based concept, description-based concept, intended use and situation of use (physical and social). The system of categories and subcategories is presented in Table 5.

Table 5: System of categories and subcategories

Categories	Description of subcategories	Codes
Experience	Features with indication of usage	**FE**
	Individual experience within context	**IEC**
	Episodic data	**ED**
Knowledge	Principle-based concept	**PBC**
	Description-based concept	**DBC**
Context-of-use	Intended use	**IU**
	Situation	**ST**

Exemplars of the application of this system of categories to visuals and text are further explained in the Data analysis process (Section 5.4). Appendix C presents exemplars of the application of each category.

5.3 The experiment

The experiment investigated users' and designers' individual experience and how these would influence their understanding of product usability and the differences in

their concepts. Twenty-five sets of data were collected in two different periods: September to October 2004 and May to June 2005. A multicultural sample of an adult population comprising administrative staff and international postgraduate students was recruited from the Queensland University of Technology (QUT) in Australia, to participate in this experiment. The types of products selected for the experiment represented different contexts-of-use, and comprised grass shears, barbeque grill, blender, alarm clock, global positioning system device (GPS) for street navigation, treadmill, scooter, and public rubbish bin. The experiment sessions took place at the Human-Centred Design and Usability Research Laboratory of the Faculty of Built Environment and Engineering at QUT.

The sessions were video- and audio-taped. The experimental apparatus consisted of an audio-tape recorder, a flat microphone on the table, two digital cameras — one focussed on the participant and the other focussed on the task (drawing) — and a video mixer that combined these two sources of images onto one screen. In addition, the participant was provided with paper, pencils and markers for the drawing task. The participant was also provided with a written copy of the instructions at each of the three steps of the experiment.

Figure 3 shows an image of a participant during the visual representation of the concepts segment of the session. Here, the participant simulates the action of squeezing a lime in order to remember how to draw a squeezer.

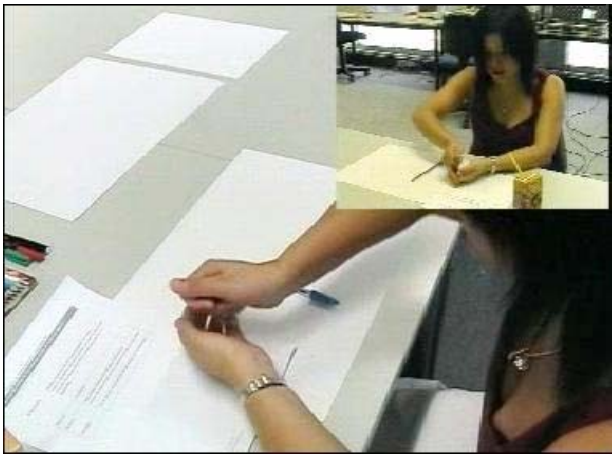


Figure 3: Participant during visual representation of concept

Figure 4 shows an image of another participant during the retrospective interview. This image shows the participant explaining her concept to the researcher by referring to each part of the drawing.

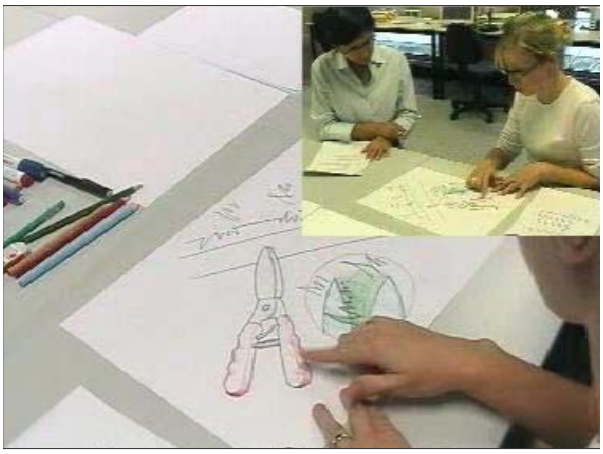


Figure 4: Participant at retrospective verbal protocol

Sets of data collected from the experiment's sessions consisted of visuals (drawings) produced by the participants, and transcriptions from verbal reports (retrospective and interviews).

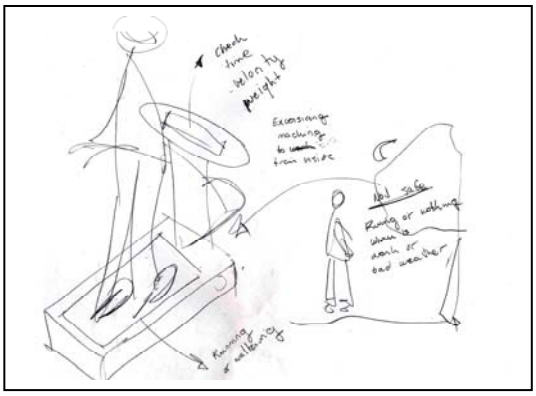


Figure 5: A visual representation of concept

> …from memory, what it has is the band where you run, that it moves and so that you can run and walk; and then it has all this information on the top where you can see your time, weight, velocity or whatever that you are doing… While you are doing these things on the machine you can check all these kind of things.

Figure 6: A segment from a retrospective report

Figures 5 and 6 show the data collected from a user participant. Figure 5 shows a user's visual representation of a treadmill, and Figure 6 shows a segment from the same user participant's retrospective report.

5.4 Data analysis process

The process of data analysis comprised two activities (Figure 7):

1. The first activity involved transcribing data collected in visuals and text, and identifying the categories that emerged in relation to experience, knowledge and context-of-use. This was an iterative process that started from the pilot experiment and continued throughout the experiment until the categories were clearly defined and translated into a coding scheme.
2. The second activity involved coding the data collected and creating memos (commentary and theory) in parallel with the coding process. Memos were used to capture information that emerged from the coding process itself, and to understand and define the causal relationships between codes that were related to the Research Questions of the study.

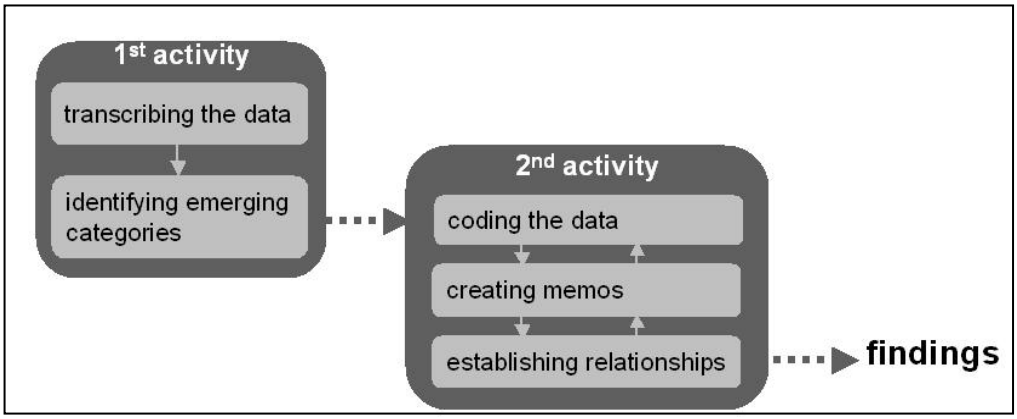


Figure 7: The process of data analysis

The outcomes of the analysis were then interpreted, and relationships were identified, which could respond to (a) the research questions dealing with the aspects of experience that influence understanding of a product's use, and (b) the nature of the differences between designers' and users' understandings of a product's context-of-use. These findings are presented in Chapter 6. The following sections describe the two data analysis activities mentioned previously: (i) transcribing data and

identifying emerging categories and (ii) coding the data, creating memos and establishing relationships.

5.4.1 Transcribing data and identifying emerging categories

The data that were collected helped inform the subsequent iterative process of data analysis; that is, the identification of categories was constantly evolving, and was completed along with the analysis process. The categories identified from the pilot experiment (Table 5) were extended during the final experiment, and subcategories explaining different aspects of experience, knowledge and context emerged from the data. This was translated into a coding scheme, where the scope of the interpretation of each code and its application to the data collected were also refined during the process. Table 6 presents the final definition of the coding scheme.

Table 6: Definitions and scope of interpretation of the coding scheme

	Codes	Definition	Scope for interpretation
Experience	***FE*** Feature with indication of usage	Product's parts or features that reveal aspects of its environment of use or of the intended use.	Indications about the feature's functionality and/or descriptions of the feature's intended activity.
	IEC Individual experience within context IEC – a IEC re the product's intended activity	A person's knowledge about the product that is based on his or her previous experience. Such experience refers to the use of the product that is based on doing or seeing.	References to ownership, a feature's characteristics that reveal mental models, procedures of use, social environment or environmental setting in which the product has been used (time, weather, and intensity of use).
	ED Episodic data	A person's memory of a past experience that indicates a particular situation in which a product was used. This refers to occasion, situation, and/or environment of use.	Memories associated to aspects of use (e.g. maintenance) during an occasion or situation (e.g. a trip), which are linked to the person's sensorial (smells, visual clues), or emotional experience (feelings).
Knowledge	***PBC*** Principle-based concept	A person's knowledge of a product that is based on his or her conceptualisation of relationships between the product's parts and functionality, including the product's procedures of use.	Indication about the process of use of the product, procedures regarding the realisation of the intended activity in relation to the product's parts/features.
	DBC Description-based concept	A person's knowledge of a product that is based on his or her concepts about the purpose and characteristics of a product's features.	Indications as to placement, shape, functions, and intended use of product or its features. References to interaction issues (e.g. assembly of some parts). Description of features in connection to the whole product.
Context-of-use	IU Intended use	Product's purpose of use and intended user. Conveys references to user–product interaction and usability issues.	Indications about the use of a product/part/feature, type of users, and characteristics connected to user–product interaction (e.g. intensity of use) and usability aspects (e.g. ease of use). May refer to a non-existent intended use.
	ST Situation or Context **ST–p** ST re the physical context-of-use **ST–s** ST re the social context-of-use	Product's situation/ context-of-use. This refers to the social or physical environments in which a product is used.	References to a place or location (physical environment of use), family and/or friends (social environment of use), and occasions (type of gathering, meal, season, time of the day, weather, other). May relate to a non-existing situation/context-of-use.

5.4.2 Coding the data, creating memos and establishing relationships

In the process of coding the data, texts and visuals were interpreted according to the coding scheme. In a drawing or text, the same segment could be given more than one code, depending on what that segment told about the person's experience and concepts, and about the product's context-of-use. Figures 8 and 9 are examples of the application of how the coding scheme was applied; the software ATLAS.ti facilitated the process of coding the data and creating memos. Representative examples of the application of all the codes can be seen in Appendix C.

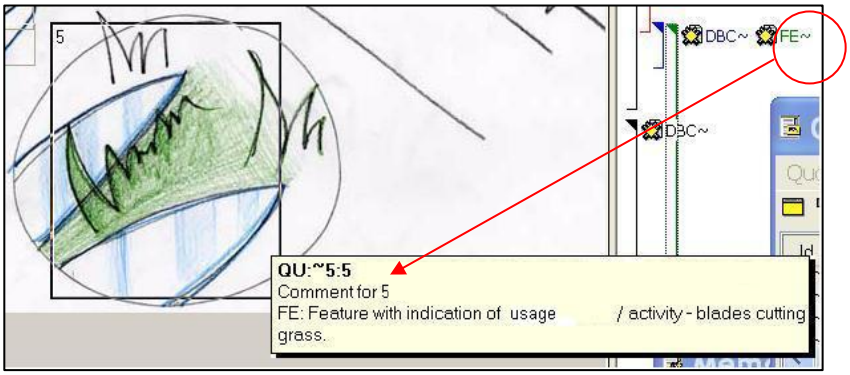


Figure 8: Application of the code FE (Feature with indication of usage) in a segment of a drawing

Figure 8 illustrates a segment of a participant's drawing about her concept of a grass shears in which the code FE (feature with indication of usage) has been applied. This segment of the drawing depicts the shape of grass shears' blades, indicates the environment of use by placing the grass shears blades (feature) on a grass area, and provides clues about the intended activity by showing the blades cutting grass.

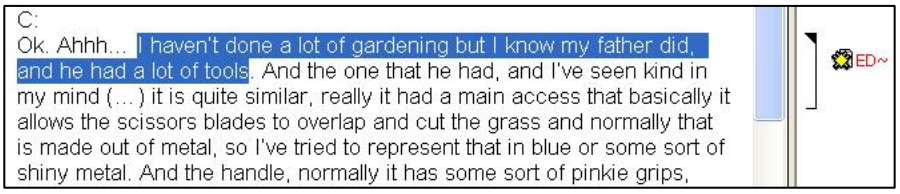


Figure 9: Application of the code ED (Episodic Data) in a text segment

Figure 9 shows the application of the code ED (episodic data) to a segment of an interview in which the participant talks about the use of the 'grass shears' from her memories of her father using and owning them. In this case, the code ED (episodic

data) identifies that the participant's knowledge comes also from a particular past experience in her life, in her home environment, from which she has recalled some visual clues to describe the grass shears.

The process of creating memos took place during and after the coding of visuals and text; this activity resulted in two types of memos: commentary and theory (Figures 10 and 11). Commentary memos were written in parallel with the coding itself, and this was helpful for the iterative and evolving process of the coding scheme definition. This activity allowed the recording of emerging information such as differences in the application of the code, or the scope of the code's interpretation in each case. Figure 10 shows a commentary memo about a participant's drawing of a blender. In this commentary memo the researcher identifies that the participant is part of the designer's group, refers to the participant's experience with the product he is asked about (he is also a user), and states that her interpretation of the participant's knowledge is based on three types of visual clues: drawings, annotations and arrows.

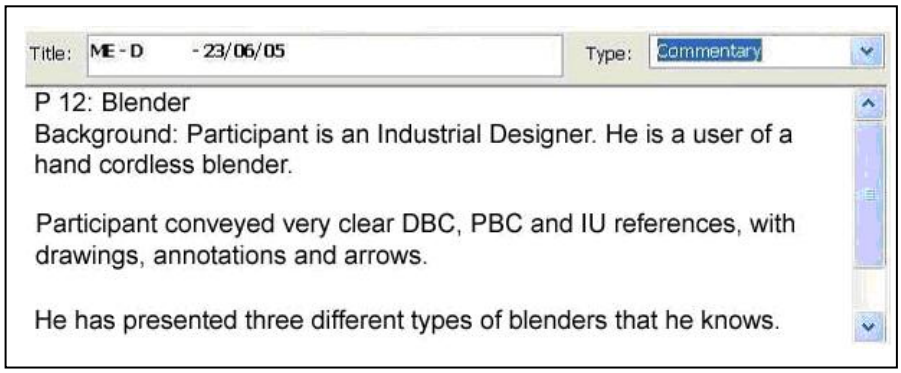


Figure 10: Commentary memo

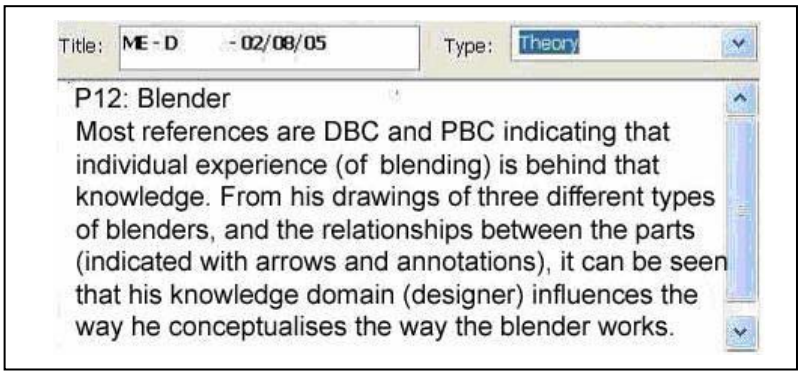


Figure 11: Theory memo

Theory memos were written after the coding process of text and drawings had been completed, and after the commentary memos had been written. Theory memos recorded relationships found with regard to the participant's knowledge and experience about a product's use and its context-of-use. Figure 11 shows a theory memo from a drawing that corresponds to the same participant and product referred to in the commentary memo from Figure 10. This theory memo explains that references to the participant's concepts of a product's characteristics (DBC), his conceptualisation of the product's procedures of use (PBC), and his knowledge of the product's intended use (IU) are based on his individual experience of using this type of artefact. The memo also shows that there is a relationship between the participant's knowledge domain (design) and his understanding of how the product works, and that this has influenced his concepts.

From the theory memos, it was found that emerging relationships had 'experience' as a common denominator. Therefore, theory memos were organised in statements according to four types of experience: no experience or little experience, experience and cultural background, experience and context-of-use, and experience and knowledge domain. Table 7 defines the scope of interpretation in each group.

Table 7: Types of experience found in theory memos

Type of experience	**Description**
No experience or little experience	Participant has no first-hand experience at all with the product. References consist of a basic description of the product's features and reveal little understanding of how it works. Statements do not reveal context-of-use issues.
Experience and cultural background	Participant's cultural background influences his or her experience and knowledge about the product's usage and its context-of-use.
Experience and context-of-use	Participant has experience from using or owning the product; he or she knows the product usage and the context of its use.
Experience and knowledge domain	Participant's knowledge domain influences his or her concepts about product usage, and produces references to aspects of use or context-of-use particular to his or her area of expertise.

Statements from theory memos were organised not only to reveal the participants' references to experience, but also to compare the two groups of participants: designers and users. This comparison was done separately for each set of data collected; that is, visuals, retrospectives and interviews. Figure 12 presents a segment of this comparison.

Users	Designers
NO EXPERIENCE or LITTLE EXPERIENCE Lack of experience prompts users to refer to familiarity with similar products. Familiarity is used as a reference to describe the product and its general characteristics (DBC) mostly. Such descriptions are broad and do not describe the intended use of the product.	NO EXPERIENCE or LITTLE EXPERIENCE Lack of experience prompts designers to describe concepts based on familiarity with similar products. Designers' concepts based on familiarity describe the product and its features. Such descriptions can be broad and inaccurate, and can also include a product's characteristics from the designers' imagination.

Figure 12: Comparing users' and designers' theory memo from drawings

The segments presented in Figure 12 relate to theory memos that reveal no or little experience by the participants with regard to a product's use. This shows that lack of experience prompts users to describe general characteristics of a product from familiarity with similar products, while designers would use familiarity to describe a product's features and to invent new ones (as if they were designing a new product). Appendix D presents the overall comparison of theory memos from the designers' and the users' groups.

Finally, establishing relationships was the last part of the data analysis process. This arose from the theory memos that were interpreted as revealing relationships that emerged from the participant's references to knowledge, experience and context-of-use. These relationships focus on explaining the different ways in which aspects of human experience influence people's understanding of product usability. For example, Table 8 shows two forms of relationships that emerged from the statements in theory memos presented in Figure 12.

Table 8: Relationships from theory memos in users' and designers' drawings

Participant	Relationship	Description
Users	Familiarity + lack of IEC → broad DBC	Use of familiar mental models leads to a broad or general understanding of a product's characteristics; but without individual experience, it does not support the users' understanding of a product's intended use or context-of-use.
Designers	Familiarity +lack of IEC → inaccurate DBC or FE	Use of familiar mental models supports descriptions of a product and its features; but without experience, such descriptions can be inaccurate or wrong.

Legend: → (generates, leads to), IEC (Individual experience within context), DBC (description-based concept), FE (Feature with indication of usage)

Relationships were identified from the participants' references to their experience in relation to their concepts of a product's use and its context-of-use. All theory memos were interpreted in this way. Table 8 shows how relationships were established from theory memos to a synthesised form of expression. A comparison of users' versus designers' references, interpreted as in Table 8 and organised according to the four groups of experience relationships (Table 7), followed this process. Appendix E presents a table with all relationships found from this process.

5.5 Summary

In this chapter were discussed the methodological approaches of the study's research design. The aim of the study was to explore the nature of the differences between users' and designers' concepts of everyday products, and to identify how users' experience influences their understanding of product usability. To address these two concerns, the experiment design employed observation, visual representation of concepts, retrospective verbal reporting, and interview as the data collection methods. In this experiment, it was considered that participants had to have some

knowledge about the product they were being asked about. Products were selected to represent different everyday contexts-of-use (i.e. home, office, sports), and participants were asked to provide their concepts about one type of product.

A pilot study contributed to the defining of the coding scheme and the approach to interpreting the data collected. Definitions of the system of categories focussed on identifying aspects of experience, knowledge and context-of-use revealed by the participants' concepts, and on understanding the nature of the differences between users' and designers' concepts. The experiment was conducted during two periods of time, and gathered a multicultural sample from an adult population. The experiment sessions were video- and audio-taped.

Analysis of data comprised two activities: (i) transcribing data and identifying emerging categories and (ii) coding and interpreting data in the form of relationships. In the first activity, identification of emerging categories resulted in new sub-categories within the individual experience and context-of-use categories, and in a more detailed scope of interpretation for each category. The second activity comprised three tasks: coding data, creating memos and establishing relationships. In the second activity, the collected data were used to inform the iterative process of the data analysis, memos were written while coding data, and relationships emerged from the evolving process. Data were analysed separately for visuals, retrospectives and interviews. Each set of data analysis was organised in relation to the four types of experience found in the theory memos: (i) no experience or little experience, (ii) experience and cultural background, (iii) experience and context-of-use, (iv) experience and knowledge domain. Responses from users and designers were compared at each stage of the process to identify similarities and differences between their concepts.

Chapter 6 presents the experiment findings, and elaborates on the process of interpreting outcomes. It describes how these dynamic relationships between user, experience, context-of-use and knowledge about a product's use respond to the research questions of this study.

Chapter 6:

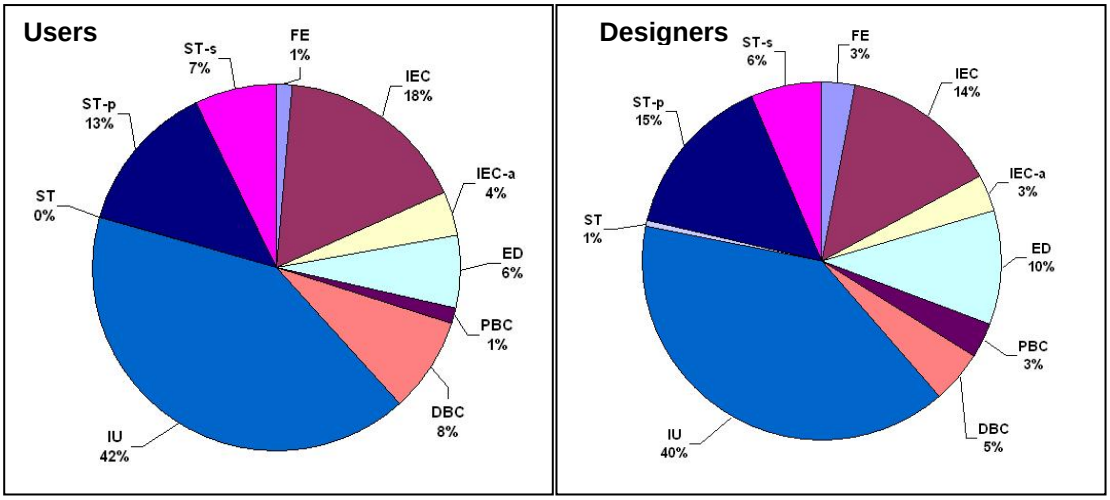
Findings

Chapter 5 described the research design devised for this study, the methods employed for data collection, and the interpretation of categories that emerged from the data collected. It also presented the experiment design and a step-by-step description of the process of data analysis. This chapter presents a brief description of the overall results from the experiment and the findings from the study. Findings are based on the interpretation of results into conceptual principles addressing experience and context-of-use issues in relation to the design of a product's usability. This chapter includes the presentation of nine causal relationships between experience, knowledge and context issues, which were established from the conceptual principles. Finally, the validation of the data is discussed.

6.1 Overall results

As described in the previous chapter, results were obtained from coding the data, creating memos and establishing relationships. The data collected were organised by comparing designers' and users' references to experience, knowledge, and context, and by organising the data according to their relation to four types of experience: (i) no experience or little experience, (ii) experience and cultural background, (iii) experience and context-of-use and (iv) experience and knowledge domain (Table 7). The processes of coding, memo writing and establishing relationships were done separately for drawings, retrospectives and interviews. The following sections present a brief description of the overall results from this process.

Coding. The coding of visuals and retrospectives shows that users' descriptions of a product's use refer mainly to the intended use of the product, while designers' descriptions focus on describing the product's features. For ease of comparison, results were tabulated into frequency tables, showing users' and designers' number of references in every category (Appendix F). This comparison indicated that in general, the user group referred to the product's social context-of-use (ST-s) and its intended use (IU) more than the designer group did; while the designer group referred more to the features and descriptions of all parts of a product (DBC), but also to a principle-based concept of how a product works (PBC).



Legend: IU (Intended use), ST (situation), ST-s (situation regarding the product's social context-of-use), ST-p (situation regarding the product's physical context-of-use), FE (Feature with indication of usage), IEC (Individual experience within context), IEC-a (Individual experience within context-of-use regarding the intended activity), ED (Episodic data), PBC (Principle-based concept), DBC (Description-based concept).

Figure 13: Comparison of users' (left) and designers' (right) interviews

Figure 13 shows an example of the results from the coding process. Here a graph is provided to visually compare the code frequency from designers' and users' interviews. In Figure 13 it can be seen that even though the distributions of references in both groups are similar, it is clear that users referred more to descriptions of a product's components (DBC), while designers made more references to the products' features within its context-of-use (FE), and to its principles of use (PBC). Likewise, users provided more references to their experience with the product (IEC) in its context-of-use (ST-s, ST-p), than designers,

who referred more to the product's features with indications of its context-of-use (FE).

Frequency tables revealed the level of importance of each type of reference in the case of the users' and the designers' groups. Frequency tables for each section of the experiment session (visuals, retrospectives and interviews) are presented in Appendix F.

Memo writing and establishing relationships. The process of writing theory memos assisted the identification of relationships from the participants' references to experience, knowledge and context. From these relationships, four types of experience groups were identified: (i) no experience or little experience, (ii) experience and cultural background, (iii) experience and context-of-use and (iv) experience and knowledge domain. These results were organised into two groups, designers and users, which helped to visualise the differences between designers' and users' experience. Relationships identified were later expressed in a synthesised form for ease of comparison. This is presented in Figure 13. Here, findings from the memo writing process and the relationships found from them are summarised.

In Figure 14, the users' column shows that this group referred more to the situation or social context of a product's use (coded as ST, ST-s) and to familiarity with other features or products to deliver their concepts. In each experience-related group, designers referred mainly to product descriptions (DBC) and the social context-of-use (ST-p).

Users	Designers
No experience or little experience **a.** IEC (seeing) → DBC (catalogue of representations) **b.** Familiarity → IU + FE + [DBC or PBC]	**No experience or little experience** **a.** IEC (seeing)→ DBC of new products **b.** No IEC or ED → IU (inaccurate)
Experience and cultural background **c.** IEC* or IEC-a* + ED* → IU* + ST-s* + DBC* or PBC* (***** X type of IEC → X type of ST-s)	**Experience and cultural background** **c.** IEC-a* + ED* → IU* + FE* + ST-p* + DBC* (***** X type of IEC → X type of ST-p)
Experience and context-of-use **d.** [IEC or IEC-a] + ED → IU + ST-s + [DBC or PBC]	**Experience and context-of-use** **d.** [IEC or IEC-a] + ED → IU + FE + ST-p + [DBC or PBC]
Knowledge domain **e.** IEC (professional) → ST-p + IU + [focussed PBC or DBC]	**Knowledge domain** **e.** IEC / IEC-a → DBC + PBC + IU + ST-p

Legend: → (generates, leads to), + (and), IEC (Individual experience within context), IEC-a (Individual experience within context regarding the product's intended activity), DBC (Description-based concept), ED (Episodic data), IU (Intended use), FE (Feature with indication of usage), PBC (Principle-based concept), ST (situation), ST-p (situation – regarding the product's physical context-of-use)

Figure 14: Relationships between experience, context-of-use and knowledge

For example, in the relationship identified as '**d**' under 'Experience and Context-of-use' in the users' group, the expression **[IEC or IEC-a] + ED → IU + ST-s + [DBC or PBC]** indicates that their individual experience within the context of a product's use (IEC) or their individual experience regarding the product's intended activity is complemented by the user's episodic experience in a particular situation. This experience generates an understanding about the product's intended use (IU) and about the social context in which it is used (ST-s). Such understanding includes a

description of the product's features (DBC), or description of the principles of the product's functionality. This reveals that in the case of users who have experience of using the product in its intended activity, their knowledge of product's usability is based on an understanding of the product's use and its functionality in the social situation of use.

The relationship identified as '**d**' in the designers group under 'Experience and Context-of-use' group, **[IEC or IEC-a] + ED → IU + FE + ST-p, [DBC or PBC]**, shows a different emphasis. In this case, this relationship indicates that the designer's individual experience within the context of a product's use (IEC) or within their experience of doing the activity (IEC-a) is accompanied by episodic experience (ED). Such experience generates understanding about the product's intended use (IU), the product's features within context-of-use, the physical context of the product's use (ST-p), and a description of its features (DBC) or a description of the principles of the product's functionality (PBC). This relationship is slightly different from the user's case, as this reveals that for designers who have experience of using the product in its intended activity, their knowledge of product usability is based on an understanding of the product's use and its features in its physical context-of-use. Appendix D presents a comparison of all designers' and users' theory memos.

The relationships found from the interpretation of both users' and designers' references (Figure 13) show connections between different types of experience and people's understanding of different aspects of product usability. These relationships were further interpreted in the following statements:

1. **No experience or little experience** (relationships **a** and **b**): Lack of experience leads to inaccurate or wrong descriptions of products, features and characteristics. Likewise, familiarity with similar products with no reference to context-of-use generates inaccurate descriptions of products involving wrong concepts of the product's intended use. Familiarity, visual memory, and lack of experience can also lead to descriptions of products that had not been used before and that could come from imagination. Experience from 'seeing but not doing' brings forth a visual memory that can be referred to as a 'catalogue of representations' based mostly on descriptions.

2. **Experience and cultural background** (relationship **c**): Cultural background influences individual experience and generates strong concepts about products. Experience of seeing or doing an intended activity, associated to an episodic experience that is referred to a particular cultural background, generates specific understanding or knowledge of the product's usability. This knowledge becomes the automatic concept about the product's intended use and of its social or physical situation of use that is relevant to the cultural setting in which the product was experienced. This knowledge can include understanding of the product's features and functionalities, which can be based on descriptions of its components or descriptions about the principles of the product's functionality. This type of relationship can lead to misunderstanding about the product's use and functionality in a different cultural setting. Therefore, users from a cultural background different from that of the place where they are experiencing a product are prompted to make incorrect applications of their previous knowledge and concepts to the immediate environment (new context-of-use).

3. **Experience and context-of-use** (relationship **d**): Experience from 'using and doing' that includes some episodic experience brings forth a visual memory of the experienced product, leading to description-based and principle-based concepts. This also generates knowledge about the product's features within its context-of-use, the product's intended use, and about the user–product interaction. Familiarity with similar products, and experience involving the product being used in its intended activity, generate knowledge about intended use, user–product interaction and context-of-use issues. When experience takes place within the product's context-of-use, it produces knowledge about the social context-of-use. Episodic knowledge and experience within the context are directly related to individual experience of owning and using the product, within a context-of-use that has cultural relevance for the user. This relationship (between episodic experience and context-of-use) also leads to a broader knowledge of intended use and the product's characteristics.

4. **Experience and knowledge domain** (relationship **e**): Knowledge domain uses references from visual memory and visual imagination to deliver concepts of a

product's usage when there is a lack of experience. In that sense, professional experience generates concept descriptions set in a specific area of domain focussing on a particular product's characteristics of use (intended use, context-of-use). Knowledge domain influences how people describe, represent and explain their concepts. Professional knowledge that conveys experience of doing generates not only a product's description but also knowledge about its context-of-use. In the case of the design domain, lack of experience of doing produces insufficient knowledge about the product's characteristics.

6.2 Findings: conceptual principles addressing experience and context-of-use issues

In order to address the research questions and establish this study's findings, results from drawings, retrospectives and interviews were compiled and interpreted into a number of statements (Appendix G). Some of these statements were related to the user's experience, and others were related to the differences and similarities between designers' and users' concepts. These statements respond to the two research questions that the experiment addressed and, therefore, they comprise the main findings of this study. As such, these findings are presented as conceptual principles that address experience and context-of-use issues in relation to the design of a product's usability. The following sections present these conceptual principles in relation to the research questions.

6.2.1 Findings addressing Research Question 1: what aspects of the user's experience influence his or her understanding of product usability?

Findings show five areas of human experience that influence the user's understanding of product usability. These are 'conceptual principles connecting human experience to product usability', and comprise the following: familiarity, experience from seeing, experience from doing, experience from using, and experience from expert domain. Table 9 presents these principles.

Table 9: Conceptual principles connecting human experience to aspects of product usability

Conceptual Principle	Definition
1. Familiarity	Familiarity with other similar products leads to superficial knowledge of a product's characteristics and of its intended use.
2. Experience from seeing	Experience from seeing (not using the product) leads to inaccurate knowledge of a product's characteristics, and to incorrect understanding of its characteristics and of its context-of-use.
3. Experience from doing	Experience from 'doing' (using the product) generates understanding of a product's context-of-use, its features and its intended use.
4. Experience from expert domain	Experience from the user's expert domain leads to knowledge that is set or constrained into the specific area of domain.
5. Experience from cultural background	Experience from the users' cultural background determines the user's preferred concept of a product's use.

These principles are explained next, and an example from the data collected during the experiment is provided to illustrate each of them.

1. **Familiarity** with similar products leads to superficial knowledge of a product's characteristics and of its intended use. Familiarity seems to rely on visual memory. An example is a designer's visual concept of a digital water sports camera. Figure 15 illustrates that to represent his concept of this product, he has referred to familiarity with the standard features of any type of camera (shutter, lens, zoom, flash), but his drawing shows no detail related to the 'digital' functionality of a camera.

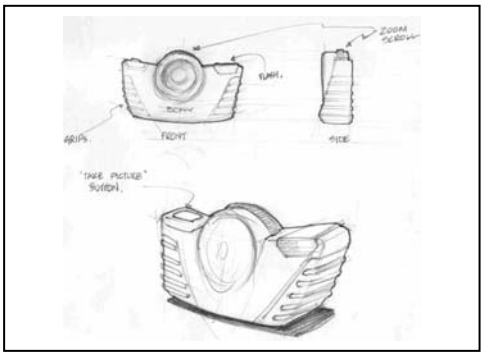


Figure 15: Designer's concept of a water sports camera

2. **Experience from seeing** leads to inaccurate knowledge of a product's characteristics, and to an incorrect understanding of its characteristics and of its context-of-use. Experience of 'seeing but not doing' produces a visual memory that acts as a catalogue of representations to which a user refers, to describe a product that he or she has not used. This leads to product descriptions that are broad (not detailed) or inaccurate, and to descriptions of the product's intended use that lacks understanding of the product's features and its context-of-use. This type of experience can also lead to concept description of whole new artefacts (concepts from imagination). For instance, Figure 16 shows a segment from a user's retrospective report of grass shears, indicating that she has drawn the product that she has seen before. However, her report demonstrates that she refers to a similar product — the pruning shears that are used mainly for light pruning of tree leaves or shrubs — which she has not seen being used in the activity of cutting grass. In this retrospective account she also refers to other uses that the grass shears could have, but which come from her imagination.

> Ok, I've tried to draw the ones I've seen. So this is used to clip the grass manually, that's what I imagine because I've seen these ones cutting the trees, so I've got this (pointing at drawing) […] easy ones too?. So, this is like a scissors, big ones, so you kind of hold them like this, so that's what I've also written that it could be used to many other things than clipping grasses, it can be used to cut the trees, and for some other purpose too, like if you want to cut a big wire or something and these are really really big ones, so you can use to cut the wires too…

Figure 16: Segment from a user's retrospective report about her visual representation of grass shears

3. **Experience from 'doing'** (using the product) generates understanding of a product's context-of-use, its features and its intended use. Experience of using a product and doing its intended activity usually conveys episodic experience and generates knowledge and a visual memory that includes observations and knowledge about the product's features within its context-of-use, its intended use, and about the user–product interaction. Different types of experience generate different knowledge of an artefact's use and its context-of-use. An example is one user's reference to a treadmill. During the interview, the user stated that she used treadmills when she went to the gym. The segment presented

in Figure 17 shows the user's concept about this type of product, its operation, its intended use, and its context-of-use. Her references are supported with observations about what she had done while using it (interacting with the controls), or from observations of other people using it.

> Ahhhh…. A treadmill is, as I understand it, is usually a flat surface which is moving …people use the treadmill, they would walk on it, often, and then they use the controls to make it goes faster so they can --- basically they run on the spot rather than around the block… or down to the park… and people generally use it because they are overweighted… ahh but they might just also use it to keep fitted, they might use it because they've got some kind of problem; if my diabetes now comes up that means I need to do lots of exercises to keep the diabetes down and I would say it's probably the same for, you know… a lot of health issues could be dealt with exercise; and the running machine actually is good one piece of equipment because you can go very fast or very slowly. It speeds up your heart rate… and cleanses your body at a fare rate.
>
> You know, it has pictures; I like pictures rather than terms that I don't necessarily understand. If you are very much into sports it might make sense to your… if you are using of computers a lot, I mean, I use computers here but a lot of other people are more heavily into technology than I am, or into that kind of thing, and its language, language I don't always understand. But if you got some little picture of someone going up the hill and someone going down the hill and have numbers and beeps going along showing that you are going 10km an hour (laughs) it seems to me the best way. And I think there are much simpler ways to say you want to do so many km an hour and to keep it at that level or whatever. Some of the programs are actually quite good, they just need to be simpler, I think.

Figure 17: Segment from a user's interview about the use and context-of-use of a treadmill

4. **Experience from the individual's expert domain** leads to knowledge that is set or constrained into the specific area of the domain. In addition, users' knowledge from an expert domain that does not include experience of using a product, leads to descriptions supported by visual memory and imagination; consequently, this can generate inaccurate descriptions of the product's intended use. Examples are found in the differing concepts that one user and one designer had of a portable GPS device for street navigation. The user was an expert in GPS systems that are used in the militia, while the designer was an expert interface–design practitioner with many years of experience in the field. Figure 18 shows a visual representation of the expert user's concept, which explains how a GPS system transmits the global position of anything in the world. His visual representation shows a satellite and the transmission of a signal to a receiver (an antenna) that is part of a GPS device. The interface of the device indicates a screen that displays

the global position and the controls; a minimum reference to the size and context-of-use of the device is indicated by the words ‘palm top’ and ‘vehicle mounted’. The expert designer’s concept, presented in Figure 19, is quite different. His concept has emphasised the interface aspects of the device: the display, the controls, the size and shape of the device. However, his concept does not show the GPS functionality.

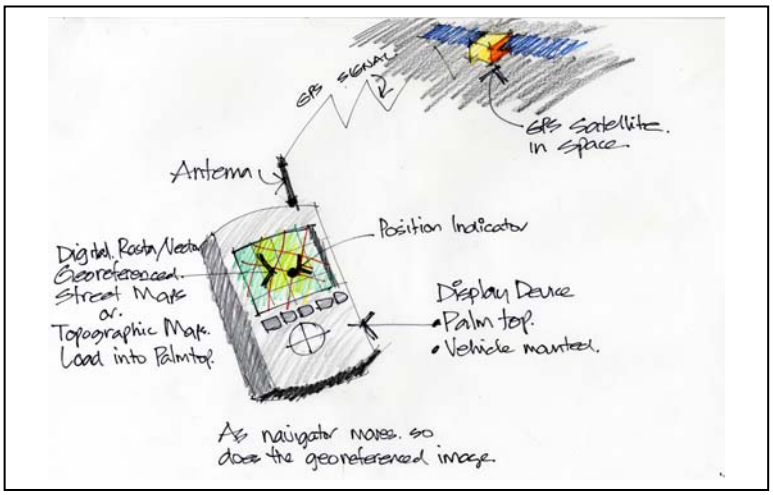


Figure 18: An expert user’s concept of a GPS system

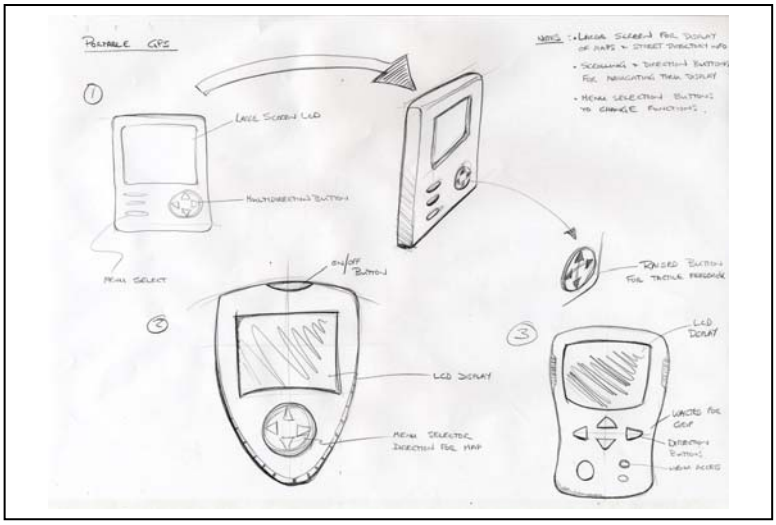


Figure 19: An expert designer’s concept of a GPS device

5. **Experience from the individual’s cultural background** determines the user’s preferred concept of a product’s use. Users’ cultural backgrounds influence their interpretation of everyday products, and when confronted with a different cultural setting (e.g. as tourists), users tend to automatically apply these concepts, leading

to usability problems that frustrate the users' interaction with everyday products. Problems or errors can be related to lack of understanding of a product's intended use and of its context-of-use. Consider, for instance, a user's concept of the intended use of a scooter. Figure 20 presents a segment from a user's interview in which he comments about the use of scooters. His concept is based on references to the use of scooters in China, where ladies are the main users of scooters, employing them instead of bicycles to commute to work. Everyday products that are for public use are the types of products that are most frustrating for users from different cultural backgrounds. Another example of this comes from the researcher's own experience of an Asian student studying temporarily in the United States of America. During the first days of her stay in the USA, she took out her rubbish and put it into the public postal mailbox. She was confused because the shape, size and colour of the mailbox were similar to those of the public trash bins in her home town.

> In China it is for transportation. Many young ladies use it for transportation, to commute from home to work. Transportation in China is just something like bicycle. But here in Australia I have seen people also running scooters. But I think mostly here they ride it for fun, not for transportation.

Figure 20: Segment from a user's interview about his concept of a scooter

6.2.2 Findings addressing Research Question 2: what is the nature of the differences between users' and designers' understandings of product usability?

Findings about the differences between users' and designers' concepts were organised into eight 'conceptual principles addressing similarities and differences between users' and designers' concepts about product usability'. These principles are presented in Table 10.

Table 10: Conceptual principles comparing users' and designers' concepts about product usability

Similarities and differences	**Conceptual principles**
Similarities	1. Lack of experience and familiarity lead to misunderstandings of a product's use and of its context-of-use.
	2. Experience of doing the intended activity usually involves episodic knowledge that leads to understanding product use in its context-of-use.
	3. Cultural backgrounds generate established concepts of a product's use and of its context-of-use.
	4. Expert domains convey experience results in knowledge about the product's intended use and its context-of-use.
Differences	5. Users' knowledge of a product's context-of-use is broader than that of designers.
	6. Users refer more to the product's social context or environment of use, whereas designers focus more on the product's features.
	7. Designers' episodic experience generates a catalogue of visual representations about the product's intended use, while users' episodic experience generates strong concepts about a product's context-of-use and its intended use.
	8. User's expert knowledge can be complemented with familiarity to similar products in their expert domain to understand a product's use, while designers cannot use this to design a product's concept.

The eight conceptual principles that compare users' and designers' similarities and differences between their concepts about product usability' are further explained next.

Similarities: 1. *Lack of experience and familiarity* will seriously inhibit users and designers from arriving at a basic understanding of a product's use and of its context-of-use. Familiarity and visual memory help users and designers in similar ways, by providing descriptions of products that had not been used before.

2. *Experience of doing* the intended activity involves episodic knowledge that leads to understanding product usability in its context-of-use. This experience assists designers and users to generate concepts that convey most aspects of a product's use (intended use, features within context-of-use, interaction issues and principle-based/description-based concepts).

3. *Cultural background* influences both designers' and users' concepts. Foreign cultural references that are applied to different cultural environments can generate incorrect understanding of a product's use. When experience and episodic knowledge take place within a relevant cultural framework, then users and designers achieve sound knowledge of a product's use, of its characteristics and of its context-of-use.

4. *Expert domain* influences users and designers in similar ways. An expert domain that conveys experience will result in knowledge about the product's intended use and its context-of-use. Individual experience within a person's expert domain leads to a particular description of a product's use in a specific context-of-use, or to hypothetical constructions of a different context-of-use.

Differences:

5. Users' knowledge of a product's *context-of-use* is broader than that of designers' knowledge. This is because users rely not only on their experience, but also on their familiarity with other products; designers rely more on their knowledge domain.

6. Users refer more to the product's *social context* or environment of use, whereas designers focus more on the *product's features*. This mandates how a product's description is expressed or represented.

7. Designers' *episodic experience* generates a catalogue of visual representations about the product's intended use in the context in which the experience took place. On the other hand, users' episodic experience (as in a particular cultural setting) generates strong concepts that become their automatic idea of a product's context-of-use and its intended use.

8. Knowledge from an *expert domain* that does not convey experience influences users and designers differently. Although they may lack experience with a new product, users' with expert knowledge are assisted by their familiarity with similar products in their expert domain; this helps them to develop broad concepts of a product's intended use. However, in the case of designers who lack experience with a new product, their expert knowledge does not include the familiarity with similar products that users enjoy. Consequently, they are limited in their ability to develop correct concepts of a product's use and of its context-of-use.

For ease of comparison and to summarise findings, these conceptual principles have been re-interpreted into relationships that demonstrate how the different types of experience influence the user's knowledge of a product's use and of its context-of-use. Such relationships have been identified as 'causal relationships', and these are explained in the following section.

6.3 Causal relationships

In the previous section, thirteen conceptual principles were identified, comprising (a) five principles that connect human experience to product usability and (b) eight principles that compare similarities and differences between users' and designers' concepts about product usability. From these conceptual principles, a set of nine types of 'causal relationships' was identified and has been established in a summarised form. This summary is presented in Table 11. In the left column the

relationships are presented in a synthesised form for ease of comparison; the right column presents a description or interpretation of them.

These nine causal relationships explain the cause-and-effect relationships between experience, knowledge, and context-of-use. They explain how different types of experience trigger people's knowledge of a product's use, intended use, and context-of-use, and how this influences their understanding of product usability. For example, the causal relationship No 3, [**IEC-a → DBC + FE**], indicates that the experience of doing the intended activity (IEC-a) generates knowledge about the product's characteristics (DBC) and its features (FE) in the context-of-use.

Table 11: Causal relationships

Causal relationships	Description
1. IEC-a → ST + IU	Experience of doing the product's intended activity (IEC) **generates** knowledge about the product's intended use (IU) and its context-of-use (ST).
2. IEC-a → DBC + FE	Experience of doing the product's intended activity **generates** descriptive knowledge of a product's features in their context-of-use.
3. IEC-a → PBC +FE	Experience of doing the product's intended activity **generates** knowledge of the product's rationale of use and of its features in their context-of-use.
From:1, 2, 3, 4 ED + IEC + ST → DBC + IU + FE	Memory of a particular occasion, individual experience and knowledge of context of a product's use **generates** descriptive knowledge of the product, its characteristics, its intended use and its features in context-of-use.
4. IEC (specific) → DBC (specific)	Individual experience from a specific knowledge domain (culture/profession) **generates** specific knowledge of a product's features and its characteristics.
5. IEC (specific) → PBC (specific)	Individual experience from a specific knowledge domain (culture/profession) **generates** specific knowledge of a product's rationale of use.
6. IEC (seeing) → DBC new products	Experience from seeing a product's use **generates** descriptive knowledge of new products that might come from imagination.
7. X Culture + IEC → DBC + IU + ST in X Culture	Individual experience within a particular culture **generates** knowledge of a product's features, its characteristics, its intended use and its context-of-use within that culture.
8. **X** Culture + IEC → **wrong** DBC + IU + ST in **Y** culture	Experience in particular culture **generates incorrect** or inaccurate descriptions of a product's features, its characteristics, its intended use and its situation of use when applying it in a different culture.
9. IEC + ED → IU + ST	Individual experience and memory of a particular occasion **generates** knowledge of a product's intended use and its context-of-use.

Legend: → (generates), → wrong (generates incorrect or inaccurate). IEC (Individual experience within context), IEC-a (Individual experience within context regarding the product's intended activity), DBC (Description-based concept), ED (Episodic data), IU (Intended use), FE (Feature with indication of usage), PBC (Principle-based concept), ST (situation), ST-p (situation regarding the product's physical context-of-use).

Five other types of relationships were found between experience, context-of-use and knowledge; these are relationships of associations, equivalences and negations, and are presented in Table 12.

Table 12: Other types of relationships between experience, knowledge and context-of-use

Other relationships	**Description**
IEC- a **is a** ED + IEC + ST	Experience of doing the product's intended activity (IEC) **is equivalent to a** memory of a particular occasion, using the product, and knowing the context of a product's use.
IEC (seeing) **is-a** Visual memory	Experience from seeing a product's use **is equivalent to** visual memory of similar products and/or features.
IEC = = ED	Experience (of any kind) (IEC) **is associated with** episodic experience (ED).
IU = = ST	Intended use **is associated with** knowledge of a product's context-of-use.
IEC – [ED or IU or ST] < > DBC or PBC	Experience that lacks memory of a particular occasion, intended use or knowledge of the product's context-of-use **does not generate** description-based knowledge or principle-based knowledge of the product.

Legend: **is-a** (is equivalent to), = = (is associated with), – (does not include), < > (does not generate), ED (Episodic data), IU (Intended use), ST (situation), IEC (Individual experience within context), DBC (Description-based concept), PBC (Principle-based concept)

In Table 12 for example, the first relationship, [**IEC = = ED**], shows that the users' individual experience within context is associated to his or her experience at a particular occasion (episodic experience).

Causal relationships and associations presented in Tables 11 and 12 describe the relations between different types of experience with different aspects of product usability, and present a synthesis of findings from this study. These relationships also explain the aspects of experience that influence people's understanding of a product's use, which can be employed in a design process to enhance the design of product usability. However, conveying this new knowledge into a design activity requires devising a means that can assist designers to understand and implement it.

6.4 Validation of data

The validity of the data collected and the knowledge produced were considered at every stage of the study: during data collection, data analysis, and interpretation of results.

Data collection was based on data elicited from the participants during the experiment; therefore, it conveys the participants' perspectives. During data analysis, the employment of retrospective verbal protocols immediately after the visual representation of concepts task, and open-ended interviews, supported the data analysis process by identifying the users' perspectives about the concepts of a product's use as provided in their drawings. The researcher's interpretation of data was based on the participants' inputs, observations annotated during the experiment, and the researcher's interpretation of relationships between experience, context and knowledge that emerged from the participants' references in visuals and verbal reports.

Data were analysed at three different periods of time, with an interval of six weeks between each period. This allowed time for reflection and for self-verification of the researcher's perspective during the iterative process of the analysis. Interpretation of data included the activity of writing memos, which recorded the researcher's evolving thought process, the process of corroborating evidence from different sources (drawings, retrospectives, interviews) and from different participants, and the description of complexities of the research process. From this it can be said that results from experiments could be replicated if the study were conducted again with the same coding scheme, and equivalent participants in the same context.

6.5 Summary

This chapter presented the results from the experiment and the interpretation of those results with regard to the research questions. This provided the basis to establish this study's findings regarding (a) aspects of users' experience that influence users' understanding of product usability and (b) similarities and differences between

designers' and users' understandings of everyday product usability. Findings demonstrate that human experience, knowledge of a product's context-of-use and knowledge about its usability are interrelated concepts. From these findings, a set of nine causal relationships that identifies how different types of experience trigger people's understanding of product usability was defined (Table 10).

The validation of findings relies on the process of data collection and iterative interpretation of results during various stages of the study — a process that effectively conveys the participants' perspectives and the researcher's observations. This was procured through retrospective verbal protocols and interviews, which allowed participants to interpret their own concepts and helped in diminishing the risk of misinterpreting results due to the researcher's bias. By repeating the data analysis on three occasions separated by intervals of several weeks, the researcher was able to reflect on and verify the iterative process of the analysis.

The relationships found between experience and product usability were the foundation for establishing conceptual principles that are relevant to the design process. To make these principles applicable in design, it is necessary to devise a means that can convey these relationships to designers, and so assist them during the early stages of design projects. This is discussed as part of the implications and significance of findings for the design domain, which are presented in Chapter 7. The implementation of findings into a design tool is then presented in Chapter 8.

Chapter 7:

Discussion and Implications of Findings

In Chapter 6 the interpretation of results revealed two groups of findings that were expressed in the form of conceptual principles. Such principles focussed on (i) addressing human experience in connection to the understanding of product usability, and (ii) comparing users' and designers' concepts about product usability. From these findings it was possible to establish nine types of causal relationships between aspects of human experience and aspects of product usability. The overall findings demonstrate that human experience drives concept formulation about a product's use, and influences the scope and direction of this knowledge regarding a product's context-of-use and usability. This chapter discusses the findings of the study, the implications of these findings to the design theory and practice, and the contributions of this new knowledge to the design field.

7.1 Discussion of findings

The discussion of findings is presented around three aspects: (i) the relevance of experience and context for the design of product usability, (ii) the influence of differences between designers' and users' concepts about product usability for the design practice and (iii) the methods currently employed to uncover aspects of experience in relation to product usability.

7.1.1 Relevance of experience and context for the design of product usability

Previous studies that relate the design of user–product interaction to issues of human experience have evolved from a focus on assessing product usability at the final stages of design, to a focus on accessing human experience as a means to generate

engaging product designs (Frascara, 2002; Plowman, 2003; Overbekee, 2002). Although the later studies touched on aspects of experience in product design, none of them have explored the aspects of human experience that influence people's understanding of product usability, and how this information could be included in the design process.

This study's definitions of experience and context-of-use supports the findings. Here, experience was defined as people's comprehension of their life events underlying their understanding of the world, and resulting from their interactions with products in a particular situation. Likewise, context was defined as the relationship 'use–activity–task–situation' that takes place during people's interactions with products. These definitions — that connect experience and context of use to user-product interaction — support the emphasis that findings place on (a) the role of diverse types of experience that reveal some sort of interaction with products and (b) the impact of such experiences in people's understanding of a product's use and of its context-of-use. In this way, the understanding of product usability is connected to experience and context-of-use. This is evident in the findings related to Research Question 1. Here, the findings revealed five components of human experience that were related to aspects of product usability: (i) familiarity, (ii) experience from seeing, (iii) experience from doing, (iv) experience from expert domain and (v) experience from cultural background (Table 9). These different types of experiences involve diverse aspects of product usability, such as intended use, knowledge of features, understanding of the principles of a product's use, and context-of-use.

The relationships found between experience and product usability contribute new knowledge to the design field, as this knowledge addresses an area that has been overlooked in current literature about user–product interaction and the design of product usability. These findings contribute with original knowledge in two areas:

1. The aspects of product usability (revealing important context-of-use considerations) that are directly related to particular aspects of human experience,
2. The aspects of human experience that can be identified and explored as part of the process of designing product usability.

This study defined ‘product usability’ as the dimension of the user–product interaction that is affected by the user experience and the product’s context-of-use. Based on this definition and on the findings presented above, it is considered that this new knowledge is relevant for the design of product usability, and that this must be made available to designers in a way that will help them to implement it in their design activities. However, further research into the relationships between experience and product usability is needed in order to deliver broader knowledge about other aspects of experience that could influence people’s understanding of a product’s use.

7.1.2 Influence of the differences between designers’ and users’ concepts about product usability for the design practice

Previous studies about design activity and knowledge in design have explored the issues of expertise (Chi, 1988) and the differences between designers’ and users’ (Norman, 1988; Krippendorf, 2000). However, the studies reported here highlight the fact that expert designers use experience as a source of knowledge more than novice designers, who prefer a deductive method for problem solving in design activities. These studies also emphasised that differences between designers’ and users’ concepts about everyday products result in the generation of product designs that are difficult to understand by the intended users (Popovic, 2002), or product designs that do not support the eventual use that users expect of the products (Redstrom, 2006). Although these issues are considered important for the design practice, current literature provides no indications of (a) aspects in which designers and non-designers’ concepts are different with regard to aspects of product usability or (b) the influence that differences between designers’ and users’ concepts have on the way designers design product usability. These two issues have been addressed by the findings related to Research Question 2 (Table 10), which are presented in the form of eight conceptual principles. The first four principles reveal the areas of experience that influence in similar ways designers’ and users’ concepts of product usability. These are: (i) lack of experience and familiarity, (ii) experience of doing, (iii) cultural background and (iv) expert domain. The last four principles compare the areas in which designers’ and users’ concepts are different: (i) context-of-use, (ii) social context-of-use versus a product’s features, (iii) episodic knowledge and (iv) expert domain and lack of experience.

These findings do more than merely agree with the existing research which has shown that designers' and users' concepts are different: the findings from this study provide new knowledge and deeper understanding. The eight conceptual principles that address similarities and differences between designers' and users' concepts reveal aspects of knowledge that have not been addressed by previous studies. Consequently, these are original findings that contribute to the design knowledge domain. The new knowledge — comprising the four conceptual principles that compare differences between designers' and users' concepts about a product's use — can contribute to the design process by influencing the way designers design product usability. This knowledge can (a) assist them to be aware of the implications of their design decisions and (b) lead them to investigate areas that they might not otherwise deem important, but which matter to the users. In this way, this knowledge can influence and enrich the current process of designing product usability

7.1.3 Methods currently employed to uncover and to address aspects of experience in relation to product usability

Methods employed in previous studies to explore design and design processes have involved drawings, collages, and 3D mock-ups to elicit knowledge from participants, and to uncover information of the observed reality (Sanders, 2002). These techniques have been used to explore aspects of human experience with regard to users' behaviour and their activities in several situations (Cooper, 2003; Slesswijk Visser et al., 2005), but not in situations dealing with aspects of experience in relation to product usability. In this study, visual representations of concepts in conjunction with verbal protocols were effectively employed to uncover aspects of human experience that reveal how experience influences people's concepts about a product's use.

This study revealed that combining visuals with retrospective reports and interviews is a valuable source for gaining a holistic understanding about the influence of human experience on people's knowledge about a product's use and its context-of-use. Visual representation of concepts allowed the researcher to visualise users' and designers' concepts of products as they see them in their minds. Whilst verbal reports allowed the researcher to access the participants' own interpretations of the visual representations they had made, and eliminated the risk of the researcher misinterpreting concepts; interviews allowed the researcher to gain a greater

understanding of the usability issues that were related to the participants' experience. In this way, this methodological approach supported the process of analysis and interpretation of data collected and therefore provided one of the contributions of this study. However, outcomes from the data collection and data analysis process show that further investigations can be carried out (i) to uncover and explore other aspects of experience in different domains of knowledge and (ii) to gain in-depth detail within the aspects of experiences already uncovered in this study, and how these can possibly change with regards to the users' demographics.

In addition to the contribution of this study's methodological approach to the exploration of aspects of human experience, its application also allowed the identification of nine causal relationships that describe the influence of experience in people's knowledge and understanding of product usability (Table 11). The relevance of this knowledge for the design of product usability has been discussed in previous sections (7.1.1 and 7.1.2). However, in order to make this information accessible for designers in a design task, another type of methodological approach is needed in order to address aspects of experience in the design of product usability.

Recent studies that have explored aspects of user experience and context-of-use have developed methods and techniques to access the experiential world of users and to elicit their views about potential contexts of interaction (Cooper, 2003; Sleeswijk Visser et al., 2005). These methods contribute to idea generation during the early stages of a design process, and produce information from the users' views about current and future contexts-of-use. While such approaches can contribute to the development of innovative products in new contexts-of-use, those methods do not aim to assist the design of product usability. Moreover, previous studies have shown that the application of user research through generative techniques requires intensive preparation before and after a session with users has been conducted. As this is the same for both small-scale and large industry projects, these studies have also acknowledged the need for less-intensive methods, suitable for smaller projects that cannot afford extensive user research (Sleeswijk Visser et al., 2005).

Consequently, another type of methodological approach is needed in order to address aspects of experience in the design of product usability. The issues discussed above

must be considered when devising ways to explore the users' experience and to communicate results to designers. Applying findings from this study in a design process requires methods that are applicable to industry projects and for the practicing designer — methods that are not intensive in preparation or extensive in user research, but which can clearly address aspects of experience in relation to product usability.

The previous sections have discussed overall findings regarding the relevance of this study for the design of product usability, its influence for the design practice, and with regard to the methods employed in the area of product usability. Contributions and new knowledge that these findings provide have also been presented. The following section presents implications of these findings for the design domain.

7.2 Implications of findings

The findings of this study not only convey new knowledge that is relevant for the design of product usability, they also have important implications for its application in two design domain areas: (i) design theory and (ii) design practice.

1. **Implications for design theory**: Current design research has already established the existence of differences between users' and designers' concepts (Norman, 1988), and that these differences can influence the success of the design of the user–product interaction (Popovic, 2004). As stated in the discussion section, findings from this study have confirmed previous research, but have also identified new knowledge, in particular with regard to the areas of experience in which designers' and users' concepts are different (Table 10). Therefore, it can be said that this study has implications for design theory, as the new knowledge contributes to addressing a theoretical gap that had been acknowledged in design theory for almost twenty years. This new knowledge implies that as greater detail had been identified about the differences between designers and users with regard to their understanding of product usability, then greater detail can be attained as well in other areas of interest, such as differences between designers and non-designers about their familiarity with everyday products. The methodological

approach employed in this research can assist in extending the results from this study into other areas of interest.

2. **Implications for design practice**: Current design processes usually focus on user research that often emphasises only predetermined areas that the designer deems important. This study's findings have demonstrated that designers' and users' concepts are different, and have elaborated in the areas of human experience that are related to aspects of product usability. These findings have three implications:
   i. In the design of product usability, designers must pay attention to the differences between their own concepts and the users' concepts of a product's use, so that designers do not only design from their own understanding and experience, but also consider the areas of human experience that trigger the users' understanding of product usability (Table 9 and Table 10).
   ii. The design of product usability must pay attention to the social aspects of a product's use. The findings stress that the social context-of-use provides insightful information for the design of product usability. Whilst designers mostly refer to the physical environment in which a product is used, users relate more to the social environment of use. Reference to diverse aspects or components of the social context-of-use should be included in the design of product usability to facilitate users' understanding of a product's use.
   iii. The design of product usability must investigate users' familiarity with the product's usability. This finding can be connected to other studies that delivered methods to uncover users' familiar knowledge (Blackler, 2005). Familiarity is also related to the user's expert domain and cultural background as sources to uncover clues about the users' previous experience. Reference to this should be included in the design of product use in order to assist the user's understanding of product usage, and to prevent potential usability problems.

The first and second of these implications led to a definition of design principles that are relevant for a design process. These are the design principles related to the identification of aspects in which users' and designers' concepts of product

usability are different. Such differences are grouped in Table 13 into four areas: (i) context-of-use, (ii) social context-of-use versus a product's features, (iii) episodic knowledge and (iv) expert domain and lack of experience.

Table 13: Design principles addressing differences between users' and designers' concepts

Areas of differences	Users' concepts	Designers' concepts
Context-of-use	Familiarity with other products supports broad concepts and descriptions of the product's context-of-use.	Knowledge from design domain that might be limited to the designer's experience can lead to limited concepts or hypothetical constructions of a product's context-of-use.
Social context-of-use versus product's features	Concepts of a product's use are related mainly to the social context-of-use.	Concepts of product's use are related mainly to the product's features.
Episodic knowledge	Episodic experience leads to strong concepts about the product's intended use and its context-of-use.	Episodic experience support concepts that are based on a catalogue of visual representations (from memory) about the product's features.
Expert domain and lack of experience	Familiarity to similar products in user's expert domain support concepts and descriptions about the product's intended use.	Design expert domain and lack of experience lead to hypothetical concepts about the product's use and features, which can be incorrect.

These design principles can help designers to reflect on how their concepts are different from those of users, and to be aware of the areas that need to be emphasised in the design of product usability. For instance, Table 13 shows that in general, designers pay more attention to the product's features than to context-of-use issues. Nevertheless, these four design principles must be further explored in regard to each of the areas identified, and with consideration given to the participant's demographics and different areas of expertise. This could lead to new knowledge about other areas of differences between designers and users regarding their understanding of product usability, and to knowledge about other ways in which such differences can influence expert performance in different domains. Examples include comparing differences between novel and expert

designers' concepts of product usability, or comparing differences between novel and expert professionals in areas that require expert skills, such as expert use of medical equipment or military equipment. Such new knowledge presents implications that can influence not only the design of devices and equipment, but also the training of experts in different areas of the domain.

The third of these implications derives from the causal relationships (Table 11), and led to the definition of another set of design principles that can be applied in a design process. Table 14 presents design principles for the design of product usability based on aspects of human experience that correspond to aspects of product usability.

Table 14: Design principles related to the areas of human experience corresponding to aspects of product usability

Sources of experience		Aspects of product's usability
Familiarity	→	Inaccurate or incomplete concepts of a product's **intended use** (IU). This can be associated with a product's description-based concepts (DBC).
Episodic experience	→	Preferred concepts of a product's **social context of a product's use** (ST-s). This can be associated with knowledge of the product's intended use (IU), features with indication of usage (FE), description-based concepts (DBC) and physical context of a product's use (ST-p).
Cultural background	→	Strong concepts of a product's **social context-of-use** (ST-s) ingrained in a particular culture/tradition. This can be associated with knowledge of the product's intended use (IU), description-based concept of features in context-of-use (DBC) (FE), and principle-based concepts (PBC).
Expert domain	→	Partial concepts of a product's **description-based concepts of features/functions** (DBC) (FE) that are focussed on a specific area of expertise. This can be associated with knowledge of the product's intended use (IU), principle-based concept (PBC) and physical context-of-use (ST-p).

Legend: → (generates), IU (Intended use), DBC (Description-based concept), FE (Feature with indication of usage), ST-p (Situation regarding the product's physical context-of-use), PBC (Principle-based concept), ST (Situation), ST-s (Situation regarding the product's social context-of-use).

The design principles presented in Table 14 show four sources of experience that influence people's understanding of product usability. Each of these sources is

connected in importance to a particular aspect of product usability. These design principles can guide the design of product usability by highlighting the sources of human experience that are relevant to particular usability aspects of a product's design. For example, cultural background generates strong concepts of a product's social context-of-use (ST-s), which is ingrained in a particular culture or tradition. The user's cultural background can influence his or her understanding of a product's usage and its context-of-use, and can also generate knowledge about the product's intended use, a description of its features in the context-of-use, and principle-based concepts that explain the product's functionalities that correspond to the person's particular cultural environment. These principles also support one of the premises of this study, that 'human experience broadens or limits the users' concepts of a product's usability'.

Furthermore, these design principles (Table 14) can be employed in the early stages of the design process to inform designers about the areas of human experience that must be addressed to support particular aspects of the design of product usability. Consequently, designers can enhance users' understanding of product usability by designing and incorporating 'clues' that appeal to particular areas of the intended users' experience.

These principles have implications for application to design practice, in that the principles imply a shift from a design approach that is object-centric or experience-centric towards a design approach that considers a middle point: a relationship between experience and product usability as point of departure for the design process.

7.3 Limitations and transfer of knowledge

This study is limited to the exploration of those aspects of users' and designers' experience that influence their concepts about everyday product usability. The findings of this study uncovered five areas of human experience in connection to aspects of product usability, from which nine causal relationships were established (Table 11). Nevertheless, the number of causal relationships found could be limited, due to the size and characteristics of the sample of participants. To compare how

demographic criteria might influence the results of this study, similar studies would be needed, using larger samples of participants (for both the user and the designer groups), whose backgrounds represent different genders, ages, cultures, expertise and professions.

The application of knowledge gained from this study can be identified with regard to three areas: (i) the design of products of everyday use, (ii) the design for a broad range of users and (iii) the methodological approach.

1. Due to the scope of this study, new knowledge is transferable to product designs mainly in the context of everyday activities. Considering that the issues of technological complexity have not been addressed in the selection of product types for this study's experiment, it is suggested that additional studies are required to explore the extent to which this study's new knowledge can be transferred to the design of high-technology products for expert use.

2. This study's new knowledge of conceptual and design principles can be transferred to the design of products aimed to a wide range of users. This is because participants selected for the experiment represent not only local but also multiple-user profiles from diverse cultural backgrounds and different age brackets. For instance, these design principles can be applied to the design of products of public use, or to products in international settings (e.g. airports, railway stations).

3. The new knowledge also impacts on methodological approaches employed to explore relationships between experience and understanding of product usability, as it can be transferred to other types of studies that require the exploration of human experience in different settings. For instance, visual representations of concepts in conjunction with verbal reports can be applied in research into the influence of expertise in the use of specialised products. This application could assist in gaining greater knowledge about the differences between novice and expert users in domains such as health and

the military. In using this methodological approach, results can be applied to devise training methods for novices to learn the use of specialised products.

7.4 Contributions

As stated and explained in Section 7.2 Implications of findings, this study presents relevant knowledge not only for the design process, but for the design domain in general. Such new knowledge derived from the relationships found between experience, context-of-use and knowledge of product usability (Table 11) is summarised in the conceptual principles (Table 9 and Table 10) and the design principles (Table 13 and Table 14). All these address the importance of including context-of-use in the design of product usability by connecting aspects of human experience to aspects of product usability. This constitutes an original contribution to knowledge that has not been explored before, and which therefore has implications for design theory. As principles are applicable to the design of product usability, it also has implications for the design process. This contribution to knowledge not only responds to the interest of the author's research inquiry, but responds also to the interest of the design community in this topic, which has been stated in previous studies and through current on-line discussions of the Design Research Society (JISC, 2006).

The sections on the discussion of findings (Section 7.1) and the implications of findings (Section 7.2) have presented the ways in which this study's new knowledge contributes to the design domain. However, all contributions of this study can be summarised in the following four statements:

1. Findings from this study have contributed with an initial identification of the aspects of experience that influence human understanding of product usability.
2. Conceptual principles provide increased detail in understanding the way that individuals acquire knowledge of product's use from different types of experience.
3. Design principles support understanding of implications of designers' and users' differences for the design of product usability.
4. Methodological approaches that are based on the use of visual representation of concepts in conjunction with verbal protocols provide means for further

exploration of aspects of human experience related to people's understanding of product use in diverse settings and in different domains.

7.5 Summary

This study's findings address aspects of people's experience that influence their understanding when interacting with products. The findings are demonstrated as being relevant to the design field, as no other study has focussed on exploring the influence of experience and context on the design of product usability. This study provides new knowledge about the aspects of product usability in connection to aspects of human experience. The findings about the differences between designers' and users' concepts are relevant for design practice, as these provide new knowledge about (a) the aspects in which such concepts are different and (b) the influence of such difference on the design of product usability. They also demonstrate that methods employed to uncover aspects of experience in relation to product usability (visual representation of concepts and verbal protocols), provide a valuable source to gain a greater understanding of the human experience in connection with the understanding of a product's use.

The findings convey new knowledge that has implications for both design theory and design practice. First, it has implications for design theory, as the differences between designers and non-designers, although established by previous studies, had not been researched in detail. The findings from this study provide greater detail about the differences between designers' and users' concepts of product usability. Second, this study provides new knowledge with regard to design practice as it presents two sets of new design principles: design principles addressing differences between designers and users concepts of product usability, and design principles about the areas of human experience that correspond to aspects of product usability. The first set of principles about differences between designers' and users' concepts imply that in current design practice, user research can be improved by providing better clues to designers about the areas of experience that prompt users' understanding of a product's use, and in this way avoid relying only on designers' individual interpretations of the users' needs. The second set of design principles, which connects areas of human experience to aspects of product usability, implies

that this new knowledge can be applied in the early stages of the design process; it also implies a shift from a design approach that is object-centric or experience-centric to a middle point, at which the design approach to be applied takes account of the relationship between experience and product usability as the initial stage for the design process. The application of these principles to the design of product usability can enhance people's understanding of product.

This study's new knowledge can be transferred to the design of products of everyday use, to the design of products for a broad range of users, and for design processes exploring aspects of human experience. This is because the scope of this study has produced results derived from products in the context of everyday activities, and has drawn participants from different age groups and from a variety of cultural backgrounds, representing multiple user profiles. Knowledge related to the methods employed to uncover aspects of experience can be adopted as research methodology for other studies that require exploring the influence of experience in people's understanding of particular aspects of a user–product interactions.

The findings and new knowledge that emerged from this study contribute to the design domain in diverse ways. First, they have contributed with an initial identification of the aspects of experience that influence human understanding of product usability. New knowledge consisting of conceptual principles provides insights about the way individuals understand product usability from different types of experience. Second, new knowledge consisting of design principles supports the design of product usability by informing designers about the differences between their concepts and the concepts of users about product usability. Third, new knowledge about the methodological approach provides support to the study of human experience in connection to people's understanding of product use in diverse contexts-of-use and in different domains.

Findings and contributions from this study can inform and guide the design process of product usability. As presented in the discussion of findings (Section 7.1), this study suggests that a methodological approach is required to implement these findings and make them accessible to designers. The Implementation of Findings will be further developed and discussed in Chapter 8.

Chapter 8:

The Experience and Context Enquiry Design Tool (ECEDT)

Chapter 7 presented new knowledge for the design domain conveyed in a number of design principles that are relevant for the design of product usability; these principles are related to aspects of human experience and product usability, and similarities and differences between designers' and users' concepts. New knowledge also comprised a set of causal relationships between experience, knowledge and context-of-use; these relationships show the aspects of experience that can influence the users' understanding of product usability. However, assisting designers to use this new knowledge to support the design of product usability requires devising a methodological approach that makes new knowledge available and understandable to them, and that makes this usable as part of a design process. In order to address this requirement, this chapter presents a tool that has been devised as a research application prototype for implementing these findings. The design of this research application prototype provided a means to carry out a trial run, which aimed (a) to verify whether causal relationships bring useful information that supports the design of product usability and (b) to explore requirements for a tool that can be employed in the early stages of the design process. This tool was implemented for a trial use only, and its design is limited with regard to its functionality and interface design. The following sections present (a) a brief revision of current tools that address context-related issues in design activities, (b) the approach undertaken to envision and outline the basis of a tool that was based on this study's findings, (c) the research application prototype — the Experience and Context Enquiry Design Tool (ECEDT), (d) a description of ECEDT's characteristics and (e) observations from the use of ECEDT in a trial run. This is followed by a discussion about opportunities for further

developing ECEDT. Finally, the third research question of the study — “How can human experience and context-of-use issues enhance the design of product usability?” — is addressed, and conclusions presented about potential contributions of ECEDT to design activity.

8.1 An overview of context-related tools used in design activities

The literature shows an increasing interest in addressing the topic of the design of tools as means to convey contextual information and to assist in the design of interactive user interfaces of products and systems. In previous studies, software programs were devised to support the use of environmental information (context) in the design of interactive applications. This has been studied mainly in the computer sciences and software engineering fields to support the design of user interfaces (Van den Bergh and Connix, 2005). In those studies, integrating context issues in the design of interactive applications responded to the need for supporting user interactions in changing environments. Van den Bergh and Connix (2005) referred to various context-modelling toolkits and frameworks that exemplify three types of programming approaches supporting the design of context-sensitive user interfaces: (i) widget-based frameworks, (ii) services-based approaches and (iii) blackboard approaches.

The widget-based framework approach relies on the concept of context widgets, which are software components providing applications with access to contextual information from their operating environment (Salber et al., 1999).In a different way, the service-based approach focuses on the user from whom the tool gathers information. The blackboard approach aims at gathering information into a central storage space to be retrieved and used later, through queries posed by other applications. Of these three approaches, only one, the widget-based framework, presents relevant information to this study. The Context Toolkit developed by Salber et al. (1999) is based on this approach and it was designed as a toolkit that handles context information in interactive applications. In their study, the Context Toolkit collected, stored, and interpreted environmental information (such as user location and the identity of persons within the tool’s operating environment) from other applications into a new one, for example a ‘PersonFinder’. The rationale of this

Context Toolkit is analogous to the way designers conduct user research and then interpret such information into their concept designs.

Slesswijk Visser et al. (2005) reported on methods used in current research and design practice for mapping contexts of people's interactions with products. They focussed on methods employed to conduct user studies with generative techniques that support contextmapping studies. Their work addressed the role of context information in the design process by involving intensive user participation as a form of Participatory Design. Under this approach, contexmapping is a framework that assists designers exploring the context of a variety of aspects (e.g. emotional, social, functional) of the user–product interaction. Their approach is based on the argument that the designers' view about the context of a user–product interaction is a guess based on a personal view. Slesswijk Visser et al. (2005) explained that contextmapping techniques follow a sequence of research steps that includes preparation, sensitising participants, group sessions, analysis and communication. Various types of toolkits for generative research are used as part of these steps; for example the do-say-make technique that employs collages, cognitive mapping and Velcro modelling toolkits. Generative techniques have been explained previously in this study as part of Chapter 4. As stated previously, this type of technique requires extensive user research, and requires resources that better suit large projects involving multidisciplinary teamwork. Moreover, contextmapping techniques can provide information about various aspects of the user's ideas about his or her user–product interaction, but this information is always fragmented and requires detailed analysis in order to identify context-related issues; consequently, it still depends on the designers' interpretation of raw data.

Van Welie's doctoral thesis (2001) included a description and categorisation of tools currently used in design activities within diverse fields of domain. This was related to task-based user interface design tools (TBD-UID) devised to help designers model more accurate and detailed scenarios (possible contexts-of-use). According to Van Welie (2001), tools within this category support activities such as knowledge elicitation, task analysis, scenario development, sketching, interface modelling, and prototype development. Van Welie identified the existing tools (research and

commercial application tools) that correspond to these categories. These are tools supporting:

- Data collection tasks: The Noldus Observer, U-Tel, EL-TaskModels,
- Model specification tasks: WinCrew, CTTE, ERGOWEB, Visio,
- Analysis tasks: The Noldus Observer, WinCrew, CTT,
- Envisioning activities: ScriptWerx, Storyboard, Scenario, Browser,
- Specifying envisioned model tasks: GOMSED, QGOMS, ALACIE, CTTE, Visio,
- Analysing envisioned model tasks: GOMSED, QGOMS, ALACIE, CTTE,
- Early prototyping tasks: VTMB, CTTE.

One of the main problems identified with these tools is their limitation of being unable to be part of the integral design process; they usually stand alone, and have limited capability to interface with other tools used in design activities (Van Welie, 2001). No one of these tools provides the type of information that can be accessed through user research and with the contextmapping techniques.

This brief overview of context-related tools used in design activities in various domains has shown two broad types of approaches: one based on computer applications and another based on user research. While computer-based tools present limitations as to how they integrate a design process, the literature shows that the identification of context-related issues in product design tasks still depends on methods that require extensive user research.

8.2 Envisioning a design tool to support the design of product usability

The tools described previously have been designed to explore, create or define contexts as scenarios of product interaction. In contrast, this study suggests an approach that focuses on informing designers about the aspects of human experience that derive from the user's knowledge of a product's context-of-use, in order to enhance the user's understanding of a product's usability. This approach is based on the nine causal relationships presented in Chapter 6 (Table 10), which describe the cause-and-effect relations between aspects of human experience, knowledge and

product usability. Figure 20 shows one of the nine causal relationships and its interpretation.

IEC + ED → IU + ST	Individual experience and memory of a particular occasion **generates** knowledge of a product's intended use and its context-of-use.

Legend: → (generates, leads to), Individual experience within context-of-use (IEC), Episodic experience (ED), Intended use (IU), Situation (ST)

Figure 20: Causal relationship

This study's causal relationships have two components: aspects of human experience and aspects of product usability. Figure 21 identifies these two components in the causal relationship presented before (Figure 20). In this example, the user's individual experience within context-of-use (IEC) and his or her experience of a particular occasion (ED), leads to his or her understanding of a product's intended use and of its context-of-use.

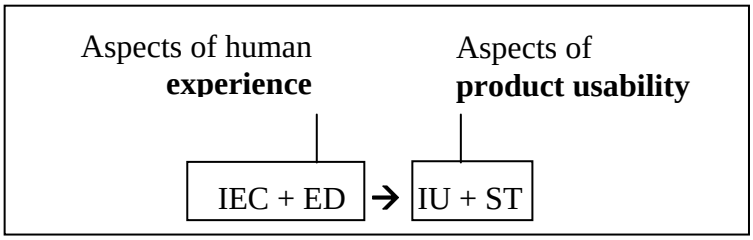


Figure 21: Components of a causal relationship

In order to support the design of product usability and to enhance the user's understanding of a product's use, a design tool has been envisioned to include and interpret the nine causal relationships in a way that informs designers about the aspects of human experience that must be addressed. Figure 22 illustrates how one causal relationship can be used to support the design of product usability. In this example, to support the design of a product's usability and to enhance the user's understanding, a product's INTENDED USE and SITUATION (or context-of-use), require that designers incorporate references to the user's experience and his or her episodic experience with similar products. Such references are related to the user's

experience of seeing this type of product in its context-of-use, or references to the user's memory of doing the intended activity with similar products; in addition, it requires incorporating references to the user's episodic experience or memories of an occasion that he or she relates to this type of product.

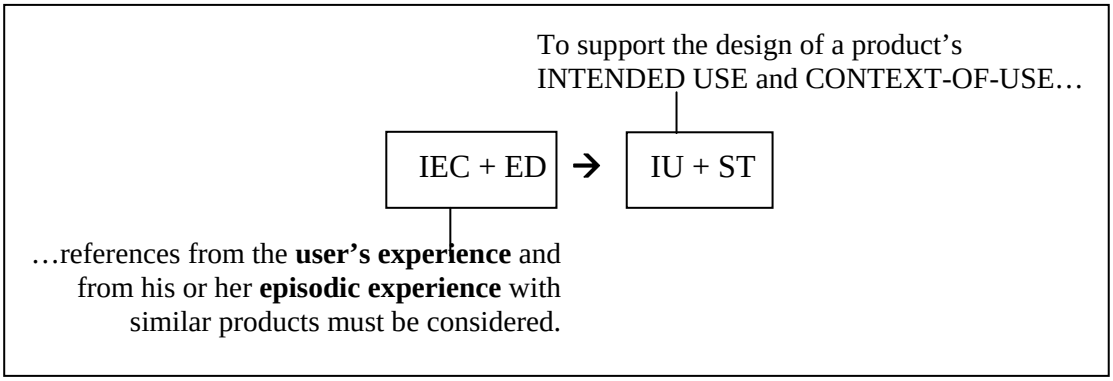


Figure 22: Interpretation of a causal relationship to support the design of product usability

This approach outlines the basis for an experience–context enquiry tool that designers can use to inform their design process about the different aspects of the user's experience — experience that can influence their understanding of a product's use. The following sections explain how this approach has been implemented and how it works.

8.3 The Experience Context Enquiry Design Tool (ECEDT)

This study's approach to supporting the design of product usability has been implemented into a research application prototype named the *Experience Context Enquiry Design Tool* (ECEDT). This tool is proposed as an example, to illustrate how the causal relationships deliver information that supports the design of product usability. The ECEDT contains a database of causal relationships between human experience and product usability, and a Web-based search tool. In this way, ECEDT can inform designers about the aspects of human experience that are related to the user's understanding of particular aspects of a product's use.

ECEDT combines three sources of information to deliver references to the user's experience that are relevant to the product being designed. They are:

1. The designer's input through keywords and menu selection,
2. A database comprising this study's design principles and causal relationships,
3. The World Wide Web (Web).

The designer's input is of two kinds: (i) an initial keyword describing the type of product being designed and (ii) his or her selection of choices from predetermined menus. The ECEDT's database matches the designer's input with the causal relationships found in this study. Based on this, a Web-based search is automatically activated. As a result, ECEDT shows a series of examples that illustrates human experience within the context of a product's use, or within the context of the activity that a product supports, in connection to the aspects of product usability that are relevant to the design project.

Figure 23 shows an overview of the ECEDT information flow step by step. In this diagram, the start point [1] requests the designer to input a keyword(s) that best represents the product he or she is designing (e.g. barbeque grill). This keyword influences the tool's background presentation [2] by bringing an image of a similar product from the Web; it also influences the combination of words that the search engine [8] will use to deliver the information to the designer. A series of menus [3, 4, and 5] are presented to select the most relevant information required for the design project. ECEDT matches the designer's input (selections) with its database, and results are presented in another screen [6]. Another selection menu is presented to the designer [7], presenting the areas of user experience most relevant to the design. By selecting one of them, the designer activates a Web search by connecting to one of the web search resources [8]. This search employs both the combination of keywords input by the user, and the ECEDT's database. Outcomes from the Web search are presented to the designer in a results screen [9] and in the form of visuals and text illustrating particular aspects of human experience that can be referred to in a design process to enhance the user's understanding of a product's use. A detailed description of each screen is presented in a sub-section titled 'Functionality of the ECEDT's information system'.

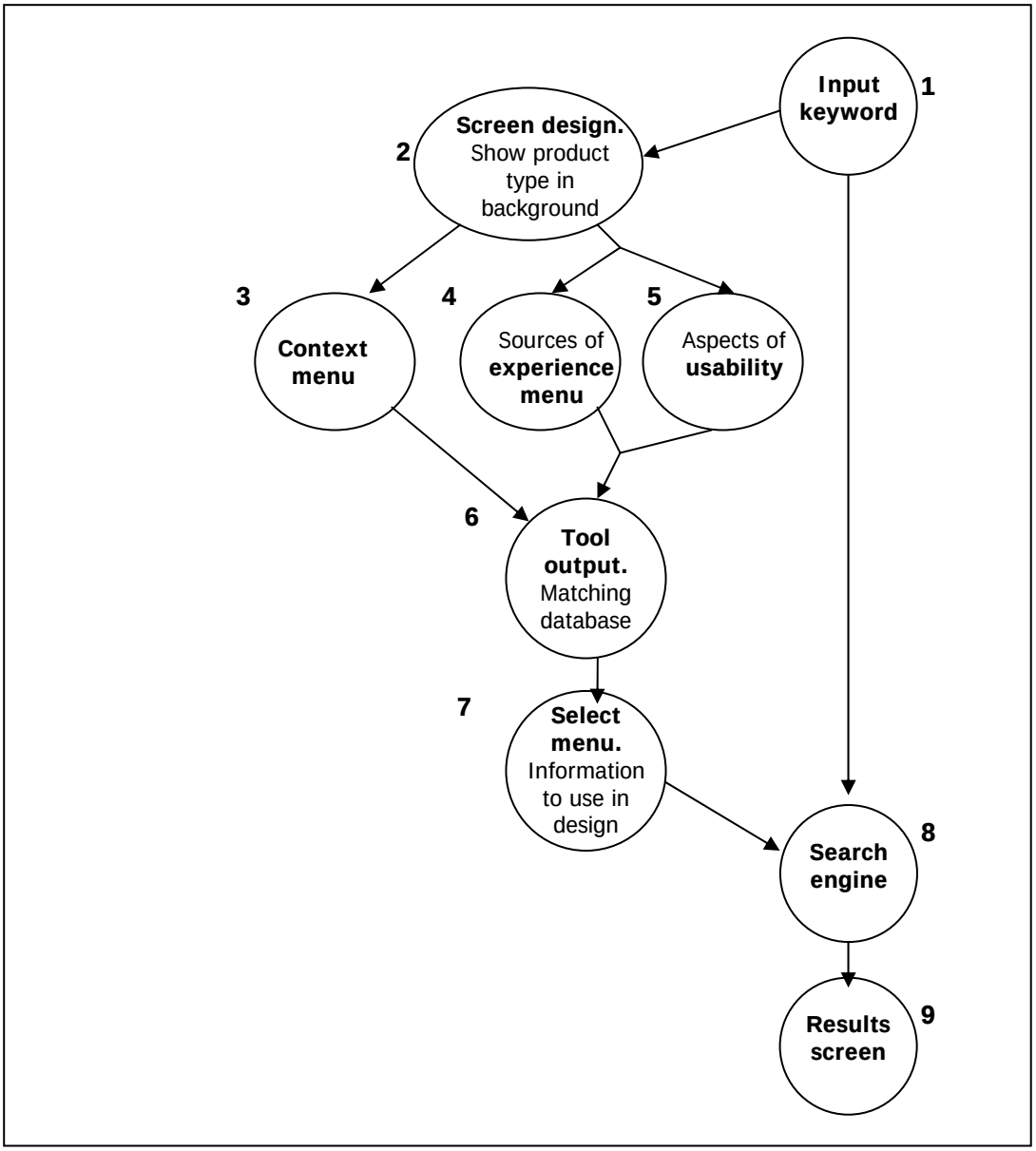


Figure 23: Overview of the ECEDT information flow

Previous studies have outlined four aspects that must be considered in the design of an interactive tool to support design activities (Van Wiele, 2001; Myer, 1995). These are (i) the use of a conceptual framework, (ii) the capacity of interfacing with other tools, (iii) representation issues and (iv) useage issues. In this study, ECEDT is presented as a research application prototype for implementation of findings, and as such, it has focussed mainly on the conceptual principles that support it, and on the representational aspects that are relevant to the functionality of the tool in a trial use.

8.4 Functionality of the ECEDT's information system

ECEDT comprises four underlying processes that are invisible for the end user (designer), in a number of selection-menu screens. The processes involved are:

1. Entering keywords for a session's database,
2. Building information for a session's database,
3. Matching the session's database information with the ECEDT's database,
4. Retrieving information by linking ECEDT with a Web search engine.

The session's database is the temporary database that is created from the information input by the designer at each step of the session. This information is developed from the initial keyword and the choices made by the designer in the various selection menus. The ECDET's database comprises the design principles (Table 14) presented in Chapter 7, and the nine causal relationships (Table 10) presented in Chapter 6. The following sections describe each of these four processes.

8.4.1 Entering keywords for a session's database

Figure 24 shows the initial screen, which starts a session. Here, the designer inputs a keyword that best represents the type of product he or she is designing. Figures 25 and 26 show how the designer's initial input (keyword) affects the ECEDT in every instance of the session. It influences the tool's background by contextualising the session according to the design intention, and it influences the search engine by including the keyword in the combination of words to search the Web.

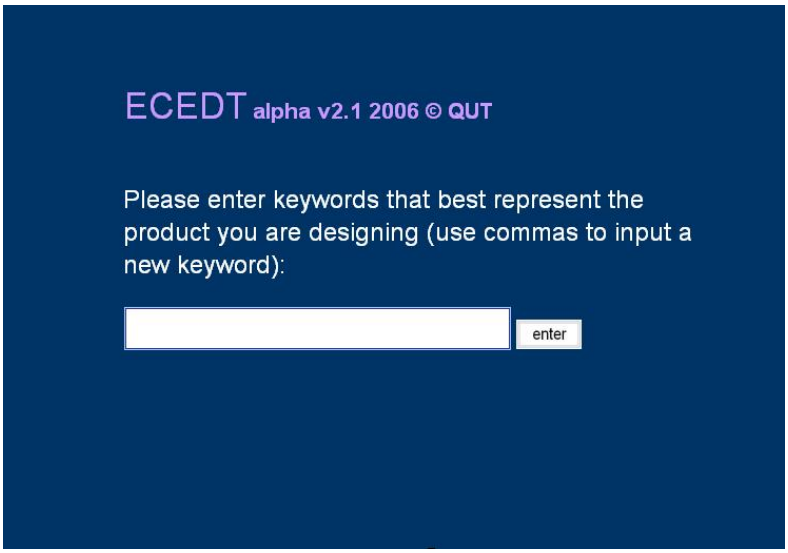


Figure 24: Initial screen: input of keyword

Figure 25 shows the ECEDT main menu screen indicating the steps that a designer must follow to build the information for the session's database.

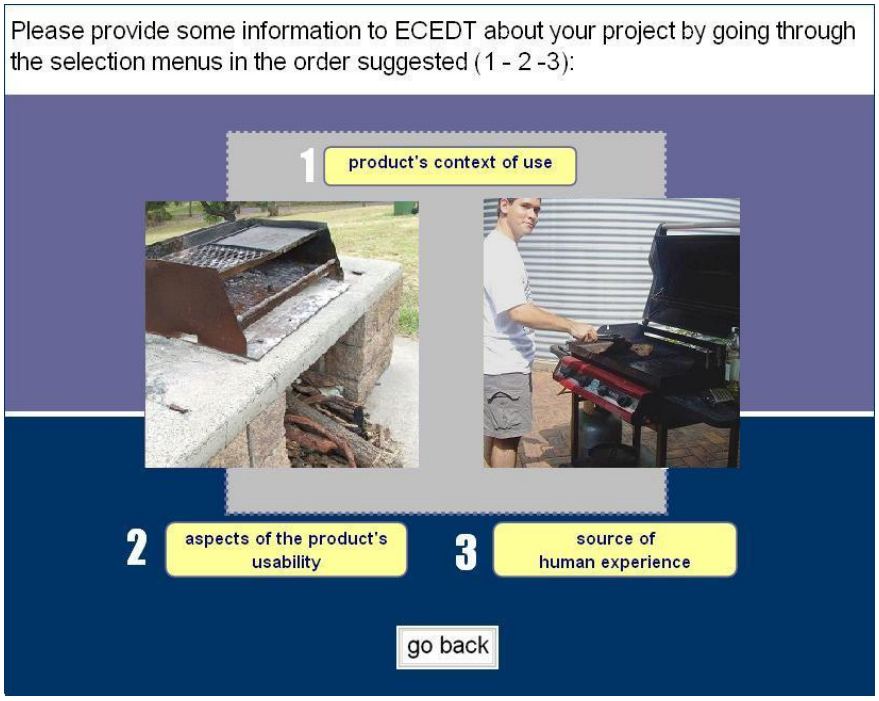


Figure 25: Main menu screen

8.4.2 Building information for a session's database

As previously explained, the session's database refers to the information entered by the designer in the different selection menus. Figures 26, 27 and 28 show the selection menu screens that support the session's database information development.

Figure 26 presents the context menu screen, where the designer selects the context-of-use that relates to the product being designed. Context-of-use choices are shown as domestic, social environment, public use or workplace related, and individual or private environment. Here the designer can make all the selections that apply to the design project. The designer's selection is kept in the session's database to be used in later steps of the session.

Figure 26: Context menu screen

From the Context menu screen, the designer can use either the *aspects of the product's usability* menu screen, or the *source of human experience* menu screen. These menus are supported by design principles contained in the ECEDT's database. Once the designer selects his or her choices in any of these menus, the ECEDT's database will match it with its corresponding part according to the design principles. Figures 27 and 28 show these menus.

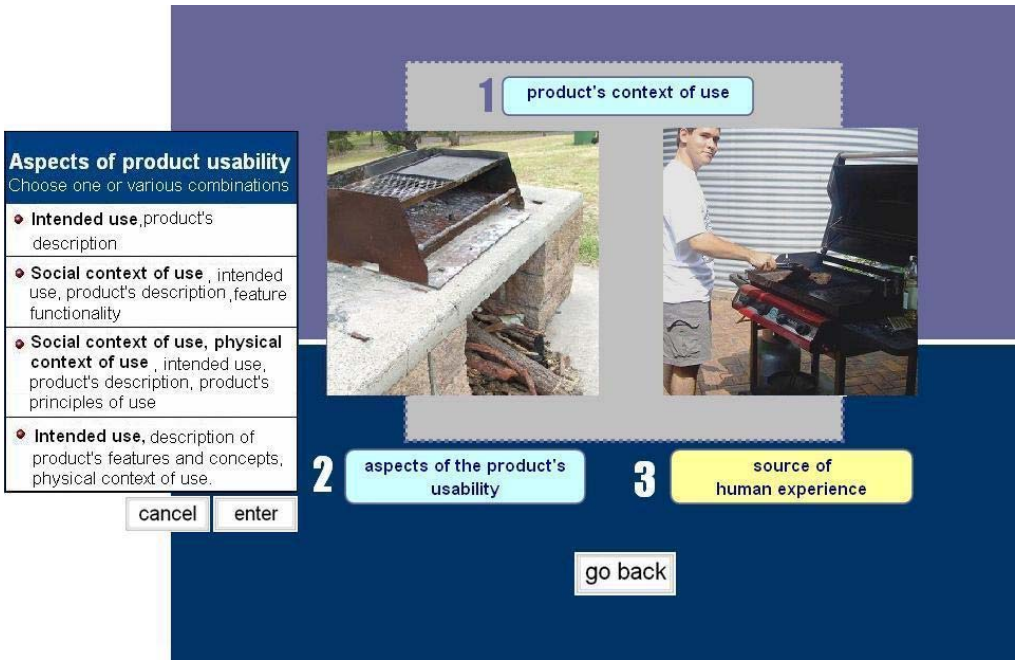


Figure 27: Aspects of usability menu

Figures 27 and 28 show the different choices that can be selected in each screen. The designer can select all that applies to the design project.

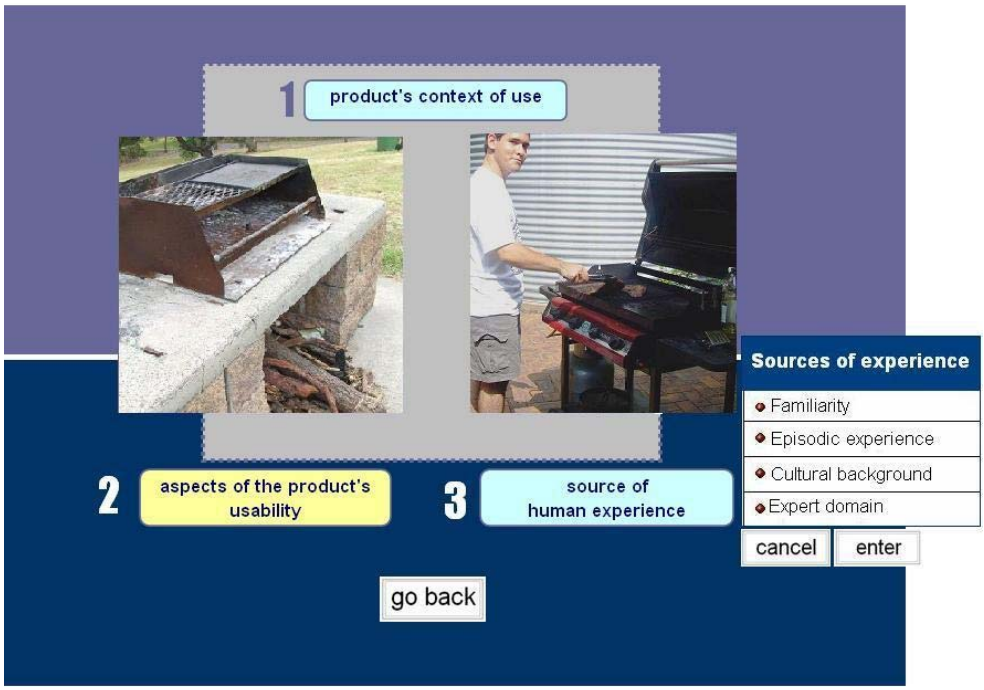


Figure 28: Sources of experience menu

The designer's input, through selections made in each of the menus presented, becomes part of the session's database. This is matched to the ECEDT's database to bring up the information the designer needs to support the design of product usability.

8.4.3 Matching the session's database information with the ECEDT's database

The session's database information is matched with the ECEDT's database (the design principles in Table 14) in the Pre-results screen (Figures 29 and 30), where sources of experience and the corresponding aspects of usability that are relevant to the design project are presented. Figures 29 and 30 show that the designer can choose what to do with these pre-results: confirm and continue (by selecting from the menu), go back to the sources of experience and aspects of usability menus (by selecting the 'go back' option), or cancel and start from scratch (selecting the 'restart' option). Figure 29 presents the sources of the user's experience corresponding to the selections that the designer chose from the usability menu (Figure 27). Figure 30 presents the aspects of product usability corresponding to the selections that the designer chose from the sources of experience menu (Figure 28).

Figure 29: Pre-results screen: matching aspects of usability with sources of experience

Figure 30: Pre-results screen: matching user's experience with aspects of usability

At this point, the designer chooses to work with one of these sources and proceed with the following steps. For example, if the designer chooses to start working with *Cultural background*, ECEDT will present a new menu (Figure 31), which presents to the designer the areas of product usability that correspond to cultural background.

Later during the session, the designer can come back to this screen to select another source and continue working.

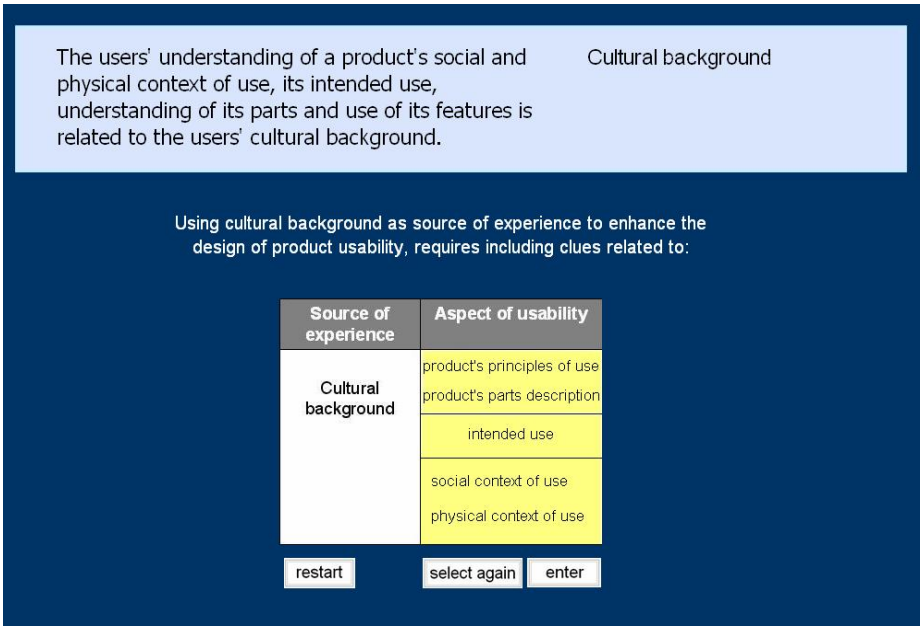


Figure 31: Cultural background menu presenting connections to aspects of product usability

Figure 32 shows how the session's database information is now matched with the ECEDT's database (causal relationships in Table 10). Here, it can be seen that once the designer selects the aspects of usability that he or she wants to work with (Figure 27), the tool matches these choices to the causal relationships stored in the tool's database; as a result, it brings up the Pre-results screen (Figure 30) with the corresponding sources of human experience. Then, once the designer confirms the information presented in the pre-result screen, ECEDT matches it again with the tool's database and brings up the menu corresponding to the selection made (Figure 31).

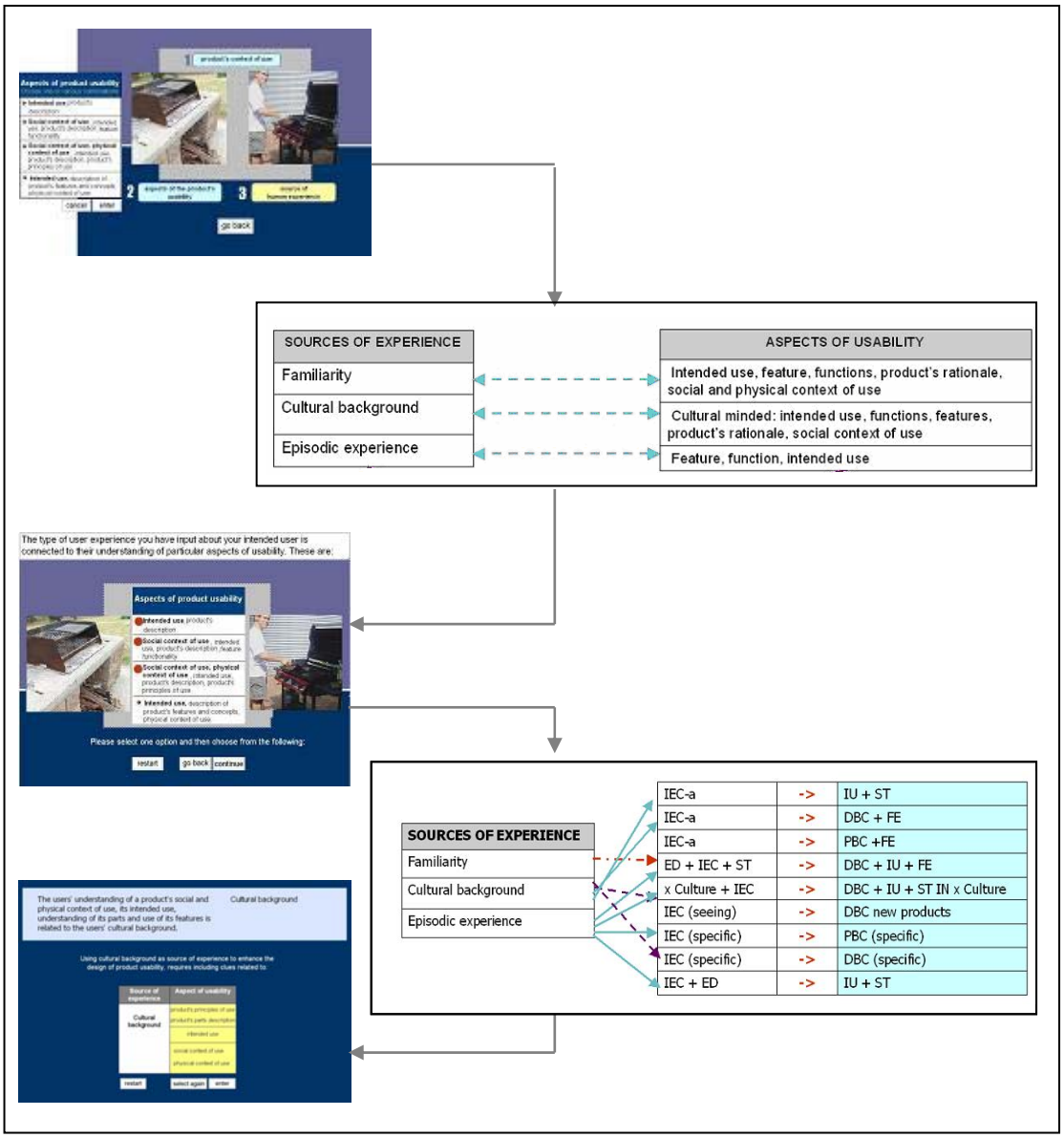


Figure 32: Matching the session's information database with the ECEDT database

8.4.4 Retrieving information with ECEDT Web-based search engine

Choices made by the designer during a session are matched with the components of the causal relationships stored in the tool's database. All previous are now linked to the ECEDT Web-based search engine. The Web-based search menu is presented in a new screen; this is shown in Figure 33.

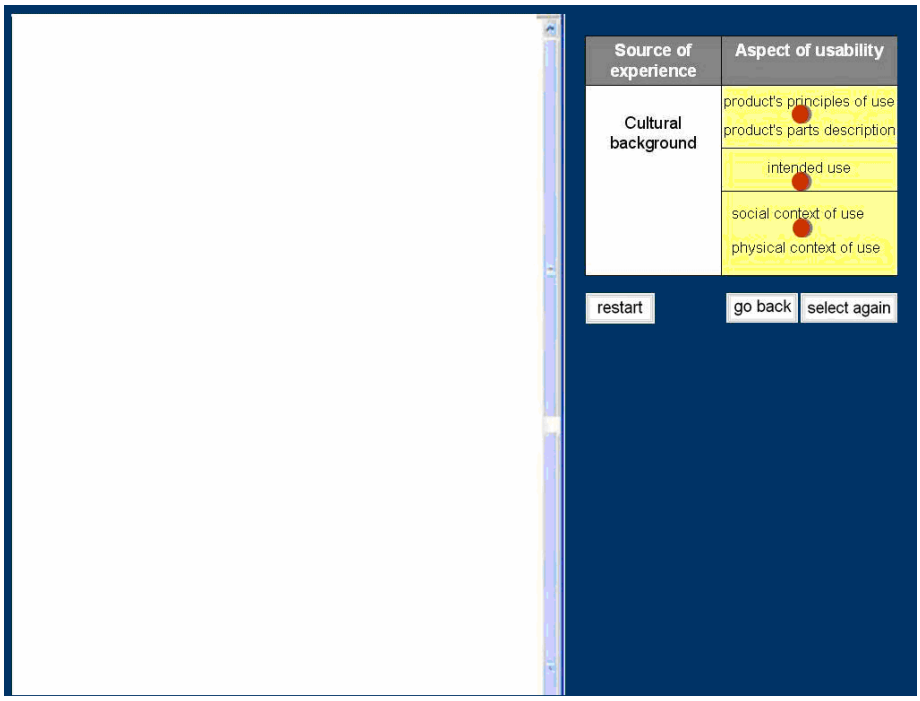


Figure 33: The ECEDT Web-based search screen

The Web-based search menu presents the designers with a number of choices relevant to the aspects of usability that he or she might want to support in the product design. The designer can select one choice at a time, as ECEDT automatically runs the search and presents the results on the left side of the screen. Results are presented in visual and text form (Figure 34).

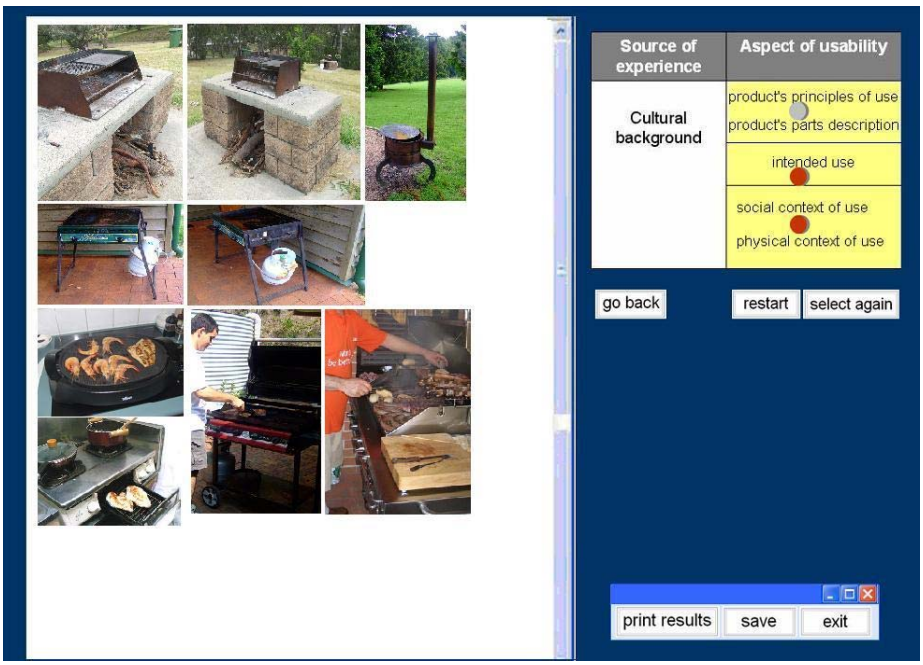


Figure 34: Results screen

The Results screen (Figure 34) brings up the information that ECEDT has enquired about. This shows results from one of the selections; that is, information regarding human experience in diverse situations that are related to the designer's selection on the menu, which is shown on the right side. In this example the designer chose 'intended use' as the aspect of usability to search in relation to cultural background. The design tool has retrieved information in the form of images revealing different references to the intended use of a barbeque grill in different cultures.

8.5 Arising issues from the observation of ECEDT in use

This research application prototype is presented as an example to demonstrate how findings can be implemented in a tool that can be used by designers. A trial run was conducted to verify how relevant the information presented by the tool is for designers and to verify how this type of tool might work in a design process. The trial was conducted by asking a design practitioner to apply it while designing a consumer product. This section describes the trial and the issues observed during the use of ECEDT. Finally, a discussion about how ECEDT informs the design process is presented.

8.5.1 Implementation of ECEDT in a trial run

The research application prototype (ECEDT alpha version) was tested in a trial run with six industrial designers. The aim of the trial was to verify the relevance of the information collected by the ECEDT for designers. It was not the purpose of the trial to test the functionality of ECEDT as a tool, but to explore the user's requirements (the designer) that arise from using it in a design task. In that sense, the alpha version was not a fully functional prototype. A specific design task was created for this trial and ECEDT was implemented with a sample database of visuals related to such design task. This sample database was built by employing the causal relationships identified from the study and by using a web-based browser to collect the visual information, in the same way that ECEDT would function.

A design brief (Appendix H) was provided to the designers. It presents the design task, the context of the design requirement and the dynamics of the session. The design task was to design a barbeque grill that would be marketed in Australia and

diverse countries overseas. The design requirement presented in the brief stated that the product must be family-oriented, and that it must be considered that in diverse countries it is used in different ways for different purposes. Finally, the brief specified that each concept should identify the intended user, the purpose of use (functions), the product's characteristics (features), the interaction issues related to it, and the context of its use.

The trial sessions were conducted individually (researcher-designer), and each session had two stages. In the first stage the designers were asked to design by employing their usual techniques for concept design. In the second stage, the designers were asked to initiate concept development with the assistance of the ECEDT tool. A questionnaire about the process undertaken was presented to the designers after each design task (Appendix H). The designers were provided with a demonstration of the ECEDT tool prior to the start of the trial, to familiarise them with the tool's interface. The researcher explained the demonstration version, and a conversation about the tool's capabilities and limitations took place during this part of the trial. It was explained to the designers that the focus of the trial was to observe their interactions with ECEDT during the conceptualisation stage of a design project.

The trial took place between October and December 2006 at the Human Centred Design Research and Usability Laboratory from the Faculty of Built Environment and Engineering of the Queensland University of Technology (Australia). The participants, all industrial designers, were design practitioners and researchers from different cultural backgrounds (China, Korea, Botswana, South Africa and Australia) who were currently working in the School of Design of the Queensland University of Technology. The designers' ages ranged between 23 and 39 years old; two of them were female and four were male designers. From the six, two of them had more than ten years experience as design practitioners, and one was a recent graduate. Four of them were international PhD candidates who had lived at least two years in Australia. The product selected for the trial — a barbeque grill — was chosen because in Australia, barbeque grills are a type of product of common use everywhere; all designers participating in the trial had some prior knowledge about the product.

8.5.2 Observations from the trial

In the first stage of the design task, the designers developed a concept that they continued developing in the second stage of the trial. This section presents the outcomes of one designer's concept design in order to illustrate issues arising from the trial. These are the concepts developed by the Chinese designer.

During the first stage, the designer developed a concept of a barbeque grill that could accommodate a single user or various users, based on a circular table shape as used in Eastern cultures (China). There were separate grills, so that different numbers of burners could be lit, in proportion to the number of users (Figure 35). The first concept was based on his own experience and from previous observations about the use of the barbeque grill. This was explained within the answers provided to the questionnaire. His design approach was recorded in a mind map that he presented along with his concept design (Figure 36). The designer stated that in a short design project, he would design first from his experience; but in a long-term design project, he would inform his design process with observations and user research that takes time to conduct.

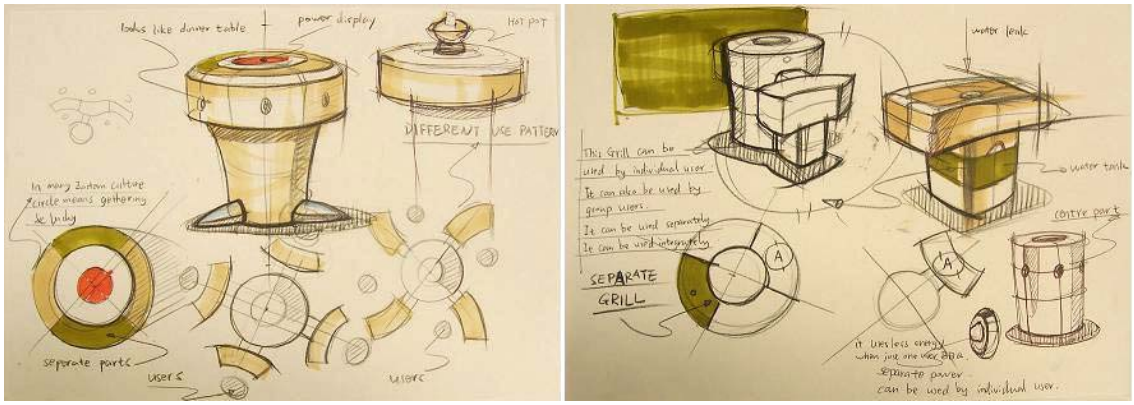


Figure 35: Designer's concept one

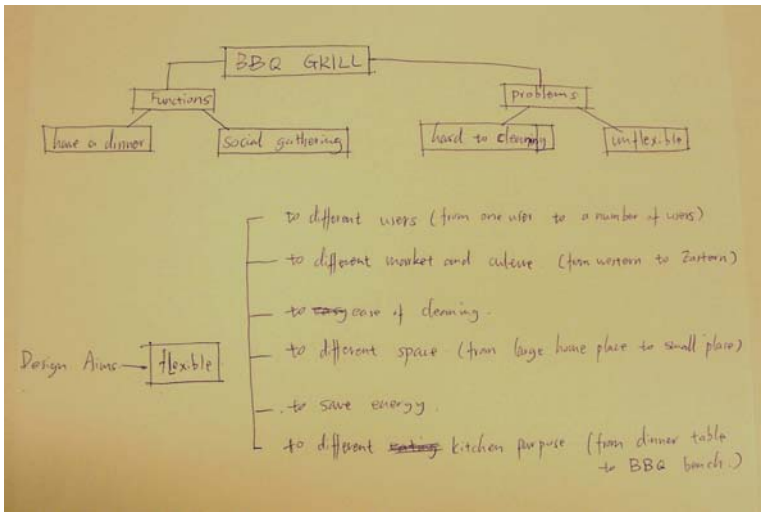


Figure 36: Designer’s mind map about his design approach to concept one

In the second stage, the designer produced a redesign of the previous concept based on the visual information provided by ECEDT (Figure 37). In the questionnaire that followed this design task, the designer stated that he looked first at the reference that he deemed more important for this product; this was Cultural Background (Figure 38). According to the designer, the visual information provided about users’ experience with regard to cultural background, episodic experience and familiarity ‘prompted’ him with ideas and inspiration to resolve some aspects of the design. These aspects were related to how a BBQ grill is used, which led him to redesign the product structure (parts), and to add some features such as a suspended grill, and a feature from which accessories (tongs) could be hung. The second concept can be seen in Figure 37.

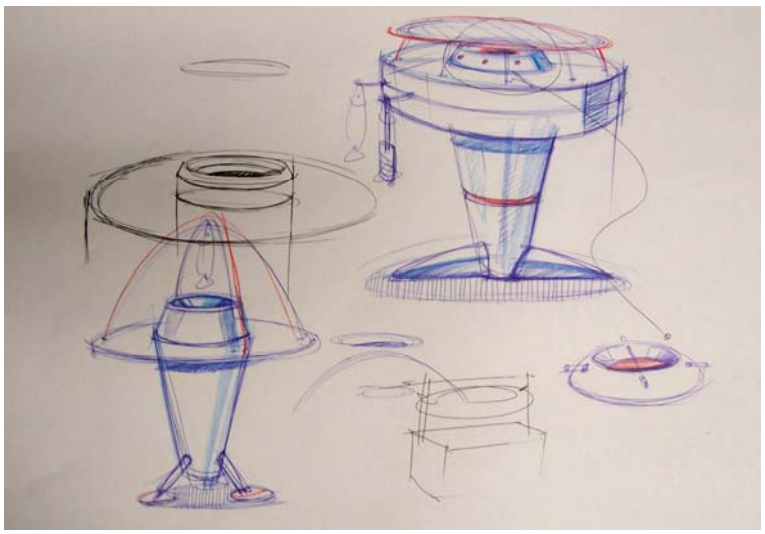


Figure 37: Designers’ concept two — redesign

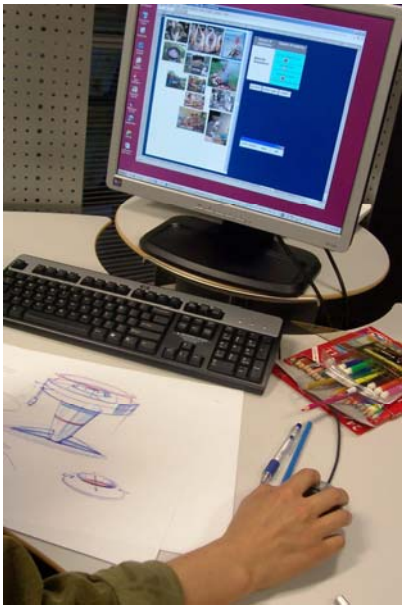


Figure 38: Designer using ECEDT during design task

Observations from the six designers during the design tasks were consistent. Five observations of them with regard to the use of ECEDT during a design task are presented here:

1. The designers preferred to draw first from their experience. They stated that the early stage of a design process (conceptualisation stage) is the moment in which creativity takes place. Therefore, they considered that starting a concept design based on visuals of existing products might narrow down the scope of their creativity. One designer stated that the first part of the conceptualisation stage follows a divergent process, and for him, the use of the ECEDT tool allowed him to accomplish a convergent process, in which he could develop more details on his original ideas. Nevertheless, the designers also acknowledged that this type of information-based tool could be very helpful to provide information as part of the user research, especially in short-term projects that lack the time and resources to conduct an ethnographic type of user research (observations).

2. Even as a research application prototype, ECEDT was able to interact with the designers to some extent. The designers explained that as ECEDT was presenting visual information about this type of product, it ‘prompted’ them with various

ideas to be considered in the design task. Thus, using ECEDT and designing (sketching) was an iterative activity during the design task.

3. The designers required a highly visual and interactive information resource. One of the designers stated: "…visuals are not good enough; it requires some detailed description. For example, a video that talks about the parts of a product…" This can be noted in everyday design practice, where designers prefer visual and multimedia information to static information. ECEDT presented still images only, and one active link to a website explaining further detail about the use of gas BBQ grills. This helped the designer to demonstrate his point of view, as he explained that further insight could be achieved with references that provide more detail about the visuals presented. In the same line, another designer indicated that it would be desirable that images could be connected to the context from which they were 'extracted', in order to better understand the information presented.

4. The interface design was not adequate for the designers. This influenced the response of the designers to the information presented by the tool. Visuals were understood in relation to the product to be designed (BBQ grill), but they did not support the designers' understanding of the relationship between experience and usability that the image conveyed. For the designers, visual information was the most appealing and this distracted the designers from the 'wording' presented in the screen in relation to the experience and product usability relationship to which the images referred. Even though the designers were already employing the relationships through each of the steps of the ECEDT tool, and the images conveyed the information they required, the interface design was a critical issue to resolve in order to make designers aware of the clues that they could employ to enhance the usability of their product designs.

5. The designers would have liked the tool to work out the relevance of the images shown with regard to the design project. This is an important issue; however, it is also linked to the designers' information literacy capability and information retrieval skills, as this is a tool whose database resource is based on web information. In the trial, one designer only entered 'BBQ' as the keyword to start

the tool search engine; however, he could have used the word ‘grill’ as well. Other designers input keywords that were not related to the type of product to be designed. As the tool requests the designer’s input to build a session database, the issue about the designers’ information retrieval skill must be considered in the design of ECEDT’s.

During the trial it was possible to observe and gather the comments from the designers about the tool’s features. This is summarised in the following list:

- Current interface is not user-friendly. Menus are confusing. They do not help designers to relate to the experience–usability relationship.
- Multimedia information such as videos and Internet links can be more suggestive for the design process than visuals only.
- Product’s context menu choice might not be relevant. Three out of the six designer participants preferred to select all the options, so that all information given can provide background information about the activity that such a product supports.
- Current features deliver information as in a ‘data collection activity’, but do not support the designers’ analysis. Two more features or functionalities are required: first, the capability of ‘drag and drop’ visuals from the results field to a ‘new file’ that the designer can create for each project; second, a function that supports an analysis activity. Two of the designers stated that it would be desirable for a function that supports analysis of the information presented to also show the ‘path’ of selections (from menus) realised during the session. This could help for later analysis with regards to relevance of information presented.

These observations are supported by the designers’ responses to the questionnaire applied after each design task.

8.5.3 Further development of ECEDT

The trial was employed not only to assess the relevance of the information gathered through the application of causal relationships, but also to explore requirements for implementing this type of tool in the early stages of a design process

(conceptualisation stage). From these results, five areas have been identified for further development:

1. Human experience–product usability interface. The interface design of the tool must focus on emphasising the human experience–product usability relationships, so that designers can relate visual information retrieved in connection to such relationships. This will benefit the conceptualisation stage of the design of product usability. Interface design must also focus on making the tool easy to use by improving the intuitive use of its functions, and helping the users to map out the location of all the functional elements.

2. Reference retrieval. The tool must have the capability of retrieving visual, audio and multimedia references. As explained previously, still images might not be as suggestive as multimedia references, which can contain relevant information for designers to better understand the information presented to them.

3. Interactivity. The tool must allow for interactivity while the designer is using the tool and the sketching process. It was observed that the designer was sketching while browsing the information presented by tool. The design of the tool must support and facilitate the conceptualisation stage of a design task — functions that present important challenges in its development.

4. Connectivity. There must be connectivity to web-based search engines. In its current form, ECEDT employed a sample database. The connectivity to web-based search engines is still a feature of the tool that must be studied and implemented.

5. Relevance of information. The information retrieved must be relevant. Not all the information that the tool gathered and presented to the designer was relevant to the design task at hand. Some form of filtering the information must be provided to facilitate designers' focussing only on the information relevant to the project.

6. Management and storage. Results from a session's database must be able to be effectively managed and stored. The results from the session's database were

various. These can be the string of keywords input at the start of the session, the areas of experience selected to initiate the web-based search, and the visual information that results from the search. All these require some level of management for storing, filtering, selecting, and sharing information.

7. Organising information. The tool needs the capability of organising information that is to be used later in the pre-analysis of data. Currently, the ECEDT is largely a data collection tool; another capability is required in order to facilitate the designer organising this information to be used later in a design process. This capability can be related to a memo-writing function, so that designers can record their thoughts while browsing and considering the information presented; it can also be related to organising the data with regard to the data's meaning to the design of product usability. For instance, the data can indicate whether the information is related to the users' cultural background with regard to the intended use of an artefact.

Improvements in these aspects are needed to produce a fully operational tool — a Beta version — which is required in order to test ECEDT under real conditions, with design practitioners, on a daily basis, performing real design tasks within the complexities of a project's development. The Beta version will assist in refining the applicability of the causal relationships in a design process, and will assist in assessing the functionality of the tool, and its extents and limitations with regard to issues such as time constrains, requirements for sharing information and storing results.

8.6 Potential contribution of ECEDT to the design activity

The design of ECEDT, and results from the trial, present the basis for responding to the third research question of the study: "How can human experience and context-of-use issues enhance the design of product usability?" The ECEDT provides a medium that brings to the design process relevant information about human experience and contextual information with regard to a product's use and related activities. That information would otherwise have to be gathered through an extensive user research process that cannot be afforded in every design project. This approach aims to

overcome problems with previous studies, in which the outcomes of user research are so complex and abundant that it is hard for designers to analyse and apply that research into their designs. The use of visuals as a medium for the communication of relevant information aims to overcome the situation in which 'findings presented as facts do not stimulate designers to play with data' (Sleeswijk Visser et al., 2005:137). Presenting outcomes in a visual form appeals more to designers, because visuals are rich in information and broad in interpretation, they leave room for designers' creativity and can help to trigger the generation of human-centred designs as the information is presented contextualised with regards to a human activity. ECEDT can potentially help small-scale projects and design consultancies, and can support student design projects that do not have the time or resources to conduct extensive user studies.

8.7 Summary

A design tool has been envisioned in order to make findings available in the design process. The tool, named ECEDT, is based on the design principles and causal relationships found among experience, context and knowledge. The findings suggest that addressing these relationships in the design process can help to improve the users' understanding of product usability. Contrary to other methods that have emerged from recent studies, ECEDT does not aim to create contexts as scenarios of product interaction. It is a tool that assists designers to find representations of different aspects of a product's use (the social or physical context-of-use, intended use, principle-based concepts, description-based concepts) so that they can be inspired by this information and use it to support the design of a product's usability. ECEDT combines the designer's input, a database based on this study's findings, and a Web-based search-engine.

Outcomes of the tool consist of visuals and text about contextual information of a product's use and related activities that can potentially inform designers about various aspects of use that must be considered as part of the product's characteristics. A trial was implemented in order to verify the relevance of the findings in a product design task, and to explore the requirements for the design of a tool of this kind. Results of the trial suggest that further development of the tool is required in seven

areas: (i) interface design, (ii) capability of retrieving multimedia types of references, (iii) interactivity between the use of the tool and the sketching process, (iv) connectivity to web-based search engines, (v) relevance of the information retrieved, (vi) managing and storing results from a session's database and (vii) capabilities to pre-analyse the data collected. A Beta version of the tool must be developed in order to test these findings, and the concept of this tool, under the real conditions of a design project.

Chapter 9:

Conclusions and Future Directions

The connection between experience and context-of-use have been recognised in previous studies about product usability in HCI and in Design. However, none of those studies have explored how the inclusion of aspects of experience and context-of-use in the design process can support the design of product usability. This research has investigated these issues, and has established that experience, context-of-use and usability are not only connected, but that the specific relationships between them can assist in the design of product usability.

This study was carried out to investigate the aspects of experience and context-of-use that influence users' and designers' understandings of a products' use, and to investigate the differences between their concepts and how this influences the design of product usability. It also explored ways in which experience and context-of-use issues could be included in design to support the design of product usability.

For the purposes of this study, definitions were stipulated for the terms 'experience', 'context-of-use' and 'product usability'. Experience results from some level of people's interaction happening within a particular situation; it refers to people's perception of such interactions and their life events underlying their understanding of the world. Context-of-use refers to the relationship between use–activity–task–situation that takes place during people's interaction with products, providing users with an understanding of a product. It is a dynamic entity as it changes according to user experience and culture. Based on these two descriptions, product usability is presented as the dimension of the user–product interaction that is affected by the

product's context of interaction and the user experience. Then, the design of product usability can be supported if user experience and the user's knowledge about a product's context-of-use are considered in the early stages of the design process.

Results from this study demonstrate that human experience is at the core of human knowledge, and leads the scope and direction of this knowledge regarding a product's context-of-use and its usability. Findings show that users' and designers' individual experience, their knowledge (concepts) of a product's context-of-use, and their understanding of the product's usability, are interrelated factors.

This has been demonstrated on the basis of the conceptual principles connecting human experience to aspects of product usability (Table 9), and the conceptual principles comparing users' and designers' concepts about product usability (Table 10).

The conceptual principles connecting human experience to aspects of product usability that were identified in response to the first research question of this study, present new knowledge for the Design domain with regard to (i) the aspects of product usability that are directly related to particular aspects of human experience and (ii) the aspects of human experience that can be addressed as part of the process of designing product usability. This is new knowledge that is relevant for the design of product usability and must be made available to designers.

New knowledge has also been provided by the conceptual principles comparing users' and designers' concepts about product usability, which addressed the second research question of this study. Whilst the differences between users and designers have been addressed by existing research, the identification of their differences with regard to their concepts about product usability is original knowledge that has not been addressed by any other study, and which contributes to the design knowledge domain. Such new knowledge can assist designers to enhance their current design process of product usability.

Another area in which this study has provided new knowledge is with regard to the methodological approach undertaken towards the study of human experience. The

study has demonstrated that combining visuals with verbal reports is a valuable source to gain understanding about the influence of human experience on people's concepts. The methodological approach applied to interpretation of data led to the identification of causal relationships (Table 11) that describe ways in which experience influences people's understanding of product usability. This knowledge presents a valuable contribution to the methodologies currently employed in the design field with regard to the understanding of human experience.

This new knowledge in design has implications for the application of design theory and for design practice. Conceptual principles providing greater detail about the differences between users and designers with regard to product usability, extend current theory with regard to differences between designers' and users' mental models (Norman, 1988). This not only contributes to design theory; it also reveals the ways in which such concepts are different, informs designers of aspects of users' experience that must be considered in their design process, and leads to a better understanding of how to improve the user–product interaction. These findings support the interest of an international community of practicing designers who aim to design usable products for a diverse range of users in a global market.

The conceptual principles identifying areas of experience that relate to specific areas of product usability and differences between designers' and users' concepts, were translated into design principles that can be applied in the early stages of the design of product usability. This has several implications for design practice. First, it implies that current design processes can be simplified; they do not have to include extensive user research that relies heavily on the designers' interpretation of the users' need, before they can gain insights on the aspects that are most relevant for the users' understanding of a product's use. Second, it implies that the design of product usability is closely connected to the social aspects of a product's use. Third, it implies that 'familiarity' is an issue that must be further explored in relation to the design of product usability. Moreover, the application of these design principles implies a shift from an object-centric or experience-centric design approach to a middle-point approach that departs from the relationships found between experience and product usability.

In order that this new knowledge can effectively contribute to the design of product usability, these findings need to be made available to designers in a suitable manner. As an outcome of this study, a design tool, the ECEDT, is proposed. This is an example of how design principles and causal relationships could be implemented. ECEDT provides a means for designers to include experience and context-of-use issues in the design of a product's usability. The ECEDT presents a different perspective from that of other methods that elicit information from users in order to define new contexts-of-use; in contrast, it aims to inform the designer of the aspects of human experience and context-of-use that must be triggered in the product design to support users' understanding of a product's usability. The ECEDT was tested in a trial, and it was verified that contributions of this study can be applied in a design process. In this way, this tool, even at a research application prototype stage, provided answers to the third research question of this study, and demonstrated that experience and context issues can support the initial stages of the design of product usability.

Future directions

Having stated the areas in which this study has delivered new knowledge and the implications of such knowledge to design theory and practice, three other areas can now be suggested for further investigation: (i) aspects of human experience relevant to product designs from emerging technologies, (ii) the application of causal relationships to users groups with specialised needs and (iii) the application of this study's methodological approach to other studies.

In terms of designs related to emerging technologies, further investigation is required to explore other areas of human experience that might influence people's understanding of a product's use in relation to different types of product categories. This is especially relevant to product development in industries with emerging technologies and new applications that challenge people's experiences and interactions with new products. More importantly, extending this study to products that embed new technologies can help address the latent needs of a global community and the increasing trend of people who constantly commute to live and

work overseas, and who are permanently challenged by designs that are difficult to use.

Further study is needed to explore whether causal relationships found between experience and product usability are also representative and applicable to the case of users with special needs. Such studies could verify or disprove these causal relationships, or uncover new ones. Two types of completely different user groups present an interesting challenge to this study: people with specialised expertise and people with disabilities. Applying this study's methodology to investigate the validity of these causal relationships in these two different groups of users could improve the understanding of how relevant the identified aspects of user experience are for these two types of users in the design of product usability. In the case of people with specific expertise, this study would require considering novice and expert users (in a specific domain), and the aspects of their experience that allow them to become experts in the use of specialised types of products (e.g. medical devices). In the case of people with disabilities (e.g. a group of elderly users) studies would require the consideration of cognitive and physical issues that influence their experience, and also of the different ways in which they are challenged by everyday products. The application of this study's methodology to these groups could benefit the design of products for a broader range of users.

The proposed design tool ECEDT has demonstrated its potential contribution in the design field. At this stage, two potential applications of the design tool have been identified: (i) informing the design of user–product interaction so that designers can make informed decisions and interpretations of the user's views about product usability and (ii) supporting the design for product usability during the initial product development stages by addressing aspects of human experience that are relevant to the design of product usability. While this design tool represents only one possible way to implement findings from this study, further investigation needs to be done in order to improve it. Three aspects for improvement have been identified from the trial: (i) connectivity to web-based search engines, (ii) relevance of the information retrieved, and (iii) storage capacity. Exploring how to enhance the ECEDT — or proposing other ways to implement findings in an accessible manner for designers —

responds to the design community's interest in the study of context-of-use and user experience issues in product design.

In conclusion, this study has demonstrated the relevance of its findings, which contribute to the design of more usable products. New knowledge, delivered in the form of conceptual principles and design principles, can assist the design of products that incorporate new technologies that are often difficult to use by the intended user; and it can address the latent needs of various groups of users — for example international travellers — who are often challenged by products that are difficult to understand. In this way, this study has addressed an existing gap of knowledge with regard to the interrelationships between experience, context-of-use and usability. This study not only responds to the current interest of the design community that strives to design products for global markets; it also provides a means to support the design of product usability through the design of ECEDT.

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Appendices

Appendix A:

Experiment forms

A.1 Invitation and Screening questionnaire

INVITATION

My name is Marianella Chamorro from the School of Built environment and Engineering at QUT. Thank you for expressing interest in collaborating with this study. This study is part of my PhD degree and it is intended to contribute to the design processes that can improve usability of everyday products/artefacts. As part of this study we are interviewing selected members of the general public as well as professional designers to determine what their thoughts about certain artefacts are. I am conducting. I wish to thank you in advanced for your time.

The test consists on a one-on-one interview at QUT Gardens Point campus. This test will take approximately one hour of your time. Please have in mind that if you participate in this test, it will be unpaid as this is an academic research study only. All your comments will be kept anonymous in the presentation of the research outcomes.

As a necessary step in this stage of the study, we need some information to help us organize the study outcomes. That is the intention of this questionnaire; please fill it out and return it by email to the address below as soon as you can. We will contact you to organize a day and a time for your participation.

Email completed questionnaires to: m.chamorro@qut.edu.au . Thank you!!

Personal Information (this section will not be disclosed)

1. Name:
2. Surname:
3. .Age: 18 – 25 [ ] 26 – 30 [ ] 31 – 35 [ ] 36 – 40 [ ] 41 – 50 [ ] 51 – 60 [ ] 60 – 70 [ ]
4. Email:
5. Tel. :

Questions	Answers	Research use
6. Which continent have you spend more time of your life:	Asia [ ] Africa [ ] North America [ ] South America [ ] Europe [ ] Australia [ ]	
7. Country of origin		
8. Country of actual residency		
9. Do you consider yourself a traveller?	Yes [ ] No [ ]	
10. Where have you travelled? (mark all the appropriate options)	[ ] My country of residency [ ] Elsewhere:	

	Asia [ ] Africa [ ] North America [ ] South America [ ] Europe [ ] Australia [ ]	
11. In your trips, have you managed to communicate and get information in other language than your mother tongue? (If YES please mark little or good enough)	Yes [ ] Little [ ] Good enough [ ] No [ ]	
12. Do you enjoy using artefacts that are technologically innovative?	Yes [ ] No [ ]	
13. What kind of information you look at when facing an artefact that you haven't used before?	[ ] Symbols [ ] Shape and/or colour [ ] Similarities with other products [ ] I had used before [ ] Other (please mention)	
14. Have you participated in a research interview like this?	Yes [ ] When_____ No [ ]	
15. What type of objects do you feel more familiar with? (mark all that applies): Domestic gardening Tools Domestic cooking artefacts Outdoors – camping devices/ accessories Sport equipment / accessories Vehicles Objects of public use	 [ ] [ ] [ ] [ ] [ ] [ ]	

Thank you! Your collaboration is valuable.

For any questions regarding this study, please contact:

Marianella Chamorro Koc,
QUT Gardens Point - Block D 304
m.chamorro@qut.edu.au

A.2 Consent form

Project: Including context of use and user's experience in the product design process

Researcher: Marianella Chamorro Koc
PhD Candidate in Industrial Design
Queensland University of Technology
2 George St. Brisbane, QLD 4001
School of Design and Built Environment
Room D304 - Ph: 3864 9184

By signing below, you are indicating that you:

- have read and understood the information sheet about this project;
- have had any questions answered to your satisfaction;
- understand that if you have any additional question you can contact the research team
- understand that you are free to withdraw at any time, without comment or penalty
- understand that you will be video and audio taped and that the data will be kept in a safe and secure place where only the research team can access it
- understand that you can contact the research team if you have any questions about the project, or the Secretary of the University Human Research Ethics Committee on 3864 2902 if they have concerns about the ethical conduct of the project; and
- agree to participate in the project.

Name _____

Signature _____

Date __/__ /___ / ____

A.3 Experiment question 1 – Visual representation of concepts

QUESTION 1	
INTRODUCTION	*Welcome and thank you very much for your participation in this session.* *To help the understanding of the question that follows, you could think about yourself as someone who uses and interacts with this artefact/product everyday or on a frequent basis.*
PRODUCT	*Juice maker*
TASK	*Please provide a drawing(s) about the artefact mentioned above.* *Include in the drawing enough information to explain what is this artefact, and any other information regarding its use.*
MATERIALS	*You can use any or all the paper and materials provided to you by the researcher.*
DYNAMICS OF THIS QUESTION	*Responses to this question will be video taped for the purpose of studying the outcomes after the session.*

A.4 Experiment question 2 – Retrospective verbal protocol

QUESTION 2	
INTRODUCTION	*Following the first part of this session, this question is intended to understand your views on the idea you have drawn before. Please refer to the indications summarised in the following table:*
PRODUCT	*Juice maker*
TASK	*Please explain what have you represented in the drawing (describe all the information you tried to represent)* *In this part of the test, there will not be exchange of comments between the interviewer and the participant that could influence in any way the answer to this question.*
DYNAMICS OF THIS QUESTION	*Responses to this question will be audio taped for the purpose of transcription.*

A.5 Experiment question 3 – Interview

INTRODUCTION	*This is the last part of this session; you will be asked a short question that we will need to record in order to be able to transcribe for analysis. You do not need to take notes or write; the following indications are provided for your reference only:*
PRODUCT	*Juice maker*
INTERVEW	*Please try to explain what is this product used fort? When and how do you think it is used? For what purposes or occasions?* *In this part of the test, comments between the interviewer and the participant in regard to the extension of the answer will be allowed. But, no comments that could influence in any way the answer to this question should take place.*
DYNAMICS OF THIS QUESTION	*Responses to this question will be video and audio taped for the purpose of transcription.*

INTERVEW *These questions are available only for the researcher*	*Other questions that can be used to extend the participant's responses:* - *What do you think is the use of this product? Does it have other type of uses?* - *Who do you think is the principal user of this type of product?* - *When and where is it used mostly? Would it be the only place or situation in which it is used?* - *Is there any particular occasion (event of your life) to which you relate the use of this product?* - *In your own experience, have you used this product? Could you describe the type of use you give to this product? for what purposes and occasions?*

Appendix B:

Outcomes from Pilot Experiment

Outcomes of the Pilot Experiment regarding participants-product selection process

The Pilot experiment was also useful to evaluate the experiment criteria in regard to the selection of participants and type of artefact presented to each of them. This was done by comparing users and designers' initial outcomes and by looking at the similarities and differences regarding the following set of inquiries:

a. do cultural differences influence their understanding or expression of concepts?
b. do gender and age influence in their understanding or expression of concepts?
c. does the selection of an artefact influence the outcomes in regard to gender?
d. do issues of gender-culture-age bracket-expertise influence outcomes?

Cultural differences in relation to the participant's understanding of a product's use and their concept description were observed from comparison of two users: a 50 years old female Australian, a 30 years old Sri Lanka female, and one designer: a 26 years old female Australian. The artefact used for the test was the grass shears. Gender and age differences in relation to the participant's understanding of a product's use and their concept description were observed from comparison of three users of different ages: a 50 years old Australian male, 20 years old Asian male, 20 year old Indian female, and a designer: 30 years old African male. The artefact used in this case was a water sport camera. Differences regarding the participants' level of expertise and its relation to their understanding of a product's use and their concept description were observed from comparison of one user and one designer, both of them experts in their own field, from the same age bracket and same cultural background. Artefact used in this observation was a GPS for street navigation. In this case, expertise in their knowledge domain was not as influential as individual experience. None of the participants were frequent users of this type of artefact; but the user representative is knowledgeable in regard to GPS systems while the designer is not. The experienced user representative was able to provide principled-base type of knowledge, while designer focused on description of features and the use of them. This coincides with findings from existing literature in which experts are experts in

their own domain, but they cannot extend this level of expertise to other areas (Chi et. al., 1988). In essence, findings showed that:

- Age influence was not possible to be determined in these outcomes. In the cases where there was a generational gap among participants, results were influenced by their individual experience and not by the age factor (grass shears). In one case (water sports camera), the results show that the age factor has been alleviated by the influence of the participant's professional background (architects).
- Gender influence was important in these outcomes. Results show that gender factor had an influence only in relation to usability issues that refer to human-artefact interaction where differences between male and female physical strength impact on the artefact use (mechanical operation of grass shears: lack of force, safety, ease-of-use).
- Use of familiar mental models helped participants to overcome lack of experience in using a particular artefact and enabled them to express their concept of the artefact by referring to features of a similar one. Only in the case of one designer his knowledge domain in regard to visual representation dominated the task and led him to forget about usability issues and context of use.
- Knowledge and professional domain influenced outcomes in different ways. Knowledge domain (design domain vs. user domain) influenced participants in how their concept is represented (use of elevations in designers' case, focus on details in case of users). Professional domain influenced outcomes in regard to the participant expertise about the use of a particular artefact. This was observed when an expert designer and expert user were compared. In this case, the expert user was knowledgeable about the artefact and provided principled-base references. The designer was knowledgeable about the design process and only provided descriptive-based references. It shows that if 'expertise' has to be compared, then both designer and user must be 'experts' in the use of the artefact itself.

These outcomes were taken into consideration during the selection of participants and artefacts for the final experiment.

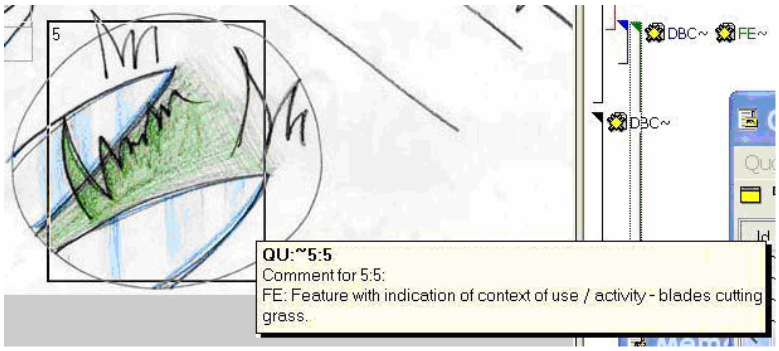
Appendix C:

Exemplars of the application of the coding scheme

C.1 Exemplars of coding scheme applied to drawings

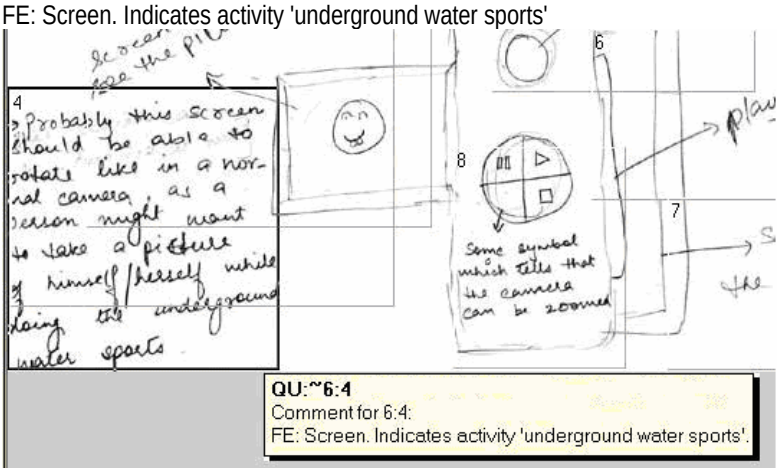
FE: Feature with indication of context of use

DRAWING: 5.5
FE: Feature with indication of context of use / activity - blades cutting grass



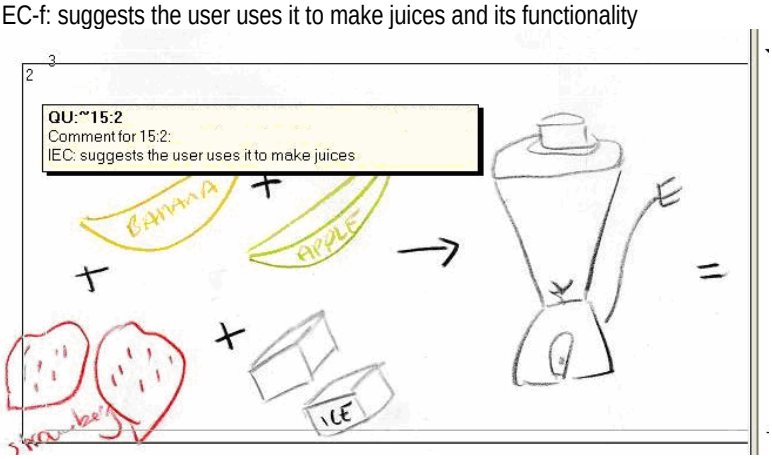
FE: Feature with indication of context of use

DRAWING: 6.4
FE: Screen. Indicates activity 'underground water sports'



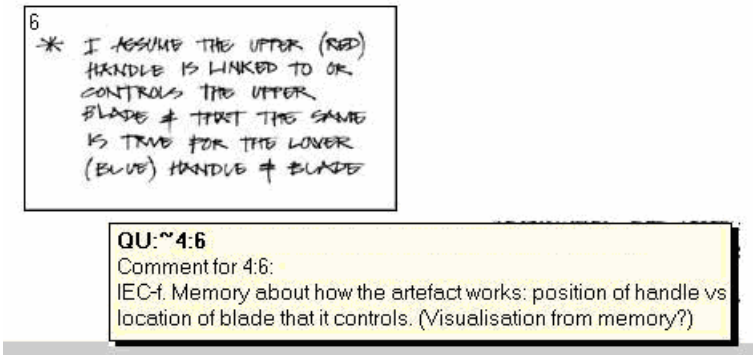
IEC-f: Individual experience about the functionality of a product

DRAWING: 15.2
IEC-f: suggests the user uses it to make juices and its functionality



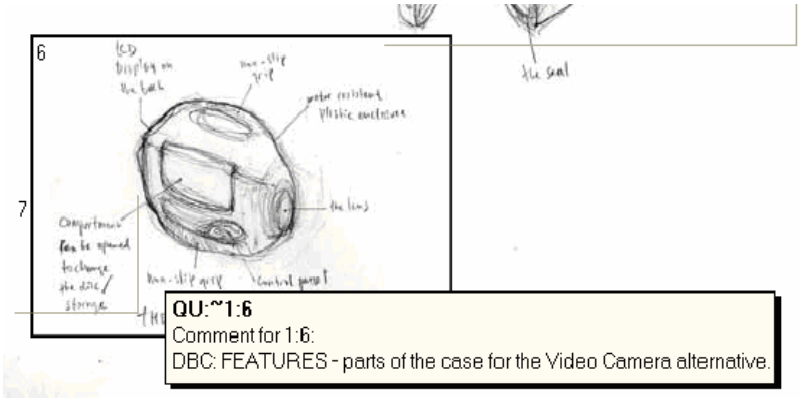
IEC-f: Individual experience about the functionality of a product

DRAWING: 4.6
IEC-f. Memory about how the artefact works: position of handle vs. location of blade that it controls



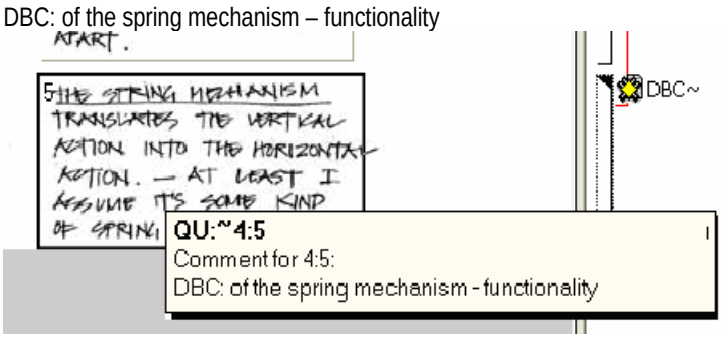
DBC: Descriptive-based concept

DRAWING: 1.6
DBC: FEATURES - parts of the case for the Video Camera alternative



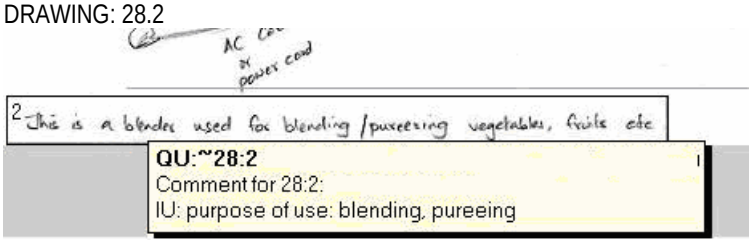
DBC: Descriptive-based concept

DRAWING: 4.5
DBC: of the spring mechanism – functionality



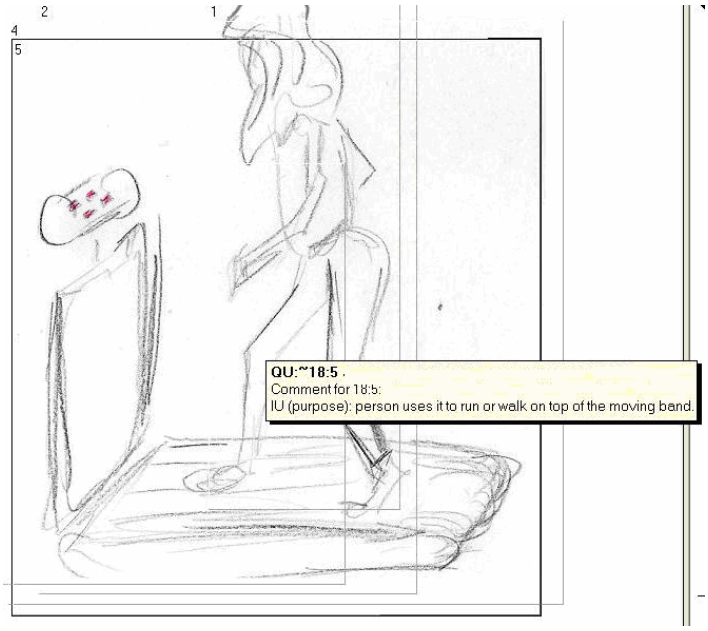
IU: Intended use

DRAWING: 28.2



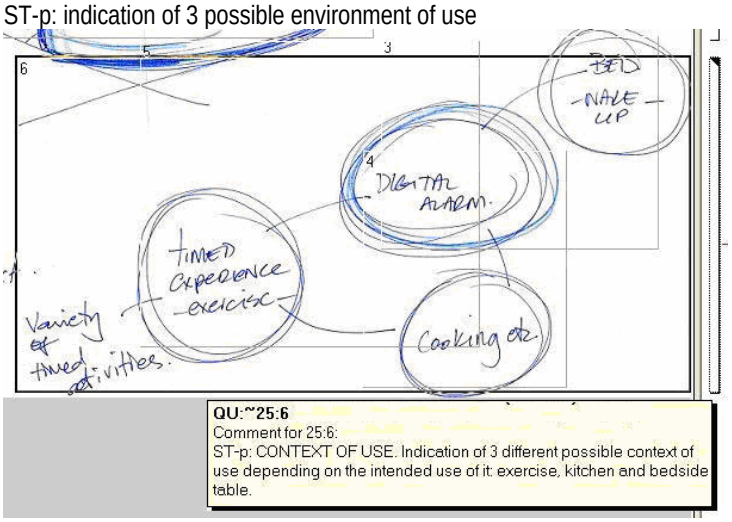
IU: Intended use

DRAWING: 18.5
IU (purpose): person uses it to run or walk on top of the moving band



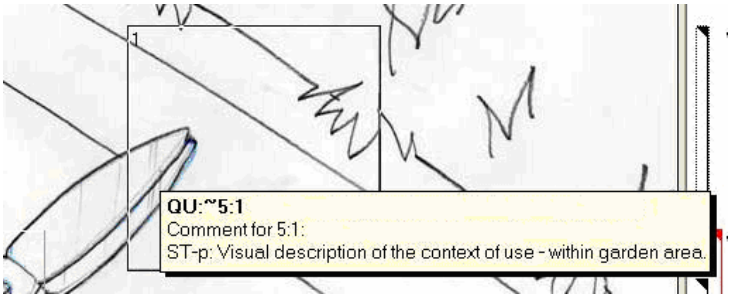
ST-p: Situation of use – physical context of use

DRAWING 25:6
ST-p: indication of 3 possible environment of use



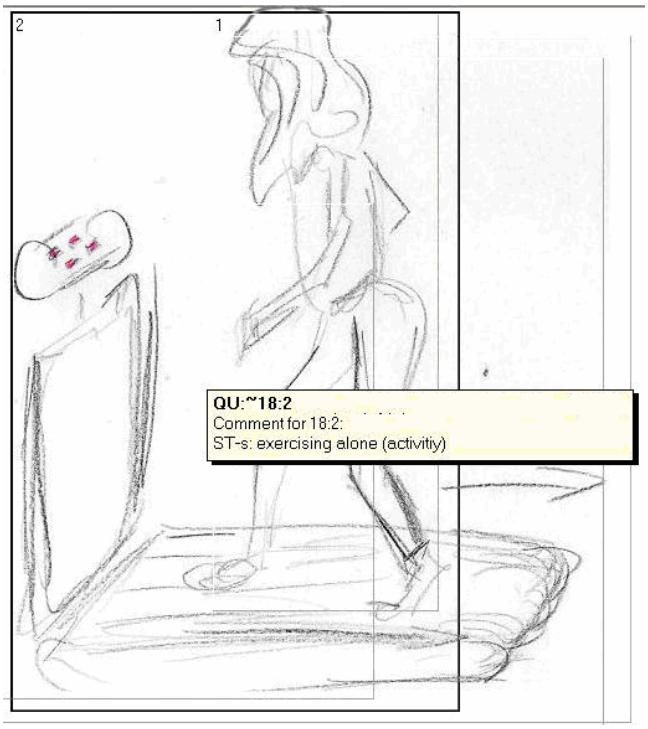
ST-p: Situation of use – physical context of use

DRAWING 5:1
ST-p: Environment of use of garden shears



ST-p: Situation of use – physical context of use

DRAWING 18:5
ST-s: Social environment of use of treadmill



C.2 Exemplars of coding scheme applied to transcripts from retrospectives and interviews

FE: Feature with indication of context of use

Retrospective 9:3:

and what I've done is to try and chose some of the features which are essential, for example, here I thought of some grips when you are holding it because under the water might be a bit slippery and ahh...

FE~

IEC: Individual experience within context of use

Retrospective 15:9:

F:
Of course. I think it does have an on-off buttons just on the side here. I can't remember, because, normally it doesn't because it's battery operated and if the electricity goes off it will keep going on battery. It must have an on-off button somewhere...

IE

IEC-f: Individual experience about the functionality of a product

Interview 3:20

C:
Ahh... I think what I remember, just to mention, most garden tools are either green or red. I don't know if that means anything to you but for me, everything, they are normally green with metal, or red with metal, that's what I can remember, because green to me is like, you obviously understand immediately it is for garden use, it is for the natural environment, that particular colour. But red, I've seen red shears before, like my father's, but they would obviously would be unusual because normally they are green, but I think red was maybe from a fashionable time where they tried their products in and out, but I think they use red so you wouldn't loose the shears among all the clippers, and so they came up, but now I've noticed in the different stores that they it's gone back to kind of green colour skin of the shears.

IEC-f~

IU~

IEC-a: Individual activity about the intended activity

Interview 3:16

it kind got stuck in there and you have to open it up and reach and get it out with your fingers. And I remember cutting myself on the shears, so, just because the way things can get caught up in there if it wasn't completely sharp, so especially that age, you know, maybe not with 5 years, 10 years, but I remember they weren't too old, scissors... because they are scissors, you are cutting only paper and small things, when you are cutting like little tree branches, they get blant after a while, so trying to get things like... if you are going to be cutting tree branches, and then you are trying flowers stems, it's getting blant, and then so application transfer is not adequate further to other situations. So, yeah, that is quite interesting..

IEC-a~

ED: Episodic experience

Retrospective 3:2

C:
Ok. Ahhh… I haven't done a lot of gardening but I know my father did, and he had a lot of tools. And the one that he had, and I've seen kind in my mind (…) it is quite similar, really it had a main access that basically it allows the scissors blades to overlap and cut the grass and normally that is made out of metal, so I've tried to represent that in blue or some sort of shiny metal. And the handle, normally it has some sort of pinkie grips,

ED~

PBC: Principle-based concept

Interview 20:11

gives feedback from whatever you set it to be. Aumm the other item I can possibly think of, or another type of setting is, similar to maybe domestic use, but maybe for alternative activities, whether that might be cooking or standard, it's similar to stop watch but different in the fact that it gives the alarm element. So when thinking of digital alarm clock I'm thinking on, as I said earlier, it's a digital device, you can set digits, it has an alarm component, and clock element into it… so I think that from my understanding of a digital alarm clock, it might have different uses, or best explanations I can think of how one is used….

PBC~

DBC: Descriptive-based concept

Retrospective 19:6

R:
The second sheet that I drew was about maintenance and sort of the construction of the bin. So, the first one is just an empty shell, it has a middle shell with a round bin inside and a plastic bag. Somehow the bag is in there, you empty it, just grab the bag up empty it, that's quite easy to get out if you need to get out the whole bin inside there, it's quite easy to take it out as well. Cigarette containers would be on the edges where there the cigarette container things are, and the lids just come off quite easily. That's sort of the construction, I know that just, I've seen people, maintenance people do it…

DBC~

IU: Intended use

Interview 5:3

L:
(Reading the question) Please try to explain what is the SHEARS GRASS used for?
Primarily of course for cutting grass, ahh… on… you want me to … the areas in which you used it, obviously it is at home. According to the description, the grass shears you use them in inaccessible areas where a mower can't get, but where you basically want to tie the lawn.
What do I use it for?
Depending on your uses… I don't know. It is sort of close to edges or up (…) so it is use for trimming, for finishing off.

IU~

ST: Situation of use

Interview 20:6

standard example I think. Other examples or other alternative uses for particularly the alarm facility I think is in the small portable alarm devices, so something that might time a particular activity, and I think a good example of that is exercise, so possible like a running or jogging type device, something that might wrap it in the wrist, very similar to a watch, but that hast the ability to have the time set, so it gives some audible feedback. I am not sure of these digital alarms that vibrates, I know with

ST~

ST-p: Situation of use – physical context of use

Retrospective

get the message across and not confuses. So, auhhh I put down here that the product is a water sports camera and my my understanding is that it is used for underwater photography or maybe it can be used in some sort of heavy surf; but it is meant to be like a super water proof camera, not just something that is used maybe near the water or that needs to be just water proof. I mean this is something that, for my understanding ahhh....is a....something that is ahhh.. submerged in the water for long time and will probably under fairly rough conditions.

ST-p~

ST-p: Situation of use – physical context of use

Interview 9:13

R:
Yeah, I think it could be used across the board for those people, it can be for a family, say you have an occasion and then, you can jump into the pool and then people start taking pictures, ahh say maybe in a wedding then there is a bit of fun and then you can also use it. And then you can also use it for professional purposes, especially in research.

ST-s~

Appendix D:

Comparison of designers' and users' memos

D.1 Comparison of memos from sketches

USER	DESIGNER
NO EXP: No indications to an individual experience of using the tool (no IEC, FE, ED, ST) cannot produce knowledge of any kind (DBC or PBC). Familiarity helps to overcome lack of experience (IEC). In some cases, familiarity with similar products aids a user's understanding of an artefact use. DBC references are supported by this, context of use or intended user references are not. Familiarity is related to visualisation from memory. In some cases it helps users to build concepts that are rich in details surpassing the state of DBC only providing some references to use and context (IU, FE).	NO EXP In using visuals to represent concepts, designers will produce mostly DBC references (descriptions). Lack of experience (ED, IEC, and ST) leads to DBC type or references only, including some reference to context (FE) that ca be wrong. Familiarity with similar devices influences concepts/knowledge about products never used before. In this regard, knowledge domain allows designers to generate any type of product, but, lack of experience regarding the activity generate misconceptions that are then included in the design concept. (For example: the rubber grips on the corner of camera to hold it underwater are too small and inadequate for manipulation underwater).
LITTLE EXP Any type of knowledge (expert, novice) that has been motivated with some experience of some kind (ED, IEC, ST), will produce concepts that indicate understanding of the general principles of an artefact (DBC and PBC).	
EXP Familiarity and experience (IEC) together produces insightful references to a product's definition, including references to the artefact's context of use (ST-s). Individual experience about doing an activity with an artefact produces immediate reference to the context of use (ST-s, FE). This also generates references to DBC and PBC together and includes some knowledge of use and context (IU, FE). Usually, specific references to user-artefact interaction (IU- interaction) indicate that knowledge comes from individual experience (IEC, ED, IEC-f).	EXP Individual experience (IEC) about the use of a product leads to knowledge that include detailed descriptions (DBC) of the artefact and to references of the context of its use (ST-p). Designers tend to explain concepts by using many DBC references; nevertheless, when individual experience is involved, at least one main PBC about the whole use of the artefact is presented. Individual experience will always produce DBC, IU and PBC type of references and will support knowledge.
EXP + GENDER Gender issues can also influence the way participants present their concepts (*maybe it influences how they conceptualise things as well). Just one DBC reference could be enough to explain it all. When experience (IEC) is behind a DBC reference, all the elements are in place, shapes and names are accurate.	
EXP + KNOWLEDGE DOMAIN Experience (ie. professional background) influence understanding of artefacts. Expert users are more focused in certain aspects of their knowledge about an artefact and might be more concerned about the technical aspects of their field of domain (as they are not 'superficial' observers) and will report on that experience (IEC-f). Expert	

knowledge can produce DBC and PBC references, but perhaps PBC references will prevail. Expert users references about and artefact DBC are related to the USE of it, this is also indicative of experience behind their knowledge. KNOWLEDGE DOMAIN Lack of previous individual experience can be overridden by knowledge domain. Knowledge domain influences users' knowledge and concepts. It not only refers to familiarity with similar products but to the user's professional background. When knowledge domain comes from a creative field (Architecture), concepts are 'created' from visualisation from memory and visualisation from imagination. References produced in this case are mostly IU, PBC, DBC, and FE that provides some reference to context. Knowledge domain influences they way users think about the artefacts that surround them. An artefact is the sum of its components in engineering. Users' who come from engineering fields would use 'isotopic views' to show the front and lateral side of an artefact and number of features and its names within the artefact body (DBC) will be shown.	DESIGN KNOWLEDGE DOMAIN Knowledge domain help designers to focus on specific aspects of their concept presentation and to produce DBC and IU type of references of the product in isolation with minimum reference to context of use (FE). However, lack of individual experience will limit their references to context of use. In some cases, DBC and IU references together indicate not only description of features but knowledge about the use of it and it will also indicate that there is experience behind this knowledge. Design knowledge domain can also lead the designer to describe the use of an artefact by differentiating them by the type of use. PBC references are used to explain an artefact's overall concept, and then DBC, IU and ST-p are used to explain the aspects of use and context of use. Many times descriptions will be generated from an organised design thinking process and not due to an individual experience.

D.2 Comparison of memos from retrospectives

USER	DESIGNER
LITTLE EXP Individual experience (IEC) that comes from 'seeing' the activity (IEC-s) rather than 'using' produces a basic understanding of an artefact (shape and use) with little knowledge about its features and interaction issues. Seeing generates a visual memory. Visual memory detached from experience works as a catalogue of representations with little information behind. When visual memory is generated within an artefact's context-of-use (ST-p), then users are able to refer to the intended use (IU) of the artefact and to DBC and PBC references. Familiarity with similar products helps the user to produce concepts or knowledge (DBC, PBC, IU) about artefacts that had not been used before. (** If individual experience is not presented in any form of IEC or ED, how could this user provide a PBC reference and show a good understanding of IU and about the artefact itself?).	NO IEC Designers with no individual experience of any kind (IEC, ED) will produce DBC references about <u>new</u> design concepts (VI, CONCEPT FROM IMAGINATION) of artefacts that do not exist.
NO/ LITTLE EXP + KNOWLEDGE DOMAIN Knowledge domain from creative fields (architecture) allows users to be creative about their understanding of an artefact they have not used before. Familiarity with similar products enables users to refer to some DBC and IU providing limited references to context (FE) but not to the overall context of use of the artefact.	
EXP Individual experience (IEC) of using an artefact produces knowledge that supports detailed description of an artefact's use (IU) and features (DBC, PBC and FE) in its environment of use (ST-p) Individual experience (IEC, ED) about doing the intended activity (IEC-a) produces more detailed descriptions (PBC, DBC) of the artefact in relation to its use (IU) and human-artefact interaction (IU-interaction). The type of individual experience (IEC) would influence on the references to context of use (ST-p). When users can substitute the artefact for any other mean to accomplish the intended activity; this will lead to references of ST-p and IU, but not much about features will be referred.	EXP When individual experience (IEC) is part of the person's knowledge about an artefact, description about it will include use, features and functionality of an artefact (IU, DBC and PBC) and also references to FE. This type of knowledge is embedded in experience (IEC-a) and most likely in episodic experience as well. This works same for designers and users. In the case of designers, they would concentrate more in describing what they know rather than including elements from imagination (design process). Designers can produce detailed visualisation from memory (VM) about things they have used/seen in the past when individual experience is part of that memory (IEC, ED). Those VM lead to DBC type of descriptions about the artefact's features. Individual experience influences in knowledge domain; new design concept can be based on familiar mental models that are described in terms of DBC, PBC, and FE.
EXP + GENDER Gender might influence in different ways how users express their concepts. A male user express his knowledge of an artefact from a general description of features or components (DBC) accompanied by some references to the use of the artefact (IU). He goes from the general to some specific, but in a very general way.	

Likewise, individual experience that is based on frequent use (IEC and ED) of an artefact, produce PBC type of knowledge. Those PBC references will not only describe the relationships among parts/features, but the relationship between an artefact's functions and the intended use of it. All this generates 'knowledge domain'. The BBQ Grill is a good example of the Australian male knowledge domain about outdoors cooking. EXP + KNOWLEDGE DOMAIN Even when participant is asked to describe something they dislike, or something they had seen long ago, if they possess knowledge and experience regarding the artefact, they would refer to the intended use, features and context of use (IU, DBC, and ST-p). Knowledge domain influences participants' representation of knowledge. Previous knowledge that comes from some sort of experience (IEC) might include some visualisation from memory (VM), that help to 'reproduce' his knowledge by explaining part-by-part (DBC). This description includes intended user (IU).	
KNOWLEDGE DOMAIN Knowledge domain / expertise (from the user) will produce PBC and DBC type of references, but mostly PBC, in order to explain the generalities of a system/concept. DBC descriptions could also include some IU and ST-p. Knowledge domain influences the way users think and represent an everyday artefact. Due to their professional knowledge domain, some users explain their concept as if they were designing. References are mostly PBC type as there couldn't be any reference to existing artefacts' features. Knowledge domain from creative fields influences the way users explain their concepts about artefacts. In this case, more DBC type of references will be produced from imagination (VI) and visualisation from memory (VM).	KNOWLEDGE DOMAIN In the case of an industrial designer, knowledge domain and some individual experience (IEC, IEC-a) produce different type of knowledge about an artefact. This combination produces DBC, PBC, IU and ST-p type of references, in combined statements. DESIGN DOMAIN Designers refer to existing knowledge by providing DBC type of references that are based on experience (IEC) of seeing and knowing. Knowledge domain influences 'how' participants refer to their concept of everyday artefacts. In this case, the designer explained her concept of existing digital alarm clocks by breaking the concept down into design issues: 'scenario of use', 'characteristics of use'. As a result, references can be more DBC, IU and ST-p than PBC.

D.3 Comparison of memos from interviews

USER	DESIGNER
NO/ LITTLE EXPERIENCE Experience comes not only from USING but from SEEING. Lacking from experience in using an artefact, users will relate to familiar mental models and based on that they will provide references to intended use (IU), intended user and interaction (human-artefact interaction). Some references to context (FE, ST) could be conveyed from imagination (VI) but could be inaccurate. It will be difficult to provide references to DBC or PBC as users will not remember well artefact's features.	NO/ LITTLE EXPERIENCE Designer with not experience at all with the artefact will produce concepts based on similar products and mostly from assumptions (visualisation from imagination). References to ST and IU will be produced based on assumptions as well. Designers lacking of experience with an artefact, will develop more on intended use descriptions (IU) based on a broad general concepts (PBC) rather than developing on details of features. As part of the intended use descriptions some references to use and context of use are provided.
EXPERIENCE + CULTURAL BACKGROUND Cultural background influence person's concepts of everyday artefacts, sometimes to a greater extent than contextual references from the person's surroundings. For example: a user participant who has been living in Brisbane for 2 years, have recalled the public trash bin concept from his country and forgot completely about the public trash bins that he sees in his current everyday environment.	EXPERIENCE + CULTURAL BACKGROUND Individual experience (IEC) and episodic knowledge (ED) in addition to culture related knowledge, produces knowledge that conveys DBC concepts, IU references and references to the context of its use (ST-p, ST-s) * Knowledge based on cultural practices.
EXPERIENCE Individual experience of doing the intended activity (IEC-a) produces multiple references to intended use (IU) and context of use (ST). Individual experience influences a person's knowledge about the context of use (ST) of an artefact, its purpose of use (IU) and its intended users. When episodic experience is also involved, then the social context of its use (ST-s) will also be part of this knowledge. These two (ED + ST) come together when experience involves: owning, using, enjoying the activity within a cultural relevance. This experience leads to more detailed references to intended use, users and context of use (IU, ST). Visualisation from memory (VM) will also be included in DBC type of descriptions. Artefact users' will refer to the intended use (IU) of the artefact by referring to episodic experiences (ED) and its context of use (ST). Descriptive concepts (DBC) are used mostly as exemplars to the experience being referred. Some artefact users who are only concerned on using it but not 'understanding' it (i.e mechanical artefacts), would mostly refer to a broad general concept (PBC) as a point of departure for further references regarding the use of it, leading the participant to include references to episodic experience as well (ED). This type of users will refer to individual experience within context (IEC) mostly and to context of use (ST) in some extent.	EXPERIENCE Individual experience which involves SEEING and USING an artefact and some episodic experience (ED), will produce sound concepts of an artefact, based not only on descriptions (DBC) but also based on reference to various aspects of use (IU) and the situations (ST) in which the artefact is used or can be used. This is the ideal knowledge situation for any designer to work. Individual experience that conveys the intended activity within context (IEC), features, functions, and episodic experience (ED), will produce concepts which always includes context of use and intended use (IU). This knowledge would tend to drive designers' concept definition of an artefact design.

Individual experience (IEC, ED) and knowledge domain related to an artefact, bring up many references about intended use (IU - purpose of use, users, human artefact interaction), all them placed within the user's primary context of use KNOWLEDGE DOMAIN Knowledge domain influence people's concept of artefacts. If user has an idea of an artefact but has not used it, he/she would not only rely on familiar mental models but on knowledge domain to 'create' a concept from imagination (VI). This new concept will be explained by referring to DBC and IU (intended user, intended use and interaction issues). People with expert knowledge (i.e. 'sales man') will always provide PBC references of the artefact/system they know to explain purpose of use, users, and context of use. If this knowledge conveys individual experience, references of IEC and ST will be produced. Knowledge domain (professional) influences concept of everyday artefacts. For example: an engineer will produce more DBC and PBC references of the machine itself rather than references to the use of it. When there is lack of experience with a device, knowledge domain and individual experience (doing, seeing) back up concept development.	DESIGN KNOWLEDGE Designers, who can draw concepts from design knowledge domain and from some individual experience (IEC and ED)., would refer mainly to intended use (IU) and context of use (ST). Design knowledge domain can produce diverse references regarding different context of use, intended use, and users. Definitions can be broad and diverse but if it lacks of experience, concepts produced will come from knowledge domain only, which can be insufficient to address users' needs.

Appendix E:

Relationships between experience, knowledge and context of use

Interpretation of statements in regard to possible relationships between experience, knowledge and context of use

Focus of the interpretation:

- What do outcomes say about Experience, Context of use, Knowledge? / What aspects of the user's experience influence their understanding of everyday product usability and its context of use?
- What is the nature of the differences between designers and users?

E.1 Relationships found from sketches

Users	Designers
NO EXPERIENCE ▪ No IEC ⇨ no DBC, no PBC ▪ Familiarity + Lack of IEC ⇨ broad DBC (no ST, no IU) ▪ Familiarity → VM ⇨ DBC only EXPERIENCE ▪ Any type of IEC → DBC or/and PBC ▪ IEC ⇨ IU (interaction)	NO EXPERIENCE ▪ No IEC ⇨ DBC only ▪ Familiarity + Lack of IEC ⇨ broad/ wrong DBC / FE EXPERIENCE ▪ IEC ⇨ DBC + IU + PBC
EXPERIENCE & CONTEXT OF USE ▪ Familiarity + IEC ⇨ [DBC/PBC + IU] + ST-s ▪ IEC (doing) ⇨ [ST-s / FE / IEC-f] + IU + [DBC & PBC]	EXPERIENCE & CONTEXT OF USE ▪ IEC ⇨ DBC + IU + PBC and ST-p depending on the nature of the exp.
KNOWLEDGE DOMAIN ▪ IEC (professional) ⇨ focused PBC / DBC + IEC-f + FE ▪ No IEC + Knowledge domain ⇨ DBC (= VM + VI)	DESIGN KNOWLEDGE DOMAIN ▪ IEC (professional) ⇨ focused DBC/IU in isolation + minimum FE) ▪ IEC (professional) ⇨ focused IU diverse ST-p (hypothetical DBC, IU)

Legend: → (generates). IEC (Individual experience within context), IEC-a (Individual experience within context regarding the product's intended activity), DBC (Descriptive-based concept), ED (Episodic data), IU (Intended use), FE (Feature with indication of usage), PBC (Principled-base concept), ST (situation), ST-p (situation regarding the product's physical context of use).

E.2 Relationships found from retrospectives

Users	Designers
NO EXPERIENCE ▪ Seeing → VM ▪ VM + No IEC ⇒ catalogue of representations (no ST) → DBC ▪ Familiarity ⇒ DBC or PBC, IU + FE EXPERIENCE ▪ VM in ST ⇒ DBC or PBC + IU ▪ IEC (using) ⇒ IU + DBC/ PBC/ FE + ST-p ▪ IEC-a (doing) / ED ⇒ PBC (features) + DBC + IU (interaction)	NO EXPERIENCE ▪ No IEC/ED ⇒ DBC of new artefacts EXPERIENCE ▪ IEC/ IEC-a ⇒ IU, DBC /PBC + FE ▪ IEC / IEC-a / ED → VM ⇒ DBC
EXPERIENCE & CONTEXT OF USE ▪ X Type of IEC ⇒ X Type of ST-p ▪ IEC ⇒ IU, DBC, ST-p	EXPERIENCE & CONTEXT OF USE ▪ IEC/ IEC-a ⇒ DBC /PBC, IU, ST-p
KNOWLEDGE DOMAIN ▪ IEC (professional) ⇒ focused PBC / DBC → DBC from VM + VI ▪ PBC ⇒ ST-p + IU	DESIGN KNOWLEDGE DOMAIN ▪ IEC / IEC-a ⇒ DBC, IU, PBC, ST-p

Legend: → (generates). IEC (Individual experience within context), IEC-a (Individual experience within context regarding the product's intended activity), DBC (Descriptive-based concept), ED (Episodic data), IU (Intended use), FE (Feature with indication of usage), PBC (Principled-base concept), ST (situation), ST-p (situation regarding the product's physical context of use).

E.3 Relationships found from interviews

Users	Designers
NO EXPERIENCE ▪ IEC (seeing) ~ Familiarity (VI) ⇒ ▪ VI → some FE + ST that can be inaccurate EXPERIENCE + CULTURE ▪ IEC [ST in culture X] → incorrect DBC/ PBC in ST-culture Y ▪ IEC + ED-a → ED + ST-s + ED + IU	NO EXPERIENCE ▪ VI ⇒ broad DBC or IU EXPERIENCE + CULTURE ▪ IEC + ED [culture] ⇒ DBC + IU + ST-p + ST-s [culture]
EXPERIENCE & CONTEXT OF USE ▪ IEC-a → IEC + ED + ST ▪ IEC-a → IU + ST + FE ▪ IEC + ED → ST ▪ DBC → IU + ST + FE ▪ IEC, ED → IU within ST	EXPERIENCE & CONTEXT OF USE ▪ IEC-a + ED ⇒ IU ▪ FE + ED + IEC-a → ST (ST-P, ST-s) + IU + IEC-f
KNOWLEDGE DOMAIN ▪ Knowledge + Familiarity → VI ⇒ DBC + IU ▪ Expert Knowledge + IEC ⇒ PBC + IU + ST	DESIGN KNOWLEDGE DOMAIN ▪ IEC + ED → IU + FE + ST-p / ST-s

Legend: → (generates). IEC (Individual experience within context), IEC-a (Individual experience within context regarding the product's intended activity), DBC (Descriptive-based concept), ED (Episodic data), IU (Intended use), FE (Feature with indication of usage), PBC (Principled-base concept), ST (situation), ST-p (situation regarding the product's physical context of use).

Appendix F:

Code frequency tables

F.1 Code frequency table from drawings

HU: Q1 DRAWING CODING
File: [D:\RESEARCH DESIGN 2004\PILOT TEST SET 5 Sept 04\ANALYS...\Q1 Drawing coding.hpr5]
Edited by: Super
Date/Time: 20/09/05 10:06:48 AM

Codes-Primary-Documents-Table

Code-Filter: All
PD-Filter: All

	PRIMARY DOCS																														
CODES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Totals
Experience																															
FE	1	0	0	0	1	1	0	1	2	0	0	2	2	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	13
IEC-f	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Knowledge																															
PBC	1	0	0	0	0	0	2	0	0	0	0	1	1	1	1	2	2	1	1	0	1	0	0	1	1	0	0	0	1	0	17
DBC	2	2	17	5	4	5	4	6	6	4	1	1	4	4	0	2	2	1	2	2	0	4	4	5	0	3	2	1	1	1	95
Context of use																															
IU	5	3	2	1	0	3	1	3	0	0	2	1	2	3	1	4	2	2	1	1	5	1	3	1	3	6	1	1	3	0	61
ST-p	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	1	0	0	1	0	6
ST-s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Totals	9	5	19	7	6	9	7	10	8	4	3	5	9	9	3	8	6	5	5	3	6	6	8	7	6	10	3	2	6	1	195

F.2 Code frequency table from retrospectives

HU: Q2 RETROSPECTIVE CODING
File: [D:\RESEARCH DESIGN 2004\PILOT TEST SET 5 Sept 04\A...\Q2 Retrospective coding.hpr5]
Edited by: Super
Date/Time: 20/09/05 10:22:39 AM

Codes-Primary-Documents-Table

Code-Filter: All
PD-Filter: All

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Experience																									
FE	1	0	0	0	0	2	0	0	1	0	0	1	0	0	4	0	1	0	0	0	0	0	0	1	11
IEC	0	4	1	1	1	0	1	2	1	0	1	0	0	2	1	1	1	0	2	0	0	0	1	1	21
IEC-a	0	1	0	0	3	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	8
ED	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Knowledge																									
PBC	1	0	0	0	3	1	2	1	1	2	2	0	1	1	0	3	1	0	1	0	0	0	0	0	21
DBC	3	5	2	4	5	5	3	8	4	1	1	1	6	2	1	2	2	1	3	4	1	1	1	2	68
Context of use																									
IU	2	3	1	4	2	6	1	6	0	2	1	0	3	1	0	3	2	1	2	3	2	2	3	1	51
ST-p	0	2	1	0	0	0	1	1	0	0	0	0	1	0	0	0	1	0	0	2	1	0	1	0	11
ST-s	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
VI	3	0	0	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
VM	0	1	2	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	2	9
Totals	10	16	8	11	14	16	9	19	7	5	5	3	11	7	7	9	10	2	8	10	5	3	6	7	209

F.3 Code frequency table from interviews

HU: Q3 Interview coding
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Edited by: Super
Date/Time: 20/09/05 10:40:59 AM

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Code-Filter: All
PD-Filter: All

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Experience																									
FE	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	1	3	1	0	0	0	0	8
IEC	1	3	1	0	3	4	0	2	1	3	7	3	4	3	0	4	2	2	5	2	3	4	4	5	66
IEC-a	1	0	3	0	2	0	2	1	0	0	1	0	0	1	0	0	0	0	0	0	0	3	1	0	15
IEC-f	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
ED	0	1	4	0	2	0	0	1	0	2	1	2	3	2	2	1	1	1	3	1	1	2	1	0	31
Knowledge																									
PBC	1	0	0	1	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	2	0	1	0	0	8
DBC	4	0	0	0	0	1	0	0	0	3	1	1	2	1	1	1	1	0	1	2	5	1	1	4	30
Context of use																									
IU	9	11	11	7	12	10	7	9	9	8	5	5	5	6	4	6	5	7	2	10	4	5	7	4	168
ST	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
ST-p	5	2	4	4	2	2	2	3	2	1	1	3	2	1	3	1	3	3	0	5	2	1	2	3	57
ST-s	0	2	1	0	1	4	2	2	3	0	2	2	2	0	1	0	1	0	0	2	0	0	2	2	29
VI	2	2	0	1	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
Totals	23	21	25	13	22	22	13	22	16	17	20	16	18	15	11	14	13	14	14	26	15	17	18	18	423

Appendix G:

Interpretation of findings from drawings, retrospectives and interviews

G.1 Interpretation of findings from sketches:

What do outcomes say about Experience, Context of use, Knowledge? / What aspects of the user's experience influence their understanding of a everyday product usability and its context of use?

Lack of experience leads to broad/ wrong descriptions of artefacts and its characteristics (features, functions). Familiarity with similar products helps to arrive to broad descriptions, but these could be inaccurate or incorrect. Familiarity relies on visual memory. Any type of experience can lead to descriptions of artefacts/features and to description of their principles. These descriptions would involve concepts of intended use as well.

Regarding Context of use, outcomes suggest that users' descriptive or principled concepts about the artefact and its context of use depend on the nature of their experience. Experience regarding the artefact's intended activity and familiarity with similar products produces knowledge about intended use, human-artefact interaction issues, as well as references to the context in which the artefact is used.

Knowledge domain helps to draw concepts from visual memory and visual imagination when there is lack of experience. Professional experience in regard to an artefact will produce focused concepts of its intended use and features.

* What aspects of the user's experience influence their understanding of everyday product usability and its context of use?

- Familiarity added to some sort of experience (seeing, doing)
- Experience (doing) leads to an overall understanding of the context of use and a product's characteristics (features) and use.
- Professional knowledge that involves a product's use produces focused knowledge of product's characteristics.
- Professional knowledge in isolation (no experience involved) produces a catalogue of descriptions from visual memory and imagination.

* What is the nature of the differences between designers and users' understanding/ knowledge of a product's context of use?

Outcomes suggest the following:

- SIMILARITY: Lack of experience influence in the same way designers and users' knowledge of a product's use. Familiarity is not enough to arrive to basic understanding of a product's use. Some experience will always help to build correct understanding of a product's use/ context of use.
- DIFFERENCE: Users' knowledge of a product's context of use is broader as, they not only rely on their experience but also on familiarity with other products to determine it. Designers' descriptions of a product's use and context depends on the nature of the experience they have had (seeing, doing, etc.)
- SIMILARITY: Professional knowledge domain influences in similar ways users and designers. For the users, knowledge will be focused to their area of domain. For designers, their concepts expressed in terms of descriptions of intended use will lead to hypothetical constructions of context of use.

G.2 Interpretation of outcomes from retrospectives

What do outcomes say about Experience, Context of use, Knowledge? / What aspects of the user's experience influence their understanding of a everyday product usability and its context of use?

Experience from 'seeing but not doing' produces a Visual memory that can be referred as a catalogue of representations based mostly on descriptions. Familiarity and Visual memory influences similarly in this situation, but added to lack of experience produces descriptions of new artefacts of artefacts that had not been used before. In this sense, descriptions can be inaccurate or wrong.

Experience from 'using and doing' added to some episodic experience, produce visual memory of the experienced artefact, which leads to descriptive and principled concepts. It also produces knowledge about features within context of use and intended use/human-artefact interaction issues, and context of use.

The type of experience influences directly in the type of context of use that users recall from artefacts used/ seen. Context of use is identified from the users' experience.

Professional experience produces a focused knowledge/ concept descriptions of an artefact's characteristics (intended use, context of use). These descriptions convey Visual memory and Visual imagination. Also, knowledge domain influences on how these descriptions are presented.

* What aspects of the user's experience influence their understanding of a everyday product usability and its context of use?

- Visual memory and familiarity to other similar products
- Experience in using and doing added to some episodic experience leads to comprehensive definition of the product's intended use, characteristics within context, and principles.
- The type/nature of their experience influences in their understanding of the type of context of use they can identify.

- Professional knowledge domain that involves experience produces focused descriptions of the product's characteristics. These descriptions can also come from visualisation from memory and from imagination, therefore, inaccurate descriptions.

* What is the nature of the differences between designers and users' understanding/ knowledge of a product's context of use?

Outcomes suggest the following:

- SIMILARITY: Lack of experience leads to broad descriptions of new artefacts or artefacts that had not been used before. Visual memory and familiarity is used as an aid.
- SIMILARITY: Experience of using, doing added to some episodic knowledge produces concepts that convey most aspects of a product's use (intended use, features within context of use, interaction issues and principled/descriptive based concepts).
- DIFFERENCE: In the case of designers, experience and episodic knowledge produces a catalogue of representations from visual memory, from which they understand the artefacts they had seen/used. (Does this become 'prototypes' in the designers' mind?)
- DIFFERENCE: Users' concepts about a product's context of use are influenced by the type of experience they have had.
- SIMILARITY: Users' professional experience leads to a focused description of a product's usability; the focus is related to the specific professional experience they had with the artefact.
- DIFFERENCE: Designers are influenced by their design domain, it mandates how product's description is expressed or represented. Users' would relate it to the social context or environment of use, designers would focus more on the product's features.

G.3 Interpretation of outcomes from interviews

What do outcomes say about Experience, Context of use, Knowledge? / What aspects of the user's experience influence their understanding of a everyday product usability and its context of use?

Lack of experience (doing) and familiarity with similar products, lead to product's descriptions in terms of intended use, features and context of use that can be broad or inaccurate.

Cultural background influences individual experience and creates strong concepts from products. In the case of users who come from different cultural background, their experience can create wrong application of their concept to the immediate surrounding (new context of use). In the case of users from the same cultural background, experience and episodic knowledge leads to correct product's definition of its characteristics that includes its intended use and their context of use.

Individual experience about doing an activity (within context) that conveys episodic knowledge produces knowledge about the product's intended use and context of use. When experience takes place within the product's context of use, it produces knowledge about the social context of use. Episodic knowledge and experience within context is directly related to individual experience of: owning, using, within a context of use of cultural relevance for the users. This relationship (ED + ST) also leads to wide knowledge of intended use and product's description.

Professional knowledge and familiarity of other products can be aided of visualisation from imagination to produce product's description of its characteristics and intended use. Professional knowledge that conveys experience produces not only product's description but knowledge about its context of use. In the case of the design domain, knowledge with no experience produces insufficient knowledge about product's characteristics.

* What aspects of the user's experience influence their understanding of a everyday product usability and its context of use?

- Experience from seeing and visualisation from imagination
- Cultural background and episodic knowledge within that culture
- Individual experience and episodic knowledge within context of use produces knowledge of a product's intended use and its context of use
- Focused experience will produced limited knowledge, constrained to the area of experience
- Expert knowledge and experience produces knowledge about the product's use, characteristics and its context of use. But professional knowledge without experience will no lead to understanding of the product's context of use.

* What is the nature of the differences between designers and users' understanding/ knowledge of a product's context of use?

Outcomes suggest the following:

- SIMILARITY: Lack of experience, or experience based on visual memory leads designers and users to broad/inaccurate concepts of a product's use, features and context of use.
- Cultural background influences likewise to designers and users. When foreign cultural references are applied to a different cultural environment, it can produce incorrect understanding of a product's use. When experience and episodic knowledge takes place within a relevant cultural framework, then users and designers achieve sound knowledge of a product's use, characteristics and context of use.
- SIMILARLY: Experience of doing the intended activity involves episodic knowledge that leads to understanding of the product usability in its context of use.
- DIFFERENCE: Experience that comes from a focused activity that generated 'focused' episodic knowledge produces understanding of the product's principled concept and of its context of use. Similarly, any experience that is accompanied by episodic knowledge produced understanding of the product's use within the context in which the experience took place.

- SIMILARITY: Expert domain that conveys experience will result in knowledge about the product's intended use and its context of use.
- DIFFERENCE: Knowledge from field domain (professional) that do not convey experience and is based mostly in familiarity (or visualisation from imagination), influences differently users and designers. Users can use familiarity to achieve broad knowledge of a product's description and its use. In the case of designers' this is insufficient knowledge, as it would not support knowledge that they can use to build correct concepts of a product's use.

Appendix H:

ECEDT Trial run

H.1 Brief for the design of a BBQ grill (v.1)

BBQ grills are used all over the world for different purposes. In Australia BBQ grills are the centre of social gatherings at home, while in Latin America, BBQ grills are used mainly in the countryside, restaurants and in very special occasions at home. In terms of using BBQ grills for different types of cuisine styles and traditional dishes, there is a large variety of uses that requires diverse functions and features in a BBQ grill.

Your design task is to design a BBQ grill that will be marketed in Australia and in various countries overseas. Your design should be family oriented, and therefore the design must cater for the needs of a diverse range of users. At this stage of the project, there are no limitations with regard to functionality, material choice, etc.

At this stage of the project you are requested to focus on the CONCEPT DESIGN of the BBQ Grill. You can produce as many design sketches as you wish, but in each concept you should identify:

- Who is the intended user (describe the users' profile)
- What is the purpose of use (functions)
- How are its characteristics (features)
- How does it work? (interaction issues)
- Where is it used?

Dynamics of the session

- For this design task you are expected to conduct an individual brainstorming session with the tools that you are presented with. Please record outcomes of your brainstorming in a mind-map, concept map, or any other type of annotation in paper
- After the brainstorming, initiate your concept design. Please use one paper per concept
- Once finished with your concept design, please provide a written description of your concept(s)

Thank you!
October 5th, 2006

H.2 Questionnaire after Session v.1

*Responses should be audio taped

1. How much time have you spent in this task?
2. Please describe step-by-step your activities for accomplishing this task
3. How did you inform your design work about the product, use, users?
4. Is it the same process you do for every design task?

Thank you!

October 5th, 2006

H.3 Brief for the design of a BBQ grill (v.2)

BBQ grills are used all over the world for different purposes. In Australia BBQ grills are the centre of social gatherings at home, while in Latin America, BBQ grills are used mainly in the countryside, restaurants and in very special occasions at home. In terms of using BBQ grills for different types of cuisine styles and traditional dishes, there is a large variety of uses that requires diverse functions and features in a BBQ grill.

Your design task is to design a BBQ grill that will be marketed in Australia and in various countries overseas. Your design should be family oriented, and therefore the design must cater for the needs of a diverse range of users. At this stage of the project, there are no limitations with regard to functionality, material choice, etc.

At this stage of the project you are requested to focus on the CONCEPT DESIGN of the BBQ Grill. You can produce as many design sketches as you wish, but in each concept you should identify:

- Who is the intended user (describe the users' profile)
- What is the purpose of use (functions)
- How are its characteristics (features)
- How does it work? (interaction issues)
- Where is it used?

One more consideration: your clients wish to produce and market a new design of a BBQ Grill that is easy to use by the intended user group.

Dynamics of the session

- For this design task we ask you to use the ECEDT tool along with the brainstorming or creativity technique that you would usually employ. Please use the material that you are presented with to record or annotate your thoughts or/and outcomes of this stage of the session (as you would usually do). The ECEDT print menu is not fully functional, for which we ask you to use instead the PRINT SCRN button from your keyword to capture the outcomes shown in the screen and past it in another document (a picture manager or word document).
- After using the tool initiate your concept design. Please use one paper per concept
- Once finished with your concept design, please provide a written description of your concept(s)

Thank you!
October 6th, 2006

Session management

* Session should be video and audiotaped
* Use two cameras, one focussed on screen, another focussed on designer's activity

H.4 Questionnaire after Session v.2

1. Please describe step-by-step your activities for accomplishing this task
2. Please comment on how your previous knowledge influenced your design concepts, and how the information brought up by ECEDT influence your design concepts.
3. Was the information provided by ECEDT helpful/interesting/relevant to your design work?
4. Do you think this type of tool can help you in designing better user-product interactions? Do you think this tool is adequate for the early stages of a design task?
5. Do you have any suggestions about the tool?

Thank you!

October 6th, 2006