Nelson Mandela Metropolitan University

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An Investigation into the Use of Guidelines and Patterns in the Interaction Design Process

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Submitted in fulfillment of the requirements for the degree of Philosophiae Doctor in the Faculty of Science at the Nelson Mandela Metropolitan University.

30 January 2009

Promoter: Prof J.L. Wesson

Acknowledgements

Prof Janet Louise Wesson, my promoter, provided unfailing support, good ideas, suggestions and support, and encouraged me when things seemed dark.

Dr Martijn van Welie, of Satama Amsterdam, shared inspiring ideas about interaction design (IxD) patterns and helped with formulating the research questions and documents at the beginning of the research. Dr van Welie kindly gave permission for the use of his *Interaction Design Pattern Library* for research purposes.

Dr Douglas van Duyne, Dr James Landay and Dr Jason Hong kindly gave permission for the use of their *Design of Sites* collection of IxD patterns for research purposes.

Dr Lynette Barnard assisted me with the execution of the empirical study and with the evaluation of website designs produced by the participants. Dr Barnard kindly gave permission for the use of her collection of E-commerce design guidelines for research purposes.

Mrs Janine Nel and Mrs Brenda Scholtz assisted me with the evaluation of website designs produced by the participants in the empirical study.

Ms Marinthea Snyman and Ms Bridget Cowley provided valuable assistance with refining and capturing my list of references.

The thirty-three masters and honours students registered for the 2004 post-graduate E-Commerce module at NMMU participated in the empirical study and generated very useful data. They are not named for reasons of confidentiality.

Mrs Iona Cowley, my wife, supported me unfailingly during this work and I dedicate this thesis to her.

Summary

Design guidelines are used in interaction design (IxD) for physical design and for evaluating the usability of designs and interactive products. Guidelines are widely used for physical design and evaluation, but have a number of problems. IxD patterns have been proposed as an alternative to guidelines, as they are claimed to have several advantages over guidelines. A small number of empirical studies provide evidence that patterns are beneficial when used in IxD. Additional research on the usefulness of IxD patterns is required. The primary research question investigated in this thesis was thus: *How useful are IxD patterns as physical design and evaluation aids in IxD, as compared to design guidelines?*

The role of guidelines and patterns as design and evaluation aids in IxD was investigated and a comparison of guidelines and patterns, based on a set of guideline and pattern properties, was conducted. The concept of pattern and guideline usefulness was explored and a research agenda for guidelines and patterns was identified, together with a set of research questions for an empirical study.

The empirical study of the use of patterns for evaluation, redesign and new design, as compared to guidelines, was conducted at the Nelson Mandela Metropolitan University in 2004. The participants were a purposive sample of post-graduate Computing students, who were regarded as novice interaction designers. Two equivalent groups were formed, one that used patterns and one that used guidelines.

Patterns were found to be as useful as guidelines when used as evaluation aids. Guidelines and patterns were identified as effective tools for identifying and explaining usability issues and design features. Best-effort matched sets of guidelines and patterns produced substantially different result sets when used to identify issues and features, with fairly low overlap. A substantial evaluator effect was observed for the use of guidelines and patterns for evaluation, and the results obtained were similar to those obtained by Molich *et al.* in their Comparative Usability Evaluation (CUE) studies. There was no statistically significant difference between the effectiveness of guidelines and patterns for evaluation. There was also no statistically significant difference between the perceived efficiency, effectiveness and satisfaction in use of

guidelines and patterns for evaluation. Guidelines and patterns were found to be used in similar ways for evaluation.

Patterns were found to be more effective than guidelines for redesign. Patterns were found to be as useful as guidelines when used for new design. There was no statistically significant difference between the effectiveness of guidelines and patterns for new design. There was also no statistically significant difference between the perceived efficiency, effectiveness and satisfaction in use of guidelines and patterns for redesign and new design. Guidelines and patterns were found to be used in similar ways for design.

There was no statistically significant difference between the perceived usefulness of the format, content, ease of learning, and usefulness as personal and shared design languages, of guidelines and patterns. Both participant groups were equally agreeable to using guidelines and patterns in the future. The perceived usefulness of pattern collections was found to depend on the usability of the collection interface and the content quality of the patterns.

The results of the empirical study thus provided empirical evidence that patterns were as useful as guidelines for evaluation and new design, and were perceived as positively as guidelines were. Patterns were found to be superior to guidelines for redesign. Patterns can therefore be used with a measure of confidence as early stage design aids for physical design and evaluation in the future. In addition to these findings, a number of opportunities for further research were identified.

Key Words: Interaction design, design guidelines, interaction design patterns, usability evaluation, empirical study

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Chapter 1: Introduction

1.1 Background

Interaction design (IxD) is a design discipline concerned with the definition and creation of interactive products (Garrett 2002; Preece, Rogers and Sharp 2006; IxDA 2007b). IxD supports the intended users of the products in particular contexts of use by defining the form and behaviour of the products and user interaction with them.

Interactive products can be objects, activities, services and environments (Reimann and Forlizzi 2002), all of which have a digital aspect. These products are transforming society due to their utility and value (Knemeyer 2006). IxD is thus economically and socially important (Thackara 2002). IxD is user-centred since it requires an early and ongoing focus on users and their goals and tasks, and iterative design and evaluation throughout a project (Gould and Lewis 1983; Dix, Finlay, Abowd and Beale 2004; Preece *et al.* 2006).

IxD is also a design process incorporating four related activities that are usually carried out in a systematic and iterative way (Preece *et al.* 2006: 428). These activities can thus be modeled as a generic lifecycle. The activities are:

1. Identifying user needs and establishing requirements;
2. Developing alternative designs that satisfy the requirements;
3. Building interactive versions of selected alternative designs; and
4. Evaluating the usability and user experience of these versions.

Developing alternative designs involves conceptual design, followed by physical design. Conceptual design produces conceptual models that describe what products will do for users and how users can interact with the products at an abstract level and without focussing on details (Johnson and Henderson 2002: 26). Physical design involves the detailed design of the user interaction and the user interface of products, based on conceptual models (Preece *et al.* 2006: 429). Physical designs are used to build high-fidelity interactive versions of products, including functional prototypes.

Observational and analytical methods used during requirements specification provide some of the knowledge required for physical design (Newman and Lamming 1995; Stone, Jarrett, Woodroffe and Minocha 2005). There are, however, many physical design problems that the knowledge provided by these methods cannot solve (Newman and Lamming 1995: 373). There are also limits to the personal design knowledge and experience of interaction designers that can be used to solve physical design problems (Dix *et al.* 2004: 53).

Several design aids that address the problems of physical design have been developed (Sutcliffe 2000). Design guidelines are the most commonly used and generally accepted physical design aids (Newman and Lamming 1995: 374; (Dix *et al.* 2004: 259; Shneiderman and Plaisant 2005: 60; Stone *et al.* 2005: 166). A guideline is a brief textual rule that can be applied to solve a particular class of design problems. Guidelines are generally grounded in theory (Koyani, Bailey and Nall 2006), possibly with supporting empirical evidence. Guidelines exist for a number of product types at various levels of detail.

Guidelines are also used by designers and usability experts for evaluating the usability of interactive versions of physical designs by inspection (Mayhew 1999: 246). There are two ways of using guidelines for usability evaluation, namely heuristic evaluation (Nielsen 1994) and guideline review (Newman and Lamming 1995; Stone *et al.* 2005). Heuristic evaluation is an inspection method in which a design is systematically checked for usability issues using a set of heuristics (general usability principles). Guideline review is an inspection method in which a design is checked for adherence to a checklist of design guidelines.

Guidelines are widely accepted and routinely used by interaction designers for physical design and evaluation. Guidelines are, however, claimed to have a number of shortcomings (Thimbleby 1990; Newman and Lamming 1995; van Welie, van der Veer and Eliëns 1999). For example, it can be difficult to select the most appropriate guidelines for a particular design problem from a collection of guidelines.

Interaction design (IxD) patterns have been proposed since the mid 1990s as an alternative to design guidelines as physical design aids and, more recently, as

evaluation aids. A pattern captures the essence of a successful solution to a recurring physical design problem in a specific context (Appleton 2000). A pattern has a multi-part format and is generally grounded in good practice. Patterns are syntactically and semantically more complex than guidelines.

IxD patterns originated from software design patterns used in object-oriented software engineering (Gamma, Helm, Johnson and Vlissides 1995). Software design patterns were inspired by the work of Christopher Alexander on architectural design patterns (1979).

The use of patterns as alternatives to guidelines was based on claims that patterns did not have the shortcomings of guidelines and had advantages over guidelines when used in design (van Welie *et al.* 1999; Griffiths and Pemberton 2000; Tidwell 2003). Pattern languages, which are networks of linked patterns, were also claimed to be useful as personal and shared design languages (van Welie and van de Veer 2003).

Patterns have become better known to researchers and practitioners in recent years. A number of IxD pattern languages have been written (Borchers 2001; van Welie and Traetteberg 2001; Graham 2003; Tidwell 2003; van Duyne, Landay and Hong 2003; Cooper, Reimann and Cronin 2007). Several of these languages have been published in book form. Patterns are being used in IxD, in some cases in conjunction with guidelines and other physical design aids (Dix *et al.* 2004: 284).

The advantages claimed for patterns were initially justified by analogical reasoning (Bayle, Bellamy, Casaday, Erickson, Fincher, Grinter, Gross, Lehder, Marmolin, Moore, Potts, Skousen and Thomas 1998). These claims were subsequently supported by references to the capture of best practice, as IxD pattern languages began to emerge (Tidwell 1999). Designers were encouraged to accept patterns and their benefits at face value, using naïve induction and without scientific proof. A small number of empirical studies have shed some light on these claims in recent years. These studies are reviewed in the next section.

1.2 Relevance of Research

The two goals of an IxD pattern language are *"... to share successful HCI* (Human-Computer Interaction) *design solutions among HCI professionals, and to provide a common language for HCI design to anyone involved in the design, development, evaluation, or use of interactive systems*" (Borchers 2001: 39).

Borchers (2000; 2001) carried out two studies of the educational use of IxD patterns. The first study focused on the use of patterns by first-year students (essentially novice designers) designing prototypes during a HCI design course. The students were able to apply the patterns to solve design problems. The students also regarded patterns as memorable and useful and were receptive to using them in future projects. The second study focused on understanding and writing patterns, but not on applying them in design.

Dearden, Finlay, Allgar and McManus (2002) conducted three related studies of the use of pattern languages in participatory web design by small groups of end-users. The aim was to study the use of pattern languages in support of the second goal of Borchers' definition. It was found that the use of pattern languages enabled end-users to produce viable designs, in the form of paper prototypes. The participation of facilitators, and the physical form (paper-based and collated in a number of ways) and components of the format of pattern languages, were found to influence the success of the participatory design process. The end-users also enjoyed the activity of pattern-supported design.

Wesson and Cowley (2003) compared the use of matched sets of guidelines and patterns for a partial evaluation of an E-commerce website by a small group of usability experts. The results suggested that guidelines and patterns could be used successfully for heuristic evaluation. Guidelines were found to be easier to use than patterns as they took less time to understand, learn and apply.

Chung, Hong, Lin, Prabaker, Landay and Liu (2004) carried out a study of the use of pre-patterns by designers for evaluation, followed by design, in ubiquitous computing,

as compared to not using pre-patterns for the same tasks. Two equivalent groups were used for each treatment. Designers were classified as either novice or experienced and worked in pairs of equivalent experience. Application mock-ups (consisting of textual descriptions of functionality and storyboards) were evaluated and the designs produced were paper prototypes. The results showed that patterns helped novice designers to create better designs and novice and experienced designers to design for unfamiliar domains. Patterns enabled designers to solve certain design problems with less effort. Designers enjoyed using patterns and used patterns to communicate design ideas to each other. Chung *et al.*'s study was the first comparative study of the use of patterns for design and evaluation.

The four studies discussed above provide evidence that patterns offer several advantages for IxD, and contribute useful knowledge about the use of patterns. There were, however, a number of issues that these studies did not address.

Guidelines are a *de facto* reference standard against which other IxD aids may be judged. It can thus be argued that patterns should be compared to guidelines as a baseline to establish the relative benefits of pattern use. Borchers (2001; 2002) studied the use of patterns by first-year students for design. Chung *et al.* (2004) studied the use of patterns by designers for design and evaluation. Neither study compared pattern use with guideline use. Application mock-ups, rather than actual products, were evaluated in Chung *et al.*'s study. Wesson and Cowley (2003) compared the use of guidelines and patterns for the heuristic evaluation of an actual interactive product (a website) in an exploratory study, but used a very small sample (two usability experts).

None of the above studies addressed the redesign of existing interactive products as part of maintenance after release. Redesign is most commonly the extension of functionality or the correction of selected, previously identified usability problems (Lientz and Swanson 1980; ISO/IEC 14764 2006).

Dearden *et al.* (2002) found that the physical form and format of pattern languages influenced the success of participatory design. None of the studies compared the effects of pattern and guideline format, content, collection structures and interfaces, on design and evaluation activities and deliverables.

There is thus a clear need for further research to extend the knowledge of IxD patterns, using the issues discussed above as a point of departure. The exploratory discussion suggests that this research should be inherently multi-factorial. The need for further research leads to the thesis statement given below.

1.3 Thesis Statement

Existing research provided evidence that patterns are beneficial when used in IxD. The thesis statement is thus: *IxD patterns are as useful as design guidelines when used as physical design and evaluation aids in IxD*.

A working definition of the usefulness of guidelines and patterns is the extent to which they help interaction designers achieve their goals. A set of research questions to test the thesis statement is given in the next section.

1.3.1 Research Questions

The primary research question, based on the thesis statement, is: *How useful are IxD patterns as physical design and evaluation aids in IxD, as compared to design guidelines?*

Existing theoretical and practical knowledge about the use of guidelines and patterns in IxD was critically investigated and an empirical study was conducted to extend the existing body of research, in order to answer this research question.

Seven subsidiary research questions were derived by analysing the primary research question. These questions, the associated research methods and the chapter addressing each question are shown in Table 1.1.

#	Research Question	Research Method	Chapter
1	What is the role of physical design and evaluation aids in IxD?	Literature review	2
2	How do IxD patterns compare to design guidelines as physical design and evaluation aids?	Literature review and critical reflection	3
3	How can the usefulness of patterns as physical design and evaluation aids, as compared to guidelines, be empirically evaluated?	Research design	4
4	What are the results of the empirical study of guidelines and patterns?	Quantitative and qualitative empirical research	5
5	How useful are patterns, as compared to guidelines, based on the empirical study?	Analysis of results	5
6	What are the implications of the research findings for IxD theory, practice and future research?	Inductive and deductive reasoning	6
7	What conclusions can be drawn from the research findings?	Critical reflection	7

Table 1.1 Research Questions, Associated Research Methods and Chapters

1.3.2 Research Aim and Objectives

The research aim, derived from the primary research question, is: *Determine how useful IxD patterns are when used as physical design and evaluation aids in IxD, as compared to design guidelines.*

Eight research objectives were derived by analysing the research aim and the seven subsidiary research questions (Section 1.3.1). These objectives are:

1. Investigate the role of physical design and evaluation aids in IxD.
2. Critically compare guidelines and patterns as physical design and evaluation aids for IxD.
3. Identify research questions for an empirical study to evaluate how useful patterns are as physical design and evaluation aids, as compared to guidelines.
4. Design the empirical study to evaluate how useful patterns are as physical design and evaluation aids, as compared to design guidelines.

5. Conduct the empirical study to determine how useful patterns are, as compared to design guidelines.
6. Analyse the results of the empirical study to determine how useful patterns are, as compared to design guidelines.
7. Analyse the implications of the research findings for IxD theory, practice and future research.
8. Draw conclusions from the research findings.

1.3.3 Research Contribution

This research will contribute to the theoretical knowledge of how useful patterns are when used as physical design and evaluation aids in IxD, as compared to guidelines (Wesson and Cowley 2005). It will supplement and extend the findings of the studies by Borchers (2001; 2002), Dearden *et al.* (2002), Wesson and Cowley (2003) and Chung *et al.* (2004).

Additional knowledge of pattern use will assist pattern use to be formalised within the IxD process. It will also facilitate training interaction designers and software developers to use patterns, and contribute to the development of pattern tool support (Wesson and Cowley 2005). This will enhance the quality of the IxD process and the interactive products produced, contributing to IxD practice.

The research is expected to reveal a number of unanswered questions about pattern use, contributing to future research in IxD as a discipline.

1.3.4 Research Scope

Four other categories of design aid, namely design rationale, theories, cognitive models and claims (Sutcliffe 2000), are excluded from consideration as these are less well-known and less commonly used design aids.

The use of guidelines and patterns by designers for new design, evaluation and redesign will be compared by means of an empirical study. New design will involve the physical design of a new interactive product from a scenario. Evaluation will involve identifying usability issues and good design features in an existing interactive product. Redesign will involve the physical redesign of aspects of the existing product to correct usability issues. Designs will be implemented as medium fidelity prototypes, rather than functional prototypes.

Interaction designers, who use guidelines and possibly patterns for design and evaluation, would be the ideal subjects for the empirical study. South Africa is the setting for the empirical study, but has a limited number of interaction designers. Consequently, a best-effort purposive sample of participants will be employed in the empirical study, as representative as possible of the population of interaction designers.

The empirical study will be further constrained to the use of guidelines and patterns for design and evaluation tasks for one category of interactive product, due to the diverse nature of these products (Reimann and Forlizzi 2002). The category of interactive product chosen will be of practical and economic importance. The limitation of the empirical study to a single category of interactive product implies that the choice of guidelines and patterns will be restricted to those aids that are specifically intended for the physical design and evaluation of the selected category.

Data will be gathered on the process of using guidelines and patterns and the experiences of participants in the empirical study. Data will also be gathered on guideline and pattern formats, content and collection structures and interfaces.

The thesis structure, as determined by the research aim, is given in the next section.

1.4 Outline of Thesis Structure

Chapter 2 presents a literature review of the role of design and evaluation aids in IxD. The objective of the review is to highlight the use and importance of guidelines and patterns for physical design and evaluation in the IxD process. The background of the user-centred and multidisciplinary nature of IxD is explored. Several definitions of IxD are presented and used to synthesise a comprehensive definition. The generic IxD lifecycle and a number of lifecycle models contributing to the generic lifecycle are discussed. Activities forming part of the generic lifecycle are reviewed with respect to their goals, techniques, deliverables and challenges. An overview of the use of guidelines and patterns in physical design and evaluation is included.

Chapter 3 presents a literature review of guidelines and patterns. The objective of the review is to provide information about the claims that patterns have several advantages over guidelines, when used for physical design and evaluation. The background, definition, properties, classification and organisation of guidelines and patterns are compared. Guidelines and patterns are also compared with respect to their selection, use, benefits and problems. An analysis of guideline and pattern usefulness and the review of guidelines and patterns are used to formulate the set of research questions required for the empirical study.

Chapter 4 presents the experimental design and methodology required for the empirical study of guideline and pattern use. The design and methodology is based on the set of research questions presented at the end of Chapter 3. The objective is to study the usefulness of guidelines and patterns when used for evaluation, redesign and new design. The activities and deliverables of the empirical study are discussed. The chapter ends with a discussion of shortcomings and possible sources of error of the empirical study.

Chapter 5 presents the results of the empirical study and the analysis of the quantitative and qualitative results in order to determine how useful patterns are, as compared to design guidelines, for IxD.

Chapter 6 deals with recommendations for IxD theory, practice and future research arising from the research. The significance of the results of the empirical study for IxD theory and practice is discussed. Finally, several suggestions for future research are presented.

Chapter 7 presents the conclusions arising from the research. The summary of the research findings, a discussion of problems encountered and a summary of the contributions made by the research are discussed.

The next chapter presents a literature review of the role of design and evaluation aids in IxD in order to highlight the use and importance of guidelines and patterns for physical design and evaluation. It is the first of two literature review chapters.

Chapter 2: Interaction Design

2.1 Introduction

The aim of this chapter is to investigate the role of design aids in the interaction design (IxD) process (Research Objective 1, Section 1.3.2). The chapter reviews IxD in order to explain the relationships between IxD concepts and activities and the use of guidelines and patterns for physical design and usability evaluation.

Several authors have defined IxD in different ways that reflect their perspectives on the nature of IxD. The background and definition of IxD are explored in the next two sections. The definition, in particular, is required to provide a coherent foundation for understanding the role of guidelines and patterns in the IxD process.

2.2 The Interaction Design Discipline

2.2.1 Background

IxD emerged from an industrial design project and evolved into a multidisciplinary field over a period of 27 years. Bill Moggridge realised the need to explicitly design the experience of using software while testing the prototype of the GRiD Compass (the first laptop computer) in 1981 (Lauster 2003; Moggridge 2006a; Moggridge 2006b). Moggridge was the lead designer for the Compass. He called this early application of industrial design to the design of Human-Computer Interaction (HCI) "*SoftFace*" (a contraction of "*software*" and "*interface*"). When Moggridge and Bill Verplank worked as consultants at the IDEO and ID Two design firms from 1986 to 1992, they started to call what they did "*interaction design*", instead of "*user interface design*" (Lauster 2003; Verplank 2007).

The numbers of designers creating interactive products for business, home use and entertainment grew as consumer interest in these products mushroomed from the mid 1980s onwards. HCI had traditionally "owned" the design of interactive products as an academic discipline (Preece *et al.* 2006: 10). The designers, however, came from a variety of academic disciplines, design practices and interdisciplinary fields, including HCI. These designers applied the theories, models and methods native to their disciplines, practices and fields to the development of interactive products.

It soon became apparent that diverse skill sets were required to produce successful interactive products and designers started to work together in multidisciplinary teams. New kinds of specialised jobs emerged, particularly in the area of web design and development, from the mid 1990s onwards. These included interaction disciplines such as information design (ID), information architecture (IA) and user experience (UX) design. Some designers began to call themselves interaction designers, rediscovering the name used by Moggridge and Verplank (Cooper *et al.* 2007: xxix).

The explosive growth in the number of corporate websites from 1995 onwards raised corporate awareness of IxD substantially (Cooper *et al.* 2007: xxix). Cooper *et al.* claim that the poor interactivity of the World Wide Web (due to limited functionality and responsiveness) set back progress in IxD by approximately a decade.

Winograd (1997) presented arguments for the necessity of IxD in his visionary work "*From Computing Machinery to Interaction Design"*. He foresaw the broadening of the scope of computing to support communication to a much greater degree than computation. This broader scope would incorporate the new discipline of IxD, which would focus on the design of the interaction between people and computer-based systems with an emphasis on the needs of the users and the use of the systems in a social context.

A debate arose from 2000 onwards about which interaction discipline "owned" the design of the user experience (UX) inherent in interactive products, and what it should be called. The UX unfolds when users interact with products. Armitage (2003) made a strong case for UX design as the overarching discipline. The entire May/June 2005 issue of <*Interactions*> (*Interactions* 2005) was devoted to this debate. Researchers

and practitioners reached a partial and uneasy consensus that all the interaction disciplines contributed to the UX and no single discipline "owned" it.

"*Interaction design*" (IxD) is currently accepted by a substantial constituency as a suitable name for the discipline concerned with the design of the behaviour of interactive products (Preece *et al.* 2006: 9). IxD has a broader scope than HCI, which is research-orientated. IxD has evolved to have theoretical and research aspects, in addition to its practical aspect, and overlaps with the parts of other disciplines, practices and fields explicitly involved in IxD activities.

A large number of researchers and practitioners currently regard themselves as interaction designers. The Interaction Design Association (IxDA) was established on 29 September 2005 to represent the interests of interaction designers worldwide (IxDA 2007a). There are currently over 1,500 registered members.

A number of different definitions of IxD are discussed in the next section in order to synthesise a comprehensive definition of IxD.

2.2.2 Definition

Reimann and Forlizzi (2002) define IxD as "*a design discipline dedicated to defining the behavior of artifacts, environments, and systems (i.e., products)*". IxD defines the form of interactive products as it relates to their behavior and uses. It anticipates how the use of these products mediates human relationships and affects human understanding. It explores the dialogue between interactive products, the people that use them and their context of use. This context can be physical, cultural or historical. Reimann and Forlizzi's definition of IxD incorporates the possibility of non-digital products seen as systems, but does not explicitly state that IxD is part of UX design.

One of the goals of IxD is to improve the human condition through ethical, purposive, pragmatic and elegant design (Reimann and Forlizzi 2002). IxD is thus seen as a value-centred and value-driven design discipline. This view of IxD is shared by

Goguin (2003) from a semiotic perspective and McMullin (2008) from a user and business needs perspective.

There is a narrow and a broad definition of IxD (Moggridge 2006b: 659). Moggridge's narrow definition of IxD is "*the design of the subjective and qualitative aspects of everything that is both digital and interactive, creating designs that are useful, desirable, and accessible*." This definition explicitly states that products are digital. It focuses on aesthetic and qualitative values, as traditional design practices (e.g. graphic design, industrial design and architecture) also do. Moggridge's definition is thus value-centred and value-driven. Moggridge's broad definition of IxD is "*the design of everything that is both digital and interactive*." This definition includes design to satisfy aesthetic and qualitative values and the activities of computer science, graphic design, HCI, psychology and other disciplines that contribute to the development of interactive products. The researchers and practitioners in the various disciplines may work as individuals on IxD research or practice, but more typically work in multidisciplinary teams.

Preece *et al.* (2006: 8) define IxD as "*designing interactive products to support the way people communicate and interact in their everyday and working lives*". They view IxD as a combination of "pure" IxD and the overlap with contributing disciplines in the broader sense expressed by Moggridge. Preece *et al.*'s definition of and approach to IxD is grounded in the empirical tradition of HCI.

IxDA defines IxD as "*the branch of user experience design that illuminates the relationship between people and the interactive products they use*" (2007b). According to IxDA, IxD "*defines the structure and behaviours of interactive products and services and user interactions with those products and services*". The IxDA definition views IxD as a subfield of UX design and does not explicitly state that the products are digital. The view that IxD is a subfield of UX design is not unanimously held. Cooper *et al.* (2007: xxx) maintain that the models and methods of UX design do not apply to the design of complex, digital, interactive products.

In this thesis, IxD is not viewed as a subfield of UX design (Cooper 2007: xxx)), interactive products are viewed as exclusively digital (Moggridge 2006b: 659) and

IxD is viewed as a value-centred and value-driven discipline (Reimann and Forlizzi 2002; Goguin 2003; Moggridge 2006b: 659; McMullin 2008).

A definition that incorporates these three views by expanding the working definition given in Section 1.1 is as follows:
IxD is a design discipline concerned with the definition and creation of useful, desirable and accessible digital interactive products to support their users in particular contexts of use, by defining:

1. *The structure and behaviour of the products, and;*
2. *User interactions and experiences with the products or mediated by the products.*

Interactive products can be objects, activities, services and environments. Contexts of use can be physical, conceptual, cultural or historical.

The IxD process is discussed in the next section, beginning with the philosophy of user-centred design.

2.3 The Interaction Design Process

2.3.1 User-Centred Design

Successful IxD requires an early focus on users and their goals, tasks and actions, and pervasive iterative design and evaluation throughout the IxD process (Gould and Lewis 1983). User-centred design (UCD) is a design philosophy aimed at satisfying these requirements. UCD is the grounding philosophy of IxD and relates directly to the view of IxD as a value-centred and value-driven discipline, as expressed in the expanded definition of IxD (Section 2.2.2). UCD is also a design process consisting of a number of activities based upon these requirements (Norman and Draper 1986). These activities are essential components of the IxD process.

The users referred to in the definition of IxD are primary users, who use a product directly. Secondary users are people who affect or influence the development of a product or who are affected or influenced by it, but who do not use it directly. Primary users and secondary users are collectively known as stakeholders. User-centred design focuses on all stakeholders, but the major focus is on primary users.

The requirement of an early focus in UCD on users and their goals, tasks and actions implies five sub-requirements (Preece *et al.* 2006: 426):

1. User goals and tasks are the reference point in a project, not technology;
2. User behaviour and use context are studied and the product is designed to support them;
3. User behavioural characteristics are captured, and the product is designed to take these into account and compensate where necessary and possible;
4. Users are consulted throughout and their responses are taken seriously; and
5. All design decisions take the users, their work and their environment into account.

Participatory design is a variant of UCD in which users are actively involved in the design process as members of design teams (Ehn 1990; Bødker 1996). A study of participatory web design using patterns (Dearden *et al.* 2002) was discussed in Section 1.2.

The requirement of pervasive iterative design implies a Design-Build-Evaluate cycle running throughout the lifetime of a project. Product prototypes are designed and built and evaluated, issues that are discovered during evaluation are corrected and improved prototypes are designed, built and evaluated. The requirements for an interactive product generally cannot be completely specified at the beginning of a project (Dix *et al.* 2004: 234-236 and 241; Preece *et al.*: 428). Iterative design is the solution to this problem.

The requirement of evaluation throughout the IxD process implies that specific usability and user experience goals must be identified, documented and set at the start of a project (Section 2.4.1). These goals are used to guide and monitor progress

during a project. This includes the activities of designing alternatives, choosing between alternative designs and evaluating evolving product prototypes.

UCD and the use of guidelines and patterns are closely linked. The requirement of an early focus on users and their goals, tasks and actions influences the later selection and use of particular physical design and evaluation aids. For example, a telephone-based interactive product for municipal accounts might require the selection and use of interactive voice recognition (IVR) guidelines. The use of particular physical design and evaluation aids in turn supports iterative design and evaluation towards the end of the UCD process.

Considering the close relationship between UCD and the use of guidelines and patterns, pattern use could contribute towards improving the quality of UCD, if patterns are indeed an improvement on guidelines (Research Objective 5, Section 1.3.2).

2.3.2 Process Models

The process of IxD is made up of several well-defined activities (Section 1.1). The process can be described by means of a generic lifecycle model (Preece *et al.* 2006: 428). This model incorporates four basic activities (Figure 2.1):

1. Identifying user needs and establishing requirements;
2. Developing alternative designs that satisfy the requirements;
3. Building interactive versions of selected alternative designs; and
4. Evaluating the usability and user experience of these interactive versions and checking that they satisfy the requirements.

All design disciplines (e.g. architecture, graphic design, industrial design and software design) share the activities of requirements specification, development of alternative designs and design evaluation. IxD is strongly user-centred (Section 2.3.1) and focuses on product interactivity. The users must be able to interact with evolving

product prototypes, unlike other design disciplines. IxD thus incorporates the activity of building interactive versions of designs (Preece *et al.* 2006: 416).

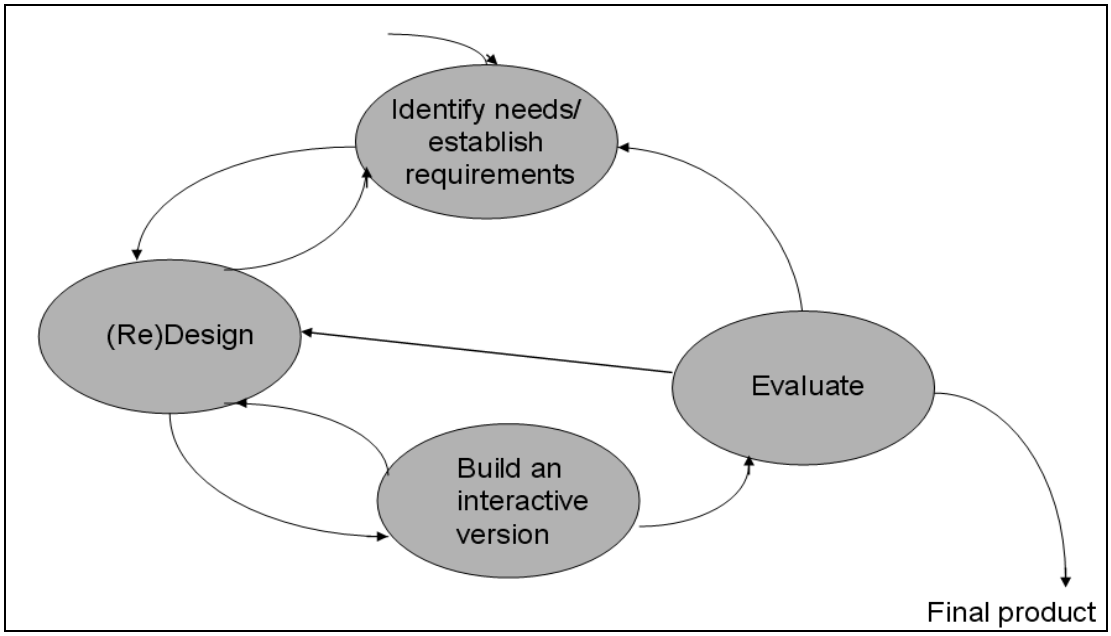


Figure 2.1: Generic IxD Lifecycle Model (Preece *et al.* 2006: 428)

The generic IxD model was derived by analysing a number of lifecycle models to identify common activities. These included software engineering lifecycle models such as the Waterfall Lifecycle Model (Royce 1970: 1-9) and Agile Development Methods (Armitage 2004; Sharp, Biddle, Gray, Miller and Patton 2006), and HCI lifecycle models such as the Star Lifecycle Model (Hartson and Hix 1989) and the ISO 13407 Human-Centered Design Processes for Interactive Systems standard (ISO13407 1999).

The lifecycle models of Dix *et al.* (2004: 195) and Stone *et al.* (2005: 15) are additional models that exhibit the generic IxD model structure. Cooper *et al.*'s Goal-Directed Design Process model (2007: 20) is one of a number of similar models used by IxD companies. Cooper *et al.*'s model is based on Crampton Smith and Tabor's five-component model of IxD (2007) (understanding, abstracting, structuring, representing and detailing), and also exhibits the generic IxD model structure.

Figure 2.1 shows the generic IxD model as a finite state machine (FSM), with directed edges depicting the possible transitions between activities (states). Identifying user

needs and establishing requirements (requirements specification) is generally the start state for the design of new products. The Evaluate activity is generally the start state for the redesign of existing products. The Design-Build-Evaluate cycle (Section 2.3.1) appears in the lower half of the FSM. The cycle is made up of the Design/redesign, Build interactive versions and Evaluate activities.

The IxD activities are performed by interaction designers, or multi-skilled practitioners wearing interaction designer "hats". *An interaction designer is a practitioner who specifies the way that users interact with an application, chooses the interface components, and lays them out in a set of views.* Designers may work in specialist IxD companies, such as IDEO (http://www.ideo.com/) or Cooper (http://www.cooper.com/).

The Design-Build-Evaluate cycle terminates when the prototype satisfies the requirements, exiting to the production version of the product via Implementation (managed and executed as a classic software engineering activity). Implementation is done by software developers. *A software developer is a practitioner who writes the application code for the interfaces and internal components of applications.* It is quite common for a client to commission a design company to do IxD for a project, the design company to do the design and then to hand it over to the client or a third-party software or engineering company for implementation (Cooper *et al.* 2007).

The four activities of IxD are reviewed in the next section. Particular attention is paid to the Design/redesign and Evaluate activities, because these activities use physical design and evaluation aids such as guidelines and patterns.

2.4 Interaction Design Activities

2.4.1 Requirements Specification

Requirements specification is generally the first activity undertaken when a new IxD project starts (Preece *et al.* 2006: 474). A requirement is a statement about an aspect of an interactive product that specifies what it must do or how it should perform, but not how to achieve this (Dix *et al.* 2004: 228; Preece *et al.* 2006: 476). Requirements specification has two aims: to identify the users' needs and to establish the requirements.

The identification of user needs requires a sound understanding of the nature of the users, their goals and tasks and the context of their activity (Preece *et al.* 2006). User needs can be cognitive, ergonomic, cultural or based on the users' history. This information is required to ensure that the product will allow the users to achieve their goals. The users referred to are primary users (Section 2.3.1). Surrogate users are employed if access to the primary users is not possible. The reference to activity covers products that support the work of their users and products that are intended for non-work use.

Establishing the requirements involves identifying and documenting a set of requirements, using the user needs as a point of departure (Dix *et al.* 2004). Requirements include functional requirements and non-functional requirements. Functional requirements state what the product must do and non-functional requirements state the constraints on the product, its operating environment or the development process.

Non-functional requirements are particularly important in the IxD process. Preece *et al.* (2006: 478) categorise non-functional requirements into data requirements, environmental requirements and user characteristics:

1. Data requirements include type, volatility, size or amount, persistence, accuracy and value of data;

2. Environmental requirements are further categorised into physical, social, organisational and technical environmental requirements; and
3. User characteristics are the key attributes of the users (age, gender, abilities, skill set, skill levels, product use frequency, nationality, etc.).

Two additional and vital types of non-functional requirements are usability goals and user experience goals. Usability goals such as effectiveness, efficiency, safety, utility, learnability and memorability (Nielsen 1993) are objective goals and can be measured empirically by means of various usability metrics. User experience goals such as enjoyability, aesthetic pleasure and motivation are subjective goals and can be measured by means of qualitative methods.

Requirements specification involves the four activities of data gathering, analysis, interpretation and presentation, carried out iteratively.

Data gathering involves studying the potential users of a product in their working, home or social environment. This may be done by observation, interviews, questionnaires and surveys, documentation study and similar product research (Stone *et al.* 2005; Preece *et al.* 2006).

Data analysis, interpretation and presentation are done using various representational techniques and notations. Presentation is representing the requirements using modelling tools. User characteristics can be modelled by user profiles and personas (Cooper, 1999). User goals and tasks can be modelled using scenarios (Carroll 2000), use cases (Jacobson, Christerson, Jonsson and Overgaard 1992), essential use cases (Constantine and Lockwood 1999) and task analysis (Annett and Duncan 1967). Recording and structuring of requirements can be done using document templates (e.g. Volere Requirement Specification Template (www.volere.co.uk/template.htm)). Functional requirements can be recorded by means of data-flow diagrams. Data requirements can be modelled by means of entity-relationship models. If an object-oriented design approach is being followed, UML diagrams (e.g. class diagrams, state charts and sequence diagrams) are appropriate.

Divergent idea-generating techniques, including brainstorming sessions (Kelly 2001), are appropriate if innovation is required to invent new products and explore their design, user and use context possibilities.

The four requirements specification activities may influence each other as requirements specification progresses. The results of analysis may initiate additional data gathering to fill in gaps in understanding. The modelling tools may affect the analysis, resulting in an emphasis being placed on certain aspects of the requirements. Designers must thus be aware of the potential for bias in requirements specification and make a conscious effort to ensure that the requirements are objective (Preece *et al.* 2006: 406).

Specifying the requirements properly at the beginning of a project is critical for the success of an IxD project (Preece *et al.* 2006). The requirements must be stable, clearly expressed, as complete as possible, correct and unambiguous before they are applied in design.

Software engineering research into the causes of software defects and the high costs of repairing these defects late in the software development lifecycle confirms the importance of good-quality requirements. Taylor (2000) highlighted the substantial contribution of requirements errors to software failures. Boehm and Basili (2001) emphasised the high costs of software defect repair at the end of a project and also identified requirements errors as an important factor in these high costs. This research is applicable to IxD projects because software is an important component of interactive products. Software defect repair in IxD projects is classified as avoidable rework, to distinguish it from unavoidable rework forming part of prototyping during the Design-Build-Evaluate cycle (Boehm and Basili 2001).

It is generally impossible to completely specify the requirements at the beginning of an IxD project. This is due to the difficulty of foreseeing what users really need and require and how they will behave when interacting with prototypes (Dix *et al.* 2004: 234-236 and 241; Preece *et al.* 2006: 428 and 474). The requirements specification activities at the beginning of a project are thus carried out iteratively until the user

needs and requirements are sufficiently well-defined and stable to allow conceptual design to start.

Requirements specification may be revisited a number of times during an IxD project (Preece *et al.* 2006). This is because feedback from the Design-Build-Evaluate cycle may suggest additions, changes and deletions to the requirements, resulting in evolutionary improvements to the prototypes. In some cases the requirements become complete only after the production version of a product has been shipped. Requirements specification for interactive products is thus an emergent process, rather than a reductionist process.

The requirements will be sufficiently complete, correct and unambiguous if the users' needs have been identified and the requirements have been properly specified. Design or redesign can start and the development process will not be delayed by unnecessary iterations.

The requirements are used to design, build and evaluate a series of progressively more concrete and detailed product prototypes during the Design-Build-Evaluate cycle. The requirements will influence the selection and use of particular physical design and evaluation aids during physical design. For example, if an interactive product for selling sporting goods online is required, web design patterns or guidelines supporting personal E-commerce are likely to be selected to aid physical design.

2.4.2 Design

Developing alternative designs involves two types of design activity: conceptual design and physical design.

Conceptual design is the process of employing user needs and goals and the requirements to produce a conceptual model (Johnson and Henderson 2002: 26; Preece *et al.* 2006: 51). A conceptual model is a high-level, abstract description of

what a product will do for and with its users (its conceptual organisation) and how its users can interact with it during use (how it operates).

The conceptual model provides a focus for IxD activities (Johnson and Henderson 2002). A lexicon of named terms can be derived from the conceptual model to promote a common understanding of the IxD project in the project team. Use-cases and scenarios can be written for the conceptual model. Physical design, implementation and testing can be done using the conceptual model as a reference base and the physical design is likely to be more consistent and coherent as a result. The conceptual model is small compared with the physical design and is thus easier for a project team to work with.

A conceptual model contains the following (Johnson and Henderson 2002: 26):

1. Major design metaphors and analogies;
2. System concepts, including data and operations on data;
3. Inter-concept relationships; and
4. Concept to application domain mappings.

The functional requirements will determine what an interactive product can do for and with its users. Various factors, including user needs and goals, interface metaphors, interaction types, interface types and the application domain, will determine how a product's users can interact with it during use (Preece *et al.* 2006: 540).

Evolutionary prototyping (Section 2.4.3) can be used to produce the conceptual model (Dix *et al.*). Prototypes are iteratively designed, constructed and subjected to rigorous testing. Alternative designs are produced during early design in order to avoid constraining the design space. If the conceptual model is inadequate, it may be used to produce final requirements and discarded (throw-away prototyping).

Designers start the process of conceptual design by studying the requirements in an empathetic way in order to form an idea of how users could interact with a product (Preece *et al.* 2006: 540). This process is assisted by creating scenarios and low-fidelity prototypes to capture ideas. These prototypes are iteratively evaluated and elaborated or discarded on the basis of feedback. Techniques such as experience

prototyping (Buchenau and Suri 2000) can help with this process. The scenarios and prototypes are shaped by the requirements and what is technically feasible. An understanding of the desired user experience will start to emerge during conceptual design.

Conceptual design is assisted if the designers keep the requirements in mind all the time and remain open to new ideas and change. Designers conduct an ongoing dialogue with other stakeholders and carry out iterative usability evaluations throughout the conceptual design process. Beyer and Holtzblatt's Contextual Design method (1998) is an example of this. The use of low-fidelity prototyping (Section 2.4.3) helps to ensure short iteration cycles. The conceptual model or the final requirements generated by throw-away prototyping during conceptual design is the foundation for physical design.

Physical design is the process of producing a physical design by prototyping and is generally based on the conceptual model or the final requirements generated by throw-away prototyping during conceptual design (Johnson and Henderson 2002: 26; Preece *et al.* 2006: 51). A physical design is the detailed design of the user interaction and the user interface of a product.

The boundary between conceptual design and physical design is ill-defined (Preece *et al.* 2006). Conceptual design focuses on the outline design of a conceptual model in an exploratory way, but it is common for details to be considered, albeit tentatively. Physical design focuses on the detailed design of the product's user interaction and the user interface, but it is common for conceptual design decisions to be revisited and reworked.

The point of departure in physical design is user needs, product requirements and the conceptual design (Preece *et al.* 2006). This includes knowledge of the nature, goals and tasks of the expected users of the product, the application domain of the product and the user tasks that the product will support.

The user's cognitive processes must be taken into account in physical design. High-level theories such as Norman's Stages-of-Action model (1988) assist designers in

achieving this. The user's affective processes must also be considered, as these contribute to usability and the user experience. Three models are generated by the use of Norman's Stages-of-Action model: the designer's model, the user's mental model and the system image. Metaphors can be useful in assisting users to develop accurate mental models of an evolving interactive product.

The next step in physical design is to select an interaction style or a collection of styles for the interactive product. The choice is determined by the user needs, requirements and lessons learned from the conceptual design. Current interaction styles are command language, menu selection, natural language, question/answer and query dialogue, form fill-in, spreadsheet-style interaction, direct manipulation (WIMP), point-and-click and three-dimensional interfaces (Dix *et al.* 2004; Preece *et al.* 2006). Most user interfaces employ a blend of two or more interaction styles.

An interactive product can be one of a variety of things. For example, it can be a desktop application, a website, a physical device or a social networking system (Dix *et al.* 2004: 204).

The physical design of an interactive product is multilayered:

1. The top level of a physical design is navigation design in the case of applications and social networking systems, site maps in the case of websites and device modes in the case of devices;
2. The middle level consists of the screens of applications, the pages of websites and the physical layouts of devices;
3. The bottom level consists of the user interface components, the tags, form elements and links of websites and the controls and displays of devices; and
4. An additional layer above the top level deals with interfaces to external environments, such as file systems, web browsers and communication networks.

At all the levels of a product, user interface elements have to be selected and their behaviours specified. All of the parts of a product must work together as a harmonious whole.

At the top level, the design must support a suitable application topology, which could be a hierarchy or a linear structure, linking screens, pages or device states in logical groups. A dialogue structure (which supports user task sequences) would generally be superimposed on top of the application topology for ease of navigation.

At the middle level (e.g. a screen or a web page or a state), feedback must be provided to the users to allow them to know where they are and what they can do. Knowledge must also be provided on where they will go or what will happen if they choose to carry out a supported action. Users must also know where they have been and what they have done. The information design and the presentation design will be strongly influenced by the dialogue structure and local situational knowledge.

Guidelines play an important role in physical design at all levels (Dix *et al.* 2004). There are numerous guidelines for a variety of application domains organised in a number of collections. Collections of a few high-level Golden Rules and heuristics and design principles are applied to the top level, overall physical design, but these principles require careful contextual interpretation. Collections of medium-level design guidelines and low-level design rules are applied to the middle and bottom levels of a physical design. Such guidelines can be specific to a particular type of product (for example, a website) and can thus be applied with little or no interpretation. Standards (which are design guidelines of high authority) are applied in the same way as general guidelines and design rules.

Style guides are collections of low-level design rules specific to a particular operating system, class of application programmes or corporate style. Style guides help designers to maintain consistency and conformance to the relevant environment's presentation design and interaction behaviour.

IxD patterns have achieved acceptance among designers as an alternative design aid to guidelines (Dix *et al.* 2004: 284). Patterns state their design context explicitly, unlike guidelines. An advantage of pattern languages is that they support complete designs at all levels, unlike the more loosely organised guideline collections.

The different factors that shape a physical design are frequently in conflict. A designer has to make trade-offs or compromises to balance the opposing forces that shape a solution (Dix *et al.* 2004: 193). Patterns explicitly state the trade-offs incorporated in their design advice, unlike guidelines. This makes patterns more attractive as physical design aids.

Physical design can be the design of a new product or the redesign of an existing product (Section 1.2). New design is based on requirements and is a full design within the IxD process. Redesign, or after-release maintenance (Lientz and Swanson 1980; ISO/IEC 14764), differs from new design in that it is a partial design that takes place after a product has been evaluated. Redesign is generally not based on functional requirements, but on a checklist of features to be added, corrected or modified. The design of new products and the redesign of existing products thus require physical design, but this clearly differs for new and existing products in terms of scale and process.

Little research has been done on redesign, although it is a commonly occurring activity in IxD. For example, websites are frequently redesigned. Four reasons for doing redesign are:

1. Extension of functionality (adaptive maintenance);
2. Correction of selected, previously identified usability problems (corrective maintenance);
3. Improvement of performance or maintainability (perfective maintenance); and
4. Correction of latent faults before they become patent (preventative maintenance).

Adaptive maintenance is the most common reason for redesign, followed by corrective maintenance (Lientz and Swanson 1980).

Detailed software design by software developers often takes place in parallel with physical design. Interactive versions of conceptual models and designs need to be built so that the models and designs can be evaluated.

2.4.3 Building Interactive Versions

Interactive versions of designs are of two kinds: prototypes and completed products. A prototype is a limited representation of a design that people can interact with to determine how suitable the design is (Preece *et al.* 2006: 530). Prototypes are necessary because it is difficult to specify all of the requirements in advance for an interactive product (Section 2.3.1). Prototyping does not guarantee an optimal design, as it is a hill-climbing design approach (Dix *et al.* 2004: 220). Good designs are more likely to result from good starting ideas, talented designers and multiple initial design ideas during conceptual design, which are eliminated one by one.

Prototypes always embody compromises (Preece *et al.* 2006). For example, a prototype may be a vertical prototype (providing limited but detailed functionality) or a horizontal prototype (providing comprehensive but superficial functionality).

Prototypes are used for four purposes (Preece *et al.* 2006):

1. To test the technical feasibility of an idea;
2. To clarify selected, unclear requirements;
3. To do usability testing and evaluation; and
4. To check that a design direction in a product component is compatible with the overall product design direction.

Prototypes can be classified into two types: Low-fidelity prototypes and high-fidelity prototypes. Low-fidelity prototypes do not much resemble the final product, in respect of materials of manufacture and appearance (Dix *et al.* 2004). Low-fidelity prototypes are useful because they are simple, cheap and quick to make and to modify, based on the results of evaluation, and support and encourage exploration of alternative ideas and designs by means of short Design-Build-Evaluate cycles. Low-fidelity prototypes are thus particularly useful during conceptual design and are throw-away artefacts, which are not integrated into the final product.

There are several types of low-fidelity prototypes (Dix *et al.* 2004):

1. Sketches are used to prototype design architectures and interface designs, and draw storyboards;
2. Storyboards are used to support role-playing by users executing tasks by augmenting scenarios with detail;
3. 3x5 index cards are used to prototype interactions, with each card representing a screen or a task element; and
4. Wizard of Oz prototypes are software mock-ups of products that users interact with and which are controlled by humans at remote computers.

Medium-fidelity prototypes are late low-fidelity prototypes that resemble the final interactive product in appearance. They are often paper prototypes consisting of top level designs (navigation design in the case of applications and social networking systems, site maps in the case of websites and device modes in the case of devices) and wireframes (mock-ups of screens of applications, the pages of websites and the physical layouts of devices). An example of a sitemap is shown in Figure 2.2. The wireframes show the information design (ID) and IxD of an interactive product and its functionality, but not its presentation design. An example of a wireframe is shown in Figure 2.3. Medium-fidelity prototypes are the physical designs produced using physical design aids such as guidelines and patterns. Medium-fidelity prototypes could therefore be used as design representations in the empirical study of guidelines and patterns.

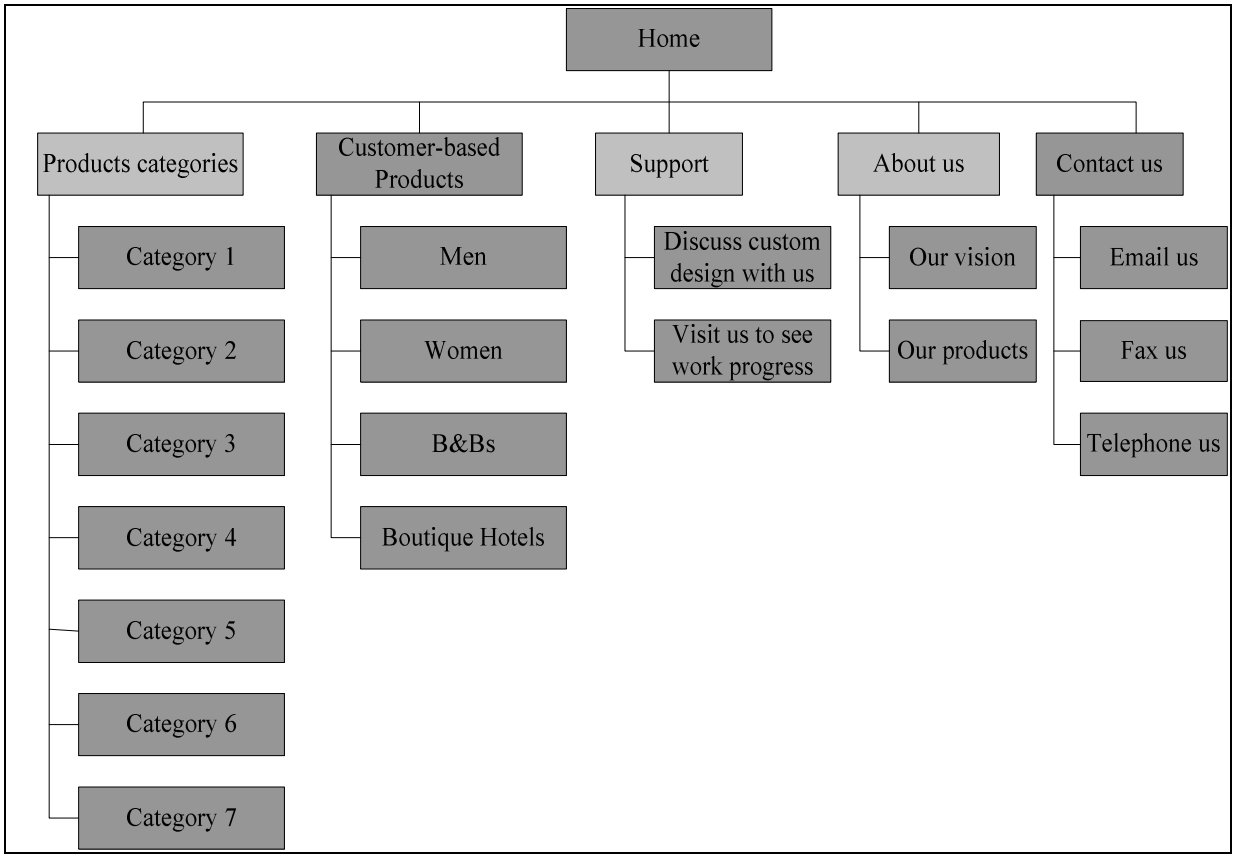


Figure 2.2: Example of B2C E-Commerce Site Map

High-fidelity prototypes resemble the final product, in respect of materials of manufacture, appearance and functionality (Rettig 1994). High-fidelity prototypes are useful for testing technical issues and marketing the product and are the result of implementing physical designs. High-fidelity prototypes can be built using programming tools, for example `Flash` and `VB.net`.

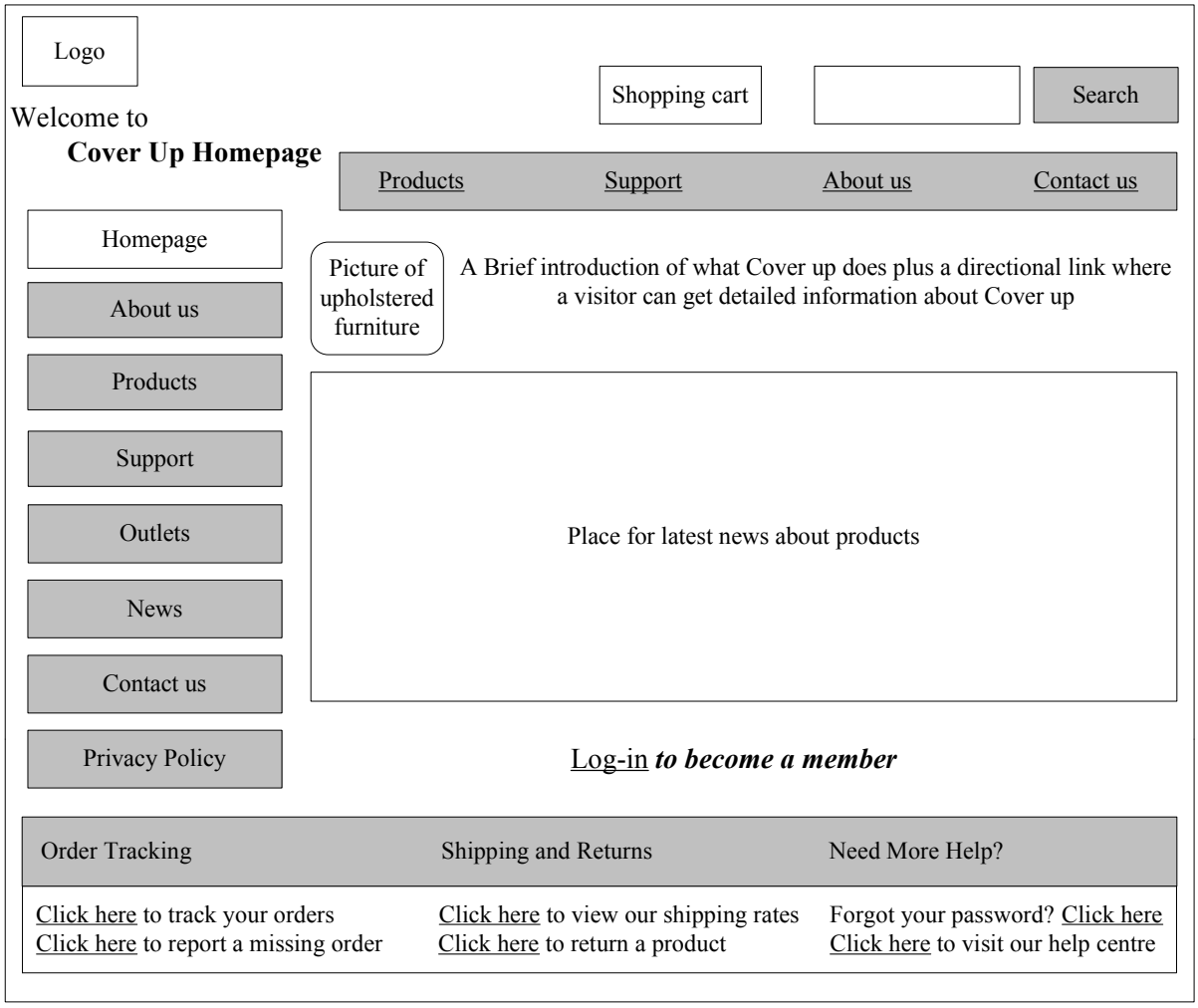


Figure 2.3: Example of B2C E-Commerce Home Page Wireframe

The final product is implemented by developers once the various prototypes have been through sufficient iterations of the Design-Build-Evaluate cycle for the latest prototype to successfully meet the requirements. This can be done either by evolutionary prototyping, in which a final high-fidelity prototype is refined into the product or by throwaway prototyping, in which the prototype is discarded and the product is developed from scratch, using the prototype as a physical design.

2.4.4 Evaluation

Evaluation is the collection and analysis of information about the experiences of users and IxD practitioners when using prototypes at various stages of an IxD project, or

completed interactive products (Dix *et al.* 2004). Prototypes can be conceptual design prototypes, early design prototypes (e.g. sketches), physical designs or interactive versions of the physical designs of applications and devices. Information is collected about the usability of prototypes or interactive products and the user experiences of the people using them. The aim of evaluation is to improve the usability and the user experience of the prototypes or interactive products evaluated. The people involved can be users, surrogate users or experts involved in product development.

Evaluation for a new interactive product begins after establishing the requirements and the creation of initial prototypes, which may be low-fidelity design prototypes or sketches (Preece *et al.* 2006). The prototypes are evaluated by means of usability testing and the evaluation feedback is used to generate improved and extended versions of the prototypes or new prototypes, starting the Design-Build-Evaluate cycle. This type of evaluation, done during design to establish whether an evolving product continues to satisfy its user needs and to improve it if necessary, is called formative evaluation. Evaluation done to check that the completed product satisfies product standards is called summative evaluation. Summative evaluation is done at the end of the design of a new product.

Summative evaluation of an existing interactive product requiring upgrading is often the first step in redesign, since the focus is generally on improving specific aspects of the product's design and not on establishing a new set of functional requirements. The interactive product is evaluated and the evaluation feedback is used to start the Design-Build-Evaluate cycle which will result in an improved or extended version of the product.

Usability evaluations can be done in natural settings, for example a user's place of work, or in a usability laboratory (Preece *et al.* 2006). Evaluations in natural settings have the advantage of gathering data on the use of an interactive product in the social setting where the product is likely to be used. Evaluations in a usability laboratory have the advantage of gathering data on the use of an interactive product in a controlled environment where extraneous and possibly confounding factors can be managed.

There are three main approaches to usability evaluation (Nielsen 1994). These are field studies, usability testing and analytical evaluation. These approaches may be used in a blended way during the lifetime of a project in order to triangulate onto a broad and multifaceted understanding of the quality of a design. Opportunistic (informal) evaluations are useful during conceptual design for deciding whether an idea is worth pursuing.

Analytical evaluation involves experts making use of two kinds of evaluations: inspections (or expert reviews) (Nielsen 1994) and theoretically based models. Inspections include heuristic evaluations and cognitive walkthroughs. Heuristic evaluation is of particular interest for this research as it involves the use of guidelines. Heuristic evaluation is a usability inspection method in which a physical design or an interactive application is systematically inspected for usability problems by one or more usability experts, using a set of heuristics. Heuristics are selected high-level, general usability principles and are so named because they are rules of thumb instead of specific guidelines.

Heuristic evaluation can be done quickly and easily by a small number of experts (four to seven) and does not require special facilities or equipment beyond a paper-based or online evaluation form. Appendix A shows an example of a heuristic evaluation form that employs Nielsen's ten heuristics.

The results of heuristic evaluation are presented in heuristic evaluation reports. Heuristic evaluation reports generally contain a discussion of usability issues and (in some cases) good design features identified in terms of the heuristics. Issues have severity ratings associated with them, often on a scale of 0 (not applicable) to 4 (serious problem). An extract from a heuristic evaluation report appears in Figure 2.4.

Detailed Findings

The following tables contain detailed findings for a total of 23 usability issues. A severity rating has been assigned to each issue, depending on the probable impact on customers.
Key to severity ratings

The findings can be grouped by type of heuristic, severity level or location by using the links below.

Group findings by: Heuristic | Severity | Location

Jump to section: Visibility | Consistency | Language | Control | Error prevention | Aesthetic and minimalist design

Return

Visibility (5 issues)

The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.

Severity	Location	Issue	Recommendation
Medium	Localisation page	The window title would benefit from a tagline to describe what the Eurostar is, as 'Eurostar bookings, timetables, fares, city breaks, and special offers' may sound more like a holiday company.	A more direct tagline could be "Eurostar - The direct high-speed passenger train operating between London, Paris and Brussels".
Medium	Localisation page	There is no tagline on the home page to describe what the website is about.	A straightforward tagline on this page would indicate to customers that they are in the right place. For example: "Eurostar - The direct high-speed passenger train operating between London, Paris

Figure 2.4: Extract from Heuristic Evaluation Report (http://www.alexpoole.info/commercial/eurostarevaluation.html, last referenced on 04/02/2009)

Heuristic evaluation reports should be carefully considered and treated with caution. It has been established that the empirical results of various usability inspection techniques, including heuristic evaluation, have some flaws (Gray and Salzman 1998) and this has raised questions about their effectiveness. A canonical framework for measuring the effectiveness of usability evaluation methods has been developed (Hartson, Andre and Willeges 2001), but a number of problems remain. Various research programmes to investigate the problems of inspection techniques and propose improvements are being conducted under the auspices of the MAUSE project (http://www.cost294.org/).

Comparative Usability Evaluation (CUE) research (Molich, Ede, Kaasgaard and Karyukin 2004: 65-74) is research conducted on the usability evaluation of an artefact by several independent evaluation teams in order to:

1. Collect data on how evaluators do usability evaluation in practice;
2. Compare the effectiveness and efficiency of different evaluation approaches; and
3. Improve evaluation practice through lessons learned.

Data are obtained by assigning a usability evaluation task to the teams, who each perform the evaluation using particular inspection techniques (e.g. heuristic evaluation or cognitive walk-though (Nielsen 1994). These teams are required to prepare an evaluation report on the usability issues discovered and the associated severity ratings. The reports are processed in order to compare and contrast the types, numbers and severity of usability issues found by the different teams.

CUE research has revealed that:

1. Most usability problems are reported by a small number of teams;
2. A large number of usability problems are identified in typical systems by teams; and
3. Large variations in evaluator performance are observed.

The results observed in CUE research are due to the evaluator effect (Jacobsen *et al.* 1998; Hertzum and Jacobsen 2001). The evaluator effect is the observation that different evaluators who evaluate the same product using a particular usability

evaluation technique tend to identify substantially different usability issue sets and rate issues differently. The evaluator effect is a measure of issue identification reliability and not of issue validity. Evaluation using current evaluation aids and evaluation methods requires human judgement and this could affect intra-rater or inter-rater variability. Possible causes of the evaluator effect include differing design mental models and variations in human performance on evaluation tasks.

Nielsen's set of ten heuristics may be too general for some new categories of interactive products (e.g. mobile devices). Category-specific high-level guidelines expressed as heuristics may be more appropriate (Preece *et al.* 2006): 688). If informed users are used as inspectors in heuristic evaluation instead of usability experts, this is called participatory heuristic evaluation (Muller, Matheson and Gallup 1998).

Guidelines are also used in the form of usability checklists, using sets of general guidelines or rules (Newman and Lamming 1995): 379) to inspect a design for structural and functional compliance with a particular category of product. A disadvantage of usability checklists is that their use is time-consuming and tedious due to the large numbers of guidelines involved (Shneiderman 2006)

Guidelines play an important part in evaluations when used in inspections. In the case of a new product, formative evaluation of prototypes, physical designs or interactive versions of designs using heuristic evaluation or usability checklist inspections may be conducted. In the case of an existing product requiring upgrading, summative usability evaluation, followed by inspection of physical redesigns or interactive versions of redesigns may be conducted.

Patterns can also be used for evaluation (Wesson and Cowley 2003; Chung *et al.* 2004). There is limited research on how patterns are selected and used for evaluation, but is possible that pattern languages may be more difficult to understand and use for evaluation than guidelines.

2.5 Conclusions

This chapter presented a review of IxD, in order to achieve Research Objective 1 (Section 1.3.2), namely "*Investigate the role of design and evaluation aids in IxD.*" The objective of the review was to identify the role of guidelines and patterns for physical design and evaluation in the IxD process.

A revised definition of IxD was synthesised using a discussion of the origins of IxD (Section 2.2.1) and an analysis of several existing IxD definitions (Section 2.2.2). The definition was based on three views of IxD, namely that IxD is not a subfield of UX design, interactive products are exclusively digital and IxD is value-centred and value-driven.

The UCD process was identified as the grounding design philosophy of IxD (Section 2.3.1). UCD and the use of guidelines and patterns were found to be closely linked. An early focus on users and their goals, tasks and actions influences the selection and use of particular physical design and evaluation aids, which in turn supports iterative design and evaluation in the UCD process. Improvements in physical design and evaluation aids could thus contribute towards improving the quality of UCD processes and interactive products.

The generic IxD model of the IxD process, resulting from a number of software engineering and HCI models, was used to explore the context of the Evaluate and Design/Redesign activities (Section 2.3.1). The Evaluate activity is generally the start state for redesign. New design and redesign take place within the Design-Build-Evaluate cycle, which includes the Evaluate and Design/Redesign activities.

Requirements specification (Section 2.4.1) and conceptual design (Section 2.4.2) were found to influence the selection and use of particular guidelines and patterns as physical design and evaluation aids. Poor requirements specification and conceptual design activities have a negative effect on the outcomes of the downstream IxD processes, including physical design and late evaluation. The results of evaluation

during the Design-Build-Evaluate cycle may require redesign and implementation at a considerable cost.

The physical design of interactive products such as desktop applications, websites and devices was found to be inherently multi-layered (Section 2.4.2). Various types of design guidelines (Golden Rules and heuristics, design principles, general guidelines, design rules and standards) were found to play an important role in the design of the various levels.

IxD patterns are starting to gain acceptance among interaction designers as physical design aids. IxD patterns express their design context and the trade-offs incorporated in their design advice explicitly and support entire designs in an integrated way via pattern languages.

The importance of evolutionary prototyping and the use of various types of prototypes within the activity of Building interactive versions was highlighted (Section 2.4.3). Medium-fidelity prototypes were identified as a suitable type of design representation for use in the empirical study of guidelines and patterns.

Guidelines were found to play an important role in usability evaluation within the Design-Build-Evaluate cycle (Section 2.4.4). Guidelines are used for formative evaluation of new interactive products and summative evaluation of existing products. Guidelines are used in the form of heuristics for heuristic evaluation and longer guideline checklists for guideline review. Patterns can be used for usability evaluation, but little is known about selecting and applying patterns for evaluation.

Chapter 3 presents a literature review of guidelines and patterns and critically compares these aids. The review is used to formulate a set of research questions for the empirical study. It is the second of the two literature review chapters.

Chapter 3: Guidelines and Patterns

3.1 Introduction

Chapter 2 presented a literature review of the role of design aids in the interaction design (IxD) process. The role of guidelines and patterns in the physical design and evaluation phases of the IxD lifecycle was highlighted. This chapter has two objectives. The first objective is to present a comparative literature review of guidelines and patterns (Research Objective 2, Section 1.3.2). The review provides information about the similarities and differences between these design aids. The claims made for the potential advantages of patterns over guidelines are investigated. The second objective is to formulate a set of research questions required for the empirical study (Research Objective 3, Section 1.3.2). These research questions are based on an analysis of the usefulness of guidelines and patterns and the literature review.

3.2 Guidelines

3.2.1 Background

Guidelines have been used in the design of interactive systems for over 35 years, which reinforces their authority and credibility as design aids (Gould 1988: 780). The history of guidelines illustrates how earlier guideline collections influenced later collections.

Guidelines evolved over time from small beginnings. Earlier guidelines disappeared or were incorporated in new collections and new guidelines emerged (Mariage, Vanderdonckt and Pribeanu 2002).

Guideline survival rates are high. Ninety percent of the 1986 Smith and Mosier guidelines and 80% of the web design guidelines dating from the 1990s are still valid (Nielsen 2007).

The first published guidelines appeared in "*User Engineering Principles for Interactive Systems"* (Hansen 1971). These guidelines comprised four usability engineering guidelines (of which the first is still particularly well known to designers), namely *Know the user*, *Minimise memorisation*, *Optimise operations*, and *Engineer for errors*.

A collection of general user interface guidelines appeared in Engel and Granda's 1975 IBM report "*Guidelines for Man/Display Interfaces"* (Gould 1988: 780). This was the first collection of guidelines to achieve wide prominence (Smith and Mosier 1986: 16). This collection had a considerable influence on later guideline collections (Koyani, Bailey and Nall 2006: iii).

Hendricks, Kilduff, Brooks, Marshak and Doyle published a collection of Human-Computer Interaction (HCI) guidelines in eight categories that related to management information systems in 1982 (Gould 1988: 780). These guidelines, based on user research and a literature review, were intended to improve workforce productivity.

Smith and Mosier published a collection of 697 guidelines in six categories (1984) that were subsequently extended to 944 guidelines (1986). These guidelines focused on the software component of user interfaces. This collection, similar to Engel and Granda's collection, had a considerable influence on later guideline collections (Koyani *et al.* 2006: iii).

Apple Computers published the first style guide, for the Apple Macintosh platform, in 1982 (Apple 1982). This was followed by commercial and non-commercial style guides for various platforms, including Microsoft Windows and Motif.

A substantial number of conference papers, journal articles and books dealing with guidelines have been published, starting in the 1980s (Mayhew 1992: 163-164).

The appearance in 1991 of the World Wide Web and its subsequent rapid growth spawned many websites providing information on design guidelines and on web design guidelines in particular (Koyani *et al.* 2006).

Guideline collections historically applied to particular design layers (e.g. application screens, web pages and device layouts) (Smith and Mosier 1986: 16). Some recent collections can be applied to the IxD process and entire designs (Koyani *et al.* 2006).

Koyani, Bailey and Nall's downloadable online book "*Research-based Web Design & Usability Guidelines"* (2006) is an example of a recent, well-structured and authoritative collection of 209 guidelines. This collection incorporates a number of features that that makes it more usable and closer in format to pattern collections. The guidelines are organised into eighteen categories, which range from high-level to low-level.

3.2.2 Definition

A design guideline is a simple, prescriptive, imperative and textual rule, grounded in theory or good practice that can be applied in IxD in order to solve a particular class of design problems (Smith and Mosier 1986: 11; Newman and Lamming 1995: 374). Examples of several "classic" E-commerce guidelines are shown in Figure 3.1 (Barnard 2004). A guideline is a single unit of design advice, as may be seen from these examples.

A guideline is prescriptive (normative) because it states how to solve certain design problems—what should be or could be or should not be done (Newman and Lamming 1995: 374; Koyani *et al.* 2006: iii). A guideline is imperative because it is expressed as an instruction or suggestion to take action, and textual because it is expressed as a written natural language sentence. Guidelines are generally grounded in theory, which may be supported by empirical evidence (Dix *et al.* 2004).

A: Category Pages	
A1	**Category Pages: Store Home Pages**
a	Show what merchandise you sell and don't sell.
b	Beware of over-emphasising promotional items.
c	The home page should show the purpose of the site.
d	Don't hide the catalogue - enable shopping from the home page.
e	Reveal the product hierarchy.
f	Provide links on the home page to purchasing options, return policy, shipping and delivery information.
g	Provide links on the home page to customer service, privacy and company background information.

Figure 3.1: Examples of E-Commerce Guidelines (Barnard 2004)

A number of guideline collections embed the guidelines in an extended format, but a distinction is made between the guidelines (explicitly identified as guidelines) and the additional information (Smith and Mosier 1986; Koyani *et al.* 2006). An example is shown in Figure 3.2 (Koyani *et al.* 2006: 64).

Figure 3.2: Example of a Modern Guideline (Koyani *et al.* 2006: 64)

"*Guideline*" is the commonly used collective name for several similar kinds of IxD aids satisfying the definition given above. Dix *et al.* (2004: 259) use "*design rule*" as the collective name for these design aids.

Guidelines may be described in terms of their properties, as discussed in the next section.

3.2.3 Properties

Guidelines have seven properties, namely format, content, design context, origins, generality, authority and level of abstraction. These properties may be largely ascribed to Dix *et al.* (2004) and Newman and Lamming (1995) and are summarised in Table 3.1.

A guideline's format defines its syntax, and its content defines its semantics (as described in Section 3.2.2). A guideline's format is its physical form or structure (a single natural language sentence). A guideline's content is a brief instruction or suggestion to take action, embodied in the sentence.

#	Property	Description
1	Format	Physical form
2	Content	Information embodied in guideline
3	Design context	Applicable class of design problems
4	Origins	Evidence of scientific or practical credibility
5	Generality	Extent to which design context is constrained by domain
6	Authority	Extent to which guideline must be applied
7	Level of abstraction	Extent to which design advice is explicitly expressed

Table 3.1: Summary of Guideline Properties

A guideline has a design context (or context of use), which is the type of design problem to which it can be applied (Newman and Lamming 1995: 374 and 376). The overall design context of all guidelines is IxD (Newman and Lamming 1995: 382).

A guideline has origins, which are an indication of its scientific or practical credibility (Dix *et al.* 2004: 259). Guidelines are generally grounded in theory. This theory can be cognitive, computational, economic, ergonomic, psychological or sociological, and may be supported by empirical evidence. Guidelines may be grounded purely in good practice, but this is much less common.

A guideline has generality, which is the extent to which its design context is constrained by the domain (Dix *et al.* 2004: 259). General guidelines apply to a variety of application domains and specific (low-generality) guidelines apply to one or a few application domains (e.g. menus or mobile devices).

A guideline has authority, which is the extent to which it must be applied in design (Dix *et al.* 2004: 259; Newman & Lamming 1995: 374-375). Some guidelines are expressed as statements of fact or instructions (high authority) and some as suggestions or hints (low authority). Some guidelines (e.g. standards) have high authority because they carry the associated authority of the standards organisations that compiled them, and not merely because they are statements of fact or instructions.

A guideline has a level of abstraction, which is the extent to which it expresses its design advice explicitly (Dix *et al.* 2004: 259). An abstract guideline expresses its design advice without providing details about what should be done. A concrete (low abstraction, general) guideline expresses its design advice by providing a certain level of detail about what should be done.

A number of guideline classes have emerged over time, as a result of the need for design support for specific aspects of IxD, including physical design.

3.2.4 Classification

Guidelines may be grouped into five classes on the basis of their design context level, generality, authority, level of abstraction and additional meta-information (Dix *et al.* 2004: 282). The five classes are Golden Rules and heuristics, Principles, General guidelines, Rules and Standards. The classes and their property values are summarised in Table 3.2. Variations of this classification scheme exist.

#	Guideline Class	Design Context Level	Generality	Authority	Level of Abstraction
1	Golden Rules & heuristics	High	High	Low	High
2	Principles	High	High	Low	High
3	General guidelines	High to low	High	Medium	High to low
4	Rules	Low	Low	High	Medium
5	Standards	Low	Low	High	Low

Table 3.2: Summary of Guideline Class Properties

Golden Rules and heuristics are small sets of abstract guidelines of high generality and low authority that have a high-level design context (Norman 1990, Shneiderman 1992, Nielsen 1994, Dix *et al.* 2004: 282). Their origins lie in the psychological, computational and sociological theories of IxD, and they are largely independent of the supporting technology used in a particular project. These guideline classes do not need detailed and nuanced interpretation. Golden Rules and heuristics are "broad-brush" design and evaluation aids that will improve the quality of any interactive product (Dix *et al.* 2004: 282).

Principles are small sets of abstract usability guidelines of high generality and low authority that have a high-level design context (Dix *et al.* 2004: 260). They do not state their context explicitly. They are often expressed as abstract nouns (e.g. consistency, learnability, flexibility and robustness), instead of the more typical textual rules. Principles may have associated specific sub-principles (e.g. learnability is supported by the specific sub-principles of predictability, synthesisability, familiarity, generalisability and consistency) (Dix *et al.* 2004: 261).

Usability principles are applied to improve the usability of interactive products (Dix *et al.* 2004: 260) and are most useful during requirements specification (Dix *et al.* 2004: 277). Design principles are used to sensitise designers to desirable high-level attributes of designs.

The origins of principles lie in IxD theories, and they are largely independent of the supporting technology used in a particular IxD project, similar to Golden Rules and heuristics (Dix *et al.* 2004: 259).

Principles can be difficult to apply (Stone *et al.* 2005: 89), because designers have to interpret them, select the most suitable ones, resolve any conflicts arising from their use and apply them to the overall design. Consistency is a particularly thorny example of a principle that requires interpretation (Grudin 1989).

General guidelines are the most numerous guidelines—there are hundreds of them in various collections (e.g. Smith and Mosier 1986; Mayhew 1992; Koyani *et al.* 2006). General guidelines are of moderate authority, because of the incompleteness of IxD theories on which many are based (Dix *et al.* 2004: 277). Koyani *et al.* provide an indication of the authority of each of the guidelines in their collection by means of a five-point "Strength of Evidence" rating (2006: xvi). The Strength of Evidence ratings were compiled by a multidisciplinary committee of experts, which gives them credibility. An example of the use of the Strength of Evidence rating may be seen in Figure 3.2.

The level of abstraction of general guidelines ranges from abstract to concrete (Dix *et al.* 2004: 277). Abstract general guidelines (approaching principles) are suitable for requirements specification (Section 2.4.1) and concrete general guidelines (approaching rules) are suitable for physical design (Section 2.4.2). General guidelines may be used to implement a variety of dialogue styles. It is possible to automate the application of concrete general guidelines by means of design tools that generate code when particular guidelines are selected for use in design (Dix *et al.* 2004).

General guidelines may conflict with each other when applied to a design task (Dix *et al.* 2004) and designers need to understand the theoretical foundations of such guidelines in the context of the design task in order to resolve possible conflicts.

Rules are concrete guidelines of low generality and high authority that have a low-level physical design context (Section 2.4.2). Rules are limited to small-scale features of a physical design and intended to determine the semantics or presentation of these features. Rules tend to be computing platform- or product family-specific, or specific to a particular enterprise environment. Rules tend not to conflict with each other when applied to a design task and designers consequently need not understand their theoretical foundations, making them easier to apply in design. Rules are most frequently encountered in style guides, together with other types of guidelines, for example, the collection of rules in the Apple Human Interface Guidelines style guide for Mac OS X (Apple 2007).

Standards are specific guidelines of low generality and high authority that have a low-level design context (Dix *et al.*, 2004: 260). They can be applied largely without interpretation and it is less important that designers know their theoretical origins. Standards are set by national or international standards bodies with the aim of encouraging compliance with them by a substantial proportion of the designer community. The term standard refers both to individual standards (guidelines) and collections of standard guidelines together with associated explanatory meta-documentation.

The authority of standards is a consequence of the authority embodied in standards bodies (Dix *et al.* 2004: 277). The existence of a standard as a standards body publication does not automatically confer authority on it. Many standards are not obligatory and achieve authority only if sufficient numbers of developers adopt and use them. Some software products become *de facto* standards in the absence of a standard issued by a standards body (e.g. X Windows).

The high development and maintenance costs of poorly designed software with low usability and the rejection of such software by users are driving the progressive adoption of usability standards by interaction designers. There is also a trend to

impose legal requirements in various countries that interactive products must comply with one or more standards (Dix *et al.* 2004). This is also contributing to the adoption of usability standards by designers.

Guidelines are incorporated into collections, so that designers may more readily find the guidelines that they need for IxD, as discussed in the next section.

3.2.5 Collections

Collections can be hard-format (e.g. contained in printed books) or soft-format (e.g. websites, specialised collection browsers or downloadable and on-line books) (Newman and Lamming 1995: 374; Dix *et al.* 2004: 259; Shneiderman and Plaisant 2005: 60; Stone *et al.* 2005: 166; Koyani *et al.* 2006).

Collections of high-level Golden Rules, heuristics and principles are usually embedded in documents as lists or shallow hierarchies together with supporting meta-information. This may also be true of small collections of specialised guidelines (e.g. large-format display guidelines).

More numerous general guidelines, standards and rules are usually grouped into categories in guideline collections according to organising principles, so that they may be more easily accessed and applied. Design context is the most commonly used organising principle. Collections generally contain higher-level and lower-level guidelines. They also contain supporting textual and graphical meta-information about the guidelines, their origins and use and examples of guideline application. The category framework and supporting meta-information of guideline collections constitute their structure.

The guidelines in Koyani *et al.*'s "*Research-based Web Design & Usability Guidelines*" (2006) are organised into 18 functional categories (chapters) by design context and design context level. Each category is prefaced by an explanatory introduction. The Design Process and Evaluation and Usability Testing categories

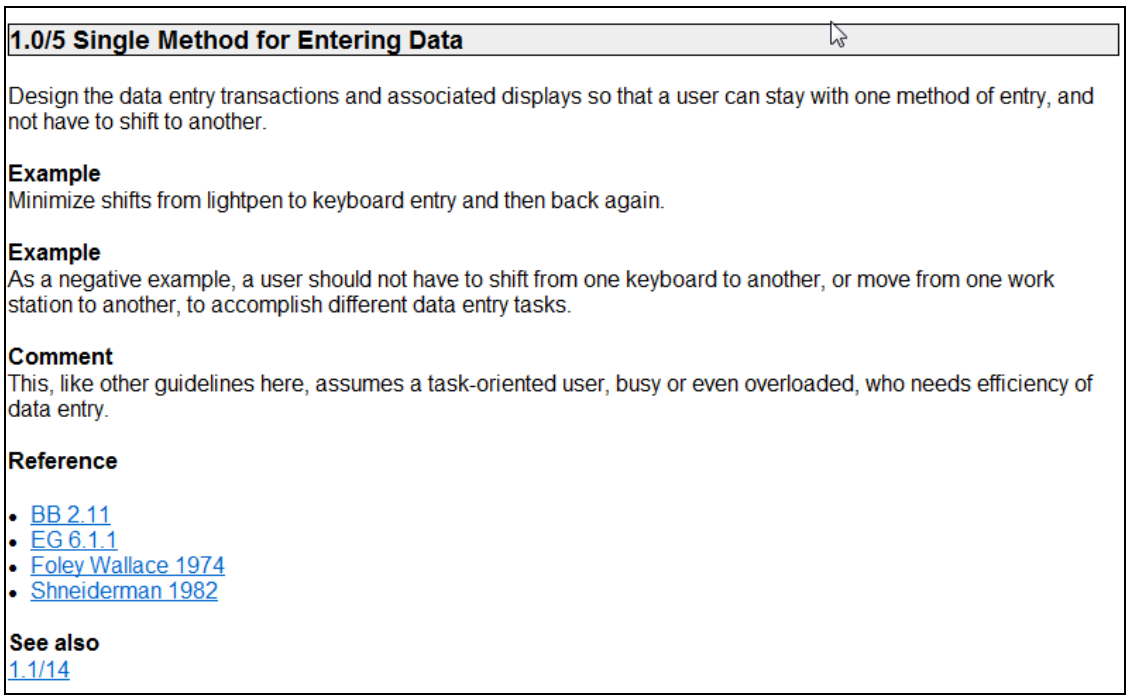
contain high-level IxD process guidelines, the Content Organisation and Search categories contain medium-level general Information Architecture guidelines, and the Screen-based Controls and Graphics, Images and Multimedia categories contain low-level general design guidelines.

Each collection is accessed by means of its particular collection interface, which is determined by whether the collection is contained in a printed book, website, specialised collection browser or downloadable on-line book.

The guidelines in the Smith and Mosier guideline collection "*Guidelines for Designing User Interface Software*" (1986) are accessed by a web browser interface. A guideline from this collection is shown in Figure 3.3. The guidelines and meta-information are textual. The guidelines in each category have associated reference codes and descriptive names and are unordered. The origins of the guidelines in the form of literature citations ("Reference") and related guidelines ("See also") may be accessed by hyperlinks.

The guidelines in Koyani *et al.*'s downloadable online book "*Research-based Web Design & Usability Guidelines*" (2006) may be accessed by an Adobe Reader interface if in soft copy form, or by a book interface if in hard copy form. A guideline from the collection is shown in Figure 3.4. The guidelines in each category have associated reference codes and descriptive names. Most guidelines and their supporting meta-information are a page or less in length and each page clearly displays the category that it falls into (supporting recognition rather than recall).

The guidelines in each category are sorted in decreasing order of "Relative Importance" ratings (Section 3.2.4), making it easy to select a short list of the most important guidelines in each category if there are development resource constraints (Koyani *et al.* 2006: xix). The "Relative Importance" rating is thus a secondary organising principle within categories in this particular collection. The "Strength of Evidence" rating is a quantitative indication of the credibility of the guideline's origins. The "Strength of Evidence" ratings were compiled by a committee of expert researchers, practitioners and authors, as were the "Relative Importance" ratings.



1.0/5 Single Method for Entering Data

Design the data entry transactions and associated displays so that a user can stay with one method of entry, and not have to shift to another.

Example
Minimize shifts from lightpen to keyboard entry and then back again.

Example
As a negative example, a user should not have to shift from one keyboard to another, or move from one work station to another, to accomplish different data entry tasks.

Comment
This, like other guidelines here, assumes a task-oriented user, busy or even overloaded, who needs efficiency of data entry.

Reference

- BB 2.11
- EG 6.1.1
- Foley Wallace 1974
- Shneiderman 1982

See also
1.1/14

Figure 3.3: Guideline Collection Browser Interface Example (Smith and Mosier 1986)

3.2.6 Selection and Use

A number of authors have suggested that designers should review guideline collections in their entirety, before using them for design for the first time (Smith and Mosier 1986; Koyani *et al.* 2006). This would be a time consuming-task for large collections.

Guidelines are used as physical design aids to support the activity of generating physical designs for a new product or a redesigned version of an existing product (Section 2.4.2).

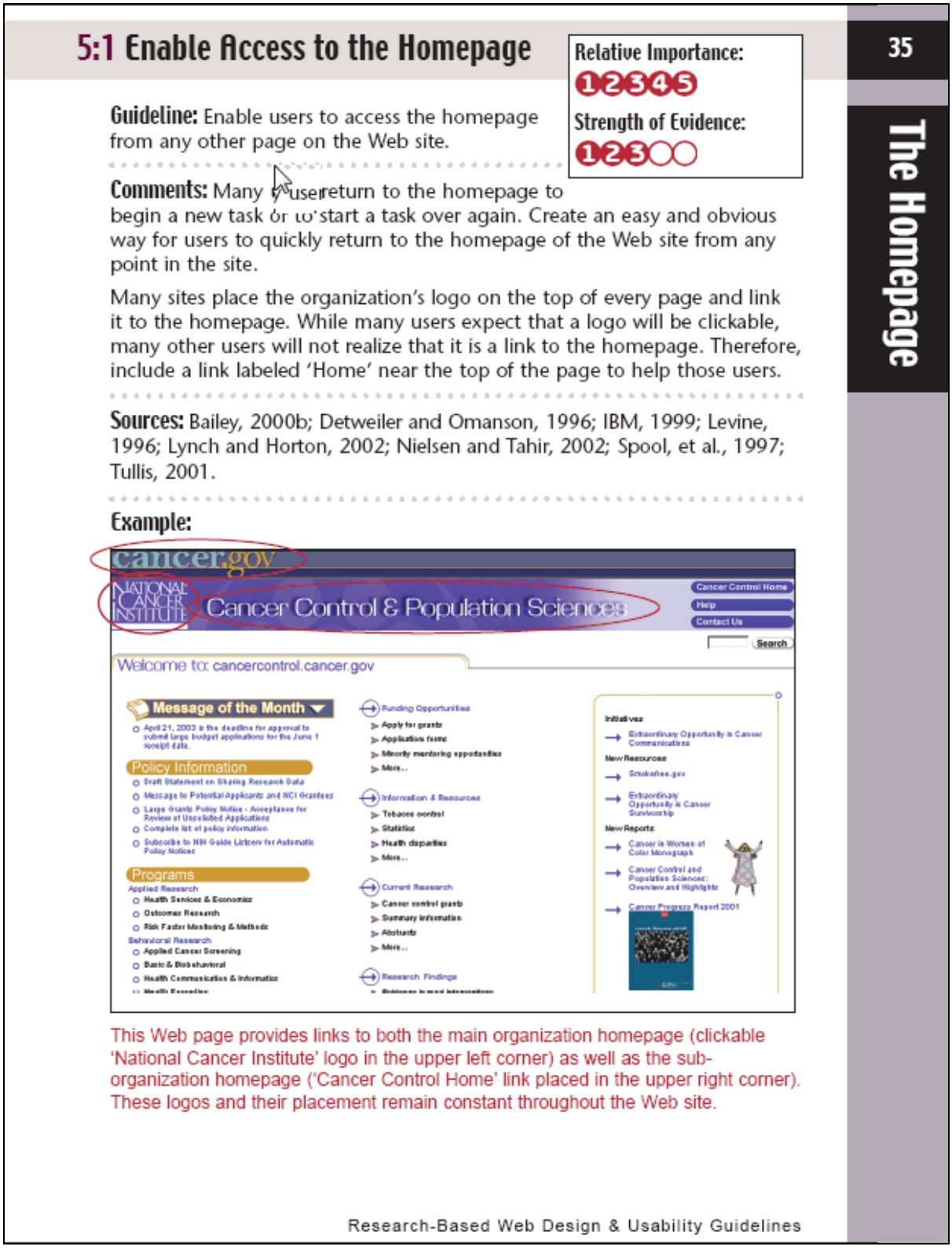


Figure 3.4: Guideline Book Interface Example (Koyani *et al.* 2006: 35)

Guidelines are used as evaluation aids at different stages of the IxD lifecycle (Section 2.4.4). They are used for formative evaluation of evolving physical designs or interactive versions of designs during development. This includes the redesign of existing interactive products. They are used for summative evaluation of completed products or existing products needing redesign or two or more products requiring comparison.

Guidelines are used to support evaluation by inspection in two ways, by means of heuristic evaluation (Nielsen and Molich 1990; Tetzlaff and Schwartz 1991; Newman and Lamming 1995: 379) or guideline review (Newman and Lamming 1995: 379; Stone *et al.* 2005: 533).

3.2.7 Benefits and Shortcomings

Guidelines have three benefits as design aids, namely making designers aware of concepts unknown to them, helping designers to make informed design choices, and suggesting overall strategies for solving design problems (Nielsen and Molich 1990); (Tetzlaff and Schwartz 1991); (Newman and Lamming 1995: 376-379).

The use of guidelines to make designers aware of unknown concepts helps inexperienced designers to become more experienced. The teaching of the use of guidelines to university students in IxD and HCI courses serves the same purpose.

Guidelines help designers to make sound decisions based on the positive experiences of other designers and thus avoid mistakes, or to design using certain techniques that have been found to produce better designs (Thimbleby 1990: 198). Guidelines thus restrict the design option space and prevent designers from making design decisions that might lead to less usable systems (Dix *et al.* 2004: 259). This implies that it might be useful to start to use guidelines early on in the design process, as long as the designer understands the assumptions behind the guidelines.

When developing products for particular platforms (e.g. `Microsoft Vista`), the rules in style manuals assist designers to produce designs that are consistent and which conform to the specific platforms (Section 2.4.2).

Although guidelines are widely accepted by designers and summarise theory and good practice, they have several shortcomings:

1. It may be difficult to select a set of applicable guidelines for a particular design problem in a large collection (even when the guidelines are categorised). This is because the applicable guidelines may be scattered throughout the collection and guidelines do not generally incorporate links to related guidelines (Section 3.2.5). Designers have a tendency to select the first guidelines found and then abandon the search (Tetzlaff and Schwartz 1991).
2. It may be difficult to select the most important guidelines for a particular design problem from those found because most collections lack information about the relative importance of guidelines. Koyani *et al.*'s guideline collection (2006) is a notable exception, as these guidelines are sorted in decreasing order of "Relative Importance" within different categories (Section 3.2.5), making it easy to select a list of the most important guidelines in each category.
3. It may be difficult to apply guidelines, because they are brief statements that may not clearly express and explain their rationale and the design context to which they apply, as described in Section 3.2.3. This is particularly true of abstract design principles and less true of concrete rules. Some modern guideline collections have associated design rationales and sensitising examples which make applying guidelines easier (Smith and Mosier 1986; Koyani *et al.* 2006). Designers tend to focus on the examples (when provided) and ignore the advice contained in the guidelines (Tetzlaff and Schwartz 1991).
4. Two or more guidelines may seem to both apply to a particular design problem, but conflict because they have different theoretical or empirical bases and aim to address different usability issues, or have different contexts. The designs produced by applying the conflicting guidelines in different sequences can differ significantly from each other (Barnard and Grudin 1988; Newman and Lamming 1995: 380-381).

5. A guideline does not provide a way of establishing whether a revised design is more usable than the original version. The only way to establish this is by a usability evaluation. If evaluation is difficult or impossible to do, the designer might simply have to assume that the guideline has done its job (Newman and Lamming 1995: 380).
6. Some authors question the validity of guidelines, as these are often based on low-level theory or small-scale empirical studies and might not scale up to complex real-world IxD projects (Thimbleby 1990: 197; van Welie, van der Veer and Eliëns 2000).

Some other cautionary comments about the application of guidelines deserve consideration. Guidelines in themselves cannot assure good design for a variety of reasons (Thimbleby 1985). Guidelines cannot replace experience or expert interaction designers, but they can facilitate the design process significantly. An expert design consultant will be able to adapt general guidelines to particular design requirements and resolve conflicts between guidelines through trade-offs (Smith and Mosier 1986: 14-16).

Patterns differ from guidelines in a number of ways, as discussed in the next section.

3.3 Patterns

3.3.1 Background

IxD patterns originated about 15 years ago and their use in IxD has grown gradually over the last eight years (Dearden and Finlay 2006). IxD patterns are not, however, as widely known or used as guidelines.

Patterns and pattern languages originated from the visionary work of the architect Christopher Alexander and his collaborators from the 1960s onwards (Alexander 1964; Alexander, Silverstein, Angel, Ishikawa and Abrams 1975; Alexander,

Ishikawa, Silverstein, Jacobson, Fiksdahl-King and Angel 1977; Alexander 1979, 1982; Alexander, Davis, Martinez and Corner 1985; Alexander, Neis, Anninou and King 1987; Alexander 1996). This early work focused on architectural design patterns and their applications.

Software engineering researchers studied object-oriented analysis and design knowledge reuse at a number of levels from the late 1980s to the early 1990s (Garlan and Delisle 1990; Garlan and Notkin 1991; Wirfs-Brock, Vlissides, Cunningham, Johnson and Bollette 1991; Coplien 1992). Certain researchers became aware of Alexander's work on patterns and discovered that patterns were useful in constructing models of successful object-oriented software designs (Beck and Cunningham 1987; Coad 1992; Coad and Mayfield 1993; Gamma, Helm, Johnson and Vlissides 1993; Anderson, Coad and Mayfield 1994). These software engineering patterns were called design patterns. Dearden and Finlay (2006) renamed design patterns to software design patterns, to distinguish them from design patterns used in other application domains, but this name is not generally used in the software engineering community. Software design patterns express problems to be solved and their solutions in terms of code structures.

Annual conferences on "Pattern Languages of Programming" have been held since 1994, notably the PLoP conferences (Martin, Reihle and Buschmann 1997; Harrison, Foote and Rohnert 1999; PLoP 1998; PLoP 1999; PLoP 2000; PLoP 2001; PLoP 2002; PLoP 2003). These conferences helped to make software design patterns widely known to software designers. Gamma, Helm, Johnson and Vlissides' ground-breaking book "*Design Patterns: Elements of Reusable Object-Oriented Software"* (Gamma *et al.* 1995) was the first of a series of popular books that disseminated software design pattern knowledge. Software design pattern collections were generally in the form of catalogues, containing idioms, code-level patterns that were not organised into pattern languages.

Design patterns that presented IxD problems and expressed the solutions in terms of suggested code structures appeared early on in the research into software design patterns and in the papers presented at the early PLoP conferences (Gamma *et al.* 1993; Gamma *et al.* 1995; Adams 1995; Riehle and Zullighoven 1995; Bradac and

Fletcher 1997; Harrison *et al.* 1999; PLoP 1998; PLoP 1999). These design patterns were called interface software design patterns, to distinguish them from software design patterns (Dearden and Finlay 2006).

HCI researchers began to use design patterns to build models of successful IxD knowledge. These patterns presented IxD problems and expressed the solutions in terms of suggested interaction behaviour. These design patterns were called IxD patterns, to distinguish them from software design patterns and interface software design patterns (Dearden and Finlay 2006). This name is generally accepted in the IxD community. The names human-computer interaction (HCI) pattern and user interface (UI) pattern are also used in the IxD community.

IxD pattern workshops were held at several international conferences (Bayle *et al.* 1998; Griffiths, Pemberton and Borchers 1999; Griffiths, Pemberton, Borchers and Stork 2000; van Welie, Mullet and McInerney 2002; Fincher *et al.* 2003; Schümmer, Borchers, Thomas and Zdun 2004). The early workshops emphasised pattern and pattern language evangelism, structure and writing.

Papers on IxD patterns began to be presented at conferences and published in journals (Nanard *et al.* 1998; Rossi *et al.* 1997; Erickson 2000; Martin, Rodden, Rouncefield, Sommerville and Viller 2001; Wesson 2001; Dearden, Finlay, Allgar and McManus 2002; Finlay, Allgar, Dearden and McManus 2002; Kok and Wesson 2002; Wesson and Cowley 2003; Cowley and Wesson 2005; Wesson and Cowley 2005; Dearden and Finlay 2006; Kotze *et al.* 2006; Koukouletsos, Khazaei, Dearden and Tseles 2006). Recent research has focused on IxD pattern language use and usefulness.

IxD pattern language collections began to be published on websites (Tidwell 1998; Tidwell 1999; Laakso 2003; Tidwell 2003; van Welie 2008), and in books (Borchers 2001; Graham 2003; Tidwell 2003; van Duyne, Landay and Hong 2003; Cooper, Reimann and Cronin 2007). Some of these books had associated websites. IxD patterns became better known to researchers and practitioners and started to gain acceptance and be used in IxD by practitioners (Dix *et al.* 2004: 284).

Emerging IxD pattern collections were organised into pattern languages from their beginnings and applied to entire designs. More recent pattern collections apply to the IxD process (Graham 2003; van Duyne *et al.* 2003; Cooper, Reimann and Cronin 2007). These combine patterns and principles (high-level guidelines).

The definition of a pattern is more complex than a guideline, as illustrated in the next section.

3.3.2 Definition

An IxD pattern is a structured, comprehensive and invariant solution to a recurring physical design problem in a context, grounded in good practice (Appleton 2000; Dix *et al.* 2004: 284-286; Dearden & Finlay 2006). An example of a pattern (in a shortened form) is shown in Figure 3.5.

A pattern is structured because it has a particular multipart format (discussed in Section 3.3.3). A pattern is comprehensive because it contains all the information required to solve the problem in its context of use (its design context). A pattern states what must be done to solve a problem and why (its design rationale). A pattern is invariant because it is a successful generic solution to a particular problem in a specific context. When a pattern is applied (instantiated), many different particular designs may be generated under different circumstances. These designs all reveal the pattern used to generate them when examined (Dearden & Finlay 2006).

Patterns are grounded in good practice because they are generally discovered (mined) in existing successful solutions to problems in particular design contexts. At least three instances of a candidate pattern embedded in a design are required, but one instance may be acceptable in some cases. Pattern origins do not generally lie in theory or experiment.

F3 SHOPPING CART

THE DESIGN OF SITES

(www.amazon.com, October 26, 2000)

Amazon.com's shopping cart keeps navigation to the rest of the site clearly indicated at the top of the page, but it makes checking out even more abundantly clear. For a business that makes money online through sales, it is critical that customers find their way through to checkout.

BACKGROUND

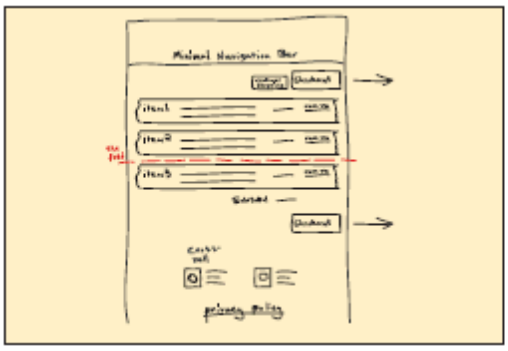
After customers select products from a CLEAN PRODUCT DETAIL (F2) page, a successful PERSONAL E-COMMERCE (A1) site will use a well-designed shopping cart to lead the customer to the start of a QUICK-FLOW CHECKOUT (F1), removing any barriers to making the purchase.

PROBLEM

Customers want to collect and purchase several items in one transaction. Online shopping carts can provide much more than their offline namesakes, such as making it easy to change the quantity of an item in the cart. However, making shopping carts simple and useful requires restraint.

SOLUTION

Give customers easy access to the shopping cart from every page of your site. On product detail pages, make the Add to Cart buttons hard to miss. On the shopping cart page itself, provide highly visible action buttons leading to checkout and action buttons to continue shopping, along with the top-level navigation elements and search features. In the detail of the contents, include product name, a short description, a link to the product page, availability time frame, price, quantity, a button to delete each item, shipping, tax, and subtotal information or links. Display a link to your return policy. Optionally, you might also cross-sell and up-sell other products on the cart page, and put a summary of the cart contents on every site page.



A good shopping cart shows customers details about what they have bought, including how much the order is going to cost, and then makes it easy to check out without being distracted.

CONSIDER THESE OTHER PATTERNS

One common feature on CLEAN PRODUCT DETAIL (F2) pages is to let people add items to the shopping cart. Shopping carts should have HIGH-VISIBILITY ACTION BUTTONS (K5) to let people start the QUICK-FLOW CHECKOUT (F1). Shopping carts are a good place for CROSS-SELLING AND UP-SELLING (G2), recommending products that may be useful, given the current items in the shopping cart. Provide links to your return policy to enable EASY RETURNS (F9) and to assure your customers that they can change their minds if they're not satisfied.

Figure 3.5 Example of an IxD Pattern (van Duyne *et al.* 2003)

Patterns are usually grouped and joined to form pattern languages. Pattern languages are collections of related patterns linked into structures according to organising principles. A pattern language is a more general and powerful design aid than its individual component patterns (since the whole is greater than the sum of its parts).

Patterns may be discussed by means of their properties, although a common model of pattern properties has not yet been established.

3.3.3 Properties

Much of the ongoing discourse on the properties or characteristics of patterns is rooted in Alexander's original and evolving ideas. Pattern properties (as discussed in the literature) are more complex than guideline properties and can be quite subtle. A survey of the work of Lea (1993), Bayle *et al.* (1998), Fincher (1999a, 1999b), Winn and Calder (2002) and Dearden and Finlay (2006) is presented in this section.

Lea (1993) discussed properties of software design patterns (which he called entries, after Alexander) and principles of pattern use and development patterns. He identified seven properties of patterns:

1. Patterns have a structured multipart format.
2. A pattern contains a well-defined problem and its solution (encapsulation).
3. A pattern contains a self-standing description of how to apply it to construct an instantiation (generativity).
4. A pattern contains a description of the constraints that must be balanced to shape a solution (equilibrium).
5. A pattern is an abstraction of successful empirical experience, located within a design context (abstraction).
6. Patterns within pattern languages have a collective ability to generate a variety of complete multilevel solutions to a design problem from a general level down to a very detailed level, depending on the particular design context (openness).

7. Sequences of patterns between levels within pattern languages may be composed to solve entire design problems, because of the self-contained yet connected nature of individual pattern narratives (composibility).

Bayle *et al.* (1998), in their review of the CHI 97 "*Putting It All Together"* Workshop, stated the following properties of IxD pattern languages:

1. Patterns are grounded in concrete examples of good practice in their design context;
2. Patterns can be used at multiple levels of the design community (the entire community, group and individual) in an integrated manner;
3. Patterns attempt to bridge the gap between physical and socio-technical design; and
4. Patterns support incremental, non-linear design processes.

Bayle *et al.* distinguished between activity patterns and design patterns. Activity patterns are value-free descriptions of social phenomena, because they do not categorise the phenomena that they describe as worthy of emulation or not. Design patterns, by contrast, exemplify a value system because they are based on proven good designs that are worthy of emulation. Patterns thus support the view of IxD as a value-centred and value-driven discipline (Section 2.2.2).

Bayle *et al.* noted that patterns had four characteristics:

1. They could be used as a *lingua franca* for a variety of people involved in design, ranging from designers to end users;
2. The patterns in a pattern language were individually applicable at different levels of scale of an entire design problem;
3. Patterns and pattern use exemplify design values; and
4. Patterns are grounded in and model good design practice.

Fincher (1999a, 1999b) also considered presentation (format), capture of practice, applicability to an entire design and value system to be essential properties of IxD patterns and pattern languages, but added organising principle as a pattern language property. An organising principle is used to group patterns into categories and link them together. Fincher (1999b) explored the use of scale, task type, information and

social values as organising principles. A composite two-stage organising principle based on design phases was synthesised from these organising principles.

Winn and Calder (2002) proposed a set of nine essential characteristics (properties) of software design patterns:

1. The content of a pattern implies an artefact at several levels, using text, examples and explanatory sketches.
2. A pattern bridges several levels of abstraction because it contains information that helps a designer to move from a general to a more detailed understanding of a problem.
3. A pattern is both functional and non-functional because it includes a solution to a problem and its rationale.
4. A pattern is manifest in a solution because the solution exemplifies the pattern used to create it.
5. A pattern captures system hot spots, by providing information about aspects of a design that will not change and aspects that will change (hot spots).
6. A pattern is part of a language, because it is connected to and shaped by related patterns, which can be at the same level as the pattern or subordinate or supra-ordinate to it.
7. A pattern is validated by use, because it is discovered in instances of existing successful solutions to problems (commonly at least three instances).
8. A pattern is grounded in a domain because it is only defined in the context of related patterns in a pattern language and the design problem to which it applies.
9. A pattern captures a big idea, because patterns provide descriptions and solutions for the most significant and recurring problems in a design context, and not for trivial problems.

Dearden and Finlay (2006) produced a list of thirteen pattern properties by combining the four properties identified by Bayle *et al.* (1998) and the nine properties identified by Winn and Calder (2002). This list was used to evaluate the degree to which a representative collection of papers and articles on IxD patterns identified pattern properties. Dearden and Finlay found that individual items in the collection generally only identified a small number of the pattern properties in the list.

This section concludes by presenting a discussion of IxD pattern format to illustrate how the various components of a pattern are used.

An IxD pattern's format (Lea 1993; Fincher 1999a; Fincher 1999b) is its multipart physical form or structure. Fincher's *Pattern Gallery* website (http://www.cs.kent.ac.uk/people/staff/saf/patterns/gallery.html) provides information about a number of formats in common use (2000). Figure 3.5 shows an example of a classical Alexandrian form, (with abbreviated Problem content), from van Duyne *et al.*'s *Design of Sites Pattern Collection* (2003).

The pattern format is intended to achieve two goals (Alexander 1977: xi):

1. To allow the pattern users to understand the essence of the pattern so that they may instantiate it in a design in the way that best fits the design space; and
2. To show the links to other patterns so that pattern users grasp holistically that the set of patterns forms a pattern language.

The classical Alexandrian form consists of five components:

1. Meaningful, solution-implying name and reference code or number;
2. Sensitising example;
3. Context of use, including related patterns to which this pattern contributes;
4. Concise problem statement, followed by detailed discussion and rationale (described in terms of conflicting forces that shape a solution to the problem), including one or more examples of known use; and
5. Solution to the problem, including an illustrative sketch or diagram and a paragraph discussing the use of related subordinate patterns.

The meaningful, solution-implying name is intended to be used as a phrase in the sentences of personal and shared design languages (Tidwell 2003; van Welie and van der Veer 2003). Pattern names tend to be short and memorable (e.g. "*Shopping Cart*" or "*Clean Product Detail*" depicted in Figure 3.5).

A designer could select and use linked patterns in a collection for a design problem and learn their names, what they were used for and how they are linked. This would make them part of her IxD mental model. The designer could use the remembered

pattern names to formulate and plan a new design. The names would be triggers to remembering the design activities associated with the patterns, which could be looked up in the collection if required.

Shared design languages, made of the personal design languages of team members, could be used by IxD teams, when talking about and working together on design problems.

The pattern reference code or number is used to assist searching for patterns and as a substitute for clickable links in book-based pattern collections (e.g. van Duyne *et al.*'s *Design of Sites*), as shown in Figure 3.5. In this example, "F3" means the third pattern in the category of basic E-commerce patterns in the collection.

The sensitising example consists of one or more prototypical pictures, diagrams or descriptions that illustrate the application of the pattern in a good design. It is intended to be used to make the pattern user receptive to the context of use, problem statement and solution components that follow. A sensitising example of the Amazon.com shopping cart is shown at the top of Figure 3.5.

The context of use explicitly states where the pattern applies in a local sub-space of the overall design space. The manner in which the pattern connects to and supports related supra-ordinate patterns and patterns at the same level is also described. The context of use in the *Design of Sites* collection is called "Background" (Figure 3.5).

The concise problem statement briefly describes the problem that the pattern solves. This is followed by a detailed discussion and the rationale (described in terms of sometimes conflicting forces that shape a solution to the problem), including one or more examples of known use. The discussion and rationale contain a number of fine-grained design steps (essentially guidelines) that will generate a good design for an entire artefact (e.g. a shopping cart) if they are *all* applied. The fine-grained design steps are bound together into a narrative.

The section containing the problem statement, detailed discussion and rationale is called "Problem" in the *Design of Sites* collection (Figure 3.5). The Problem section

in the abbreviated example is only six lines long, but is six pages long in the *Design of Sites* book and contains five examples (van Duyne *et al.* 2003).

The solution to the problem, including an illustrative sketch or diagram and a paragraph discussing use of related subordinate patterns, concludes a pattern. The solution consists of a summary of the major design steps presented in the detailed discussion and rationale. The sketch is a hand-drawn wireframe of the prototypical solution. The paragraph discussing the use of related subordinate patterns is called "Consider These Other Patterns" in the *Design of Sites* collection (Figure 3.5). The related subordinate patterns are those referred to in "Background" and "Problem".

Additional information required for solving supra-ordinate problems or subordinate problems may be accessed by following the embedded links to patterns to which this pattern contributes or related subordinate patterns.

3.3.4 Classification

The guideline properties of design context level, generality, authority and level of abstraction may also be applied to patterns in pattern languages. Patterns have design contexts that range from high-level in terms of the overall design context of a specific pattern language for the most general patterns, to low-level for the most specific, subordinate patterns. For example, the *Personal E-Commerce* (*A1*) pattern from van Duyne *et al.*'s *Design of Sites* pattern collection (2003) has a high-level design context, but the *Location Bread Crumbs* (*K6*) pattern from the same collection has a low-level design context. Their generality ranges from general to specific, their authority is high (their design advice is expressed in the form of positive instructions, not suggestions) and their level of abstraction is low (they state explicitly what must be done).

Designers use pattern collections to find the patterns that they need for physical design or usability evaluation.

3.3.5 Collections

Collections can be hard-format (e.g. contained in printed books) (Borchers 2001; Graham 2003; Tidwell 2003; van Duyne *et al.* 2003; Cooper *et al.* 2007) or soft-format (e.g. websites, specialised collection browsers or downloadable and on-line books) (Tidwell 1998; Tidwell 1999; Laakso 2003; Tidwell 2003; van Welie 2008).

The structure of a pattern collection consists of its category framework, the pattern language within the framework and supporting meta-information. Pattern collections are accessed via various types of interfaces, depending partially on its physical manifestation .

The website design patterns in van Welie's *Interaction Design Pattern Library* (formerly known as the *Amsterdam Pattern Collection*) (http://www.welie.com) are accessed by a web browser interface. The patterns are organised according to a two-level category framework. The top-level categories are *User Needs*, *Application Needs* and *Design Context*. Each top-level category consists of a number of lower-level categories, containing the associated patterns. The category framework containing all the pattern names as clickable links is displayed on an overview page (Figure 3.6). The individual patterns are each displayed on a detail page and the local pattern language environment of a particular pattern can be navigated to by links (Figure 3.7).

The website design patterns in Van Duyne *et al.*'s *Design of Sites* Pattern Browser (2003) are accessed by a web browser interface (Figure 3.8). The patterns are organised according to a multi-level category framework. The top-level category is *Site Genres*. The *Site Genres* patterns are linked to lower-level categories of subordinate patterns. The lower-level categories are organised thematically (e.g. *B: Creating a navigation Framework* and *C: Creating a powerful Homepage*). A local view of the pattern language structure is displayed above and to the left of a window that displays the current pattern. The pattern window shows only part of the pattern. The *Design of Sites* Pattern Browser is no longer available for on-line public use.

It is possible that the usability and content of different collections may affect the relative usefulness of these collections, but no research has been done on this.

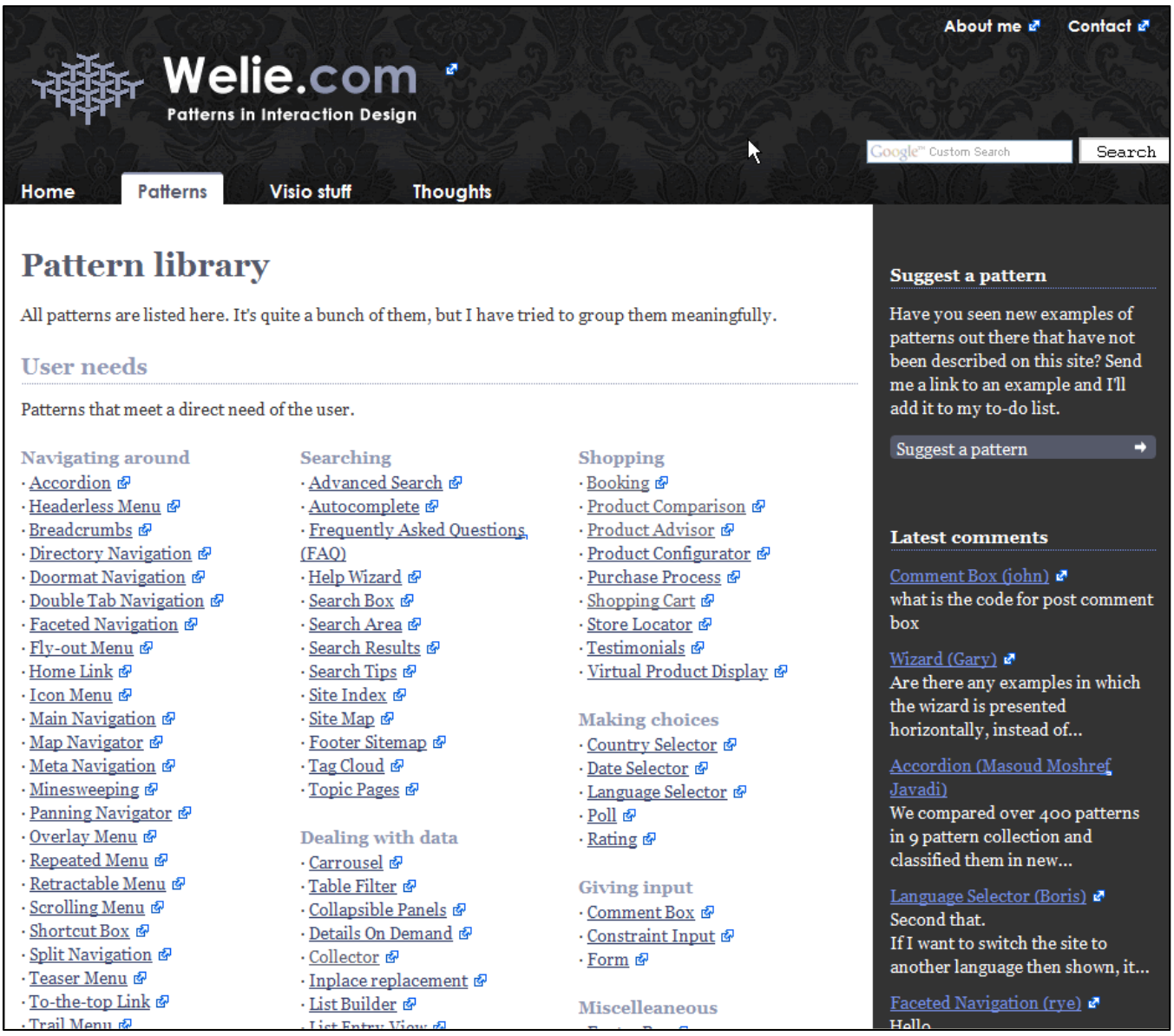


Figure 3.6: Example of Pattern Collection Overview Page (www.welie.com, last referenced on 30/12/2008)

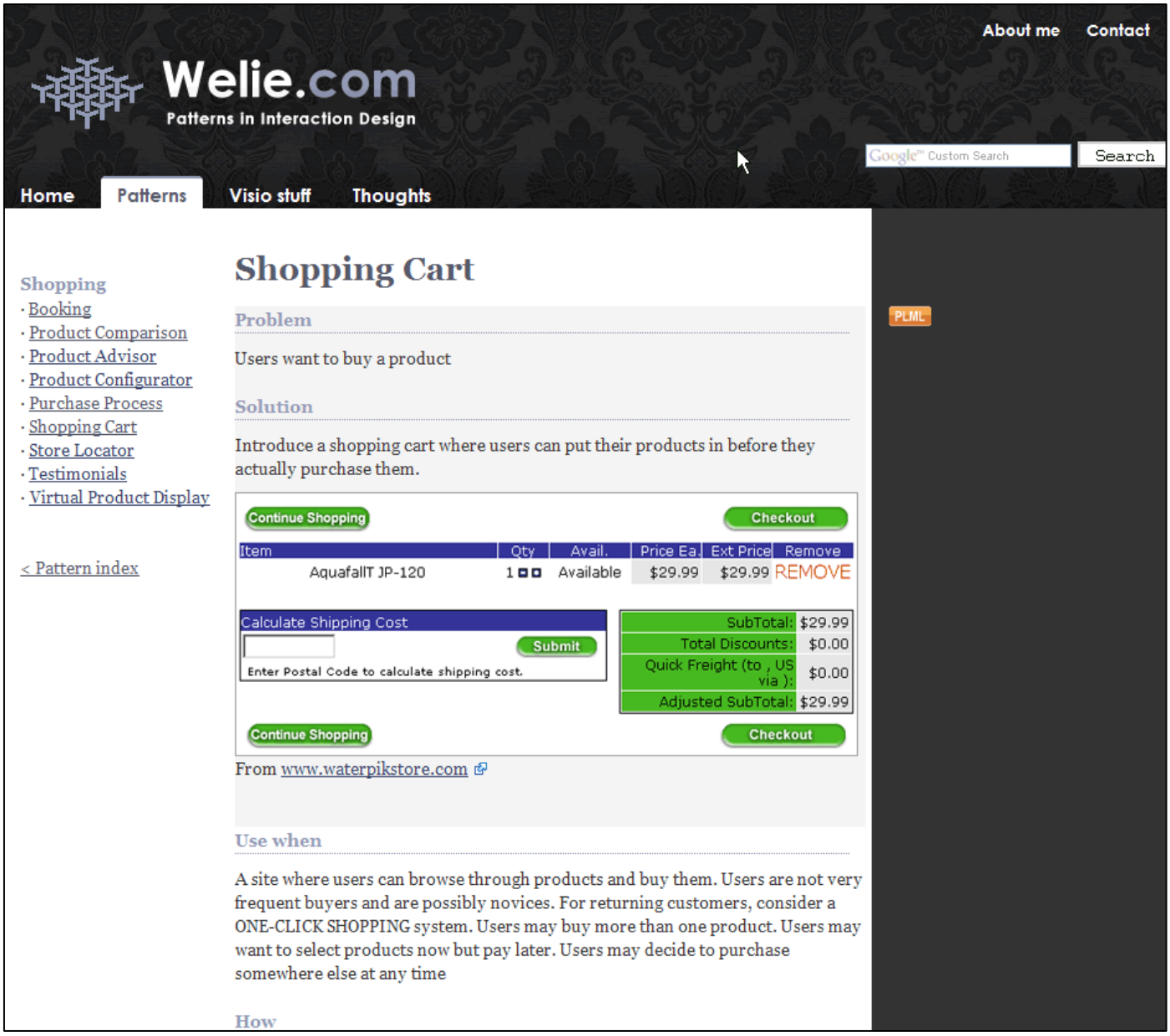


Figure 3.7: Example of Pattern Collection Pattern Detail Page (www.welie.com, last referenced on 30/12/2008)

Figure 3.8: Example of Specialised Pattern Collection Browser (http://www.designofsites.com/pb/index.html, last referenced on 30/12/2005)

3.3.6 Selection and Use

Pattern languages are particularly useful because they can support the design of an entire interactive product, from a conceptual level down to a detailed physical design level, with groups of patterns applying to each level.

Pattern languages often contain sub-languages: environmental languages (conceptual and socio-technical modelling), design languages which are used to create design representations (physical modelling) and implementation languages which are used to implement designs. These sub-languages are ordered according to the organising principle (Alexander 1977: xix-xxxiv; Graham 2003; van Duyne *et al.* 2003; Cooper *et al.* 2007).

Using patterns in a pattern language requires a holistic or systems (non-reductionist) view of design, evaluation and redesign. A component of an interactive product should not be designed and implemented or evaluated in isolation, but also the larger-scale component in which it is embedded and the smaller-scale components that comprise it. This design approach is inherently value-centred and value-driven (Alexander 1977: xiii), and thus agrees with the definition of IxD given in Section 2.2.2. Pattern languages thus inherently support complete designs (Section 2.4.2).

Small sets of patterns can form a sub-language for a particular design problem (Alexander 1977: xxxv-xxxiv). A designer examines an overview or list of all the patterns in a collection and looks for and records the most general pattern which best fits the problem, using the meaningful names of pattern names as semantic search keys. This pattern is studied and its links to associated smaller-scale patterns are noted and recorded on the overview or list.

The process is repeated for the first subsidiary pattern and so on, until all the patterns required for a project have been identified. Specific design needs that the pattern collection does not cater for are documented and added to the list of patterns that have been identified. Selected patterns can be customised to fit the particular circumstances of the design problem, if required. It must be noted that novice designers may find it difficult to identify the appropriate patterns to solve a problem.

3.3.7 Benefits and Shortcomings

Patterns and pattern languages have several advantages over design guidelines, when compared to the guideline shortcomings listed in Section 3.2.7:

1. The link structures of pattern languages make it easy for designers to select a suitable set of related patterns dispersed in a large collection, compared to guidelines, which generally lack link structures (Griffiths and Pemberton 2000).
2. Applying patterns is easier than applying guidelines, because both high-level and low-level patterns explain their rationale and the design context to which they apply, unlike guidelines (Griffiths and Pemberton 2000).
3. Patterns are derived from a sufficient number of examples of good practice, explain their rationale and the context to which they apply and describe how they may be applied to solve particular design problems. There is therefore a high probability that a usable design will result from applying patterns.
4. Patterns do not conflict because they form a connected language and do not have different theoretical or empirical bases or aim to improve different usability factors, or have clashing contexts, as guidelines do.
5. The validity of patterns is high and they automatically apply to complex IxD projects, because they are derived from a sufficient number of examples of good practice (van Welie, van der Veer and Eliëns 2000).

Four empirical studies of the use of patterns for design and evaluation were reviewed in Section 1.2. The findings are summarised below:

1. Novice designers are able to apply patterns to solve design problems. Novice designers regard patterns as memorable and useful and are open to using them in future projects (Borchers 2001; 2002).
2. Users can use pattern languages for successful design. The participation of facilitators and the physical presentation of pattern languages influence the success of the participatory design process (Dearden *et al.* 2002).
3. Guidelines and patterns can be used successfully for evaluation. Guidelines are easier to use than patterns as they take less time to understand and learn, and can be used as checklists (Wesson and Cowley 2003).

4. Design experience is more important than pattern knowledge for effective design and evaluation. Experienced designers using patterns are more effective designers and evaluators than novice designers using patterns (Chung *et al.* 2004).

Four significant studies of pattern use were carried out after the empirical study reported in this thesis (Chapter 4):

1. Saponas, Prabaker, Abowd and Landay (2006) carried out an empirical study of the use of pre-patterns by a group of participants in early design activities for a "home of the future" application, compared to a group of participants not using pre-patterns for the same tasks. Pre-patterns are newly identified or created patterns that do not have origins yet. The second treatment made use of the pure design knowledge of the participants, unsupported by design aids. This study extended the work of Chung *et al.* (2004). The pre-pattern- and non pre-pattern-using groups consisted of a substantial number of experienced designers. The pre-patterns were accessed via a specialised pattern browser, based on the Design of Sites pattern browser (Van Duyne *et al.* 2003). The design activity produced paper prototypes. The results of the study suggested that pre-patterns influence the quality of early designs and early design activities positively and were used as a shared design language. Saponas *et al.*'s study did not compare the use of guidelines and pre-patterns, nor did it evaluate the use of design aids for evaluation and redesign. The large sample size employed lends statistical credence to their results.

2. Schmettow (2005; 2007) conducted a study of the use of patterns for usability inspection of interactive products, citing earlier results reported by Cowley and Wesson (2005). Schmettow's study introduced a structured inspection method called Usability Pattern Inspection (UPI). IxD patterns were used to identify issues and suggest ways to correct the issues, using a structured reporting format. Suggestions on how to correct issues for the benefit of designers and developers is called downstream utility. UPI was found to be thorough and valid as an inspection technique and as effective as heuristic evaluation. Combining UPI and heuristic evaluation resulted in a more

comprehensive description of issues than the individual techniques. The downstream utility of UPI was found to be deficient, in that the usability reports lacked sufficient detail on how to correct issues. Current research on UPI is directed towards correcting this.

3. Kotzé, Renaud, Koukouletsos, Khazaei and Dearden (2006) conducted a comparative pilot study of the use of patterns, anti-guidelines and patterns for teaching IxD principles, as part of a larger study. Two equivalent groups of novice designers, one using patterns and the other using guidelines, performed a partial evaluation of a website and the design of a two-page website. The design activity produced paper prototypes. The study identified a need for further pattern use research. Kotzé *et al.* stated that the evaluation results were consistent with the earlier results reported by Wesson and Cowley (2003).

4. Koukouletsos, Khazaei, Dearden and Ozcan (2007) carried out a comparative study of the use of guidelines and patterns for teaching IxD principles, using two equivalent groups of novice designers. Koukouletsos *et al.* cited earlier results reported by Wesson and Cowley (Cowley and Wesson 2005; Wesson and Cowley 2005). Each group received training in IxD and pattern and guideline use. One group used patterns and the other used guidelines. Each group designed a small (two page) website using either patterns or guidelines. Two matched ("*balanced*") sets of low-level guidelines and patterns for use in the design task were produced by a reductionist process. The design activity produced functional prototypes. The design quality of the prototypes produced using patterns was found to be higher than those produced using guidelines.

3.4 Comparison of Guidelines and Patterns

3.4.1 Background

Guidelines have a longer history and a more general acceptance as IxD aids than patterns. Guidelines and patterns have evolved and guidelines have acquired some of

the characteristics of patterns (Section 3.2.1). Guideline collections historically applied to particular layers of a design, but certain modern collections apply to entire designs and the IxD process (Section 3.2.5). Pattern languages in collections have applied to entire designs and the IxD process from inception.

3.4.2 Definitions

Guidelines and patterns have different definitions, because patterns are syntactically and semantically more complex than guidelines.

1. Guidelines have a simple format and are terse and patterns have a more complex format and are verbose. This because the design advice contained in a guideline relates to one design task, while the design advice contained in a pattern relates to a number of design tasks, bound together into a narrative. The design advice in a pattern will collectively generate an entire component of a design if followed.
2. Guidelines generally do not explicitly state their design context, although the context may frequently be inferred. This may make it difficult to select the correct guidelines for a design problem. Patterns explicitly state their design context.
3. Guidelines generally do not explicitly state their design rationale. Patterns explicitly state their design rationale. Some more recent guidelines do state a psychological design rationale by explaining the benefits to the end-user of applying the guideline (e.g. Koyani *et al.* 2006).
4. Guidelines are generally grounded in theory, possibly supported by empirical studies. Patterns are generally grounded in good practice.

Pattern languages are unique to pattern collections, but there is no corresponding concept in guideline collections.

3.4.3 Properties

Some common ground is required in order to compare guidelines and patterns in terms of their properties. The seven guideline properties (discussed in Section 3.2.3 and summarised in Table 3.1) will be used as a point of departure because of their simplicity and brevity. The properties are format, content, design context, origins, generality, authority and level of abstraction. The degree to which these guideline properties are also descriptive of patterns will be explored.

Format and content are clearly common properties of guidelines and patterns. The difference between the multipart format of patterns and the single sentence format of guidelines is the most obvious structural difference between guidelines and patterns. Each of the components of a pattern is used for a particular purpose in IxD. There is thus also a functional difference between the two formats.

Patterns have meaningful, solution-implying names, for use as phrases in the sentences of personal and shared design languages (Tidwell 2003; van Welie and van der Veer 2003). Guidelines in some collections have no names, as may be seen in Figure 3.1 (Barnard 2004). These guidelines could be considered self-referentially to be their own meaningful, solution-implying names. Such "names" would be difficult to think and talk about, because they are sentences. Guidelines do have meaningful, solution-implying names in some collections. Figure 3.2 shows an example of a named guideline from Koyani, Bailey and Nall's *Research-based Web Design & Usability Guidelines* (2006). It is unknown to what extent guideline names are used in personal and shared design languages.

The pattern reference code or number is used to assist in searching for patterns and as a substitute for clickable links in book-based pattern collections (e.g. Figure 3.5). Guidelines may also have guideline reference codes or numbers, as shown in Figure 3.2. In this example, "12.3" means the third guideline in the category "Chapter 12".

Patterns have sensitising examples (e.g. Figure 3.5). Recent guidelines may also have associated illustrative examples, typically presented after the guideline design advice.

Figure 3.2 shows two concrete examples of the application of a guideline in the form of screenshots, provided at the end of the guideline.

A pattern explicitly states its design context (context of use) (e.g. Figure 3.5). Principles (high-level general guidelines) do not explicitly state their context (Section 3.2.3). The context of lower-level guidelines can be inferred to a certain extent from their content. Text in the vicinity of guidelines in collections (which may include examples) generally provides additional meta-information about the context. Guidelines generally do not describe how they connect to and support related guidelines, as can be seen in Figures 3.1 and 3.2. Figure 3.3 shows an exception to this.

The problem statements in patterns briefly describe the problems that the patterns solve and solutions to the problems (e.g. Figure 3.2). A guideline only states how to solve a problem by means of a single design step (e.g. Figure 3.1). Some modern guideline collections provide psychological design rationales (Section 3.4.2) and concrete examples for the guidelines, narrowing the gap between guidelines and patterns.

The origins of patterns lie in the capture of good design practice, not theory. The origins of guidelines lie in theory. This may consist of reports, journal articles, conference papers or references to prior reputable guideline collections on which the guideline is based. It is unlikely that designers will pay more than passing attention to the origins of guidelines. Figure 3.3 shows a set of sources below a guideline in Koyani, Bailey and Nall's guideline collection (2006). The citations within each set map onto a reference list at the end of the collection.

The generality of the design context of both guidelines and patterns may range from general to specific. Contexts may also be high-level or low-level.

Patterns are of high authority, because their design advice must be applied in design. This is not the case with guidelines. Guidelines may be statements of fact, instructions to act, suggestions or hints.

All patterns are of low abstraction, because they express their design advice explicitly. This is not the case with guidelines, as can be seen in Section 3.2.4.

3.4.4 Classification

Golden Rules and heuristics and principles have a high generality and apply to all categories of interactive products (Section 3.5.1). General guidelines also have a high generality and will apply to categories of interactive products such as flight management systems, web applications and blogging systems, although they would generally be customised to some extent for a particular category. Standards and rules tend to have low generality and apply to constrained contexts.

There is no equivalent in pattern collections to Golden Rules and heuristics, principles and standards. The closest match to patterns is general guidelines. Pattern languages are largely self-contained in respect of their overall design context, and the design context of their patterns is contained within that overall context.

3.4.5 Collections

Pattern and guideline collections can be hard-format (e.g. contained in printed books) or soft-format (e.g. websites, specialised collection browsers or downloadable and on-line books) (Sections 3.2.5 and 3.3.5).

Collections of patterns and general guidelines are structured into categories according to organising principles, so that the patterns or guidelines may be more easily accessed and applied. Modern guideline collections generally contain higher-level and lower-level guidelines and pattern collections always contain higher-level and lower-level patterns. The structure of a guideline collection consists of its category framework and supporting meta-information. The structure of a pattern collection consists of its category framework, the linked pattern language within the framework and supporting meta-information. Pattern collection structures are thus distinguished

from guideline collection structures by the presence of links that collectively model and provide access to pattern languages.

There is no corresponding pattern collection structure to the lists or shallow trees characteristic of collections of high-level Golden Rules, heuristics and principles and small collections of specialised guidelines (Section 3.2.5).

Pattern and guideline collections are accessed by means of their particular collection interfaces, which are determined by how the collection is implemented. A pattern collection interface differs from a guideline collection interface in that individual patterns contain links to related supra-ordinate, same-level and subordinate patterns, thus modelling the pattern language, unlike guidelines.

3.4.6 Selection and Use

Guidelines in a guideline collection can support the design of an entire interactive product, from a conceptual level down to a detailed physical design level, with groups of guidelines applying to each level (Section 3.2.6). The challenge for a designer is to identify a set of guidelines which best fits a particular physical design problem. This may involve reviewing a substantial part of a potentially large guideline collection, until the collection becomes familiar to the designer. Some recent collections have provided features that simplify guideline selection (Section 3.2.5). The designer then applies the design knowledge in the guidelines from the most general guidelines down to the most specific guidelines to generate the physical design. The same selection process is followed for the evaluation of an interactive product. The designer then compares the design knowledge in the guidelines to the static design and dynamic behaviour of the product to collect data for a report on the usability issues and good design features of the product.

Pattern languages can also support the various levels of design of an entire interactive product, with groups of patterns applying to each level (Section 3.3.6). A designer searches a collection for a small hierarchical set of patterns which best fits a particular

physical design problem, using the built-in pattern language. The designer then applies the design knowledge in the patterns from the most general pattern down to the most specific patterns to generate the physical design required. The same selection process is followed for the evaluation of an interactive product. The designer then compares the design knowledge in the patterns to the static design and dynamic behaviour of the product to produce usability data.

The selection of suitable design and evaluation guidance is generally made easier by the use of the pattern languages in pattern collections, which are tightly coupled to the structure of idealised designs. Guidelines in guideline collections do not model the structure of idealised designs as explicitly as patterns.

Tables 3.3a and 3.3b summarise the comparison of guidelines and patterns presented in Sections 3.4.1 to 3.4.6. The key differences between guidelines and patterns are that patterns in comparison to guidelines have a shorter history, are complex and verbose and have a multipart format. Patterns must be applied in design and express their design advice explicitly. Patterns match most closely with general guidelines and are grouped into pattern languages. The comparison of guidelines and patterns forms the basis of the set of research questions discussed in the next section.

3.5 Research Questions

3.5.1 Usability and Usefulness

It is necessary to define pattern and guideline usefulness, in order to pose a set of general research questions for the empirical study. This will be done in two stages. The first stage involves drawing an analogy between software usefulness and pattern and guideline usefulness, by argumentation. The second stage involves generating pattern and guideline research questions and usefulness attributes. This is done by reflecting on the use of guidelines and patterns in IxD and incorporating software usability attributes where appropriate, by analogy.

#	Patterns	Guidelines
1	**Background**	
1.1	Shorter history (~ 15 years).	Longer history (> 35 years).
1.2	Less generally known and accepted as IxD aids.	More generally known and accepted as IxD aids.
1.3	Collections for new application areas emerging.	Collections for new application areas emerging.
1.4	Basic structure constant, although several pattern formats exist.	Structure evolving to acquire some pattern characteristics and ease-of-use features.
1.5	Pattern languages in collections applied to entire designs from inception.	Applied to particular design layers, but some collections now apply to entire designs and support IxD process.
2	**Definition**	
2.1	Complex and verbose.	Simple and terse.
2.2	Design advice relates to a number of design steps, bound together into a narrative.	Design advice relates to one design step.
2.3	Design advice will collectively generate an entire component of a design at a particular level.	Design advice relates to one design step irrespective of design level; thus insufficient detail is provided for higher levels of design.
3	**Properties**	
3.1	Multipart format. Multiple components, each used for a particular purpose in IxD. Meaningful, solution-implying names, for use in personal and shared design languages. Reference code or number to assist searching. Sensitising examples.	Single sentence format. Single component, used for one purpose. Meaningful names and reference codes or numbers in some collections. Recent guidelines may have associated illustrative examples.
3.2	Explicitly state their design context (context of use). Describe how they connect to and support related patterns. Problem statements briefly describe problems that patterns solve and solutions to problems.	Principles do not explicitly state context. Context of lower-level guidelines can be inferred to a certain extent. State single design steps. Psychological design rationales and concrete examples provided in some collections.
3.3	Origins lie in capture of good design practice, not theory, and thus exemplify values.	Origins lie in theory, possibly supported by empirical evidence.
3.4	Generality of design context may range from general to specific. Contexts may also be high-level or low-level.	Generality of design context may range from general to specific. Contexts may also be high-level or low-level.
3.5	All patterns are of high authority, because design advice must be applied in design.	Guidelines may be statements of fact, instructions to act, suggestions or hints.
3.6	All patterns are of low abstraction, because they express their design advice explicitly.	Guideline types are of varying abstraction, depending on type of guideline.

Table 3.3a: Comparison of Aspects of Patterns and Guidelines (Part A)

4	**Classification**	
4.1	No equivalent in pattern collections to Golden Rules and heuristics, principles and standards.	Golden Rules, heuristics and principles have high generality and apply to IxD design context. Standards and rules tend to have low generality and apply to constrained contexts.
4.2	Closest match to patterns is general guidelines. Generality and design contexts vary for patterns within pattern language. Overall contexts are categories of interactive products.	General guidelines have high generality but design contexts are often categories of interactive products.
4.3	Pattern languages and their individual patterns are largely self-contained in respect of their overall design context.	Different types of guidelines vary in respect of their overall design contexts.
5	**Collections**	
5.1	Collections can be hard-format or soft-format.	Collections can be hard-format or soft-format.
5.2	Collections are structured into categories according to organising principles, for ease of access and application.	Collections are structured into categories according to organising principles, for ease of access and application.
5.3	Pattern collections always contain higher-level and lower-level patterns.	Modern guideline collections generally contain higher-level and lower-level guidelines.
5.4	Structure of pattern collections consists of category frameworks, linked pattern languages within frameworks and meta-information.	Structure of guideline collections consists of category frameworks and meta-information, or lists or shallow trees for Golden Rules, etc.
5.5	Collections are accessed by collection interfaces, resulting from collection implementations.	Collections are accessed by collection interfaces, resulting from collection implementations.
5.6	Individual patterns contain links to related supra-ordinate, same-level and subordinate patterns.	No analogue to pattern languages for guidelines. Some guidelines have links to related guidelines.
6	**Selection and Use**	
6.1	Groups of patterns in a collection support design of various levels of entire interactive product.	Guidelines in a collection can support design of entire interactive product.
6.2	Identifying a set of patterns for design problem involves hierarchical descent in collections, which is simplified by pattern language links.	Identifying a set of guidelines for design problem by search may be tedious. Recent collections have mechanisms to simplify this.
6.3	Design knowledge is applied for design and evaluation top-down, with groups of patterns applying to each level.	Design knowledge is applied for design and evaluation top-down, but designer must group the guidelines.
6.4	Pattern languages are tightly coupled to structure of idealised designs that they model.	Guidelines are not tightly coupled to structure of idealised designs but apply individually.

Table 3.3b: Comparison of Aspects of Patterns and Guidelines (Part B)

The concepts of software usability and usefulness have been associated since the idea of usability was incorporated into HCI in the 1980s and are still the subject of research. The ongoing revision of the ISO 9241 standard (2006) and certain activities of the MAUSE project (http://www.cost294.org/) are examples of this.

The general definition of software usability is the extent to which an interactive product (including its interaction model, user interface and functionality) can be used by specified users to achieve specified goals in a specified context of use, with respect to particular usability attributes (ISO 9241-11 1998). These attributes are efficiency, effectiveness and user satisfaction in the case of ISO 9241-11.

The ISO 9241-11 (1998) definition may be adapted to provide a definition of pattern and guideline usability by analogy, since both interactive products and design aids have users that use them for a specific purpose in a given context. The usability of guidelines and patterns is the extent to which they can be used by designers to solve design problems and carry out design and evaluation tasks, measured in terms of efficiency, effectiveness and user satisfaction.

Gould and Lewis (1985: 300) consider usefulness to be one of the components of usability and define a system as useful if it contains the essential functions required by users to do their work. Grudin (1992) and Nielsen (1993: 24) consider software usefulness to be an aspect of the practical acceptability of an interactive product. They define it as the extent to which software helps its users to achieve their goals. Usefulness may be decomposed into utility and usability. Utility is the extent to which software functionality can in principle support users in achieving their goals.

The ISO/IEC 9126-1 software engineering product quality standard (2001) defines quality in use as "*the capability of the software product to enable specified users to achieve specified goals with effectiveness, productivity, safety and satisfaction in specified contexts of use*". Effectiveness is defined as "*the capability of the software product to enable users to achieve specified goals with accuracy and completeness in a specified context of use*" and corresponds to usefulness.

Seffah, Donyaee, Kline and Padda (2006) developed the QUIM model of usability by critically analysing various models of usability and usability metrics. Usefulness is a usability factor and is associated with a number of measurable criteria. Seffah *et al.* state that usefulness is "...*whether a software product enables users to solve real problems in an acceptable way*." They view usefulness as depending on the features and functionality of a software product and the knowledge and skill level of the users while performing a given task.

Seffah *et al.*'s definition of software usefulness may be adapted to provide a definition of guideline and pattern usefulness. Usefulness in respect of guidelines and patterns may be considered to be the extent to which they help interaction designers to solve design problems and carry out design and evaluation tasks. Usefulness is determined by the features and functionality of guidelines and patterns (their format, content, properties and collection structure and interfaces), and the knowledge and skill level of interaction designers while selecting and applying guidelines and patterns in design and evaluation.

The primary research question (Section 1.3.1) was decomposed into 15 general research questions, by considering the overview of usefulness presented in this section and the critical review of the guideline and pattern literature presented in Sections 3.2 and 3.3. This set of general research questions forms the basis of a research agenda for the empirical study of guidelines and patterns. The origins of these questions are discussed in Section 3.5.2.

A critical review of IxD patterns by Dearden and Finlay (2006) that appeared after the empirical study identified a research agenda for pattern languages:

1. Exploring various ways of using pattern languages in IxD and evaluating the outcomes;
2. Organising pattern languages so that multilevel, whole designs can be achieved;
3. Improving the production and revision processes of pattern languages so that there are patterns for the various evolving contexts of IxD ; and
4. Clarifying the nature of value-driven, pattern-based design.

The proposed research agenda for the empirical study of guidelines and patterns is aligned with points 1, 2 and 4 of Dearden and Finlay's research agenda and extends these points by proposing a detailed set of research questions.

3.5.2 General Research Questions

Design guidelines are used as design and evaluation aids for new interactive products or redesigned versions of existing products (Section 2.4.2). Research done on the corresponding use of IxD patterns for design and evaluation was reviewed in Section 3.3.7. The need to compare the usefulness (quality in use) of guidelines and patterns was emphasised in the previous section.

The processes of designing a new product and redesigning an existing product differ (Section 3.2.6). The ways of using evaluation aids at various stages of the development of new products and the redevelopment of existing products do not vary. It would thus be sufficient for the empirical study to focus on three modes of design aid use; namely the physical design of a new product from a functional description, the usability evaluation of an existing product and the re-design of the product to correct usability issues identified in the usability evaluation.

The usability of guidelines and patterns when used by designers for these three modes partially determines their usefulness (Section 3.5.1). Questions could be framed in terms of the three standard ISO 9241-11 usability components of efficiency, effectiveness and user satisfaction (1998), applied to each of the three modes.

Three aspects of the modes of use of guidelines and patterns requiring research are thus the extent to which:

1. They are efficient, effective and satisfying design aids;
2. They are efficient, effective and satisfying evaluation aids; and
3. They are efficient, effective and satisfying redesign aids.

The first three questions (G1 to G3 in Table 3.4) focus on the comparative efficiency, effectiveness and user satisfaction of guideline and pattern use for design, evaluation and redesign.

Guidelines and patterns have differing formats and content, which are static features (Sections 3.2.3 and 3.3.3). The formats and content of guidelines and patterns partially determine their usefulness (Section 3.5.1).

Two aspects of the surface features of guidelines and patterns requiring research are thus the extent to which:

1. Their formats are a useful way of capturing design knowledge; and
2. Their contents are useful solutions to design problems.

Two questions (G4 and G5 in Table 3.4) focus on the comparative usefulness of the formats and content of guidelines and patterns.

Guidelines and patterns are organised into collections, and these collections have structures, which are collective features. In the case of guidelines, these are categorical structures. Patterns have pattern language structures overlaid on their categorical structures. Collections are accessed by means of their interfaces. The collective structures and interfaces of guideline and pattern collections partially determine their usefulness (Section 3.5.1).

Three aspects of the collective structures of guidelines and patterns requiring comparison are thus the extent to which:

1. The categories used in collections are useful;
2. The interfaces of collections influence their usefulness; and
3. The pattern languages in pattern collections (when present) are useful.

Two questions (G6 to G7 in Table 3.4) focus on the comparative usefulness of the category utility and collection interface utility of guidelines and patterns. One question (G8) focuses on the pattern language utility of patterns only. This is because there is no equivalent construct in guideline collections, making a comparison with guidelines impossible.

The designer experience of guideline and pattern use partially determines usability, which in turn partially determines usefulness (Section 3.5.1).

Seven aspects of the designer experience of using guidelines and patterns that could be compared are the extent to which:

1. They can be understood when first encountered;
2. They can be learned when first encountered;
3. They can be remembered when used subsequently;
4. They may be used in different ways to facilitate design and evaluation;
5. They are a personal design language;
6. They are a means of sharing design knowledge between designers; and
7. They achieve long-term acceptance as a design aid by their users.

The last seven questions (G9 to G15 in Table 3.4) focus on the comparative usefulness of the designer experience of guideline and pattern usage.

Table 3.4 presents the complete list of research questions. The G prefix in the question identifiers stands for "general".

3.5.3 Empirical Study Research Questions

A comprehensive set of 15 general guideline and pattern research questions is presented in Table 3.4. It was decided to answer two sets of questions in the empirical study that were regarded as pivotal in grounding future research. The first set of questions relates to the comparative effectiveness of guideline and pattern use for new design, evaluation and redesign. The second set of questions relates to the designers' subjective experience of guideline and pattern use.

ID	Research Question
A	**Primary Research Question**
G0	How useful are patterns as design and evaluation aids in IxD, as compared to guidelines?
B	**Questions on Modes of Pattern and Guideline Use**
G1	How efficient, effective and satisfying are patterns as design aids, as compared to guidelines?
G2	How efficient, effective and satisfying are patterns as evaluation aids, as compared to guidelines?
G3	How efficient, effective and satisfying are patterns as redesign aids, as compared to guidelines?
C	**Questions on Static Features of Patterns and Guidelines**
G4	How useful are pattern formats, as compared to guideline formats?
G5	How useful is pattern content, as compared to guideline content?
D	**Questions on Collective Structures of Patterns and Guidelines**
G6	How useful are pattern categories, as compared to guideline categories?
G7	How useful are different pattern collections, as compared to guideline collections?
G8	How useful are pattern languages?
E	**Questions on Designer (User) Experience of Pattern and Guideline Use**
G9	How easy to understand are patterns, as compared to guidelines?
G10	How easy to learn are patterns, as compared to guidelines?
G11	How easy to remember are patterns, as compared to guidelines?
G12	How are patterns used in doing design, evaluation and redesign, as compared to guidelines?
G13	To what extent are patterns and guidelines used as a personal design language?
G14	To what extent are patterns and guidelines a means of sharing design knowledge between designers?
G15	To what extent are patterns and guidelines accepted as long-term design aids?

Table 3.4: Pattern and Guideline Research Questions

A set of three effectiveness questions (E1, E2 and E3) was selected from the general questions G1, G2 and G3 in Table 3.4, as shown in Table 3.5. The E prefix in the revised question identifiers stands for "effectiveness".

ID	Research Question
E1 (from G1)	How effective are patterns as design aids, as compared to guidelines?
E2 (from G2)	How effective are patterns as evaluation aids, as compared to guidelines?
E3 (from G3)	How effective are patterns as redesign aids, as compared to guidelines?

Table 3.5: Pattern and Guideline Effectiveness Questions

It was necessary to provide definitions for design and evaluation aid effectiveness that suggested ways of measuring these attributes:

1. Design effectiveness is the extent to which new designs have good design features.
2. Evaluation effectiveness is the identification of a significant number of usability issues and good design features in existing designs.
3. Redesign effectiveness is the extent to which a redesign corrects a significant number of selected usability issues in existing designs or incorporates selected new features.

ID	Research Question
A	**Primary Research Question**
S0	How useful do designers consider patterns to be as design and evaluation aids in IxD, as compared to guidelines?
B	**Questions on Modes of Pattern and Guideline Use**
S1	How efficient, effective and satisfying do designers consider patterns to be as design aids, as compared to guidelines?
S2	How efficient, effective and satisfying do designers consider patterns to be as evaluation aids, as compared to guidelines?
S3	How efficient, effective and satisfying do designers consider patterns to be as redesign aids, as compared to guidelines?
C	**Questions on Static Features of Patterns and Guidelines**
S4	How useful do designers consider pattern formats to be, as compared to guideline formats?
S5	How useful do designers consider pattern content to be, as compared to guideline content?
D	**Questions on Collective Structures of Patterns and Guidelines**
S6	How useful do designers consider pattern categories to be, as compared to guideline categories?
S7	How useful do designers consider different pattern collections to be, as compared to guideline collections?
S8	How useful do designers consider pattern languages to be?
E	**Questions on Designer (User) Experience of Pattern and Guideline Use**
S9	How easy to understand do designers consider patterns to be, as compared to guidelines?
S10	How easy to learn do designers consider patterns to be, as compared to guidelines?
S11	How easy to remember do designers consider patterns to be, as compared to guidelines?
S12	How do designers use patterns in doing design, evaluation and redesign, as compared to guidelines?
S13	To what extent do designers consider patterns and guidelines to be a personal design language?
S14	To what extent do designers consider patterns and guidelines a means of sharing design knowledge between designers?
S15	To what extent do designers accept patterns and guidelines as long-term design aids?

Table 3.6: Subjective Experience Research Questions

The second set of questions (S0 to S15) specialises the 15 general questions shown in Table 3.4 so that 14 of them relate to the subjective experience of pattern and guideline use by interaction designers. Question S8 focuses on pattern languages, making a comparison impossible (Section 3.4.4). The questions are shown in Table 3.6. The S prefix in the question identifiers stands for "subjective".

3.6 Conclusions

Design guidelines and IxD patterns were discussed and compared with respect to their background, definitions, properties, classification, organisation into collections, selection, use, benefits and shortcomings. This was done in order to achieve Research Objective 2 (Sections 3.2—3.4).

Guidelines were characterised as generally accepted design aids that were useful in design, redesign and evaluation. Guidelines have a number of benefits. Guidelines make designers aware of unknown concepts, help designers to make informed design choices, and suggest overall strategies for solving design problems.

Guidelines have a number of problems. It may be difficult to select a set of applicable guidelines for a particular design problem in a large collection. Designers have a tendency to select the first guidelines found and then abandon the search. It may be difficult to select the most important guidelines for a particular design problem from a large number found. It may be difficult to apply guidelines, because they may not clearly express and explain their rationale and the design context to which they apply. Two or more guidelines may seem to both apply to a particular design problem, but conflict. Guidelines do not provide ways of establishing whether a revised design is more usable than the original version. Some authors question the validity of guidelines.

Patterns and their associated pattern languages were characterised as design aids that were becoming more accepted for physical design, but whose use for redesign and evaluation was only partially understood. Pattern languages are particularly useful because they can support the multi-level design of an entire interactive product, with groups of patterns applying to each level.

Several claims were made that patterns did not have the problems of guidelines and offered advantages for IxD. The link structures of pattern languages make it easy for designers to select a suitable set of related patterns. Applying patterns is easier than applying guidelines, because both high-level and low-level patterns explain their rationale and design context. Patterns are derived from examples of good practice, explain their rationale and the context to which they apply and describe how they may be applied. Patterns do not conflict because they form a connected language. The validity of patterns is high and they automatically apply to complex IxD projects.

The comparison of guidelines and patterns (Tables 3.3a and b) revealed that patterns have a shorter history, are complex and verbose and have a multipart format, compared to guidelines. Patterns must be applied in design and express their design

advice explicitly, which is not generally the case with guidelines. Patterns match most closely with general guidelines and are grouped into pattern languages, for which there is no guideline equivalent.

A comparison of pattern and guideline usefulness was made (Section 3.5.1). Pattern and guideline usefulness was defined as the extent to which guidelines and patterns help interaction designers to solve design problems and carry out design and evaluation tasks. Usefulness was determined by the features and functionality of guidelines and patterns and the knowledge and skill level of interaction designers.

A research agenda comprising 15 secondary research questions required to achieve Research Objective 3 (Section 1.3.2) was derived from the comparison of guidelines and patterns and the definition of pattern and guideline usefulness. The questions focused on modes of pattern and guideline use; static features of guidelines and patterns; collective structures of guidelines and patterns; and designer experience of pattern and guideline use. The agenda was extended by Dearden and Finlay's pattern research agenda which proposed a programme of pattern language improvement.

A scoped set of questions for the empirical study was drawn from the research agenda. These questions focussed on design, evaluation and redesign effectiveness and subjective experience of pattern and guideline use.

Chapter 4 describes the experimental design and methodology employed in the empirical study comparing the use of guidelines and patterns for physical design and evaluation (Research Objective 3).

Chapter 4: Research Design and Methodology

4.1 Introduction

Chapter 3 presented a comparative literature review of guidelines and patterns. This review provided information about the comparative advantages of patterns over guidelines when used for physical design and evaluation. A set of research questions for the empirical study was formulated, based on the literature review and a comparison of pattern and guideline usefulness. The objective of this chapter is to describe the research design and methodology used in the empirical study (Research Objective 3).

The experimental design is described in the next section and provides an overview of the empirical study.

4.2 Experimental Design

The experimental design was created to provide an overall plan for the research (Sytsma, 2005) and involved:

1. Choice of units of observation and analysis (participants);
2. Assignment of units for specific treatments (tasks);
3. Specification of the sequence or arrangement of treatments; and
4. Specification of the sequence of measurements or observations required.

The ideal participants would have been a sample randomly selected from the novice and experienced interaction design (IxD) practitioners in South Africa (the theoretical population). This was not possible due to the low numbers of interaction designers in South Africa and Port Elizabeth in particular (the accessible population) and the lack of a suitable sampling frame. A purposive sample of 33 Masters and Honours

students registered for the 2004 post-graduate E-Commerce course at NMMU was recruited instead, through single-step sampling.

The sample was highly selected due to the strict admission requirements for post-graduate study at NMMU. All students had successfully completed or were attending a post-graduate course in Human-Computer Interaction (HCI) and thus had knowledge of HCI at an introductory level. They had experience of software design and development as a result of their academic education and training in Computing at a novice to intermediate level. Some students had *ad hoc* contract work experience on external projects. Such students are usually employed as software developers or interaction designers (or both) after graduation. The students were thus regarded as acceptable approximations of novice designers for the purposes of the empirical study.

Designers do a significant amount of work as individuals, even though they work in project teams (Newman and Landay 2000; Newman, Lin, Hong and Landay 2003; Cook and Bailey 2005). Individual participants were therefore chosen as the units of observation and analysis. The experimental treatments, observations and research instruments were designed for individual participants.

The comparison of the use of guidelines and patterns for new design, redesign and evaluation was done using two comparable groups. One group used patterns (the *Pattern Group*) and the other group used guidelines (the *Guideline Group*).

The design aid effectiveness research questions were answered by giving three matched group-specific tasks (treatments) to the Pattern and Guideline Groups to do, in the same sequence. These tasks comprised evaluating an existing interactive product to identify usability issues and good design features, redesigning aspects of the product to correct usability issues and designing a new product from a scenario.

The reasons for doing evaluation at the various IxD lifecycle stages differ, but the ways in which evaluation are done (e.g. heuristic evaluation or guideline review) are the same (Section 2.4.4). As a consequence, only one evaluation task using guidelines and patterns was included in the empirical study.

New design and redesign both require physical design, but they are done for different reasons and differ in terms of scale and process (Section 2.4.3). As a consequence, both redesign and new design tasks were included in the empirical study.

The evaluation task was done first as it was the simplest of the three tasks. The redesign task was done next. The new design task, which was the most complex, was done last. The redesign task focused on the correction of usability issues only, and excluded the addition of new features to an existing design. The participants progressively learned the design aids as they carried out the tasks. There was thus no history threat to internal validity caused by learning effects.

The groups submitted group-specific reports and/or designs (observations) after each task. These were analysed to provide quantitative measurements of the comparative effectiveness of pattern and guideline use for evaluation, redesign and new design. Qualitative data were also collected by means of these reports.

The subjective experience research questions were answered by means of matched, group-specific, post-test questionnaires (observations), containing items to capture quantitative and qualitative data about participant attitudes towards the different design aids.

The experimental design was thus a two-group, pre-post, randomised group design using multiple measures administered in the same sequence for comparable groups. All three treatments involved one condition of the designer experience variable (novice designers), one condition of the collaboration variable (individual design) and two conditions of the evaluation aid type variable (guidelines and patterns).

4.3 Research Hypotheses and Qualitative Data

Research hypotheses were derived from the effectiveness questions and the subjective experience questions (Section 3.5.3). Several qualitative research questions that could not be answered by formulating testable hypotheses were identified.

4.3.1 Effectiveness Hypotheses

Paired null and alternative research hypotheses were derived from the evaluation, redesign and new design effectiveness research questions (E1, E2 and E3) in Table 3.5 (Section 3.5.3). The alternative hypotheses were all two-tailed. The null hypotheses are shown in Table 4.1 in the order that they were tested in the empirical study. The "0" suffix in the identifier subscripts represents "*null*".

ID	Research Hypothesises
A	**Evaluation Null Hypothesis**
H_{E10}	There is no significant difference between the effectiveness of guidelines and patterns when used for evaluation.
B	**Redesign Null Hypothesis**
H_{E20}	There is no significant difference between the effectiveness of guidelines and patterns when used for redesign.
C	**Design Null Hypothesis**
H_{E30}	There is no significant difference between the effectiveness of guidelines and patterns when used for design.

Table 4.1: Pattern and Guideline Effectiveness Null Hypotheses

4.3.2 Subjective Experience Hypotheses

Paired null and alternative research hypotheses were derived from 14 of the 15 subjective experience research questions in Table 3.6 (Questions S0 to S11 and S13 to S15).

The alternative hypotheses were all two-tailed hypotheses, with the exception of H_{S8A}, which was an upper-tailed hypothesis. H_{S80} and H_{S8A} were derived from research question S8 in Table 3.6 ("*How useful do designers consider pattern languages to be?*"). A comparison with guideline collections was impossible, as guidelines do not have an equivalent construct to pattern languages (Section 3.4.2). The null hypotheses are shown in Table 4.2 in the order that they were tested in the empirical study.

Research question S12 was "*How do designers use patterns in doing design, evaluation and redesign, compared to guidelines?*" This question was used to gather qualitative information about the process of pattern and guideline use.

ID	Research Hypothesis
A	**Primary Subjective Experience Null Hypothesis**
H_{S00}	There is no significant difference between the perceived usefulness of guidelines and patterns for IxD.
B	**Subjective Experience Null Hypotheses About Modes of Pattern and Guideline Use**
H_{S10}	There is no significant difference between the perceived efficiency, effectiveness and satisfaction of guidelines and patterns for evaluation.
H_{S20}	There is no significant difference between the perceived efficiency, effectiveness and satisfaction of guidelines and patterns for redesign.
H_{S30}	There is no significant difference between the perceived efficiency, effectiveness and satisfaction of guidelines and patterns for new design.
C	**Subjective Experience Null Hypotheses About Static Features of Patterns and Guidelines**
H_{S40}	There is no significant difference between the perceived usefulness of pattern and guideline formats.
H_{S50}	There is no significant difference between the perceived usefulness of pattern and guideline content.
D	**Subjective Experience Hypotheses About Collective Structures of Patterns and Guidelines**
H_{S60}	There is no significant difference between the perceived usefulness of the categories used in pattern and guideline collections.
H_{S70}	There is no significant difference between the perceived usefulness of pattern and guideline collections.
H_{S80}	Patterns are not perceived to be useful when linked together into pattern languages.
E	**Subjective Experience Hypotheses About User Experience of Pattern and Guideline Use**
H_{S90}	There is no significant difference between the perceived ease of understanding of guidelines and patterns when first encountered.
H_{S100}	There is no significant difference between the perceived ease of learning of guidelines and patterns when first encountered.
H_{S110}	There is no significant difference between the perceived ease of remembering of guidelines and patterns when first encountered.
H_{S130}	There is no significant difference between the perceived extent to which guidelines and patterns served as personal design languages.
H_{S140}	There is no significant difference between the perceived extent to which guidelines and patterns served as means of sharing design knowledge between designers.
H_{S150}	There is no significant difference between the perceived acceptance of guidelines and patterns as long-term design aids.

Table 4.2: Pattern and Guideline Subjective Experience Null Hypotheses

4.4 Research Measures and Variables

Research measures and associated variables were used to record participant data and quantitative data to test the effectiveness and subjective experience hypotheses (Section 4.3). Measures and variables were also used to record qualitative data to answer Research Question S12 and augment the quantitative data. Research instruments for collecting the data are described in Section 4.5.3.

4.4.1 Participant Measures and Variables

Six participant measures, sub-measures, quantitative variables and qualitative variables were used to record participant data for stratified assignment and to check group comparability. These variables are shown in Table 4.3.

ID	Measure	Variable
PM1	Personal details	Participant ID
		Surname
		Initials
		Title
		Age
		Nationality
		Gender
		Main language spoken
		Institution where studying/employed
		Degree registered for /Job title
PM2	Educational qualifications	Post-school educational qualification(s)
PM3	Academic ability	Credit-weighted Computing mean score for previous degree
PM4	Prior computing experience	Design experience:
		Design experience duration
		Rating of design experience
		Number of interfaces designed
		Interface design method(s) used
		Design software used
		Development experience:
		Development experience duration
		Rating of development experience
		Number of systems developed
		System development method(s) used
		Programming/scripting software used
PM5	Existing knowledge of patterns	Confirmation of knowledge of pattern definition
		Provision of pattern definition
		Confirmation of previous pattern use
		Information about patterns previously used
PM6	Prior experience of using patterns	Experience of pattern usability:
		Efficiency of pattern use
		Effectiveness of pattern use
		Satisfaction of pattern use
		Method of using patterns in design
		Experience of general pattern properties:
		Patterns used as personal design language
		Patterns used as shared design language
		Pattern format usefulness
		Patterns accepted as long-term design aid
		Useful aspects of pattern formats
		Non-useful aspects of pattern formats

Table 4.3: Participant Measures and Variables

The credit-weighted mean Computing score for the participants' previous degree was used as an academic ability measure. Design and development experience (Section 2.3.2) were used as two sub-measures of prior design experience.

4.4.2 Effectiveness Measures and Variables

Three evaluation measures and associated quantitative variables were used to record quantitative data to test the guideline and pattern effectiveness hypotheses (Table 4.1, Section 4.3.1). These are shown in Table 4.4, in the order in which they were used in the empirical study.

ID	Measure	Variable
E_{M1}	Effectiveness of design aid for evaluation	Number of usability issues identified Severity of usability issues identified (S_{UI})
		Number of good design features identified Benefit of good design features identified (B_{DF})
E_{M2}	Effectiveness of design aid for redesign	Redesign score (S_{RD})
E_{M3}	Effectiveness of design aid for new design	New design score (S_{ND})

Table 4.4: Effectiveness Measures and Variables

Collecting data for the evaluation effectiveness variables required the analysis and categorization of participant evaluation data. Lists of unique usability issues and good design features, together with associated ratings, were constructed from the participant evaluation data.

Collecting data for the redesign and new design effectiveness variables was more difficult. It required determining whether there was a significant difference between the quality of redesigns and new designs produced using guidelines and those produced using patterns. This was done by scoring the redesigns and new designs using an extended heuristic evaluation form incorporating B2C E-commerce specific heuristics (Appendix M).

4.4.3 Subjective Experience Measures and Variables

Twenty-three subjective experience evaluation measures were identified for recording quantitative data to test the subjective experience null hypotheses (Table 4.2) and additional qualitative data. These measures were normalised and mapped one-to-one onto variables. The evaluation measures and associated variables are shown in Table 4.5, in the order that they were used in the empirical study.

The variables SEM18, SEM19 and SEM20 were used to collect data on the process of design aid use in evaluation, redesign and new design, in order to answer Research Question S12 (Table 3.6).

ID	Measure and Variable
SEM1	Perceived efficiency of design aid use in evaluation
SEM2	Perceived effectiveness of design aid use in evaluation
SEM3	Perceived satisfaction with design aid use in evaluation
SEM4	Perceived efficiency of design aid use in redesign
SEM5	Perceived effectiveness of design aid use in redesign
SEM6	Perceived satisfaction with design aid use in redesign
SEM7	Perceived efficiency of design aid use in new design
SEM8	Perceived effectiveness of design aid use in new design
SEM9	Perceived satisfaction with design aid use in new design
SEM10	Perceived usefulness of design aid format
SEM11	Perceived usefulness of design aid content
SEM12	Perceived usefulness of design aid collection categories
SEM13	Perceived usefulness of design aid collections
SEM14	Perceived usefulness of pattern languages
SEM15	Perceived ease of understanding design aid
SEM16	Perceived ease of learning to use design aid
SEM17	Perceived ease of remembering design aid
SEM18	Process of design aid use in evaluation
SEM19	Process of design aid use in redesign
SEM20	Process of design aid use in new design
SEM21	Perceived usefulness of design aid as personal design languages
SEM22	Perceived usefulness of design aid as shared design languages
SEM23	Perceived acceptance of design aid for long-term use

Table 4.5: Subjective Experience Measures and Variables

4.5 Research Resources, Documents and Instruments

The empirical study was constrained to the use of guidelines and patterns for physical design and evaluation for one category of interactive product (Section 1.3.4). The category of B2C E-commerce websites was chosen, because of its practical and economic importance and because good-quality web design guideline and pattern collections existed that could be used in the empirical study (van Welie and Traetteberg 2001; van Duyne *et al.* 2003). It was decided to evaluate and redesign one existing website and design one new website.

4.5.1 Website Selection

The empirical study involved evaluating an existing B2C E-commerce website to identify usability issues and good design features, redesigning aspects of the website to correct usability issues, and designing a new B2C E-commerce website from a scenario.

Several South African B2C E-commerce websites were studied in order to select one for the evaluation and redesign tasks which had some usability issues but also some good design features. The Porcupine Ceramics website was identified as a suitable basic B2C E-commerce website (http://www.porcupine.co.za/). This website sells beautiful, locally-designed and made raku ceramics. A screenshot of the home page is shown in Figure 4.1. The author carried out a heuristic evaluation of this website using Nielsen's heuristics (Nielsen 1994) (Appendix A). This evaluation identified usability issues concerning the shopping cart, product pages, trust and customer service.

4.5.2 Design Aid Selection

The restriction of the empirical study to B2C E-commerce websites implied that the guidelines and patterns to be used had to come from website design guideline and

pattern collections that contained B2C E-commerce design aids. It was thus necessary to identify suitable guideline and pattern collections and matched sets of guidelines and patterns in these collections.

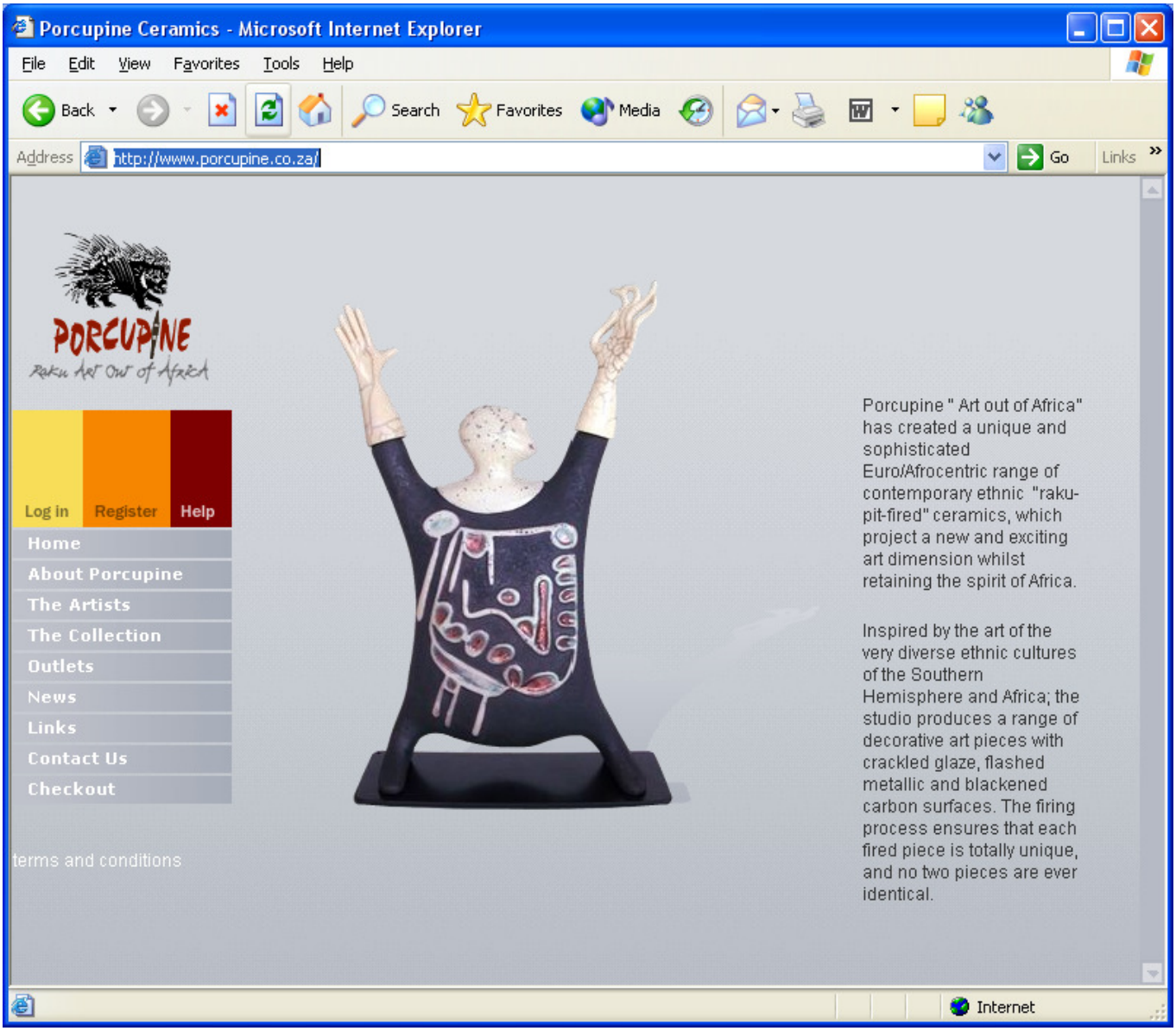


Figure 4.1: Porcupine Ceramics Website Home Page (http://www.porcupine.co.za/; Last accessed on 31/12/2008)

Two pattern collections in the form of websites were required to allow comparisons to be drawn between them in respect of their format, content, collective structures and interfaces. Van Welie's *Amsterdam Pattern Collection* (http://www.welie.com/) (van Welie and Traetteberg 2001) and van Duyne *et al.*'s *Design of Sites* pattern collection

(http://www.designofsites.com/home/) (2003) were chosen. These pattern collections are well-known, cited in the IxD pattern literature and contain B2C E-commerce patterns. Van Welie's *Amsterdam Pattern Collection* is now known as van Welie's *Interaction Design Pattern Library*. The *Design of Sites* collection is better known as a print-format book (now in its second edition), but was accessed by means of the *Design of Sites* Pattern Browser (Section 3.3.5) during the empirical study. The *Design of Sites* Pattern Browser is no longer available for public on-line use.

Barnard's *E-commerce Guideline Collection* (2004), in the form of an on-line document, was selected as the guideline collection to be used by the Guideline Group. This collection was selected because it was based on Nielsen *et al.*'s E-commerce guidelines (2001) and thus inherited some of the authority of that collection. It was free, tersely expressed, easy to access and use. Written permission was obtained from the collection owners to use these three collections for the empirical study.

Each group was provided with a list of suggested patterns or guidelines to use, but encouraged to venture beyond the list. The guidelines and patterns were chosen to provide a good fit with the evaluation, redesign and new design tasks.

#	Entry Pattern	Associated Patterns
1	Shopping Experience	Hotlist; Double Tab Navigation; Breadcrumbs; Product Comparison; Product Configurator; Virtual Product Display; Shopping Cart; Send-a-Friend Link
2	Shopping Cart	Favourites; Purchase Process; Wizard
3	Product Page	E-commerce Site; Corporate Site; Frequently Asked Questions (FAQ); Guided Tour
4	Paging	Search Results; List Builder; Stepping; Enlarged Clickarea
5	Login	Registration; E-commerce Site; Community Site; Web-based Application; Action Button
6	Register	Product Recommendations; Shopping Cart; Login; Wizard; Form
7	Form	Booking; Advanced Search; Registration; Login; Grid-based Layout; Constraint Input; Input Error Message
8	Input Error Message	Form; Constraint Input

Table 4.6: Suggested Patterns from *Amsterdam Pattern Collection* (2001)

Suggested patterns from the *Amsterdam Pattern Collection* were *Shopping Experience*, *Shopping Cart*, *Product Page*, *Paging*, *Login*, *Register*, *Form* and *Input Error Message*. Suggested patterns from the *Design of Sites* Pattern Browser were patterns in the *Personal E-Commerce* category and the *Advanced E-Commerce* category. An overview of the suggested patterns and their associated patterns from the *Amsterdam Pattern Collection* is shown in Table 4.6. There are no patterns that deal specifically with trust; guidance on trust is contained in certain patterns (e.g. the *Login* and *Register* patterns).

Overview of Suggested Categories from Barnard's E-Commerce Guideline Collection	
A: Category Pages	
A1	Store Home pages
A2	Classification schemes
A3	Product Listing Pages
A4	Images on Category Pages
A5	Winnowing
A6	Product Comparisons
B: Product Pages	
B1	Product Description
B2	Product Images
B3	Price, Other Costs and Availability
B4	Specifying Product Options
B5	Adding Products to the Shopping Cart
D: Customer Support	
D1	Fulfil Customer Expectations
D2	Access to Helpful People
E: Shopping Cart & Placing Order	
E1	Shopping Cart
E2	Adding Products to the Shopping Cart
E3	Reviewing and Editing Shopping Cart Contents
E4	Concluding Purchase and Confirmation

Table 4.7: Suggested Categories from Barnard's E-Commerce Guidelines (2004)

Suggested guideline categories from Barnard's *E-commerce Guideline Collection* were *Customer Support*, *Category Pages*, *Product Pages* and *Shopping Cart & Placing Order*. An overview of the suggested guideline categories and subcategories from Barnard's *E-commerce Guideline Collection* is shown in Table 4.7.

The corpus of design knowledge embodied in the patterns overlapped with the corpus of design knowledge embodied in the guidelines, but the two corpuses were not

identical. Table 4.8 shows a partial comparison of the design knowledge in the *Shopping Cart* pattern from the *Amsterdam Pattern Collection* with various guidelines from Barnard's *E-commerce Guideline Collection*, to illustrate the design knowledge overlap. The mapping between the corpuses is non-onto and multilevel in both directions.

Shopping Cart Pattern from *Amsterdam Pattern Collection*	**Selected Barnard's *E-Commerce Guidelines***
Provide a shopping cart for users to put their products in before they purchase them.	A shopping cart must be provided.
Product pages must have an Add to shopping cart link.	Use a simple button for the Buy mechanism.
	Beware of using clever names for the shopping cart and Buy buttons.
	Put a Buy button on enlarged product views.
After adding an item to their cart, the users are shown the current contents of the cart.	Provide strong feedback when an item has been put into the cart.
Users can inspect their cart contents at any time using a link that is available on every page.	Support easy navigation between order list/shopping cart and other shopping pages (1 of 2).
A persistent mini-cart could also be shown directly on the content pages.	Shopping cart contents to be visible at all times.
	Provide shopping instructions in the empty cart.
The description of the cart contents typically includes the name of the items, the quantity, availability and prices.	
Users can remove items from their cart if they wish and change quantities.	Enable users to change an order at any point prior to submitting it.
The description of the goods is a link to the product details.	
Users always see the total costs of a purchase, so including shipping costs if applicable.	Display a running total.
The users must also be informed of the payment options such as which credit cards are accepted.	
From the cart page, the users can continue shopping or proceed with the checkout procedure.	Support easy navigation between order list/shopping cart and other shopping pages (2 of 2).
	Enable customers to print shopping cart contents.
In order to purchase the products in the cart they need to select the checkout action.	Provide order list page that supports reviewing, editing and submitting an order

Table 4.8: Example of Overlapping Pattern and Guideline Design Knowledge

4.5.3 Research Instruments and Other Documents

Two documents were designed for recruiting participants and assigning the sample participants to the Pattern and Guideline Groups during the preparatory phase of the empirical study:

1. Project Information and Informed Consent Form (Appendix B); and
2. Group Assignment Worksheet.

The Project Information and Informed Consent Form was designed for recruiting the participants. It explained the purpose of the empirical study, the tasks involved, and the rights and responsibilities of participants. It provided a means of recording the informed consent of those participants who agreed to take part in the empirical study.

The Group Assignment Worksheet was designed for use by the author to randomly assign participants from the purposive sample to the Pattern Group or the Guideline Group, using stratified assignment. Participant academic ability measure data were captured for use in the assignment process.

Eight documents and instruments were designed for generating and collecting quantitative and qualitative data during the empirical study, as follows:

1. Pre-Test Questionnaire (Appendix C);
2. Assignment 1: The use of patterns or guidelines to evaluate an existing E-commerce site (Appendices D and E);
3. Assignment 2: The use of patterns or guidelines to redesign an existing E-commerce site (Appendices F and G);
4. Assignment 3: The use of patterns or guidelines to design a new E-commerce site (Appendices H and I);
5. Project Diary (Appendix J);
6. Post-Test Questionnaire (Appendices K and L); and
7. B2C E-Commerce Heuristic Evaluation Form (Appendix M).

The Pre-Test Questionnaire was designed for use by participants to record their data for the participant measures and variables (Section 4.4.1).

Assignments 1, 2 and 3 were treatments that were used by the participants to produce observations in the form of reports and designs. The reports and designs were analysed to generate data for the effectiveness measures and variables (Table 4.4).

The three assignments were each designed in two versions; one for the Pattern Group and one for the Guideline Group. The goals, durations, tasks and submission requirements were isomorphic to a high degree for the two versions, to ensure that the two groups received equivalent treatments.

Assignment 1 was used to perform a usability evaluation of the Porcupine Ceramics website to identify usability issues and good design features. The content of the evaluation aids used was also evaluated. The output of the evaluation was an evaluation report.

Assignment 2 was used to redesign selected aspects of the Porcupine Ceramics website evaluated in Assignment 1, using the evaluation report. The content of the redesign aids used was also evaluated. The output of the redesign was a prototype consisting of a site (or navigation) map and a collection of wireframes, and a report on the usefulness of the content of the redesign aids used.

Assignment 3 was used to design a new E-commerce website from a scenario. The format of the redesign aids used was also evaluated. The output of the new design was a prototype consisting of a site map and a collection of wireframes, and a report on the usefulness of the format of the design aids used.

The Project Diary was used by participants to keep a work record while they were doing the three assignments. The diary enabled them to record their thoughts, ideas and processes, assisting them in producing the assignment reports and designs. The diaries were submitted together with the observations resulting from Assignment 3 and were themselves observations. The diaries were analysed to generate data for the process of using guidelines and patterns for design and evaluation.

The Post-Test Questionnaire was used by participants to record data about their attitudes towards using design aids, after they had completed the three assignments. The questionnaire was designed in two versions; one for the Pattern Group and one for the Guideline Group. The questionnaire generated data for the subjective experience measures and variables (Table 4.5).

The results of the redesign and new design tasks produced medium-fidelity paper prototypes. Heuristic evaluation was used to evaluate the design quality of the prototypes (Nielsen and Molich 1990).

The wireframes of the redesigns and new designs were analogous to screen shots without the presentation design. Allen *et al.* (2005) found that heuristic evaluation of paper-based screen shots of the interface of an interactive product could be done rapidly, efficiently and easily.

Wang, Caldwell and Salvendy (2003) devised a six-stage task-based B2C E-commerce usage model. The tasks were formulating objectives, searching and refining results, using target information, decision-making, ordering and using customer service. It was decided to combine these six tasks in the form of heuristics with Nielsen's ten heuristics to produce a set of B2C E-commerce-specific heuristics. The heuristics were combined because B2C E-commerce was regarded as a mainstream interactive product.

The B2C E-Commerce Heuristic Evaluation Form (Appendix M) was created using the set of B2C E-commerce-specific heuristics. The guidance on how to use the B2C E-commerce-specific heuristics was created by combining Wang *et al.*'s description of the six tasks and task-specific design advice contained in the guideline and pattern collections used in the empirical study. It was designed for use by the usability experts to score the redesigns and new designs generated by Assignments 2 and 3. The redesign and new design scores were used to produce data for the redesign and new design measures and variables (Table 4.4).

The B2C E-Commerce Website Heuristic Evaluation Form was used to produce usability issue ratings for the different designs. It was necessary to convert the total score for the severity ratings into a design score. To do this, the usability scores were subtracted from the maximum possible usability issue score (64), divided by the maximum possible usability issue score and converted into percentages. The percentages were used as redesign scores ($S_{RD)}$ to indicate the new design and redesign quality.

4.6 Group Assignment

4.6.1 Group Assignment Method

Stratified assignment was employed to split the sample of 33 participants (Section 4.2) into two comparable groups, the Pattern Group, which used patterns and the Guideline Group, which used guidelines.

The sample was sorted by degree into Masters and Honours strata, to ensure that the distribution of degree types would be the same or nearly the same in the two groups. Each of these strata was sorted in descending order of the weighted mean Computing module mark achieved in the previous degree, to ensure that the mark distribution for each degree type would be the same or nearly the same in the two groups. The mean mark was assumed to correlate with performance on the empirical study.

The degree strata were split into two further strata consisting of those who achieved 60% to 74% and those who achieved 75% or more. Sixty percent is the minimum mark for admission into the post-graduate programmes in the Department of Computer Science and Information Systems at NMMU and 75% or more is a distinction.

Each of the four strata was split into two paired groups using pseudorandom numbers. Equivalence was ensured by checking that each group in a pair had about the same number of participants (a variation of 1 was achieved), and about the same average mark (a variation of 2 to 3 % was achieved).

Finally the split groups were vertically combined to yield the two equivalent stratified groups required for the empirical study. The Pattern Group consisted of 17 participants (52% of the sample) and the Guideline Group consisted of 16 participants (48%) of the sample.

Gender, age and racial group were not regarded as significant for the study (there were four females, the ages were clustered in a range of 21 to 25 years with five students older than 25, and the racial composition of the sample was fairly homogenous).

4.6.2 Group Data Collection

Thirty-three participants (100% of the sample) completed and submitted Pre-Test Questionnaires. Seventeen of the participants were Pattern Group participants (52%) and 16 were Guideline Group participants (48%).

4.6.3 Group Data Analysis

The Pre-Test Questionnaire data were analysed to yield descriptive statistics for the Pattern Group (n = 17) and Guideline Group (n = 16) demographic profiles. These appear in Table 4.9, both as observation counts and within-group percentages. Descriptive statistics are presented for the Pattern Group, the Guideline Group and the sample population. The descriptive statistics were analysed to determine to what degree the Pattern and Guideline Groups were comparable. Pie charts are used to discuss the various participant variables shown in Table 4.9.

Pre-Test Questionnaire: Sample Profile Descriptive Statistics per Group			**Pattern Group**	**Guideline Group**	**Totals**	**Pattern Group (%)**	**Guideline Group (%)**	**Sample Group (%)**
N			17	16	33	52	48	100
Age		<=25 years	14	14	28	82	88	85
		>25 years	3	2	5	18	13	15
Nationality		RSA	14	13	27	82	81	82
		Other	3	3	6	18	19	18
Gender		Male	14	15	29	82	94	88
		Female	3	1	4	18	6	12
Major Language		English	11	12	23	65	75	70
		Afrikaans	4	4	8	24	25	24
		Other	2	0	2	12	0	6
Degree registered for		Honours	13	13	26	76	81	79
		Masters	4	3	7	24	19	21
Educational Level		B Degree	13	13	26	76	81	79
		Hons Degree	4	3	7	24	19	21
Design Experience	Years	0	4	0	4	24	0	12
		1-3	9	11	20	53	69	61
		4+	4	5	9	24	31	27
	Level	NA	4	0	4	24	0	12
		Novice	9	9	18	53	56	55
		Intermediate	4	7	11	24	44	33
		Expert	0	0	0	0	0	0
Development Experience	Years	0	1	0	1	6	0	3
		1-3	8	9	17	47	56	52
		4+	8	7	15	47	44	45
	Level	NA	1	0	1	6	0	3
		Novice	7	6	13	41	38	39
		Intermediate	8	9	17	47	56	52
		Expert	1	1	2	6	6	6
Previous Pattern Knowledge		Yes	13	10	23	76	63	70
		No	4	6	10	24	38	30
Previous Pattern Use		Yes	1	1	2	6	6	6
		No	16	15	31	94	94	94

Table 4.9: Demographic Profiles of Groups and Sample

The age profiles of the Pattern and Guideline Groups are shown graphically in Figures 4.2 and 4.3. Eighty-five percent of the sample population fell in the 21 to 25 year age range. The remaining 15% ranged in age from 26 to 40 years old. The groups had

similar age profiles (predominantly between 21 and 25 years old), so this was unlikely to affect the results of the empirical study.

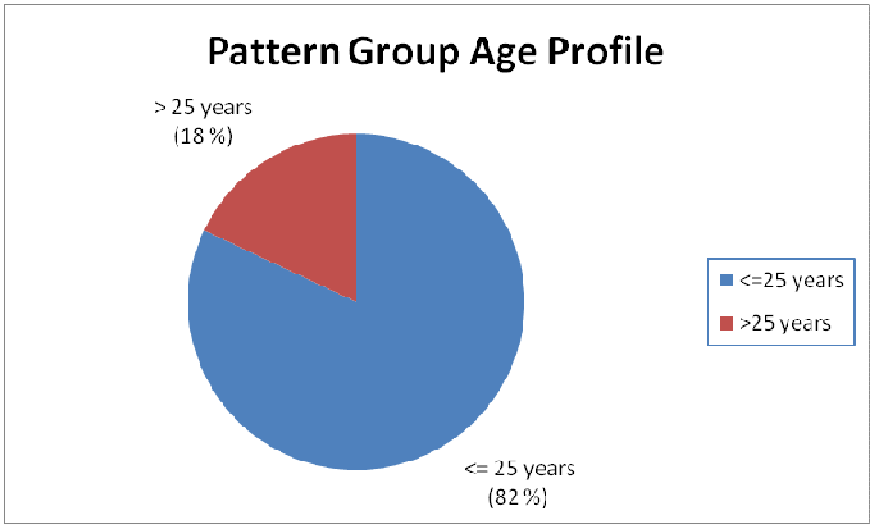


Figure 4.2: Pattern Group Age Profile (n = 17)

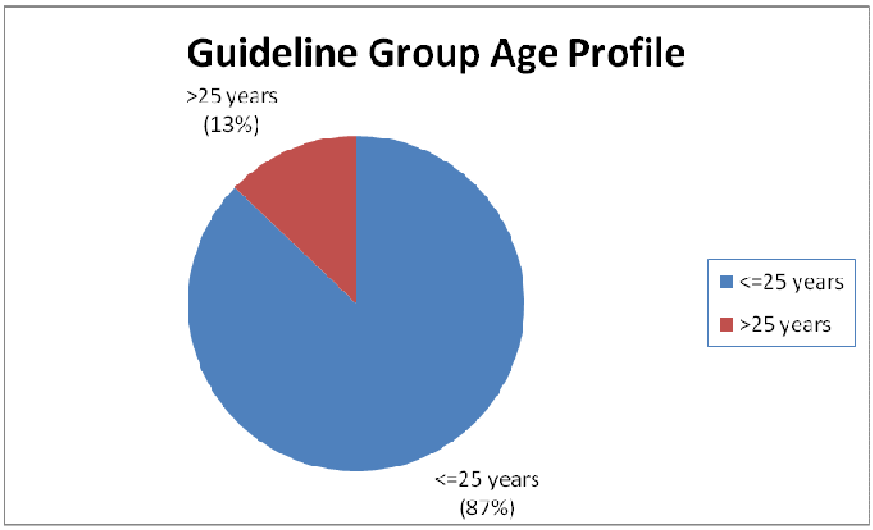


Figure 4.3: Guideline Group Age Profile (n = 16)

The nationality profiles of the Pattern and Guideline Groups are shown graphically in Figures 4.4 and 4.5. Eighty-two percent of the sample population were South African and 18% were from other countries (India, Malawi, Mozambique, Sweden, Uganda and Zimbabwe). The groups had similar nationality profiles (predominately South African), so this was unlikely to affect the results of the empirical study.

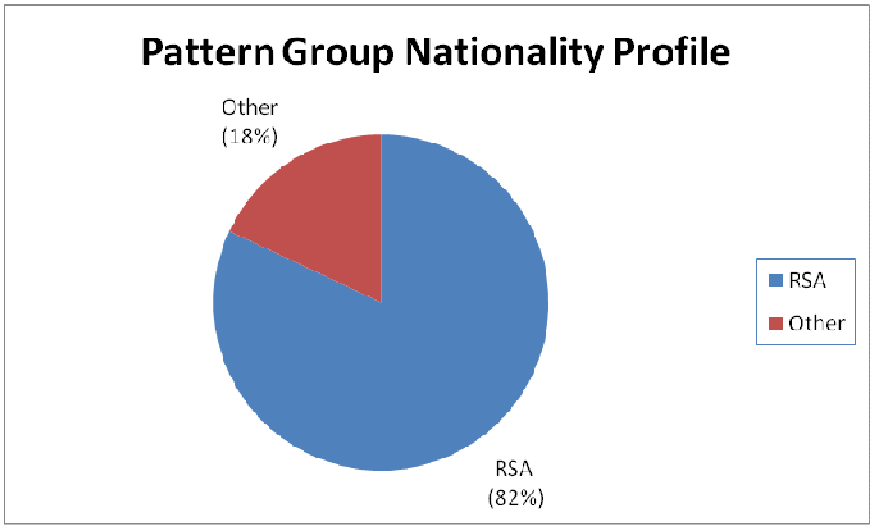


Figure 4.4: Pattern Group Nationality Profile (n = 17)

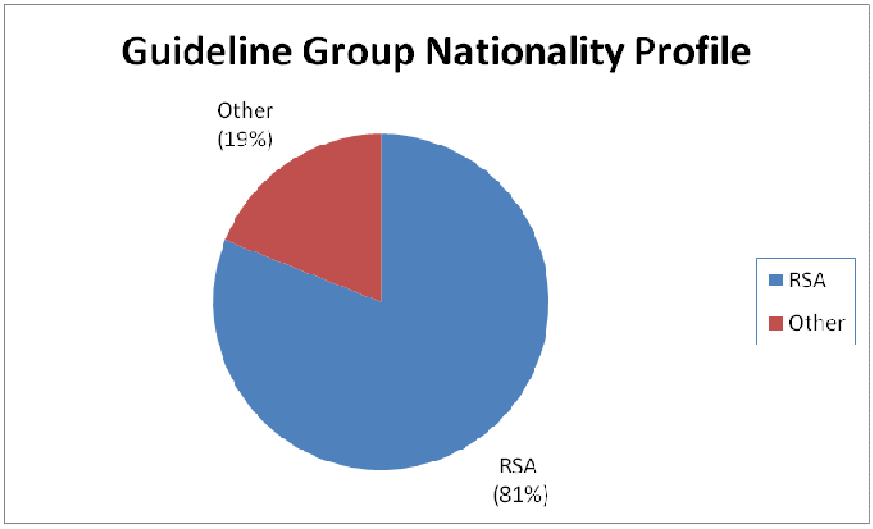


Figure 4.5: Guideline Group Nationality Profile (n = 16)

The gender profiles of the Pattern and Guideline Groups are shown graphically in Figures 4.6 and 4.7. Eighty-eight percent of the sample population were male and 12% were female. The groups had similar gender profiles (predominantly male), so this was unlikely to affect the results of the empirical study.

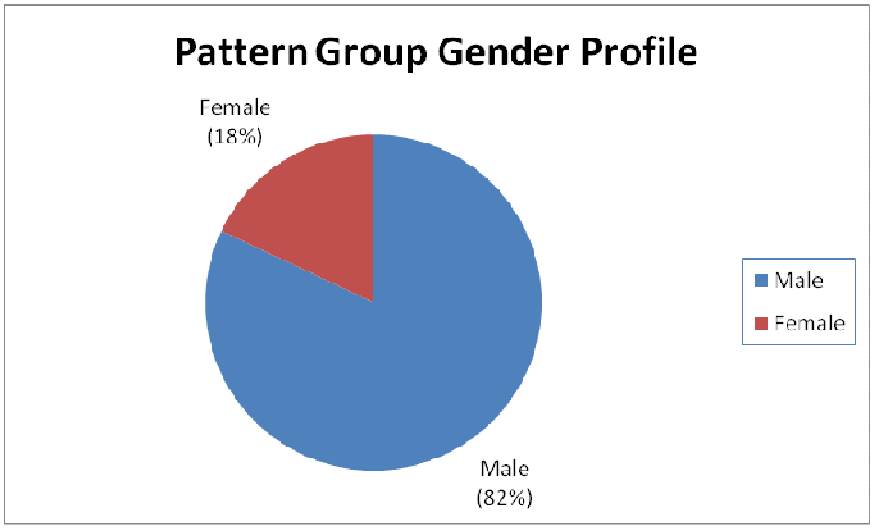


Figure 4.6: Pattern Group Gender Profile (n = 17)

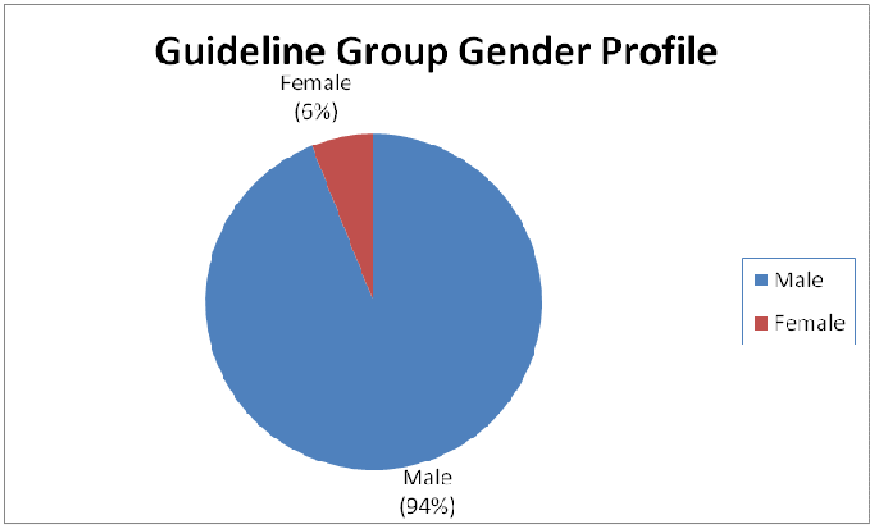


Figure 4.7: Guideline Group Gender Profile (n = 16)

The language profiles of the Pattern and Guideline Groups are shown graphically in Figures 4.8 and 4.9. Seventy percent of the sample population stated that English was used as their major language (all participants were at least bilingual) and 24% stated that Afrikaans was used as their major language. The remaining 6% spoke Chichona (a Malawian language) or Swedish. The groups had similar language profiles (predominantly English-speaking), so differences in English fluency were unlikely to affect the results of the empirical study. The empirical study was conducted in written and spoken English.

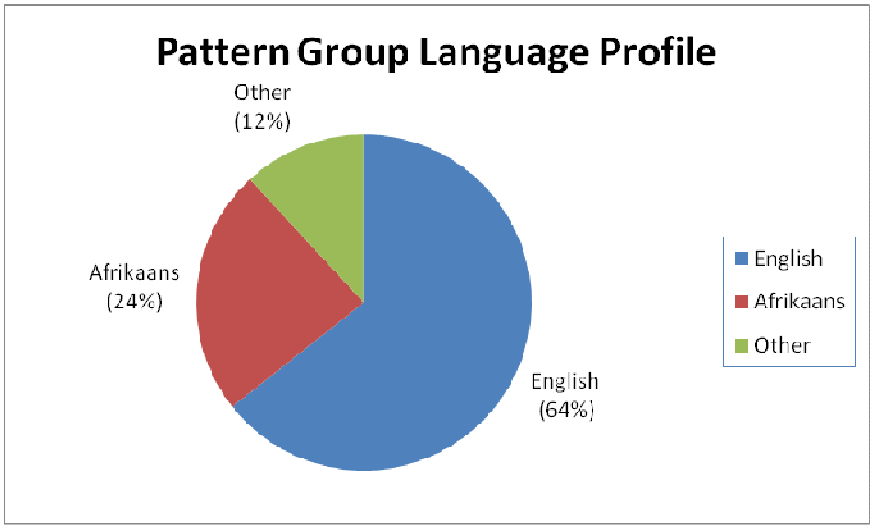


Figure 4.8: Pattern Group Language Profile (n = 17)

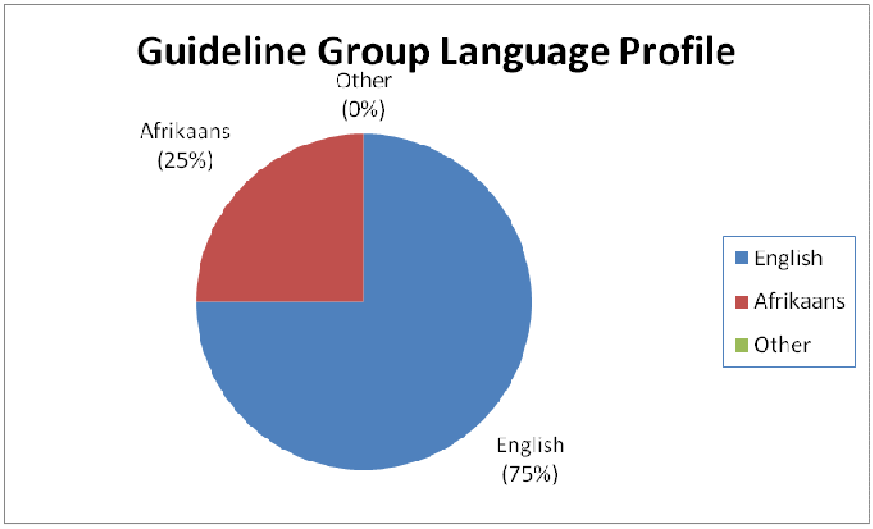


Figure 4.9: Guideline Group Language Profile (n = 16)

The registration profiles of the Pattern and Guideline Groups are shown graphically in Figures 4.10 and 4.11. Seventy-nine percent of the sample population had an undergraduate degree and were registered for an Honours degree. The undergraduate degrees were almost all in Computing. Twenty-one percent had an Honours degree and were registered for a Masters degree. The groups had similar Masters and Honours registration profiles, so differences in registration were unlikely to affect the results of the empirical study.

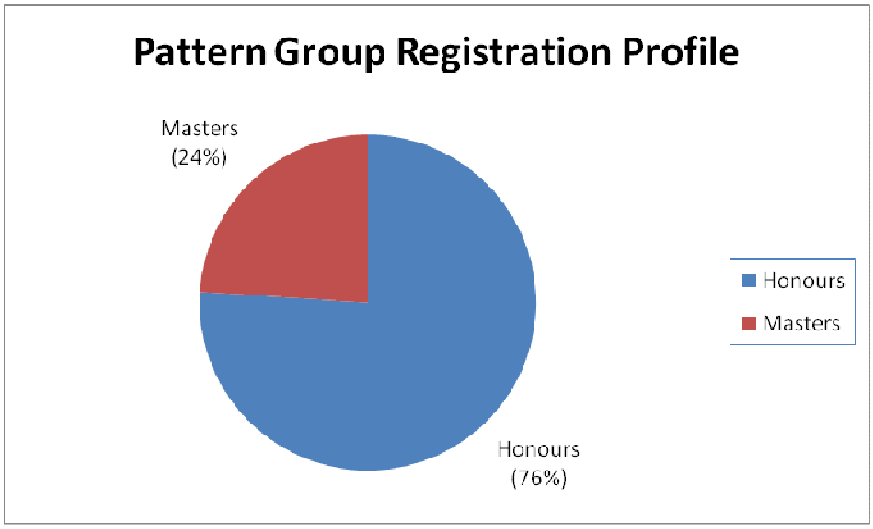


Figure 4.10: Pattern Group Degree Registration Profile (n = 17)

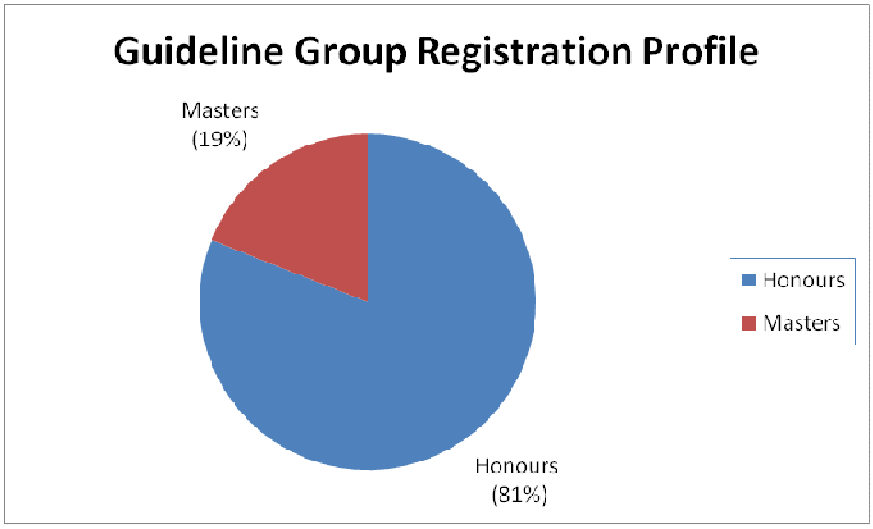


Figure 4.11: Guideline Group Degree Registration Profile (n = 16)

The academic ability profiles of the Pattern and Guideline Groups are shown graphically in Figure 4.12. The Honours participants in the sample population had a mean academic ability score of 72% and the Masters participants had a mean score of 67%. In the Pattern Group, the Honours participants had a mean academic ability score of 74% and the Masters participants had a mean score of 66%. The Pattern Group mean academic ability score was 72%. In the Guideline Group, the Honours participants had a mean score of 69% and the Masters participants had a mean score of 69%. The Guideline Group mean academic ability score was 69%. The Pattern and

Guideline Groups had roughly normal academic ability profiles (academic ability values are not shown in Table 4.9). The Pattern Group had a broader spread of scores than the Guideline Group, and a significant number of high-scoring participants (five scoring more than 80%). Differences in academic ability could possibly affect the results of the empirical study.

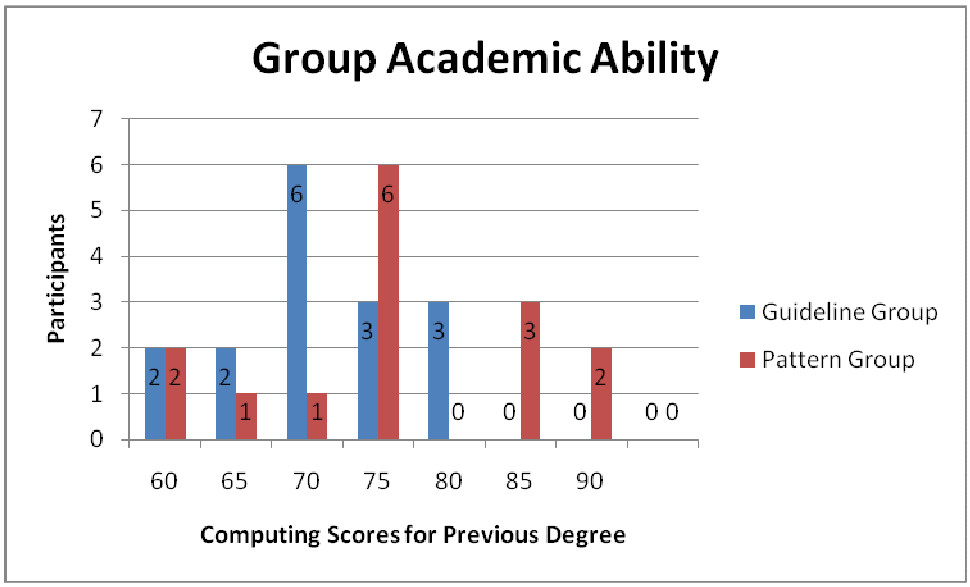


Figure 4.12: Group Academic Ability Profiles (n = 33)

The design experience profiles of the Pattern and Guideline Groups are shown graphically in Figures 4.13 and 4.14. Twelve percent (four participants, all in the Pattern Group) of the sample population had no experience, 61% had from one to three years of experience and 27% had four or more years of experience. The Guideline Group had more design experience than the Pattern Group, so differences in design experience could possibly affect the results of the empirical study. The predominant level of design experience in both groups was one to three years.

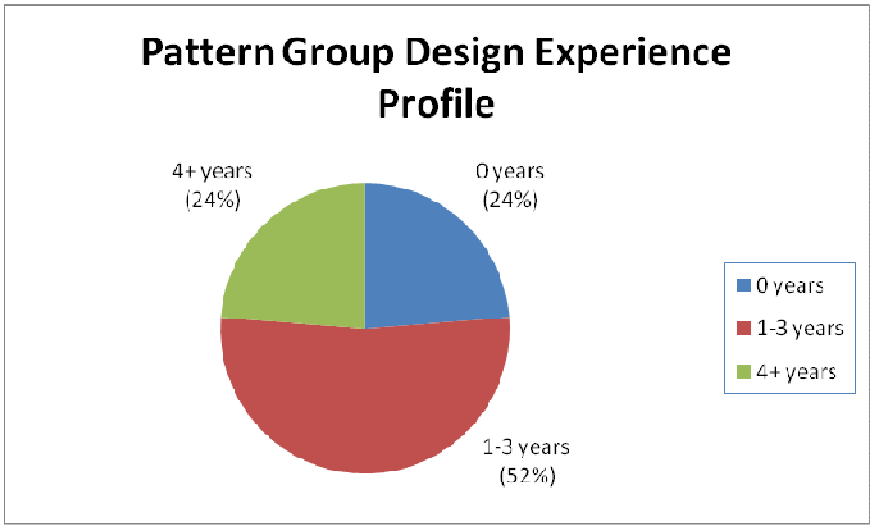


Figure 4.13: Pattern Group Design Experience Profile (n = 17)

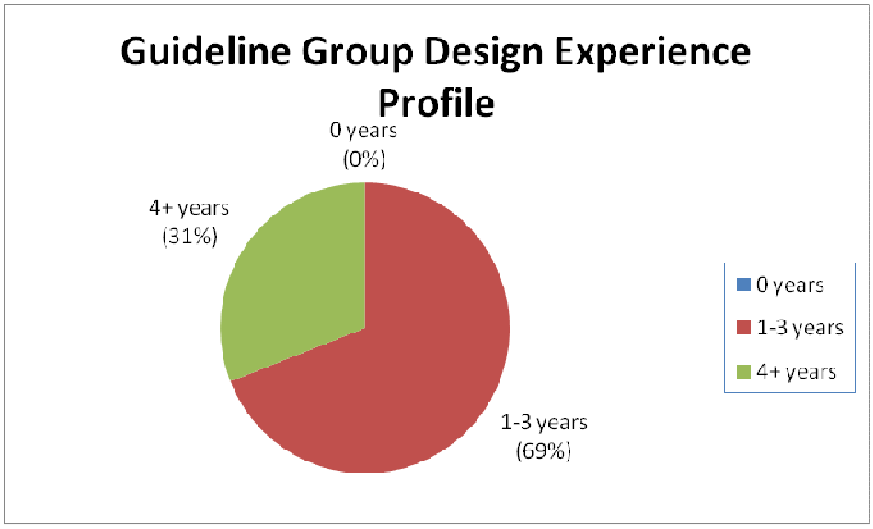


Figure 4.14: Guideline Group Design Experience Profile (n = 16)

The design level profiles of the Pattern and Guideline Groups are shown graphically in Figures 4.15 and 4.16. Twelve percent (four participants, all in the Pattern Group) of the sample population did not regard themselves as designers, 55% regarded themselves as novice designers, 33% as intermediate designers and none as expert designers. The Guideline Group had a higher design level profile than the Pattern Group, so differences in design level could affect the results of the empirical study. Both groups consisted predominantly of novice designers.

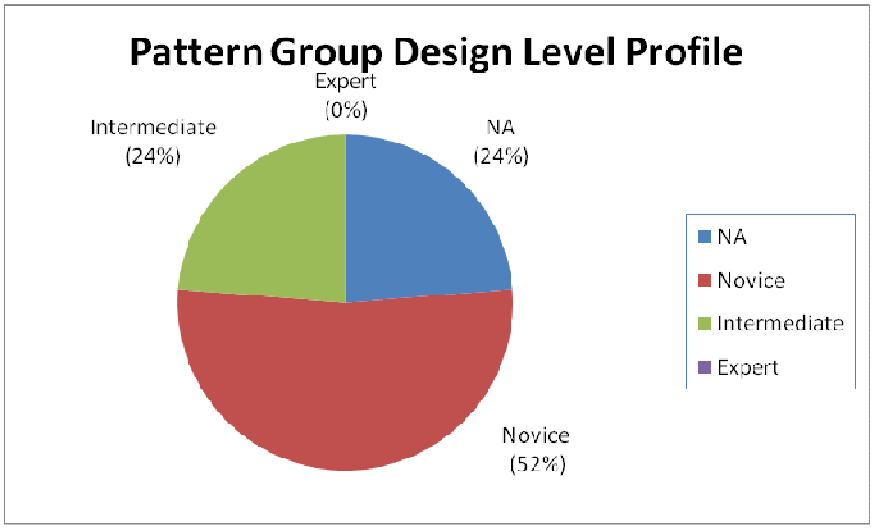


Figure 4.15: Pattern Group Design Level Profile (n = 17)

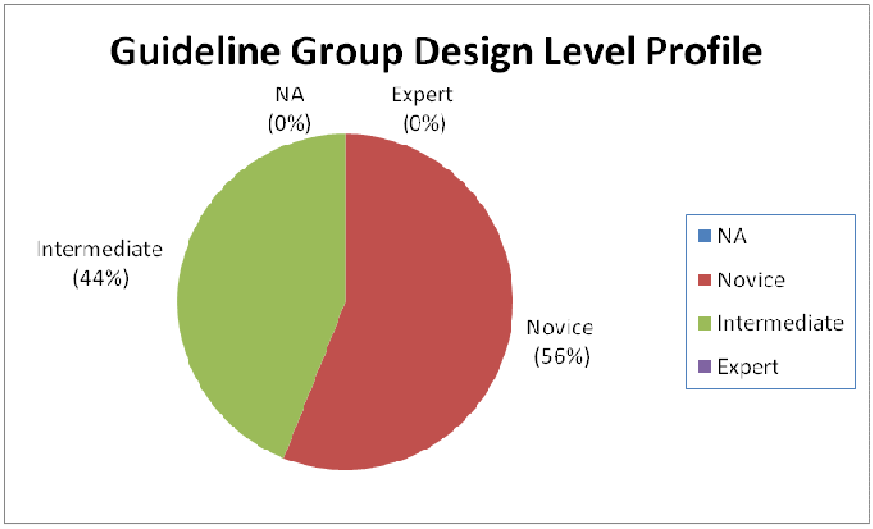


Figure 4.16: Guideline Group Design Level Profile (n = 16)

The development experience profiles of the Pattern and Guideline Groups are shown graphically in Figures 4.17 and 4.18. Three percent (one participant in the Pattern Group) of the sample population had no experience, 52% had from one to three years experience and 45% had four or more years experience. The groups' development experience profiles differed slightly, so differences in development experience could slightly affect the results of the empirical study. There was no dominant level of design experience in the groups. It was evenly split between "one to three" years and "more than four" years.

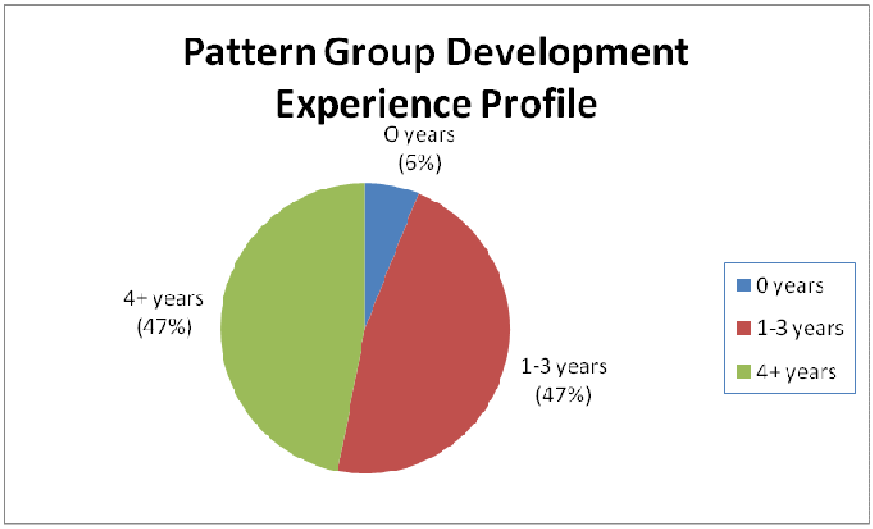


Figure 4.17: Pattern Group Development Experience Profile (n = 17)

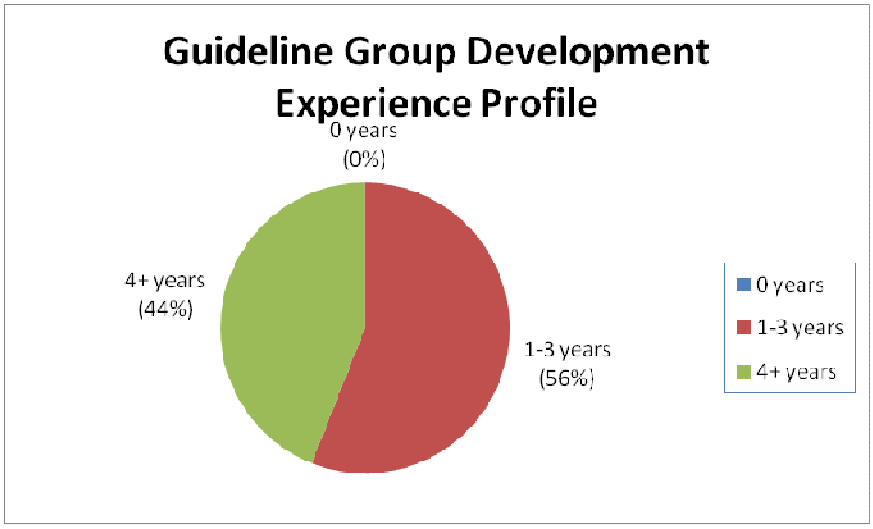


Figure 4.18: Guideline Group Development Experience Profile (n = 16)

The development level profiles of the Pattern and Guideline Groups are shown graphically in Figures 4.19 and 4.20. Three percent (one participant in the Pattern Group) of the sample population did not regard themselves as developers, 39% regarded themselves as novice developers, 52% as intermediate developers and 6% (two participants in the Pattern Group) as expert developers. The groups' development level profiles differed slightly, so differences in development level could slightly affect the results of the empirical study. The groups consisted predominantly of intermediate developers, followed by novice developers.

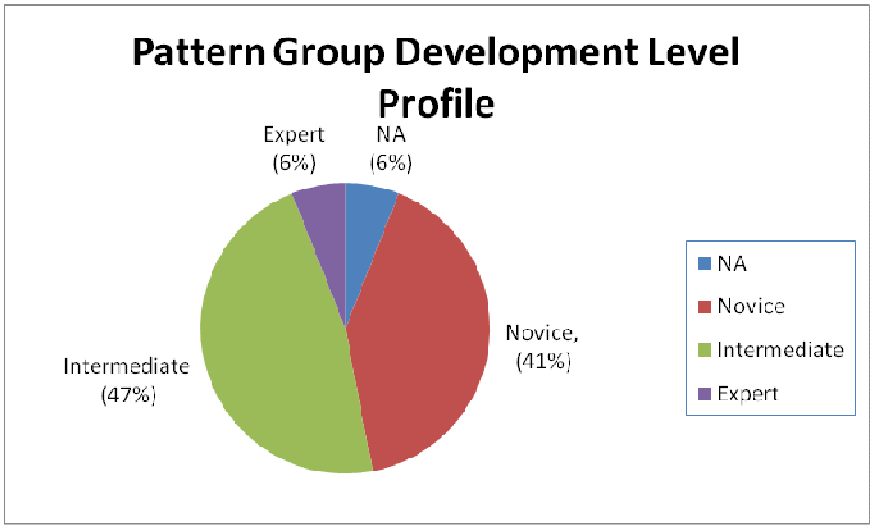


Figure 4.19: Pattern Group Development Level Profile (n = 17)

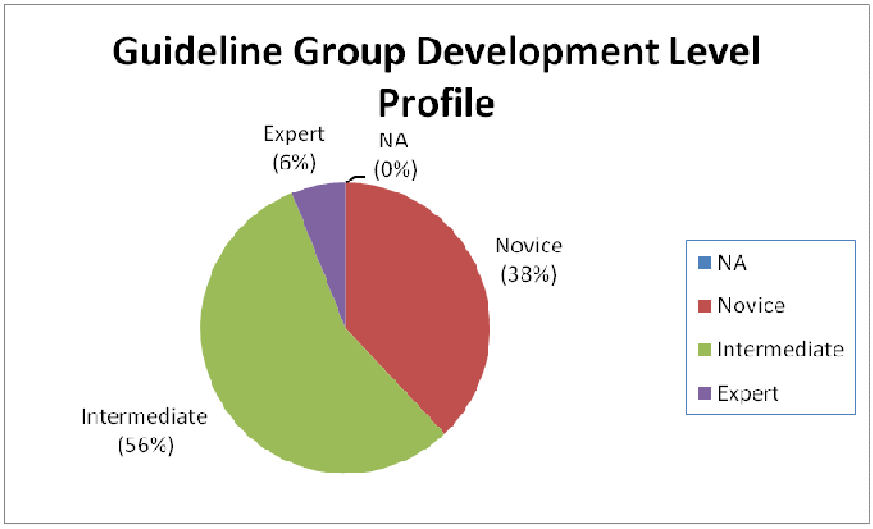


Figure 4.20: Guideline Group Development Level Profile (n = 16)

The Pattern and Guideline Groups had similar levels of knowledge of IxD patterns and previous experience of using these design aids. They had learned about IxD patterns during their HCI course (in one lecture) and about design guidelines, but not how to use these IxD aids practically. Seventy percent of the sample population knew what patterns were, but only 6% (two participants, one from each group) had previous experience of using IxD patterns. Seventy-six percent of the Pattern Group knew what patterns were, but only 6% (one participant) had previous experience of using IxD patterns. Sixty-three percent of the Guideline Group knew what patterns were, but

only 6% (one participant) had previous experience of using IxD patterns. Most of the definitions of IxD patterns given by the participants professing knowledge of patterns were deficient. These definitions generally viewed patterns as the same as guidelines.

The analysis of the Pre-Test Questionnaires revealed that the corresponding participant variable profiles of the Pattern and Guideline Groups were similar. The Pattern Group had a broader spread of academic ability scores than the Guideline Group, and a significant number of high-scoring participants The Guideline Group had more design experience and a higher design level profile than the Pattern Group. These inter-group differences in academic ability and design experience and level could possibly affect the results, but could also counterbalance each other.

In summary, the Pattern and Guideline Group participants exhibited the following general characteristics:

1. Young, South African, male, English-speaking students;
2. Registered for a post-graduate Computing degree;
3. Possessed of high academic ability in Computing;
4. Novice designers, with one to three years experience;
5. Novice to intermediate developers, with one to more than four years experience; and
6. Possessed of an awareness of IxD patterns, but did not know what they were.

The Pattern and Guideline Groups could thus be considered to be comparable groups for the purposes of the empirical study.

4.7 Data Collection

The Project Information and Informed Consent Form was read to the 33 participants. This form explained the purpose of the empirical study, the tasks involved, and the rights and responsibilities of participants. The students were invited to participate in the empirical study and all 33 agreed to participate. Individualised document packs were handed to them. They signed the Project Information and Informed Consent

Forms, and completed the Pre-Test Questionnaires. The completed documents were collected for further processing. The participants were then briefed on Assignment 1. The two pattern collections and Barnard's Guidelines were made available on a server for the Pattern and Guideline Groups to use. The participants had read-only Internet browser access to these resources for the duration of the empirical study (one month).

The participants worked on Assignment 1 and submitted the usability reports a week later at a meeting. They received Assignment 2 during the meeting and submitted the redesign documents a week later at the next meeting. They received Assignment 3 during the meeting and submitted the new design documents a week later. The Post-Test Questionnaires were handed out to the participants at the start of the E-Commerce module examination and submitted within the next two weeks.

Reminder emails were sent to 11 participants with an outstanding Assignment 3, Project Diary or Post-Test Questionnaire, which resulted in some submissions of outstanding documents. Twenty-four participants submitted a complete set of documents (15 Pattern Group and nine Guideline Group participants). Nine participants submitted an incomplete set of documents (two Pattern Group and seven Guideline Group participants). It is not known why the Guideline Group submission rate in the latter part of the empirical study was lower than that of the Pattern Group. The statistics for the final submission numbers for the various documents is shown in Table 4.10.

#	Document	Pattern Group		Guideline Group	
		Submitted	Outstanding	Submitted	Outstanding
1	Informed consent agreement	17	0	16	0
2	Pre-test questionnaire	17	0	16	0
3	Assignment 1 report:	17	0	16	0
4	Assignment 2 redesign and report	17	0	16	0
5	Assignment 3 design and report	16	1	12	4
6	Project diary	16	1	10	6
7	Post-Test Questionnaire	17	0	11	5

Table 4.10: Pattern and Guideline Group Document Submissions (n = 33)

4.8 Data Analysis

Assignment 1 was used to produce usability evaluation reports (Section 4.5.3). These reports identified usability issues and good design features for the Porcupine Ceramics website. The participant evaluation report data were analysed, categorised and merged to construct lists of unique usability issues and good design features, together with associated ratings. Descriptive statistics were calculated for the data and t-tests were used to calculate inferential statistics to test the evaluation effectiveness hypotheses (Section 4.3.1).

The empirical study of the comparative effectiveness of guidelines and patterns as evaluation aids is an example of comparative usability evaluation (CUE) research (Section 2.4.4). The results were analysed to determine whether the use of guidelines and patterns for evaluation exhibited the characteristics observed in CUE research.

Assignment 2 was used to produce redesigns and reports (Section 4.5.3). The redesigns corrected selected usability issues of the Porcupine Ceramics website. The reports analysed the usefulness of the content of the design aids used. The redesigns were medium-fidelity paper prototypes consisting of a site (or navigation) map and a collection of wireframes. The participants' redesigns were scored independently by two usability experts at NMMU using the B2C E-Commerce Heuristic Evaluation Form (Appendix M). The redesign scores were used to compare the redesigns of the Pattern and Guideline Groups, in order to characterise any systematic differences. Descriptive statistics were calculated for the data and t-tests were used to calculate inferential statistics to test the redesign effectiveness hypotheses (Section 4.3.1). Thematic analysis was performed on the qualitative data in the reports, as described in the next section

Assignment 3 was used to produce new designs and reports (Section 4.5.3). The new designs were prototypes of an E-commerce website designed from a scenario. The reports analysed the usefulness of the form of the design aids used. The designs were medium-fidelity paper prototypes consisting of a site (or navigation) map and a collection of wireframes. The participants' new designs were also scored

independently by two usability experts at NMMU using the B2C E-Commerce Heuristic Evaluation Form (Appendix M). The design scores were used to compare the new designs of the Pattern and Guideline Groups, in order to characterise any systematic differences. Descriptive statistics were calculated for the data and t-tests were used to calculate inferential statistics to test the new design effectiveness hypotheses (Section 4.3.1). Thematic analysis was performed on the qualitative data in the reports, as described in the next section.

The Post-Test Questionnaire was used to record quantitative and qualitative data about the participants' attitudes towards using the design aids after they had completed the three assignments (Section 4.5.3). Descriptive statistics were calculated for the data and t-tests were used to calculate inferential statistics to test the subjective experience hypotheses (Section 4.3.2). Thematic analysis was performed on the qualitative data collected by the Post-Test Questionnaire, as described in the next section.

The Project Diary was used to record qualitative data about the participants' thoughts, ideas and processes while using the design aids (Section 4.5.3). Thematic analysis was performed on the qualitative data collected from the diary, as described in the next section.

4.9 Thematic Analysis

Thematic analysis (Braun and Clarke 2006) was used to analyse data sets drawn from the Project Diary data corpus, as well as the other qualitative data sets produced by the empirical study. Braun and Clarke (2006: 79) state that thematic analysis is "*a qualitative research method for identifying, analysing and reporting patterns (themes) within data*."

Thematic analysis was selected because it is a flexible research method and compatible with a variety of epistemological or theoretical positions, unlike conversation analysis (CA) (Hutchby and Wooffit 1998) or grounded theory (Glaser 1992; Strauss and Corbin 1998).

Assumptions made and approaches decided on at the beginning of any process of thematic analysis should be explicitly stated (Braun and Clarke 2006: 81). The statement of assumptions and approaches that follows applies to the thematic analysis of all qualitative data gathered in the empirical study.

The thematic analysis of the data sets was conducted within the framework of an essentialist/realist epistemology (Potter and Wetherell 1987), rather than a constructionist epistemology (Burr 1995). The research aim was to understand specific ideas, concepts and processes of individual participants (the essences or attributes of these ideas, concepts and processes), rather than the socio-cultural environment in which the participants operated. The participants were requested throughout to participate in the empirical study as individuals and thus their ideas, concepts and processes within the empirical study context were assumed to be largely individually determined, rather than socially determined.

Themes were identified using an inductive, data-driven approach (Frith and Gleeson 2004), rather than a deductive, theory-driven approach (Boyatzis 1998). This was because the analysis of the data sets aimed to let the data speak for themselves. It did not employ an essentialist/realist or constructionist theoretical foundation to derive the themes, nor a pre-existing coding frame to fit them into. The inductive approach resembles grounded theory (Glaser 1992; Strauss and Corbin 1998).

A rich thematic description of complete data sets was aimed for (Braun and Clarke 2006: 83), rather than a detailed description of particular, restricted aspects of the data sets (Clarke and Kitzinger 2004). This was because knowledge of all the major themes for each of the data sets was required.

Themes were identified at a semantic level rather than a latent level (Boyatzis 1998). The meaning of the data sets was determined by identifying the themes through description and then interpreting their significance, rather than theoretically interpreting the underlying factors that shaped the themes as they were progressively identified.

The prevalence (indication of the number of instances) of the themes, in terms of the data items and their code components exhibiting or participating in the themes, was recorded. This harmonises with the essentialist/realist epistemological framework adopted.

The analysis of the data sets followed Braun and Clarke's six phases of thematic analysis (2006: 87). Attention was paid to satisfying Braun and Clarke's 15-point checklist of criteria for good thematic analysis (2006: 96).

The data items contained narratives that were partially precise, vague, ambiguous or incomplete. Incomplete narratives frequently had implicit meanings that could be inferred from the contexts in which the narratives were written. All the narratives were critically examined, interpreted and coded to identify explicit and implicit ideas, concepts or processes. Themes were identified from the coded narratives through induction and their prevalence recorded.

4.10 Shortcomings and Sources of Error

The empirical study could be criticised on the grounds that the reports and designs produced by the Pattern and Guideline Groups might be sub-optimal and lead to questionable conclusions about design aids. This is because the participants were not IxD practitioners.

The Pattern and Guideline Group participants were post-graduate Computing students. The participants were high-ability novice designers and developers who had not yet started working full-time. They had to divide their time between their research and various modules. They were equipped with theoretical academic knowledge, but not the practical knowledge of the workplace.

IxD practitioners would differ from the participants in their knowledge, experience, motivation and working environment. Such practitioners would be able to apply their accumulated design knowledge and experience and not only a particular design aid

such as patterns or guidelines. They could focus on IxD, and not have to balance competing responsibilities. They would be more productive and driven. Their work environment would tend to be user-centred, team-based and business-focused. They would tend to produce better evaluations, redesigns and new designs because of this.

It was nevertheless anticipated that proper empirical design, careful analysis and interpretation of data would lead to valid results, due to the nature and goals of the empirical study.

4.11 Conclusions

A two-group pre-post randomised group experimental design using multiple measures administered in the same sequence for the Pattern and Guideline Groups was chosen for the empirical study. The empirical study was designed to compare the results of evaluation, redesign and new design tasks.

Several sets of design aid effectiveness hypotheses, subjective experience hypotheses and qualitative research questions were derived (Section 4.3). Participant measures and variables, design aid effectiveness measures and variables and subjective experience measures and variables were determined (Section 4.4).

The domain of B2C E-commerce websites was chosen as the empirical study domain. The Porcupine Ceramics website was chosen for the evaluation, redesign and new design tasks. Suitable guidelines and patterns from well-known collections were identified and the degree of overlap of the design knowledge in these design aids was determined. The required research instruments and other documents were designed, including the B2C Ecommerce Evaluation Form (Section 4.5).

A best-effort purposive sample of 33 post-graduate E-Commerce students was identified and randomly assigned to comparable Guideline and Pattern Groups. Sample data was collected and analysed to determine how representative the sample

was of the target population. The Pattern and Guideline Groups were shown to be comparable for the purposes of the empirical study (Section 4.6).

Data was collected by means of the Pre-Test Questionnaires, the evaluation, redesign and new design tasks, the Project Diaries and Post-Test Questionnaires (Section 4.7). The calculation of descriptive and inferential statistics for the quantitative data (Section 4.8) and the thematic analysis of the qualitative data were described (Section 4.9). A number of shortcomings and sources of error were described (Section 4.10). The risk of not using IxD practitioners as participants was highlighted.

Chapter 5 presents the quantitative and qualitative results of the empirical study and the analysis of the results.

Chapter 5: Results and Analysis

5.1 Introduction

Chapter 4 described the research design and methodology for the empirical study of the use of guidelines and patterns as evaluation, redesign and new design aids. The empirical study generated quantitative and qualitative data. The objective of this chapter is to present and analyse the results of the empirical study. This analysis revealed how useful IxD patterns are, as compared to design guidelines.

The use of guidelines and patterns as evaluation aids is presented and analysed first.

5.2 Evaluation of Existing Website

5.2.1 Description of Results

The Pattern and Guideline Group participants who did Assignment 1 evaluated the Porcupine Ceramics website as a treatment (Sections 4.5.3 and 4.7). Usability issues and good design features were identified by inspection, using guidelines and patterns as usability checklists. The participants wrote evaluation reports on the website as observations.

The Pattern Group submitted 17 reports and the Guideline Group submitted 15 reports. The 32 reports were analysed and yielded 830 individual textual descriptions of usability issues and good design features.

The participants' descriptions were analysed and generalised to construct lists of unique usability issues and good design features. A severity rating (S_{UI}) value was assigned to each issue and a benefit rating (B_{DF}) value was assigned to each feature, using a five-point ordinal scale ranging from 0 (not an issue or feature) to 4 (serious issue or major benefit). S_{UI} and B_{DF} are derived variables for the evaluation

effectiveness E_{M1} of a particular evaluation aid (Table 4.4). Each issue or feature was checked to see if it was already in the relevant list. If it was not, it was checked against the website to see if it was a false positive or not. The new issue or feature was assigned a unique code, description and rating and added to the list. False positives were assigned a rating of 0 and flagged with an "F" code. The participants' descriptions were marked up with the codes and ratings as the checking proceeded.

The analysis and generalisation of the participants' descriptions resulted in the identification of 182 unique issues and 97 unique features. Twelve false positive issues were identified (7% of the 182 issues), all dealing with minor issues. Each of the false positive issues occurred only once in the descriptions. Nine (5%) false positive issues were identified by the Pattern Group and three (2%) by the Guideline Group.

The Pattern Group identified a fairly large number of issues (70% of the 182 issues) and the Guideline Group identified a smaller number of issues (57%). The two groups did not identify exactly the same issue sets, but there was an overlap between the sets. The overlap between the issues identified by the Pattern and Guideline Groups was fairly low (27%). The overlap for features was also fairly low (22%).

The issues were classified into a set of 13 categories, on the basis of similarities. These categories are shown in Table 5.1 in descending order of size. Some categories contained a large number of issues (e.g. the Shopping cart category contained 39 issues). Other categories contained a small number of issues (e.g. the Linked page category contained one issue). Good design features were also categorised, but are not shown in table format, as the main objective was to identify usability issues.

The first four categories highlighted issues concerning the shopping cart, product pages, trust and customer service. The expert heuristic evaluation of the website conducted during research planning identified similar issues in the same categories (Section 4.5.1).

The categorised issues and features showed that the Pattern and Guideline Groups were generally able to identify usability issues and good design features using patterns

or guidelines as evaluation aids. The overlap between the issue sets and feature sets of the two groups was fairly low.

#	Category Code	Category Description	# of Issues
1	SCI	Shopping cart issues	39
2	PPI	Product page issues	28
3	TI	Trust issues	26
4	CSI	Customer service issues	24
5	PDI	Page design issues	16
6	CPI	Category page issues	14
7	FI	Form issues	12
8	HPI	Home page issues	8
9	IAI	Widget interaction issues	6
10	IEI	Input error issues	4
11	EPI	Empty page issues	3
12	LPI	Linked pages issues	1
13	SSI	Selling strategy issues	1
	Total		182

Table 5.1: Usability Issue Category Data

The descriptions provided an indication of the analytical power of guidelines and patterns during issue and feature extraction. They also provided an indication of the explanatory power of guidelines and patterns. The majority of the descriptions of issues or features explained them with reference to specific patterns or guidelines. A small number of descriptions explained issues or features in terms of "pure" design knowledge (free of references to patterns or guidelines).

Four examples of participant descriptions of usability issues are shown in Table 5.2, to provide an indication of the quality of participant responses. The descriptions are paired and each pair describes the same usability issue. The first description in each pair refers to patterns while the second one refers to guidelines. The second description in Table 5.2 explains an issue in terms of "pure" design knowledge. The remaining three descriptions explain issues in terms of specific patterns or guidelines.

The participant descriptions showed that the Pattern and Guideline Groups were generally able to explain usability issues and good design features effectively in terms of the applicable evaluation aids.

Category	Description	Evaluation Aid
	CPI2: No product search facility on category pages.	
CPI	Problem 11: A major problem that I found is that there is no search facility to search for products based on various criteria, such as name, description, artist, price range etc. [...] Users need this for suggestions on what to purchase. The Shopping Experience (www.welie.com) pattern suggests that users want to browse and discover ideas for what to buy based on criteria they specify.	Patterns
CPI	There is no search feature. This makes shopping difficult for both new and old customers. A search feature that is fully enabled is necessary to allow the site's users to attempt to use the facility.	Guidelines
	SCI15: Non-standard terminology for shopping cart components.	
SCI	Shopping Cart Problem 3: The site uses the word 'buy' for the link to the shopping cart and calls the shopping cart the "checkout". This could be very confusing to the user if they are familiar with the existing shopping cart metaphor. The 'buy' link allows users to edit and view the shopping cart contents, not actually buy the items. The page should not be entitled 'checkout' because the page does not facilitate the purchase process. Pattern: Shopping Cart. Source: www.welie.com/patterns. The pattern suggests the correct use of the shopping cart metaphor.	Patterns
SCI	The shopping cart is called Buy, Checkout and Basket. A guideline in category B5 (Product Pages: Adding Products to the Shopping Cart) warns against using clever names for the shopping cart and Buy buttons. There is another guideline in category E2 (Shopping cart & Placing order: Adding products to the Shopping cart) that states: Use standard names and buttons for the shopping cart and buy button.	Guidelines

Table 5.2: Examples of Usability Issues Identified

Further analysis was required to compare the frequencies of the issues identified by the Pattern and Guideline Groups in order to characterise inter-group differences. The issues could be divided into three groups on the basis of how many participants identified them:

1. Forty percent of the issues (73 of 182 issues) were each identified by one participant only. Most of the issues were non-issues or minor (median severity rating = 1) and there were no serious issues. Twelve of the non-issues were false positives (as explained above). Twenty-four percent of the minor issues were identified by the Pattern Group and 16% by the Guideline Group, and thus the overlap between the minor issues identified by the Pattern and Guideline Groups was 0%.
2. Forty-three percent of the issues were each identified by between two and five participants. Most of the issues were moderate (median severity rating = 2). Thirty percent of the moderate issues were identified by the Pattern Group and 26% were identified by the Guideline Group, with an overlap between the moderate issues identified by the Pattern and Guideline Groups of 14%.
3. Seventeen percent of the issues were each identified by six or more participants. The issues were more serious (median severity rating = 3) and concerned the shopping cart, product pages, trust and customer service. The Pattern Group identified 16% of the issues and the Guideline Group identified 15%. Fourteen percent of the more serious issues were identified by both groups. The 14% overlap for each of the moderate and more serious issues accounted for the fairly low 27% overall overlap.

The mean success rates of the Pattern and Guideline Groups in identifying the more serious issues were the same (M = 30%, SD = 18.08 for the Pattern Group and M = 30%, SD = 20.21 for the Guideline Group). The mean success rate of the combined groups was quite low (M = 30%, SD = 11.41). The Pattern Group success rate ranged from 0% to 65%. The Guideline Group success rate ranged from 0% to 67%. The success rate of the combined groups ranged from 19% to 65%. This would account for the low standard deviation of the combined groups.

Figure 5.1 displays the success rates of the Pattern and Guideline Groups for each member of the set of more serious issues. The set of more serious issues is sorted in

ascending order of sample success rate. The variations in success rates per issue between the Pattern and Guideline Groups ranged from 3% to 59% (*M* = 27%, *SD* = 14.13). A low variation for an issue indicates that similar numbers of participants identified the issue. A high variation indicates that a low number of participants belonging to one group identified an issue, compared to a high number of participants belonging to the other group.

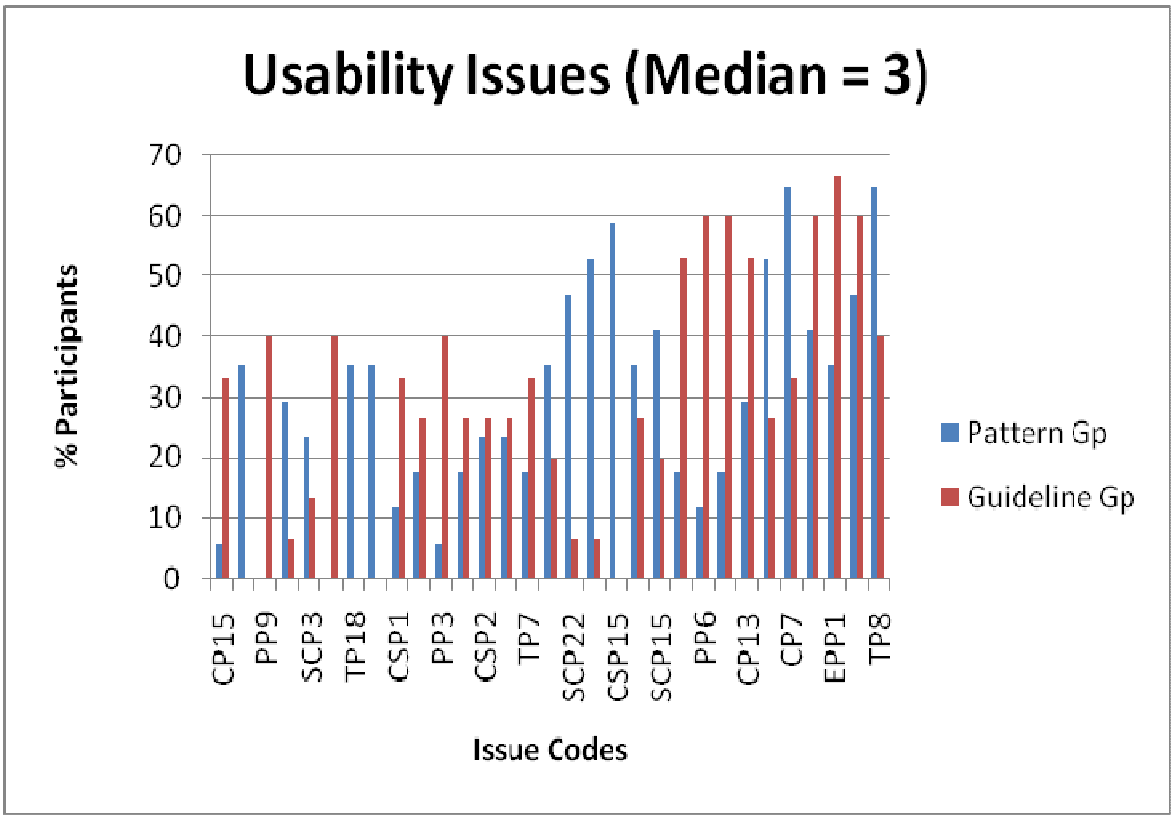


Figure 5.1: Combined Moderate to Serious Issues Identification Frequencies

The low group and individual issue overlaps may be ascribed to two factors, namely differences in the content of the guidelines and patterns and the evaluator effect (as discussed below).

Best-effort matched sets of guidelines and patterns were provided to the participants, but there were differences between the content of the guidelines and patterns. No Pattern Group participant, for example, identified the following severity rating three issue "*No guarantee policy is provided on the site.*" Forty percent of the Guideline Group participants identified this issue, for which there is a corresponding guideline

(B3c: Link to guarantees and policies), but no pattern. No Guideline Group participant identified the following severity rating four issue "*No security policy is provided on the site.*" Thirty-five percent of the Pattern Group participants identified this issue, for which there is an *Amsterdam Pattern Collection* pattern (*Login*), but no corresponding guideline.

The pattern and guideline content differences are thus partially responsible for the fairly low overlap between the issues identified by the Pattern and Guideline Groups. The 0% overlap between the minor issues identified by the Pattern and Guideline Groups may be partially ascribed to these differences. Zero percent overlaps between some of the moderate and more serious issues identified by the Pattern and Guideline Groups may also be partially ascribed to this cause.

These results show that the patterns produced substantially different result sets from the guidelines when used to identify usability issues and good design features in an existing system, even when best-effort matched sets of guidelines and patterns were used. This was partially due to pattern and guideline content differences.

Combining the list of issues identified through the use of patterns and the list of issues identified through the use of guidelines provided a more comprehensive description of issues than the individual lists. The same holds for the two lists of good design features.

Usability evaluation methods currently in use suffer from a substantial evaluator effect (Section 4.8). Different evaluators who evaluate the same product tend to identify substantially different issue sets. The zero and low overlaps for mostly minor, mostly modest and more serious issues and the variations in absolute differences in success rates shown in Figure 5.1 may be partially ascribed to this evaluator effect.

The comparative results of the use of guidelines and patterns for evaluation were in agreement with the three main results of CUE research reported by Molich *et al.* (2004: 65-74). The participants could be considered to be one-person inspection teams, since they evaluated the Porcupine Ceramics website as individuals. Most of the usability issues were identified by a small number of "teams", ranging from 3%

(one individual) to 65% of the combined groups. A large number of issues were identified and large variations in the performance of participants in identifying issues occurred. All of these results were partially determined by the evaluator effect.

The teams participating in the CUE research studies (Molich *et al.* 2004) evaluated websites using a number of inspection techniques, including heuristic evaluation, cognitive walkthroughs and pure design knowledge. Pattern- and guideline-aided inspection thus exhibited similar characteristics to other evaluation methods such as heuristic evaluation and cognitive walkthroughs.

Combining the results of a number of Pattern or Guideline Group participants gave a more comprehensive description of issues than the results of individual participants. This conclusion should be read in combination with the observation concerning the combination of issues identified using guidelines and patterns made above.

The distribution of issues and features identified by the Pattern and Guideline Groups were analysed in order to characterise individual performance in a group context. Table 5.3 shows descriptive statistics for the Pattern and Guideline Group issues, treated as continuous real-valued data on an interval scale.

Statistic	**Pattern Group**	**Guideline Group**
N	17	15
Mean (central tendency)	20	18
Standard deviation (variability)	9.58	11.62
Skewness (distribution shape)	0.78	1.84

Table 5.3: Group Descriptive Statistics for Usability Issues

Figure 5.2 shows the distribution of issues identified by the Pattern Group (n = 17). The data distribution was approximately normal, slightly skewed (0.78) and right-tailed. The shape of the distribution reflected a normally distributed portion clustered about the mean (M = 20, SD = 9.58) and a tail. The range of usability issues identified was large (Min = 7, Max = 41). The portion clustered about the mean consisted of a

relatively small number of usability issues identified by the majority of participants. The tail was made up of a larger number of issues identified by a small number of participants.

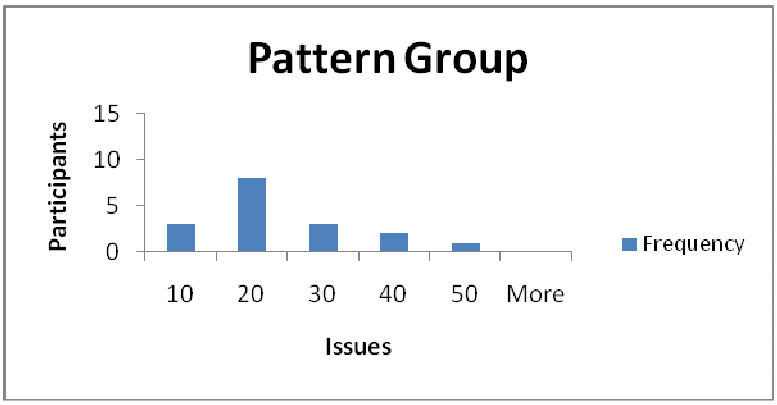


Figure 5.2: Distribution of Issues (Pattern Group, n = 17)

Figure 5.3 shows the distribution of issues identified by the Guideline Group (n = 15). The data distribution was also approximately normal, moderately skewed (1.84) and right-tailed. The shape of the distribution reflected a normally distributed portion clustered about the mean (M = 18, SD = 11.62) and a tail. The range of usability issues identified was large (Min = 6, Max = 52). The portion clustered about the mean consisted of a relatively small number of usability issues identified by the majority of these participants. The tail (which had a gap in it) was made up of a larger number of issues identified by a small number of participants.

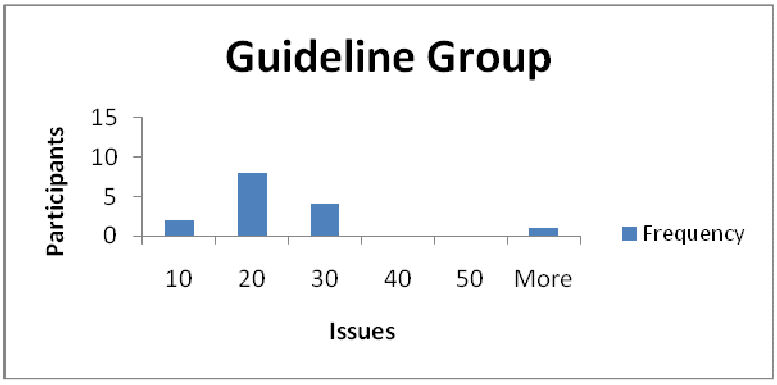


Figure 5.3: Distribution of Issues (Guideline Group, n = 15)

The distributions of the good design features identified using guidelines and patterns were wedge-shaped, are shown in Figures 5.4 and 5.5.

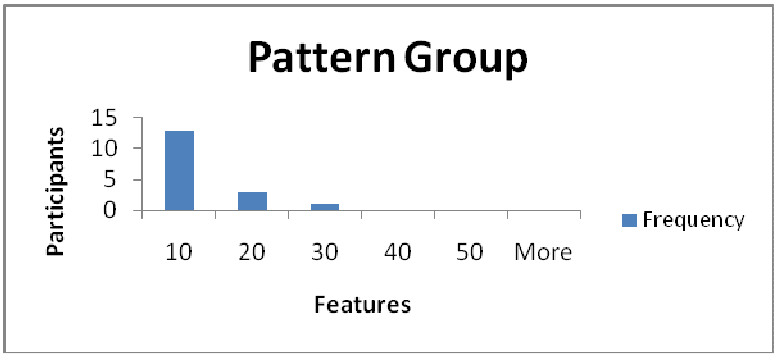


Figure 5.4: Distribution of Features (Pattern Group, n = 17)

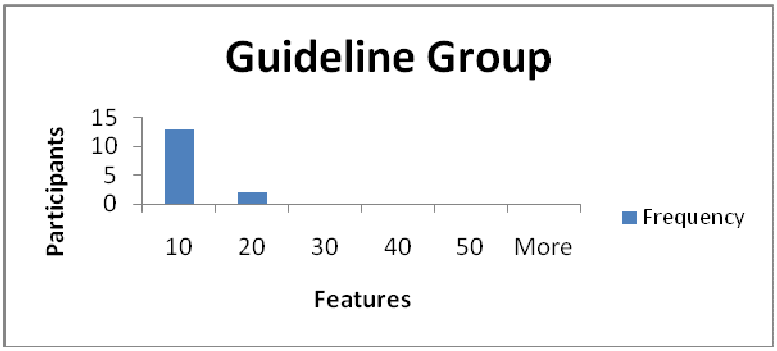


Figure 5.5: Distribution of Features (Guideline Group, n = 15)

5.2.2 Statistical Analysis of Results

Hypothesis testing was used to determine the nature of the relationship between the type of evaluation aid and the numbers of usability issues (N_{UI}) and good design features (N_{DF}) identified. The null hypothesis for the evaluation effectiveness measure (E_{M1}) is shown in Table 5.4. The alternative hypothesis is two-tailed.

ID	Evaluation Null Hypothesis
H_{E20}	There is no significant difference between the effectiveness of guidelines and patterns when used for evaluation.

Table 5.4: Pattern and Guideline Evaluation Effectiveness Null Hypothesis

The two data distributions for issues were approximately normal, slightly skewed and right-tailed (Figures 5.2 and 5.3), satisfying the requirements for t-tests. The two data distributions for features were wedge-shaped (Figures 5.4 and 5.5), and not ideal for t-tests.

Two-sample t-test statistics assuming unequal variances were computed for the number of usability issues identified by each participant in the Pattern and Guideline Groups. There was no significant difference between using guidelines and patterns to identify usability issues in an existing system ($t(27) = 0.38$, $p = 0.35$ for the stronger, one-tailed case and $t(27) = 0.38$, $p = 0.71$ for the weaker, two-tailed case).

Two-sample t-test statistics assuming unequal variances were also computed for the number of serious usability issues ($S_{UI} = 4$) identified by each participant in the Pattern and the Guideline Groups. There was no significant difference between using guidelines and patterns to identify serious usability issues in an existing system ($t(24) = 1.71$, $p = 0.29$ for the one-tailed case and $t(24) = 2.06$, $p = 0.57$ for the two-tailed case).

Two-sample t-test statistics assuming unequal variances were also computed for the number of good design features identified by each participant in the Pattern and Guideline Groups. There was no significant difference between using guidelines and patterns to identify good design features in an existing system ($t(29) = 0.22$, $p = 0.41$ for the one-tailed case and $t(27) = 0.38$, $p=0.82$ for the two-tailed case).

The null hypothesis for evaluation effectiveness ($H_{E20)}$ was therefore accepted and the alternative hypothesis rejected. There is thus no significant difference between the effectiveness of guidelines and patterns when used for evaluation.

The results of the use of guidelines and patterns as redesign aids is presented and analysed in the next section.

5.3 Redesign of Existing Website

5.3.1 Description of Results

The Pattern and Guideline Group participants who did Assignment 2 redesigned aspects of the Porcupine Ceramics website in order to correct the usability issues that they had identified in Assignment 1 (Section 4.6.3), as a treatment. The participants produced medium fidelity paper prototype redesigns of the Porcupine Ceramics website (Sections 4.5.2 and 4.5.3), as observations. The redesigns consisted of a site map and a collection of wireframes. The Pattern Group submitted 17 redesigns and the Guideline Group submitted 16 redesigns. The 33 redesigns were analysed to yield data for the redesign score (S_{RD}), which is the derived variable for the redesign effectiveness (E_{M2}) of a particular evaluation aid (Table 4.4).

The design features of the 33 redesigns were scored independently by two usability experts using the B2C E-Commerce Heuristic Evaluation Form (Appendix M) to yield data for S_{RD}. This instrument was used to check for usability issues in the redesign. The usability scores were processed as described in Section 4.5.3 to produce redesign scores (S_{RD}) which were indicative of the redesign quality.

Table 5.5 shows descriptive statistics for the Pattern and Guideline Group S_{RD} scores, treated as continuous real-valued data on an interval scale.

Statistic	Pattern Group	Guideline Group
N	17	16
Mean (central tendency)	90.47%	82.38%
Standard deviation (variability)	9.72%	15.58%
Skewness (distribution shape)	-3.20	-2.09

Table 5.5: Descriptive Statistics for S_{RD} Scores

Figure 5.6 shows the distribution of the redesign scores of the Pattern Group (n = 17). The data distribution was approximately normal, left-skewed (-3.20) and had a shoulder on the left hand side. The shape of the distribution reflected a normally distributed portion clustered about the mean (*M* = 90.47, *SD* = 9.72) and the shoulder. The range of scores was fairly low (Min = 61.00, Max = 100.00). The shoulder was made up of a cluster of lower scores achieved by a number of participants.

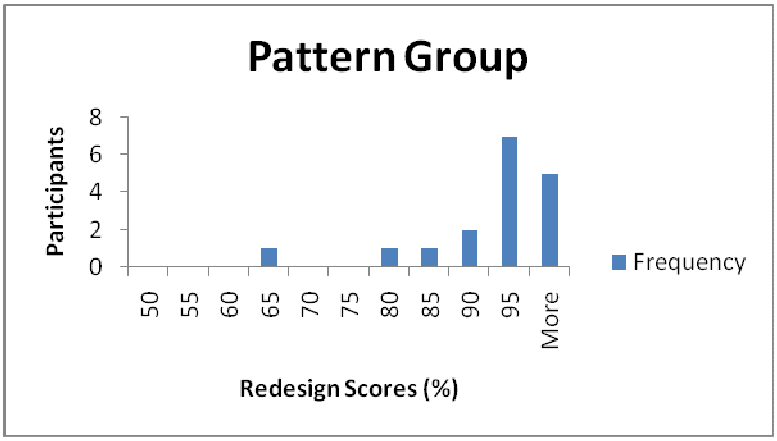


Figure 5.6: Distribution of Redesign Scores (Pattern Group, n = 17)

Figure 5.7 shows the distribution of the redesign scores of the Guideline Group (n = 16). The data distribution was bimodal and left-skewed (-2.09). The shape of the distribution reflected two distributions, one to the left of the mean (*M* = 82.38, *SD* = 15.58). The range of scores was moderate (Min = 42.00, Max = 100.00). The small left distribution, which appears approximately normal, was made up of a group of low scores achieved by a number of participants.

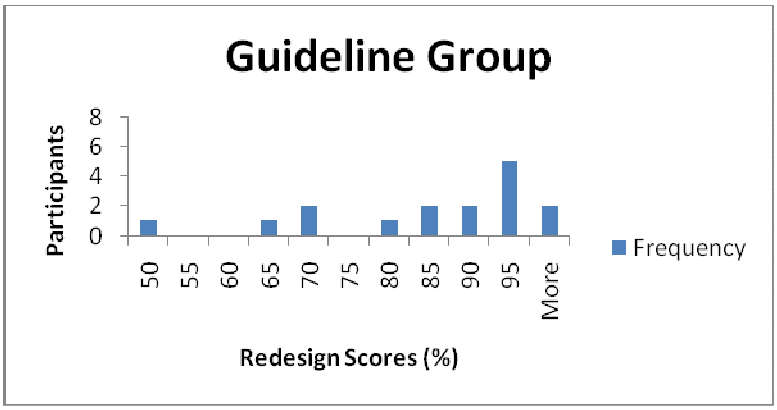


Figure 5.7: Distribution of Redesign Scores (Guideline Group, n = 16)

The redesign quality of the two groups was very good, as shown by the high means in Table 5.6 and the distributions shown in the histograms of the data (Figures 5.6 and 5.7). The bimodal Guideline Group data distribution (Figure 5.7) suggests that the Pattern Group (Mode = 94.00%) produced slightly better redesigns than the Guideline Group (Mode = 91.00%).

5.3.2 Statistical Analysis of Results

Hypothesis testing was used to determine the nature of the relationship between the type of design aid and the redesign score (S_{RD}). The null hypothesis for the redesign effectiveness measure (E_{M2}) is shown in Table 5.6. The alternative hypothesis is two-tailed.

ID	Redesign Null Hypothesis
H_{E30}	There is no significant difference between the effectiveness of guidelines and patterns when used for redesign.

Table 5.6: Pattern and Guideline Redesign Effectiveness Null Hypothesis

The Pattern Group data distribution was approximately normal, and slightly skewed with a shoulder on the left hand side (Figure 5.6), satisfying the requirements for t-tests. The Guideline Group data distribution was slightly bimodal (Figure 5.7), and not ideal for t-tests.

Two-sample t-test statistics assuming unequal variances were computed using the Pattern and Guideline Group redesign scores. There was a significant difference between guidelines and patterns as aids to redesign the Porcupine website ($t(25) = 1.71$, $p = 0.04$ for the one-tailed case and $t(25) = 2.05$, $p = 0.08$ for the two-tailed case).

The null hypothesis for redesign effectiveness ($H_{E30)}$ given in Table 5.6 was therefore rejected and the alternative hypothesis accepted. There was thus a significant difference between the effectiveness of guidelines and patterns when used for redesign. Taking the means in Table 5.5 into account, the results suggest that patterns are more effective than guidelines when used for redesign.

The results of the use of guidelines and patterns as new design aids is presented and analysed in the next section.

5.4 Design of New Website

5.4.1 Description of Results

The Pattern and Guideline Group participants who did Assignment 3 designed a new B2C E-commerce website from a scenario, as a treatment. The participants produced medium-fidelity paper prototype designs as observations. The design was a complete design consisting of a site map and a collection of wireframes (Section 4.6.3), unlike the redesign which was a partial design. The Pattern Group submitted 16 designs and the Guideline Group submitted 12 designs. The 28 designs were analysed to yield data for the new design score (S_{ND}) which is the derived variable for the new design effectiveness (E_{M3}) of a particular design aid (Table 4.4).

The design features of the 28 new designs were scored independently by two usability experts using the same B2C E-Commerce Heuristic Evaluation Form used to score the redesigns to yield data for S_{RD}. This instrument was used to check for usability issues

in the new designs. The usability scores were processed as described in Section 4.5.3 to produce new design scores (S_{ND}) which were indicative of the new design quality.

Table 5.7 shows descriptive statistics for the Pattern and Guideline Group S_{ND} scores, treated as continuous real-valued data on an interval scale.

Statistic	**Pattern Group**	**Guideline Group**
N	16	12
Mean (central tendency)	89.06%	88.83%
Standard deviation (variability)	4.54%	4.34%
Skewness (distribution shape)	-3.83	-3.42

Table 5.7: Descriptive Statistics for S_{ND} Scores

Figure 5.8 shows the distribution of the new design scores of the Pattern Group (n = 16). The data distribution was approximately normal and left-skewed (-3.83). The shape of the distribution reflected a normally distributed portion clustered about the mean (M = 89.06, SD = 4.54). The range of scores was fairly low (Min = 81.00, Max = 97.00).

Figure 5.9 shows the distribution of the new design scores of the Guideline Group (n = 12). The data distribution was wedge-shaped and left-skewed (-3.42). The shape of the distribution reflected a cluster of several higher scores on the right-hand side of the mean (M = 88.83, SD = 4.34). The range of scores was fairly low (Min = 81.00, Max = 92.00).

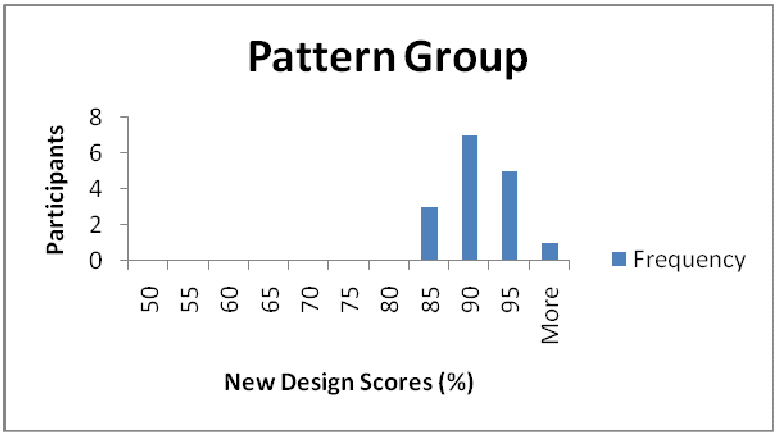


Figure 5.8: Distribution of New Design Scores (Pattern Group, n = 16)

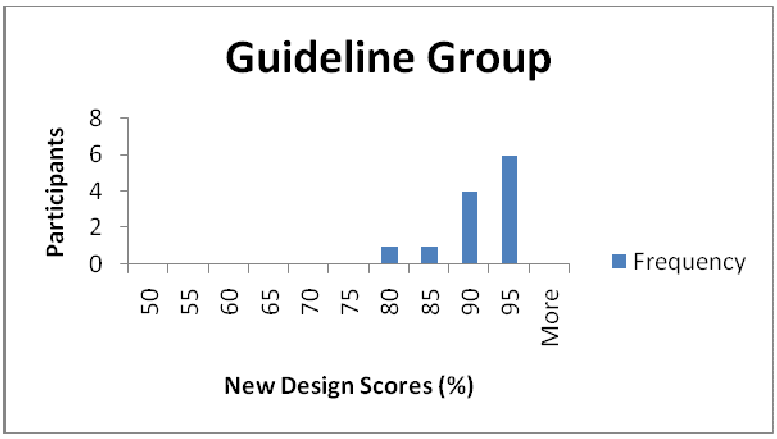


Figure 5.9: Distribution of New Design Scores (Guideline Group, n = 12)

The new design quality of the two groups was very good, as shown by the high means in Table 5.7 and the distributions shown in the histograms of the data (Figures 5.8 and 5.9). The wedge-shaped Guideline Group data distribution (Figure 5.9) suggests that the Guideline Group (Mode = 91.00%) produced slightly better new designs than the Pattern Group (Mode = 88.00%).

5.4.2 Statistical Analysis of Results

Hypothesis testing was used to determine the nature of the relationship between the type of design aid and the new design score S_{ND}. The null hypothesis for the new

design effectiveness measure E_{M3} is shown in Table 5.8. The alternative hypothesis is two-tailed.

ID	New Design Null Hypothesis
H_{E10}	There is no significant difference between the effectiveness of guidelines and patterns when used for design.

Table 5.8: Pattern and Guideline New Design Effectiveness Null Hypothesis

The Pattern Group data distribution was slightly skewed and approximately normal (Figure 5.7), but the Guideline Group data distribution was wedge-shaped (Figure 5.8) and not ideal for t-tests.

Two-sample t-test statistics assuming unequal variances were computed using the Pattern and Guideline Group data. There was no significant difference between guidelines and patterns as aids to design the new website ($t(24) = 1.71$, $p = 0.44$ for the one-tailed case and $t(24) = 2.06$, $p = 0.89$ for the two-tailed case).

The null hypothesis for new design effectiveness (H_{E10}) given in Table 5.8 was therefore accepted and the alternate hypothesis rejected. There was thus no significant difference between the effectiveness of guidelines and patterns when used for new design.

The results, analysis and discussion of the use of the Project Diaries are discussed in the next section.

5.5 Project Diaries

5.5.1 Description of Results

The Project Diaries were used by participants as individuals to keep a record of their thoughts, ideas and processes while they were doing the three assignments, as observations. The Pattern Group submitted 17 diaries and the Guideline Group submitted 9 diaries. Three Pattern Group diaries were typed and the rest of the diaries

were hand-written. The diaries were a rich source of information on design and evaluation aid use, usability issues and design features. The 26 diaries were subjected to thematic analysis to yield qualitative data. Assumptions made and approaches used in the thematic analysis of the diaries are described in Section 4.9. The qualitative data was for the process of design aid use in evaluation (SEM18), the process of design aid use in redesign (SEM19) and the process of design aid use in new design (SEM20) (Table 4.5).

5.5.2 Thematic Analysis of Results

Three evaluation themes were identified for SEM18 (Table 5.9). Forty-seven percent of the Pattern Group used patterns to identify issues and features, 29% used a blended approach of inspection, followed by the use of patterns, and 24% identified issues and features by inspection while interacting with the website, but did not mention the use of patterns. Forty-four percent of the Guideline Group used guidelines to identify issues and features, 44% used a blended approach of inspection, followed by the use of guidelines, and 12% identified issues and features by inspection while interacting with the website, but did not mention the use of guidelines.

The evaluation themes revealed three styles of evaluation aid use:

1. *Patterns- and guidelines-first*, in which the evaluation was done entirely using the evaluation aids (46%);
2. *Website-first*, in which the participants first critically applied their "pure" design knowledge of interfaces and websites to identify issues and features, and then made use of the aids to check the website (35%); and
3. *Indeterminate*, in which the narratives did not reveal whether the aids were used or not (19%).

#	Theme	Pattern Group (%)	Guideline Group (%)	Sample (%)
1	Participants reviewed evaluation aid collections. They then used the aids to check the site and identify issues and design features.	47	44	46
2	Participants identified a fair number of issues and features by inspection while interacting with the website. They then used aids to check the site to confirm that the previously identified issues were valid and to identify additional issues and features.	29	44	35
3	Participants identified usability issues and design features by inspection while interacting with the website, but did not mention the use of evaluation aids.	24	12	19
	N	17	9	26

Table 5.9: Evaluation Themes in Diaries

A majority of the participants explicitly used aids for evaluation. Seventy-six percent of the Pattern Group explicitly used patterns for evaluation and 88% of the Guideline Group explicitly used guidelines for evaluation. The difference of 8% between the two groups might reflect a greater initial effort required to learn about and use patterns.

The data for redesign varied in quality and quantity across the diaries. Three redesign themes were identified for SEM19 (Table 5.10). Fifty-three percent of the Pattern Group made design notes, referring to particular pages and issues that needed correction, 12% made redesign site maps and page wireframes, and 35% made no comments or very sketchy and general comments about redesign. Thirty-three percent of the Guideline Group made design notes, referring to particular pages and issues that needed correction, 33% made redesign site maps and page wireframes, and 34% made no comments or very sketchy and general comments about redesign.

#	Theme	Pattern Group (%)	Guideline Group (%)	Sample (%)
1	Participants made design notes, referring to particular pages and issues that needed correction per page. The site map was not discussed.	53	33	46
2	Participants sketched redesign site maps and page wireframes.	12	33	19
3	Participants provided little or no redesign process details.	35	34	35
	N	17	9	26

Table 5.10: Redesign Themes in Diaries

The redesign themes revealed two styles of redesign:

1. *Note-based*, in which design notes, referring to particular pages and issues that needed correction, were made; and
2. *Diagram-based*, in which redesign site maps and page wireframes were made.

The participants who used the note-based style used the notes as an intermediate design language, translating them into the required site map- and wireframe-based redesigns that they submitted. Just over half of the Pattern Group (53%) made design notes but only a third of the Guideline Group (33%) made design notes. The difference between the two groups might indicate that the narrative format of patterns lends itself to a narrative design representation.

Almost half of the participants (46%) explicitly used aids for redesign. Fifty-two percent of the Pattern Group participants explicitly used patterns for redesign and 33% of the Guideline Group participants explicitly used guidelines for redesign.

The data for new design also varied in quality and quantity across the diaries. Three new design themes were identified for SEM20 (Table 5.11). Sixty-five percent of the Pattern Group made design notes, referring to particular pages and issues that needed design, 18% made new design site maps and page wireframes, and 17% made no comments or very sketchy and general comments about new design. Forty-four percent of the Guideline Group made design notes, referring to particular pages and

issues that needed design, 22% made redesign site maps and page wireframes, and 34% made no comments or very sketchy and general comments about redesign.

#	Theme	Pattern Group (%)	Guideline Group (%)	Sample (%)
1	Participants made design notes, referring to particular pages and issues that needed correction per page. The site map was not discussed.	65	44	58
2	Participants sketched new design site maps and page wireframes.	18	22	19
3	Participants provided little or no new design process details.	17	34	23
	N	17	9	26

Table 5.11: New Design Themes in Diaries

The new design themes revealed two styles of new design:

1. *Note-based*, in which design notes, referring to particular pages and issues that needed design, were made; and
2. *Diagram-based*, in which new design site maps and page wireframes were made.

The participants who used the note-based style also used the notes as an intermediate design language, translating them into the required site map- and wireframe-based new designs that they submitted. Almost two-thirds of the Pattern Group (65%) made design notes but less than half of the Guideline Group (44%) made design notes. The difference between the two groups might indicate that the narrative format of patterns lends itself to a narrative design representation, as suggested in the discussion of redesign.

Almost two-thirds of the participants explicitly used aids for new design. Seventy-six percent of the Pattern Group participants explicitly used patterns for new design. Only 33% of the Guideline Group participants explicitly used guidelines for new design.

An inspection of the evaluation narratives revealed that a substantial portion of the participants were able to identify the major issues and features of the Porcupine Ceramics website. Only a small number of the analyses were superficial. The evaluation narratives taken as a whole were more complete than the redesign and new design narratives. Some very capable participants produced high-quality evaluation, redesign and new design narratives.

Several of the participants made insightful comments about the properties and use of patterns and (to a much lesser extent) guidelines as design aids. A sample of their comments is shown in Table 5.12. These comments were unsolicited, but might deserve further investigation. The following themes were identified when the comments were paraphrased:

1. Guidelines and patterns were useful;
2. Patterns were easy to remember;
3. Pattern collections might not cover all design problems;
4. Pattern formats might need modification to make them more usable; and
5. Some pattern collection interfaces and content were more usable than others.

The Post-Test Questionnaires were used by the participants as individuals to record quantitative and qualitative data about their subjective experience of using design and evaluation aids after they had completed the three assignments, as observations.

The quantitative data are described in the next section.

#	Comment
1	"*Feel that the patterns give you good ideas of what to include.*"
2	"*As I said before, the patterns are useful for designing usable sites (based on my experience with guidelines, I much prefer patterns).*"
3	"*I find that I remember some of the patterns from the last assignment, which helps with the search for patterns to use.*"
4	"*Although the patterns are very useful, they are not always directly relevant to an existing problem, but they do give some general advice.*"
5	"*I find that the design patterns are very good at illustrating what is wrong, and how to go about fixing it. The only trouble I have is that not all my problems are described in the patterns.*"
6	"*Main thing I don't like about patterns--not structured enough, should have clear lists of what to include/exclude. At the moment it is too narrative, struggle to find relevant info in a long pattern.*"
7	"*It would be a lot easier if there was a list of "stuff to include" which would be a bulleted list highlighting important points.*"
8	"*Design of Sites horrible to use. Hard to find what I want, can't always find out what category I must look in or what the pattern name means. Like that it shows related/similar patterns though.*"
9	"*The Design of Sites website uses a strange way to structure its information, and it is not intuitive what information can be found under a particular heading.*"
10	"*Amsterdam site very plain and minimalistic could be made to look more professional. But easy to find useful patterns just by looking at the names, which is good as it cuts time it takes to choose one."*
11	"*…the examples provided on the Van Welie site were useful in deciding where to place particular elements, particularly as it gave clearer descriptions then the DoS site.*"
12	"*I found the guidelines helpful.*"

Table 5.12: Sample Comments about Guidelines and Patterns in Diaries

5.6 Post-Test Questionnaire Quantitative Data

5.6.1. Description of Results

The independent variable for the empirical study of the participants' subjective experience of using design and evaluation aids was the evaluation aid type (patterns or guidelines). The dependent variables were those described in Table 4.5 (Section 4.4.3), with the exception of:

1. SEM16 (perceived ease of learning to use design aid);
2. SEM17(perceived ease of remembering design aid);
3. SEM18 (process of design aid use in evaluation);
4. SEM19 (process of design aid use in redesign); and
5. SEM20 (process of design aid use in new design).

Five-point Likert-scale items were used in the Post-Test Questionnaire (Appendices K and L) to collect quantitative data. The Pattern Group submitted 17 Post-Test Questionnaires and the *Guideline* Group submitted 11 Post-Test Questionnaires. The 28 Post-Test Questionnaires were analysed to yield data for the subjective experience dependent variables. Table 5.13 shows summary descriptive statistics for the Pattern and Guideline Group responses to the Post-Test Questionnaire items. Hypothesis testing codes are shown for the means of each item, as an alternative to statistical tests of variation from the mean. The means are coded as follows:

1. SD (strongly disagree): $1.0 <= M < 1.7$
2. D (disagree): $1.8 <= M < 2.5$
3. N (neutral): $2.6 <= M < 3.3$
4. A (agree): $3.4 <= M < 4.1$
5. SA (strongly agree): $4.2 <= M < 5.0$

Descriptive Statistics Interval Scale Data View											
Items		Guideline Users N = 11					Pattern Users N= 17				
Item Group	Item ID	N	Mean	Std Deviation	Coeff of Variation	Hypothesis Testing	N	Mean	Std Deviation	Coeff of Variation	Hypothesis Testing
C.1.	1.	11	3.8	0.6	0.2	A	17	3.8	0.8	0.2	A
	2.	9	3.7	0.5	0.1	A	13	3.4	1.1	0.3	A
	3.	11	4.4	0.7	0.2	SA	17	3.6	0.8	0.2	A
	4.	9	3.6	0.7	0.2	A	13	3.5	1.0	0.3	A
	5.	11	3.4	0.9	0.3	A	17	3.2	1.4	0.4	N
	6.	8	3.6	0.7	0.2	A	13	3.1	1.3	0.4	N
C.2.	1.	11	3.7	0.8	0.2	A	17	3.8	0.8	0.2	A
	2.	9	3.4	0.7	0.2	A	14	3.4	1.0	0.3	A
	3.	11	3.8	0.8	0.2	A	17	3.8	0.7	0.2	A
	4.	9	3.4	0.7	0.2	A	14	3.4	1.0	0.3	A
	5.	11	3.3	0.9	0.3	N	17	3.5	1.2	0.3	A
	6.	9	3.3	0.7	0.2	N	14	3.1	1.2	0.4	N
C.3.	1.	11	3.4	0.9	0.3	A	15	3.9	0.9	0.2	A
	2.	9	3.3	0.7	0.2	N	15	3.5	1.0	0.3	A
	3.	11	3.5	0.8	0.2	A	15	3.5	1.0	0.3	A
	4.	9	3.0	0.5	0.2	N	15	2.9	1.1	0.4	N
	5.	11	4.1	0.5	0.1	A	15	4.0	0.7	0.2	A
	6.	9	3.1	0.8	0.3	N	14	3.6	1.0	0.3	A
	7.	11	3.5	0.9	0.3	A	15	3.7	1.0	0.3	A
	8.	9	2.9	0.6	0.2	N	15	3.5	1.2	0.3	A
C.4.	1.	11	3.9	0.5	0.1	A	17	3.8	0.7	0.2	A
	2.	10	2.9	1.5	0.5	N	17	2.9	1.2	0.4	N
	3.	10	4.2	0.4	0.1	SA	17	4.0	0.4	0.1	A
	4.	10	2.3	1.1	0.5	D	17	2.9	1.1	0.4	N
	5.	10	4.3	0.7	0.2	SA	17	3.7	0.9	0.2	A
	6.						16	3.2	1.1	0.3	N
C.5.	1.	11	3.6	0.9	0.3	A	16	3.4	1.1	0.3	A
	2.	11	3.5	1.2	0.3	A	16	3.5	1.0	0.3	A
	3.	11	3.2	1.0	0.3	N	16	3.4	1.0	0.3	A
	4.	11	3.5	0.7	0.2	A	16	3.7	0.9	0.3	A
	5.	8	3.1	1.0	0.3	N	15	3.1	1.1	0.4	N
	6.	11	4.1	0.7	0.2	A	16	4.1	1.1	0.3	A

Table 5.13: Descriptive Statistics of Post-Test Questionnaire Quantitative Data

5.6.2 Statistical Analysis of Results

Hypothesis testing was used to determine the nature of the relationship between the type of design aid (the independent variable) and the subjective experience dependent variables. Only the null hypotheses for the subjective experience dependent variables employed are shown in Table 5.14, for reasons of space. The alternative hypotheses are two-tailed.

Hypothesis testing was used to determine the nature of the relationships between the type of design aid and the dependant variables, with the exception of H_{S80}.

ID	Research Hypothesis
A	**Primary Subjective Experience Null Hypothesis**
H_{S00}	There is no significant difference between the perceived usefulness of guidelines and patterns for IxD.
B	**Subjective Experience Null Hypotheses About Modes of Pattern and Guideline Use**
H_{S10}	There is no significant difference between the perceived efficiency, effectiveness and satisfaction of guidelines and patterns for evaluation.
H_{S20}	There is no significant difference between the perceived efficiency, effectiveness and satisfaction of guidelines and patterns for redesign.
H_{S30}	There is no significant difference between the perceived efficiency, effectiveness and satisfaction of guidelines and patterns for new design.
C	**Subjective Experience Null Hypotheses About Static Features of Patterns and Guidelines**
H_{S40}	There is no significant difference between the perceived usefulness of pattern and guideline formats.
H_{S50}	There is no significant difference between the perceived usefulness of pattern and guideline content.
D	**Subjective Experience Hypotheses About Collective Structures of Patterns and Guidelines**
H_{S60}	There is no significant difference between the perceived usefulness of the categories used in pattern and guideline collections.
H_{S70}	There is no significant difference between the perceived usefulness of pattern and guideline collections.
H_{S80}	Patterns are not perceived to be useful when linked together into pattern languages.
E	**Subjective Experience Hypotheses About User Experience of Pattern and Guideline Use**
H_{S90}	There is no significant difference between the perceived ease of understanding of guidelines and patterns when first encountered.
H_{S100}	There is no significant difference between the perceived ease of learning of guidelines and patterns when first encountered.
H_{S110}	There is no significant difference between the perceived ease of remembering of guidelines and patterns when first encountered.
H_{S130}	There is no significant difference between the perceived extent to which guidelines and patterns served as personal design languages.
H_{S140}	There is no significant difference between the perceived extent to which guidelines and patterns served as means of sharing design knowledge between designers.
H_{S150}	There is no significant difference between the perceived acceptance of guidelines and patterns as long-term design aids.

Table 5.14: Subjective Experience Null Hypotheses

Two-sample t-test statistics assuming unequal variances were computed using the Pattern and Guideline Group data. The results obtained were as follows:

1. There was no significant difference between the perceived efficiency, effectiveness and satisfaction of guidelines and patterns for evaluation ($t(23) = 1.23$, $p = 0.12$ for the one-tailed case and $t(23) = 2.07$, $p = 0.23$ for the two-tailed case). The null hypothesis (H_{S10}) was therefore accepted and the alternate hypothesis rejected.

2. There was no significant difference between the perceived efficiency, effectiveness and satisfaction of guidelines and patterns for redesign ($t(24) = 1.71$, $p = 0.49$ for the one-tailed case and $t(24) = 2.06$, $p = 0.98$ for the two-tailed case). The null hypothesis (H_{S20}) was therefore accepted and the alternate hypothesis rejected.

3. There was no significant difference between the perceived efficiency, effectiveness and satisfaction of guidelines and patterns for new design ($t(22) = 1.68$, $p = 0.05$ for the one-tailed case and $t(22) = 2.07$, $p = 0.11$ for the two-tailed case). The null hypothesis (H_{S30}) was therefore accepted and the alternate hypothesis rejected.

4. There was no significant difference between the perceived usefulness of pattern and guideline formats ($t(17) = 1.74$, $p = 0.48$ for the one-tailed case and $t(17) = 2.11$, $p = 0.96$ for the two-tailed case). The null hypothesis (H_{S40}) was therefore accepted and the alternate hypothesis rejected.

5. There was no significant difference between the perceived usefulness of pattern and guideline content ($t(22) = 1.72$, $p = 0.15$ for the one-tailed case and $t(22) = 2.07$, $p = 0.31$ for the two-tailed case). The null hypothesis (H_{S50}) was therefore accepted and the alternate hypothesis rejected.

6. There was no significant difference between the perceived usefulness of the categories used in pattern and guideline collections ($t(24) = 1.71$, $p = 0.03$ for

the one-tailed case and t(24) = 2.06, p = 0.06 for the two-tailed case). The null hypothesis (H_{S60}) was therefore accepted and the alternate hypothesis rejected.

7. There was no significant difference between the perceived ease of understanding of guidelines and patterns when first encountered (t(24) = 1.71, p = 0.26 for the one-tailed case and t(24) = 2.06, p = 0.52 for the two-tailed case). The null hypothesis (H_{S90}) was therefore accepted and the alternate hypothesis rejected.

8. There was no significant difference between the perceived ease of learning of guidelines and patterns when first encountered. (t(18) = 1.73, p = 0.46 for the one-tailed case and t(18) = 2.10, p = 0.92 for the two-tailed case). The null hypothesis (H_{S100}) was therefore accepted and the alternate hypothesis rejected.

9. There was no significant difference between the perceived ease of remembering of guidelines and patterns when first encountered (t(21) = 1.72, p = 0.26 for the one-tailed case and t(21) = 2.08, p = 0.51 for the two-tailed case). The null hypothesis (H_{S110}) was therefore accepted and the alternate hypothesis rejected.

10. There was no significant difference between the perceived extent to which guidelines and patterns served as personal design languages (t(25) = 1.71, p = 0.33 for the one-tailed case and t(25) = 2.06, p = 0.66 for the two-tailed case). The null hypothesis (H_{S130}) was therefore accepted and the alternate hypothesis rejected.

11. There was no significant difference between the perceived extent to which guidelines and patterns served as a means of sharing design knowledge between designers (t(16) = 1.75, p = 0.49 for the one-tailed case and t(16) = 2.12, p = 0.99 for the two-tailed case). The null hypothesis (H_{S140}) was therefore accepted and the alternate hypothesis rejected.

12. There was no significant difference between the perceived acceptance of guidelines and patterns as long-term design aids ($t(25) = 1.71$, $p = 0.47$ for the one-tailed case and $t(25) = 2.06$, $p = 0.93$ for the two-tailed case). The null hypothesis was therefore accepted and the alternate hypothesis rejected.

In conclusion, there was no significant difference between the perceived usefulness of guidelines and patterns for evaluation, redesign and new design.

5.7 Post-Test Questionnaire Qualitative Data

5.7.1 Pattern and Guideline Use for Evaluation

The participants' descriptions of how they used the design aids for evaluation in practice were gathered by means of item C.1.7 in the Post-Test Questionnaire, in order to answer the part of Subjective Experience Research Question S12 relating to evaluation (Section 3.5.3).

All 17 Pattern Group participants completed item C.1.7. Thirteen of the responses to item C.1.7 were usable and four were not. These were excluded from the data set for the following reasons:

1. One was blank.
2. One was partial, discussing the use of parts of patterns used but making no connection between the patterns and the website.
3. One discussed new design, not evaluation.
4. One was a polemic against patterns as an evaluation aid, stating that they could only be used for design.

A thematic analysis of the 13 usable responses was conducted as described in Section 4.9. Two themes were identified:

1. *Patterns-first pattern-based evaluation* was identified by analysing eight responses (62% of the usable responses). The steps are shown in Table 5.15.

Participants whose responses matched this theme first identified and reviewed the patterns in a collection that were relevant to a particular website genre, in order to become familiar with them ("*Familiarised myself with the patterns…*"). They reviewed the website using the selected patterns as evaluation tools while they inspected and interacted with the website, in order to identify usability issues ("*…and browsed through the site and performed certain functions*"). The design advice in the patterns was compared with the design of the website as revealed by its structure and behaviour by switching focus between them ("*Read the pattern contents and compared their recommendations to the particular page to see if it violated any*"). The usability issues identified were recorded.

#	Step	N
1	Identify relevant patterns.	0
2	Review relevant patterns.	5
3	Review website looking for usability issues, using patterns as evaluation tools,	8
4	… inspecting and interacting with the website…	1
5	…switching focus between the website and the patterns in order to comprehensively compare the website design with the pattern design advice.	1
6	Record usability issues as encountered.	2

Table 5.15: Patterns-First Pattern-Based Evaluation (n=8)

2. *Website-first pattern-based evaluation* was identified by composing five data items (38% of the usable responses). The steps are shown in Table 5.16.

   Participants whose responses matched this theme first reviewed the website looking for design features by inspection ("*I looked at the website and tried to identify what problems there were*"). They identified and reviewed the patterns in a collection that were relevant to the design features identified, in order to become familiar with them ("*…then looked at patterns for that type of site and page*"). They reviewed the website using the selected patterns as evaluation tools while they inspected and interacted with the website, in order to identify usability issues ("*…and then looked at everything mentioned in the pattern and determined whether it was present in the existing system*"). The design

advice in the patterns was compared with the design of the website as revealed by its structure and behaviour, by switching focus between them ("*When I did this I often got more ideas of additional things that I should think of*"). The usability issues identified were recorded.

#	Step	N
1	Review website looking for design features by inspection.	3
2	Identify patterns relevant to design features.	1
3	Review relevant patterns.	3
4	Review website looking for usability issues, using the patterns as evaluation tools,	4
5	…switching focus between the website and the patterns in order to comprehensively compare the website design with the pattern design advice.	1
6	Record usability issues as encountered.	0

Table 5.16: Website-First Pattern-Based Evaluation (n=5)

It was suggested in Assignment 1 that the participants should first scan the pages and site structure of the website to form a general impression of its appearance and behaviour. Only 38% of the 13 Pattern Group participants who provided usable responses followed the advice given, and 62% preferred to review the relevant patterns before reviewing the website. This could be because the patterns were unfamiliar and the participants wished to learn about them before performing the evaluation.

Eleven of the 16 Guideline Group participants completed the Post-Test Questionnaire. Ten of the responses to item C.1.7 were usable, and one was not. The single unusable response was excluded from the data set because it was blank.

Three themes were identified by a thematic analysis of the ten usable responses:

1. *Guidelines and website review guideline-based evaluation* was identified by analysing two responses (20% of the usable responses). The steps are shown in Table 5.17.

Participants whose evaluation matched this theme first identified and reviewed the guidelines in a collection that were relevant to a particular website genre, in order to become familiar with them ("*Read through the guidelines*"). They reviewed the website in order to identify usability issues by inspection ("*Looked at the site*"). The design advice in the guidelines was compared with the design of the website as revealed by its structure and behaviour by switching focus between them ("*Went back to the guidelines & compared each point to the site...*"). The usability issues identified were recorded ("*…noting possible differences*").

#	Step	N
1	Identify relevant guidelines.	0
2	Review relevant guidelines.	2
3	Review website looking for usability issues by inspection.	2
4	Use relevant guidelines as checklist to confirm usability issues in website.	2
5	Record usability issues as encountered.	1

Table 5.17: Guidelines and Website Review Guideline-Based Evaluation

2. *Guidelines-first guideline-based evaluation* was identified by analysing seven responses (70% of the usable responses). The steps are shown in Table 5.18.

   Participants whose responses matched this theme first identified and reviewed the guidelines in a collection that were relevant to a particular website genre, in order to become familiar with them ("*Went through the list of guidelines…*"). They reviewed the website using the selected guidelines as evaluation tools while they inspected and interacted with the website, in order to identify usability issues ("*I used the guidelines like a checklist*"). The design advice in the guidelines was compared with the design of the website as revealed by its structure and behaviour by switching focus between them ("*I compared the guidelines to portions of the site and made observations*"). The usability issues identified were recorded.

#	Step	N
1	Identify relevant guidelines.	0
2	Review relevant guidelines.	6
3	Review website looking for usability issues, using guidelines as evaluation tools,	7
4	… inspecting and interacting with the website…	0
5	…switching focus between the website and the guidelines in order to comprehensively compare the website design with the guidelines design advice.	0
6	Record usability issues as encountered.	0

Table 5.18: Guidelines-First Guideline-Based Evaluation (n=7)

3. *Website-first guideline-based evaluation* was identified by analysing one response (10% of the responses). The process steps are shown in Table 5.19.

   The participant whose response matched this theme first reviewed the website looking for design features by inspection ("*I browsed around on the website that I was busy evaluating,*") The guidelines that were relevant to the design features identified were identified and reviewed, in order to become familiar with them ("…*then read through the guidelines and looked at what guidelines were applicable to the site*"). The website was reviewed using the selected guidelines as evaluation tools in order to identify usability issues ("…*, whether they were applied or not*"). The design advice in the guidelines was compared with the design of the website as revealed by its structure and behaviour, by switching focus between them. The usability issues identified were recorded.

Only one of the ten Guideline Group participants who provided usable responses followed the advice given to first scan the pages and site structure of the website to form a general impression of its appearance and behaviour. Ninety percent preferred to review the relevant guidelines before reviewing the website. This could be because the guidelines were unfamiliar and the participants wished to learn about them before performing the evaluation.

#	Step	N
1	Review website looking for design features by inspection.	1
2	Identify guidelines relevant to design features.	0
3	Review relevant guidelines.	1
4	Review website looking for usability issues, using the patterns as evaluation tools,	1
5	…switching focus between the website and the patterns in order to comprehensively compare the website design with the pattern design advice.	0
6	Record usability issues as encountered.	0

Table 5.19: Website-First Guideline-Based Evaluation (n=1)

Most of the Pattern and Guideline Group members thus preferred to review the design aids before reviewing the website.

5.7.2 Pattern and Guideline Use for Redesign

The participants' descriptions of how they used the design aids for redesign in practice were gathered by means of item C.2.7 in the Post-Test Questionnaire, in order to answer the part of Subjective Experience Research Question S12 relating to redesign (Section 3.5.3). Participants were given suggestions in Assignment 2 on how to do the redesign of selected aspects of the Porcupine E-commerce website, but these focused on properties of the design and not how the design aids should be used.

All 17 Pattern Group participants completed item C.2.7. Sixteen of the responses to item C.2.7 were usable and one was not. This was blank and was excluded from the data set.

Two themes were identified by a thematic analysis of the 16 usable responses.

1. *Patterns-first pattern-based redesign* was identified by analysing six responses (38% of the usable responses). The steps are shown in Table 5.20.
   Participants whose responses matched this theme first identified and reviewed the patterns in a collection that were relevant to a particular website genre ("*I*

would first find UI design patterns relevant to the problem at hand…"). They reviewed the website using the selected patterns as evaluation tools while they inspected and interacted with the website, in order to identify usability issues to redesign ("*Used discrepancies between pattern & site to determine what needed to be added to the site*"). The relevant pages were redesigned using patterns ("*Using these suggestions each page was redesigned (one at a time), to include the elements suggested by the pattern*").

#	Step	N
1	Identify relevant patterns.	4
2	Review relevant patterns.	5
3	Review website looking for usability issues to redesign, using patterns as evaluation tools.	2
4	Redesign pages of website with usability issues using patterns.	4

Table 5.20: Patterns-First Pattern-Based Redesign (n=6)

2. *Website-first pattern-based redesign* was identified by composing ten responses (63% of the usable responses). The steps are shown in Table 5.21.

   Participants whose responses matched this theme first reviewed the website looking for usability issues by inspection ("*I looked at the website and tried to identify what problems there were*"). They identified and reviewed the patterns in a collection that were relevant to the issues identified ("…*then looked at the patterns to see if the problem identified could be fixed using a design pattern*"). They reviewed the website using the selected patterns as evaluation tools, in order to decide how to redesign ("*Patterns describe what need to be in the site and helped solve the usability problems*"). The relevant pages were redesigned using patterns ("*and redesigned it using patterns*").

#	Step	N
1	Review website looking for usability issues by inspection.	7
2	Identify patterns relevant to issues.	7
3	Review relevant patterns.	5
4	Review website using the patterns as evaluation tools to decide how to redesign.	5
5	Redesign pages of website with issues using patterns.	5

Table 5.21: Website-First Pattern-Based Redesign (n=10)

Only 38% of the 16 Pattern Group participants who provided usable responses reviewed the relevant patterns before reviewing the website, and 62% preferred to review the website before reviewing the patterns. This might reflect a growing familiarity with patterns. No mention was made by any participant of the list of issues previously identified during evaluation.

Eleven of the 16 Guideline Group participants completed item C.2.7. Ten of the responses of the pattern-using participants to item C.2.7 were usable and one was not. The single unusable response was excluded from the data set because it was blank.

Two themes were identified by a thematic analysis of the ten usable responses:

1. *Guidelines-first guideline-based evaluation* was identified by analysing six responses (60% of the usable responses). The steps are shown in Table 5.22.

   Participants whose responses matched this theme first identified and reviewed the guidelines in a collection that were relevant to a particular website genre ("*First reviewed guidelines*"). They reviewed the website using the selected guidelines as evaluation tools while they inspected and interacted with the website, in order to identify usability issues to redesign ("*Checked what was wrong with the system according to the guidelines*"). The relevant pages were redesigned using guidelines ("*If a problem was found, I corrected the system and then proceeded with the rest of the guidelines*").

#	Step	N
1	Identify relevant guidelines.	0
2	Review relevant guidelines.	6
3	Review website looking for usability issues to redesign, using guidelines as evaluation tools.	7
4	Redesign pages of website with usability issues using guidelines.	0

Table 5.22: Guidelines-First Guideline-Based Redesign (n=6)

2. *Website-first guideline-based redesign* was identified by analysing four responses (40% of the responses). The steps are shown in Table 5.23.

   Participants whose responses matched this theme first reviewed the website looking for usability issues by inspection ("*Looked at problems*"). They identified and reviewed the guidelines in a collection that were relevant to the issues identified ("*…and then at the guideline associated with it*"). They reviewed the website using the selected guidelines as evaluation tools, in order to decide how to redesign ("*Took each problem that was identified earlier and used the description of the guideline…*"). The relevant pages were redesigned using guidelines ("*I then corrected the problems as best I could*").

#	Step	N
1	Review website looking for usability issues by inspection.	4
2	Identify guidelines relevant to issues.	0
3	Review relevant guidelines.	4
4	Review website using the guidelines as evaluation tools to decide how to redesign.	1
5	Redesign pages of website with issues using guidelines.	0

Table 5.23: Website-First Guideline-Based Redesign (n=4)

Sixty percent of the ten Guideline Group participants who provided usable responses reviewed the relevant guidelines before redesigning the website, and 40% preferred to review the website and then review the guidelines. By comparison, 90% of the Guideline Group participants preferred to review the relevant guidelines during

evaluation. This might reflect a growing familiarity with guidelines. Three participants referred to the list of issues previously identified during evaluation.

An increasing number of the Pattern and Guideline Group members thus preferred to review the website before reviewing the design aids during redesign.

5.7.3 Pattern and Guideline Use for New Design

The participants' descriptions of how they used the design aids for new design in practice were gathered by means of item C.3.9 in the Post-Test Questionnaire, in order to answer the part of Subjective Experience Research Question S12 relating to new design (Section 3.5.3). Participants were given suggestions in Assignment 3 on how to do the new design of an E-commerce website from a scenario, but they were not told how to use the design aids.

All 17 Pattern Group participants completed item C.3.9. Fourteen of the responses to item C.2.7 were usable and three was not. The three unusable responses were blank and were excluded from the data set.

Two themes were identified by a thematic analysis of the 14 usable responses.

1. *Patterns-first pattern-based new design* was identified by analysing seven responses (50% of the usable responses). The steps are shown in Table 5.24.

   Participants whose responses matched this theme first identified and reviewed the patterns in a collection that were relevant to a particular website genre ("*I found the patterns relevant for each section of the site…*"). They then designed the website using the selected patterns as design aids ("*I implemented whatever they mentioned*").

#	Step	N
1	Identify relevant patterns.	4
2	Review relevant patterns.	5
3	Design pages of website using patterns.	4

Table 5.24: Patterns-First Pattern-Based New Design (n=7)

2. *Website-first pattern-based new design* was identified by composing seven responses (50% of the usable responses). The steps are shown in Table 5.25.

   Participants whose responses matched this theme first identified and roughly designed some or all of the pages and elements required for the new website by applying "pure" design knowledge ("*I designed a rough page*"). They identified and reviewed the patterns in a collection that were relevant to these pages and elements (", *then looked up patterns relating to the different elements on my page and relating to general layout*"). They then designed the website using the selected patterns as design aids ("*I implemented whatever they mentioned*").

#	Step	N
1	Identify and roughly design website pages and elements using "pure" design knowledge.	7
2	Identify relevant patterns.	7
3	Review relevant patterns.	5
4	Design pages of website using patterns.	5

Table 5.25: Website-First Pattern-Based New Design (n=7)

Fifty percent of the 14 Pattern Group participants who provided usable responses designed the new website using patterns throughout. Fifty percent made a rough design without using patterns and used patterns to refine it into a final design.

Eleven of the 16 Guideline Group participants completed item C.3.9. Ten of the responses of the pattern-using participants to item C.3.9 were usable and one was not. The single unusable response was excluded from the data set because it was blank.

Two themes were identified by a thematic analysis of the ten usable responses:

1. *Guidelines-first guideline-based new design* was identified by analysing eight responses (80% of the usable responses). The steps are shown in Table 5.26.

   Participants whose responses matched this theme first identified and reviewed the guidelines in a collection that were relevant to a particular website genre ("*Looked at the guidelines and determined what they recommended…*"). They then designed the website using the selected guidelines as design aids ("*…and implemented it appropriately*").

#	Step	N
1	Identify relevant guidelines.	4
2	Review relevant guidelines.	5
3	Design pages of website using guidelines.	4

Table 5.26: Guidelines-First Guideline-Based New Design (n=8)

2. *Website-first guideline-based new design* was identified by analysing two responses (20% of the responses). The process steps are shown in Table 5.27.

   Participants whose responses matched this theme first identified and roughly designed some or all of the pages and elements required for the new website by applying "pure" design knowledge ("*First made outline design (site map)*"). They identified and reviewed the guidelines in a collection that were relevant to these pages and elements and then designed the website using the selected guidelines as design aids ("*Used the guidelines to add the necessary components*").

#	Step	N
1	Identify and roughly design website pages and elements using "pure" design knowledge.	2
2	Identify relevant guidelines.	2
3	Review relevant guidelines.	2
4	Design pages of website using guidelines.	2

Table 5.27: Website-First Guideline-Based New Design (n=2)

Eighty percent of the ten Guideline Group participants designed the new website using guidelines throughout. By comparison, only 50% of the Pattern Group participants designed the new website using patterns throughout.

5.7.4 Pattern and Guideline Format

The participants' descriptions of the aspects of the design aid formats that were useful and not useful were gathered by means of items C.4.7 and C.4.8 in the Post-Test Questionnaire, in order to answer Subjective Experience Research Question S4 (Section 3.5.3).

All 17 Pattern Group participants completed items C.4.7 and C.4.8. Seventeen of the responses to item C.4.7 were usable. Thirteen of the responses to item C.4.8 were usable and four were not. The four unusable responses were blank and were excluded from the data set.

Two themes were identified by a thematic analysis of the usable responses:

1. Useful aspects of pattern format were identified by analysing 17 responses. The pattern components of pattern name, description, problem, solution, context of use and examples were experienced as useful and made the pattern easier to apply. The pattern format made the design solutions consistent and predictable.

2. Non-useful aspects of pattern format were identified by analysing 13 responses. There was little criticism of pattern format. Two criticisms were that the patterns were too narrative and the pattern names were not useful.

Eleven Guideline Group participants completed items C.4.7 and C.4.8. Nine of the responses to item C.4.7 were usable and two were not. Four of the responses to item C.4.8 were usable and seven were not. The 11 unusable responses were blank and were excluded from the data set.

Two themes were identified by a thematic analysis of the usable responses:

1. Useful aspects of guideline format were identified by analysing nine responses. The guideline reference codes were experienced as useful. The guidelines were experienced as concise, logical and easy to understand.
2. Non-useful aspects of guideline format were identified by analysing four responses. There was little criticism of guideline format. A criticism was that the guidelines were sometimes cluttered.

5.7.5 Pattern and Guideline Content

The participants' descriptions of the aspects of the design aid content that was useful and not useful were gathered by means of items C.4.9 and C.4.10 in the Post-Test Questionnaire, in order to answer Subjective Experience Research Question S5 (Section 3.5.3).

All 17 Pattern Group participants completed items C.4.7 and C.4.8. Fifteen of the responses to item C.4.7 were usable and two were not. Eleven of the responses to item C.4.8 were usable and six were not. The eight unusable responses were blank and were excluded from the data set.

Two themes were identified by a thematic analysis of the usable responses:

1. Useful aspects of pattern content were identified by analysing 15 responses. The pattern description, problem, solution, context of use and examples were

experienced as useful. The generality and comprehensive explanations of the content were seen as useful.

2. Non-useful aspects of pattern content were identified by analysing 11 responses. There was little criticism of pattern content. One criticism was that some patterns were too abbreviated and the examples were difficult to see because their bitmaps were too small.

Eleven Guideline Group participants completed items C.4.7 and C.4.8. Ten of the responses to item C.4.7 were usable and one was not. Eight of the responses to item C.4.8 were usable and three were not. The four unusable responses were blank and were excluded from the data set.

Two themes were identified by a thematic analysis of the usable responses:

1. Useful aspects of guideline content were identified by analysing ten responses. The guidelines were experienced as easy to understand. The content was seen as easy to understand and very specific to E-commerce.
2. Non-useful aspects of guideline content were identified by analysing eight responses. There was little criticism of guideline content. A desire for more explanatory content and examples was expressed.

5.7.6 Pattern and Guideline Categories

The participants' descriptions of the aspects of the design aid categories that was useful and not useful were gathered by means of items C.4.11 and C.4.12 in the Post-Test Questionnaire, in order to answer Subjective Experience Research Question S6 (Section 3.5.3).

All 17 Pattern Group participants completed items C.4.11 and C.12. All 17 of the responses to item C.4.11 were usable. Twelve of the responses to item C.4.12 were usable and five were not. The five unusable responses were blank and were excluded from the data set.

Two themes were identified by a thematic analysis of the usable responses:

1. Useful aspects of pattern categories were identified by analysing 17 responses. The logical grouping of patterns by site genre and page type and the links to related patterns made it easy and quick to find the required patterns.
2. Non-useful aspects of pattern categories were identified by analysing 12 responses. There was little criticism of pattern categories.

Eleven Guideline Group participants completed items C.4.11 and C.4.12. Nine of the responses to item C.4.7 were usable and two were not. Seven of the responses to item C.4.8 were usable and four were not. The six unusable responses were blank and were excluded from the data set.

Two themes were identified by a thematic analysis of the usable responses:

1. Useful aspects of guideline categories were identified by analysing nine responses. The guideline categories were experienced as well-named and well-laid out, making it easy and quick to find the required guidelines. The guidelines were experienced as E-commerce process-oriented ("*Made using the guidelines feel like a process*").
2. Non-useful aspects of guideline categories were identified by analysing seven responses. There was little criticism of guideline categories. Some category names were experienced as confusing ("*…it was not clear what the difference was between Product listing pages and Product pages*").

5.7.7 Preferred Pattern Collection

The Pattern Group participants used sets of patterns from the *Amsterdam Pattern Collection* (APC) and the *Design of Sites* (DoS) Pattern Browser.

Items C.1.8, C.2.8, C.3.10 and C.4.13 in the Pattern Group Post-Test Questionnaire were used to record which pattern collection the Pattern Group preferred for evaluation, redesign, new design and overall, in order to answer Subjective Experience Research Question S7 (Section 3.5.3). All 17 Pattern Group participants

completed items C.1.8, C.2.8, C3.10 and C4.13 and all of the responses were processed. The results of this aspect of the empirical study are summarised in Table 5.28.

#	Application	Design of Sites Pattern Browser	Amsterdam Pattern Collection	Both Sites	Nil Response	N
1	C.1.8: Usability evaluation of existing product	1	15	1	0	17
2	C.2.8: Redesign of existing product	1	15	1	0	17
3	C.3.10: New design	1	12	2	2	17
4	C.4.13 Overall	1	15	0	1	17
	N	**4**	**57**	**4**	**2**	**68**

Table 5.28: Preferred Pattern Collection Data

The *Amsterdam Pattern Collection* was preferred by the majority of the participants (88% of the total responses), The *Design of Sites* Pattern Browser was preferred by one participant (6%. of the total responses). Two participants preferred to use both sites for some of the activities (6% of the total responses).

The participants who preferred the *Amsterdam Pattern Collection*, preferred it because:

1. The *Amsterdam Pattern Collection* interface was more usable than the *Design of Sites* Pattern Browser interface (better findability, layout and navigation);
2. The *Amsterdam Pattern Collection* patterns were more understandable and simpler than the *Design of Sites* Pattern Browser patterns;
3. The *Amsterdam Pattern Collection* categories (pattern language) were more usable than the *Design of Sites* Pattern Browser categories;
4. The *Amsterdam Pattern Collection* patterns were more logical than the *Design of Sites* Pattern Browser patterns;
5. The *Amsterdam Pattern Collection* provided sufficient examples; and
6. The *Amsterdam Pattern Collection* content was more detailed than the *Design of Sites* Pattern Browser content.

The *Design of Sites* book and the *Amsterdam Pattern Collection* website are highly regarded by IxD researchers and practitioners. The author examined the *Design of Sites* Pattern Browser interface in order to understand the preferences of the Pattern Group participants and established the following:

1. A local view of the pattern language structure is displayed above and to the left of a window that displays the current pattern. The pattern window shows only part of the pattern because it is less than half the display in size.
2. The screenshots of sensitising examples were generally too small to show the detail required by an interaction designer, because of poor screen resolution.
3. It was possible to enlarge the examples up to approximately 300%, allowing a designer to see sufficient detail, but at the expense of seeing the entire screenshot.
4. The sensitising examples in the DoS print book were larger, sharper and quite usable.
5. The sketches were generally large enough to show detail and could be used as examples.
6. The *Design of Sites* Pattern Browser pattern content was abbreviated and the problem discussion in particular was greatly reduced, losing a lot of useful content and screenshots of examples in the process.

It seems likely that the *Design of Sites* Pattern Browser (now withdrawn) was intended as a marketing tool for the *Design of Sites* book and did in fact suffer from a number of usability issues.

The results obtained illustrated that the usefulness of a pattern collection is partially determined by its interface and the quality of its content (Section 3.5.2). This conclusion may apply to guideline collections as well.

5.8 Conclusions

This chapter presented and analysed the results of the empirical study. The objective was to compare the usefulness of guidelines and patterns as design and evaluation aids in IxD.

The results of the evaluation of an existing B2C E-commerce website using guidelines and patterns provided empirical evidence that patterns were as useful as guidelines when used as evaluation aids (Section 5.2).

The Pattern and Guideline Groups were generally able to identify usability issues and good design features using the applicable evaluation aids (Section 5.2.1). The categories of serious usability issues identified included the shopping cart, product pages, trust and customer service, which were the same as those identified in an expert heuristic evaluation. The Pattern and Guideline Groups were also generally able to explain usability issues and good design features effectively in terms of the applicable evaluation aids.

The patterns produced substantially different result sets from the guidelines when used to identify usability issues and features in an existing system, but there was a moderate overlap between the sets (Section 5.2.1). Similar results were obtained for good design features. Pattern and guideline content differences and the evaluator effect were partially responsible for the small overlap for issues and features. The union of the lists of issues and the lists of features provided a more comprehensive description than the individual lists.

The Pattern Group identified a fairly large number of usability issues and the Guideline Group identified a smaller number of issues. The numbers and distributions of the issues identified were similar to those encountered in the CUE studies (Molich *et al*. 2004). Pattern- and guideline-aided inspection exhibited similar characteristics to other evaluation methods such as heuristic evaluation and cognitive walk-throughs. Evaluations by a number of Pattern Group and Guideline Group participants gave a more comprehensive description of issues than individual evaluations, as is the case with Nielsen's heuristic evaluation.

There were no statistically significant differences between using guidelines and patterns to identify usability issues, serious usability issues and good design features in an existing system (Section 5.2.2). There was thus no statistically significant difference between the effectiveness of guidelines and patterns when used for evaluation.

The redesign of an existing system to correct usability issues using guidelines and patterns was investigated. The general design quality of the Pattern and Guideline Group redesigns was high (Section 5.3.1). There was evidence to suggest that the Pattern Group's redesigns were slightly better than the Guideline Group's redesigns. Patterns were found to be more effective than guidelines when used for redesign (Section 5.3.2).

The new design of an existing system to correct usability issues using guidelines and patterns was investigated. The general design quality of the Pattern and Guideline Group new designs was high (Section 5.4.1). There was evidence to suggest that the Guideline Group's new designs were slightly better than the Pattern Group's new designs. There was no statistically significant difference between the effectiveness of guidelines and patterns when used for new design (Section 5.4.2).

The Project Diaries were subjected to thematic analysis and yielded interesting results (Section 5.5). Three styles of evaluation aid use (patterns- and guidelines-first, website-first and indeterminate) were identified. Two styles of design aid use (note-based and diagram-based) were identified. Participants regarded guidelines and patterns as useful and easy to remember, but patterns may need enhancement and modification.

The analysis of the Post-Test Questionnaire quantitative data revealed that there was no statistically significant difference between the perceived usefulness of guidelines and patterns for IxD (Section 5.6). This conclusion was based on a number of subsidiary findings. The perceived efficiency, effectiveness and satisfaction of guidelines and patterns for evaluation, redesign and new design was the same for both groups of participants. The perceived usefulness of the format, content and collection categories of guidelines and patterns was the same. The participants viewed the ease of learning of guidelines and patterns, their usefulness as personal and shared design languages and the degree to which they would use them as design and evaluation aids in the future equally positively. There was thus no statistically significant difference between the perceived usefulness of guidelines and patterns for IxD.

The thematic analysis of the Post-Test Questionnaire qualitative data revealed a number of styles of pattern and guideline use for evaluation and design. Two styles that were common to evaluation and design were the use of design and evaluation aids throughout evaluation, redesign and new design and the use of "pure" design and evaluation knowledge, followed by the use of the aids. The thematic analysis of design and evaluation aid format, content and categories produced some useful information. The analysis of the preferred pattern collection data demonstrated that the usefulness of a pattern collection is partially determined by its interface and the quality of its content.

In summary, patterns were determined to be as useful as guidelines as design and evaluation aids for IxD, with the exception of redesign, where patterns were seen as more useful than guidelines.

The next chapter will discuss the significance of the literature review and empirical study for IxD theory, practice and future research.

Chapter 6: Recommendations

6.1 Introduction

Chapter 5 presented the results of the empirical study of the use of guidelines and patterns as design and evaluation aids. The objective of this chapter is to make recommendations for the theory and practice of pattern use in interaction design (IxD), compared to guideline use, and future research in this area (Research Objective 7, Section 1.3.2). These recommendations are based on the review of guidelines and patterns (Chapters 2 and 3) and the empirical study of guidelines and patterns (Chapters 4 and 5).

The recommendations for theory and practice are described in the next section.

6.2 Recommendations

6.2.1 Pattern Use for Design

Selected questions from the set of general research questions comparing the usefulness of guidelines and patterns as IxD aids (Table 3.5 and 3.6 in Section 3.6.) were investigated in this thesis.

A number of findings were established in respect of the use of patterns for design, in comparison to guidelines:

1. The general design quality of the designs and redesigns of the Pattern and Guideline Groups was high (Sections 5.3.1 and 5.4.1).

2. There was no statistically significant difference between the effectiveness of guidelines and patterns for designing a website (Section 5.4.2). However, patterns were found to be more effective than guidelines for redesign (Section 5.3.2). There was evidence from the data distributions to suggest that the Guideline Group produced slightly better designs than the Pattern Group and

that the Pattern Group produced slightly better redesigns than the Guideline Group. The mean design scores of the Pattern Group were higher for design and redesign than the mean design scores of the Guideline Group.

3. Sixty-five percent of the Pattern Group and 44% of the Guideline Group made use of design notes as an intermediate design language for recording their design activities in the Project Diaries (Section 5.5.2). Fifty-three percent of the Pattern Group and 33% of the Guideline Group made use of design notes as an intermediate design language for redesign (Section 5.5.2). A minority of the Pattern Group and a third of the Guideline Group made use of site maps and wireframes.

4. The Pattern Group rated the set of Post-Test Questionnaire items relating to perceived efficiency, effectiveness and satisfaction of patterns for new design more positively than the Guideline Group did for guidelines (Section 5.6.1). However, there was no statistically significant difference between the perceived efficiency, effectiveness and satisfaction of guidelines and patterns for new design (Section 5.6.2).

5. The Pattern Group and Guideline Group described how they used guidelines and patterns for design. Guidelines and patterns were used in two ways for design. Fifty percent of the Pattern Group and 80% of the Guideline Group identified and reviewed the design aids and designed the new website using these aids. The remainder of the two groups designed a rough website, identified relevant design aids and applied the aids to refine the website design (Section 5.7.3).

Selected findings are discussed from a patterns perspective in terms of the literature review, including related research:

1. The design quality of the designs and redesigns of the Pattern and Guideline Groups was good (Finding 1). The Pattern and Guideline Groups were highly selected and could be expected to produce outputs of good quality (Section 4.6.3). The participants were novice designers. Novice designers are generally

able to apply patterns in design (Borchers 2001; Borchers 2002). Medium-fidelity paper prototypes, in the form of site maps and wireframes were designed by the participants. Medium-fidelity paper prototypes are early designs that come after conceptual design. Pattern use influences the quality of early designs and early design activities positively, allowing designers to exclude issues and restrict the design space more efficiently, resulting in better designs (Saponas *et al.* 2006). This may be due to the known theoretical advantages of patterns and pattern languages, compared to guidelines (Section 3.3.7).

2. There was no statistically significant difference between the effectiveness of guidelines and patterns for design. However, patterns were found to be statistically more effective than guidelines for redesign (Finding 2). The mean Patterns Group design and redesign scores were consistently higher than the mean Guideline Group design and redesign scores.

   Chung *et al.* (2004) did not find any statistically significant differences between designs produced using patterns and "pure" design knowledge. Koukouletsos *et al.* (2007) found that the design quality of prototypes produced using patterns was statistically better than prototypes produced using guidelines. Koukouletsos *et al.* employed synthetic matched ("*balanced*") sets of low-level guidelines and patterns for the design task, to reduce the effect of confounding external variables on the comparison of pattern and guideline use. The prototypes consisted of small (two-page) websites.

   Chung *et al.* did not compare the use of guidelines and patterns for design. Koukouletsos *et al.* compared low level guidelines and patterns. The empirical study compared production-grade guidelines and patterns in a realistic ecological setting. Pattern collections are works in progress (Dearden and Finlay 2006) and pattern content does not exactly match guideline content in collections. Best-effort sets of guidelines and patterns which were not completely matched were employed in the current study.

3. Almost two-thirds of the Pattern Group made use of design notes as an intermediate design language in the Project Diaries, compared to less than half of the Guideline Group (Finding 3). A minority of the Pattern and Guideline Groups made use of site maps and wireframes in the design notes. It is possible that the structured, multidimensional and narrative form of patterns lends itself to a textual way of analysing, reflecting, synthesising and checking during new design. The flat and terse form of guidelines may lend itself to a more direct mapping onto a prototype.

4. The Pattern Group experienced the perceived efficiency, effectiveness and satisfaction of using patterns for design more positively than the Guideline Group did for using guidelines (Finding 4), although this was not statistically significant. The positive rating by the Pattern Group could be due to the known advantages of patterns and pattern languages, compared to guidelines (Section 3.3.7).

5. The Guideline and Pattern Groups described how they used guidelines and patterns for design and redesign. Patterns were used in similar ways for design to guidelines (Finding 5). Half of the Pattern Group participants first identified and reviewed relevant patterns and then designed the website using the patterns as design aids. A taxonomic view of identification and review was formulated by Saponas *et al*. (2006) which matched the modes of use reported by the two groups.

   There was no evidence that the Pattern Group knew how to use pattern languages to select a sublanguage for a particular design problem in order to simplify identifying suitable patterns (Section 3.3.6). Pattern languages were not mentioned in the reports of any Pattern Group participant.

Recommendations flowing from selected design and redesign research findings are presented in Table 6.1.

#	Finding	Recommendation(s)
1	The general design quality of the designs and redesigns of the Pattern and Guideline Groups was high.	• Use patterns for early design and early stage activities, as this will result in better conceptual models and physical designs.
2	There was no significant difference between the effectiveness of guidelines and patterns for design. However, patterns were found to be more effective than guidelines for redesign. Mean pattern-based design and redesign quality scores were higher than guideline-based scores.	• Use patterns in preference to guidelines for IxD as the designs produced could be better.
3	Almost two-thirds of the Pattern Group made use of design notes as an intermediate design language.	• Encourage designers to use design notes as a type of conceptual model when using patterns.
4	The Pattern Group experienced the perceived efficiency, effectiveness and satisfaction of patterns more positively than the Guideline Group did using guidelines, but not to a statistically significant extent.	• Use patterns in preference to guidelines for IxD as the user experience could be better and promote the efficiency, effectiveness and satisfaction of the IxD process.
5	Majority of Pattern Group participants first identified and reviewed relevant patterns and then designed new website using patterns as design aids. Majority of Guideline Group did likewise.	• Designers should first identify and review relevant guidelines and patterns and then design interactive applications using these design aids. • Designers should learn how to use pattern languages to search for patterns efficiently, including selecting sublanguages for particular designs. This may improve their identification of suitable patterns. • Designers should use modern guideline collections that support guideline selection more effectively.

Table 6.1: Recommendations from Design Research Findings

6.2.2 Pattern Use for Evaluation

A number of findings were made in respect of the use of patterns for usability evaluation of the Porcupine Ceramics website, in comparison to guidelines (Section 5.2):

1. The Pattern and Guideline Group participants were able to identify a comparable number of usability issues and good design features for the website using their particular evaluation aids (Section 5.2.1).

2. The most commonly identified and serious usability issues, collectively identified by the Pattern and Guideline Groups, mapped onto those identified by an independent heuristic evaluation (Sections 4.5.1 and 5.2.1). The issues identified by the groups were aspects of the shopping cart, product pages, trust and customer service.

3. The Pattern and Guideline Group participants were able to effectively explain the usability issues and good design features that they identified in their descriptions, in terms of the particular evaluation aids that they used (Sections 5.2.1 and 5.4.2).

4. Guidelines and patterns produced different result sets when used to identify usability issues and good design features in websites, even though best-effort matched sets of guidelines and patterns were provided to the participants (Section 5.2.1). The overlap for issues and features was fairly low (27% for issues and 22% for features). This was partially due to differences between the content of the guidelines and patterns used in the empirical study.

5. A more comprehensive description of usability issues was achieved by combining the set of issues identified through pattern use and the set of issues identified through guideline use (Section 5.2.1). This compensated for the low overlap for issues. The same result holds for the two sets of good design features.

6. Large numbers of unique usability issues and good design features were identified by each of the Pattern and Guideline Groups (Section 5.2.1). The range of variation in individual participant evaluation performance was large and the mean number of issues and features identified per participant was low.

7. A more comprehensive description of issues identified using a particular evaluation aid was achieved by combining the sets of issues identified by multiple evaluators using that aid. Focusing attention on the top third of the most frequently identified issues eliminated outliers (Section 5.2.1).

8. There was no statistically significant difference between the effectiveness of guidelines and patterns for evaluation (Section 5.2.2). The numbers of serious usability issues found by participants from the two groups were also found not to differ significantly.

9. The Guideline Group rated the set of Post-Test Questionnaire items relating to perceived efficiency, effectiveness and satisfaction of guidelines for evaluation more positively than the Pattern Group did for patterns (Section 5.6.1). However, there was no statistically significant difference between the perceived efficiency, effectiveness and satisfaction in use of guidelines and patterns for evaluation (Section 5.6.2).

10. Guidelines and patterns were used in similar ways for evaluation (Section 5.7.1). The majority of the participants in the Pattern and Guideline Groups first identified and reviewed their particular evaluation aids and then evaluated the website using these aids. A minority first reviewed the website, then identified relevant aids and then evaluated the website using the aids.

These findings are discussed from a patterns perspective in terms of the literature review, including related research:

1. Patterns were used to identify a comparable number of usability issues and good design features for the website to guidelines, although the Pattern Group identified more issues than the Guideline Group (Finding 1). The mean numbers and ranges of issues and features identified using guidelines and

patterns were comparable. These results agree with the observation of Chung *et al.* (2004) that patterns complement guidelines and do not replace them. The need for comparing pattern use with the use of other types of design advice was also identified by Dearden and Finlay (2006).

2. The most commonly identified and serious usability issues identified using patterns corresponded with the issues identified by an independent heuristic evaluation, illustrating that the analytical power of patterns for evaluation was comparable to that of guidelines (Finding 2). Chung *et al.* (2004) compared the use of patterns and "pure" design knowledge for evaluation, but observed that the participants did not make much use of the patterns.

3. The issues and features identified using patterns could be explained effectively in terms of specific patterns in the report and diary description narratives, illustrating their explanatory power compared to guidelines (Finding 3). Schmettow (2007) noted the importance of downstream utility in usability inspection methods. The observed pattern explanations provided the most basic type of downstream utility.

4. Guidelines and patterns produced substantially different result sets of issues and features in websites with a fairly low overlap, even though best-effort matched sets of guidelines and patterns were used (Finding 4). This was partially due to differences between the content of the guidelines and patterns used in the empirical study (Section 4.5.2).

5. A more comprehensive description of issues was achieved by combining the set of issues identified through pattern use and the set of issues identified through guideline use (Finding 5). The same result holds for the two sets of features. This finding agrees with the observation of Schmettow (2007) that combining the results of Usability Pattern Inspection (UPI) and heuristic evaluation (HE) provides a broader coverage of issues.

6. Large numbers of singular usability issues and good design features were identified by the Pattern Group, as compared to the Guideline Group (Finding

6). The range of variation in individual participant evaluation performance (in terms of the number of issues and features identified) was large. The mean number of issues and features identified per participant was low. These results were partially due to the evaluator effect and are similar to those of Molich *et al.*'s CUE studies (2004). Pattern- and guideline-aided inspection thus exhibited similar characteristics to other evaluation methods such as heuristic evaluation and cognitive walkthroughs.

7. A more comprehensive description of issues identified using a particular evaluation aid was achieved by combining the sets of issues of several evaluators who used that evaluation aid and focussing attention on the top third of the issues identified by the most evaluators (Finding 7). This compensated for the low mean number of issues identified per evaluator and the large variation in individual evaluator performances. This resembled the evaluator approach followed in Nielsen's heuristic evaluation (1990).

8. The current empirical study found no statistically significant difference in the effectiveness of patterns for identifying issues and features compared to guidelines (Finding 8). Finding 8 does not support the findings of Wesson and Cowley's study (2003) and Kotzé *et al.*'s study (2006), which suggested that guidelines might be easier to use and more effective to use than patterns, as they took less time to understand, learn and apply.

9. The Pattern Group rated the set of Post-Test Questionnaire items applying to the use of patterns for evaluation (C.1.1—6) less favourably than the Guideline Group did (Finding 9). The Pattern Group thus perceived the efficiency, effectiveness and satisfaction in use of patterns for evaluation less positively than the Guideline Group did in respect of guidelines. Finding 9 supports the findings of Wesson and Cowley (2003) and Kotzé *et al.*'s (2006).

Recommendations flowing from the evaluation research findings are presented in Table 6.2.

#	Finding	Recommendation(s)
1	Patterns were used to identify comparable numbers of usability issues and good design features for the website to guidelines.	• Use guidelines and patterns for evaluation in IxD, as they complement each other as evaluation aids.
2	Patterns identified similar serious usability issues to heuristic evaluation, but not exactly the same issues.	• Use patterns and heuristics together to obtain a better coverage of usability issues.
3	Issues and features identified using patterns could be explained effectively in terms of specific patterns.	• Use patterns to provide effective downstream utility for designers and developers in usability reports.
4	Combining set of issues identified through pattern use and set of issues identified through guideline use gives better coverage.	• This matches the recommendation made for point 2.
5	Better description of issues identified achieved by combining sets of issues of several evaluators and focusing attention on top third of the issues identified.	• Use multiple inspectors when performing UPI and HE.
6	No difference in evaluation effectiveness of patterns for identifying issues and features compared to guidelines.	• Use patterns for evaluation; they will give similar results to guidelines.
7	Pattern Group perceived efficiency, effectiveness and satisfaction in use of patterns for evaluation less positively than Guideline Group did for guidelines, but not to a statistically significant extent.	• If time constraints apply to evaluation, use HE rather than UPI, since patterns were designed primarily for design, rather than evaluation.
8	Patterns were used in similar ways to guidelines for evaluation.	• Designers should first identify and review relevant guidelines and patterns and then evaluate products using these design aids. • Teach designers how to use pattern languages to search for patterns efficiently, including selecting sublanguages for particular designs, to improve pattern identification. • Use modern guideline collections that support guideline selection more effectively.

Table 6.2: Recommendations from Evaluation Research Findings

6.2.3 Static Features and Collective Structures of Patterns

A number of findings were made in respect of the static features and collective structures of patterns (Section 5.2):

1. The following general findings were derived from Pattern Group comments:
    a. Guidelines and patterns were useful;
    b. Patterns were easy to remember;
    c. Pattern collections might not cover all design problems;
    d. Pattern formats might need modification to make them more usable; and
    e. Some pattern collection interfaces and content were more usable than others (Section 5.5.2).

2. There was no statistically significant difference between the following subjective measures in use of static features and collective structures of guidelines and patterns (Section 5.6.2).
    a. The perceived usefulness of pattern and guideline formats;
    b. The perceived usefulness of pattern and guideline content;
    c. The perceived usefulness of the categories used in pattern and guideline collections;
    d. The perceived ease of understanding of guidelines and patterns when first encountered;
    e. The perceived ease of learning of guidelines and patterns when first encountered;
    f. The perceived ease of remembering of guidelines and patterns when first encountered;
    g. The perceived extent to which guidelines and patterns served as personal design languages;
    h. The perceived extent to which guidelines and patterns served as a means of sharing design knowledge between designers; and
    i. The perceived acceptance of guidelines and patterns as long-term design aids.

3. The pattern format components of pattern name, description, problem, solution, context of use and examples were experienced as useful and made the pattern easier to apply (Section 5.7.4). The pattern format made the design solutions consistent and predictable.

4. In terms of pattern content, the pattern description, problem, solution, context of use and examples were experienced as useful (Section 5.7.5). The generality and comprehensive explanations of the content were seen as useful.

5. In terms of pattern categories, the logical grouping of patterns by site genre and page type and the links to related patterns made it easy and quick to find the required patterns (Section 5.7.6).

6. The *Amsterdam Pattern Collection* was preferred to the *Design of Sites Pattern Browser* by almost all Pattern Group participants. The usefulness of a pattern collection was found to be partially determined by its interface and the quality of its content (Section 5.7.7).

Recommendations flowing from the static features and collective structures of patterns research findings are presented in Table 6.3.

#	Finding	Recommendation(s)
1	General findings: Guidelines and patterns were useful, patterns were easy to remember, pattern collections might not cover all design problems, pattern formats might need modification to make them more usable and some pattern collection interfaces and content were more usable than others.	• Use guidelines and patterns as IxD aids, considering that the designs obtained by using patterns are likely to be better. • Use multiple pattern collections to obtain a better coverage of design context and to learn what the shortcomings of particular pattern collections are.
2	No statistically significant difference between subjective measures of static features and collective structures of guidelines and patterns.	• Make use of static features and collective structures of guidelines and patterns.
3	Pattern names, pattern description, problem, solution, context of use and examples were experienced as useful.	• Pattern names, pattern description, problem, solution, context of use and examples are important and should be used by designers to produce better designs.
4	Pattern description, problem, solution, context of use and examples were experienced as useful Generality and comprehensive explanations of content were seen as useful.	• Pattern description, problem, solution, context of use, examples, generality and comprehensive explanations of content were are important and should be used by designers.
5	Pattern category aspects of logical grouping of patterns by site genre and page type and links to related patterns made it easy and quick to find the required patterns.	• Group patterns by site genre and page types and make use of links to related patterns.
6	Usefulness of a pattern collection was found to be partially determined by its interface and the quality of its content.	• Improve the usability of pattern collection interfaces.

Table 6.3: Recommendations from Additional Research Findings

6.3 Recommendations for Future Research

6.3.1 Overview

The empirical study produced several useful findings. This section discusses questions from the set of general research questions and issues that could be further investigated (Table 3.4, Section 3.5.3).

The empirical study incorporated the independent variables of designer experience and collaboration. One condition of designer experience (novice designers) and one condition of collaboration (individual design) were employed.

It is recommended that studies based on the general research questions be conducted incorporating two conditions of designer experience (novice and experienced designers) and the alternative collaboration condition (collaborative design). This will enable the effect of designer experience in a collaborative setting on the usefulness of guidelines and patterns to be studied (Chung *et al.* 2004; Saponas *et al.* 2006). These proposed studies are discussed by category below.

6.3.2 Modes of Pattern and Guideline Use

The empirical study investigated comparative design, evaluation and redesign effectiveness of guidelines and patterns when used by participants who were novice designers.

It is recommended that the efficiency, effectiveness and satisfaction of comparative design, evaluation and redesign, incorporating the effect of designer experience in a collaborative setting, be studied.

Research questions that could be investigated include:

1. Does using patterns enable experienced designers to produce physical designs and design evaluations more quickly than using guidelines?
2. Does using patterns enable experienced designers to produce more complete and usable physical designs and find more serious usability issues than using guidelines?
3. Do experienced designers find using guidelines and patterns for design, evaluation and redesign more satisfying than novice designers do?

The empirical studies made use of medium fidelity paper prototypes. Saponas *et al.* (2006) maintain that patterns can support more complete, detailed design. Research should thus be done on the use of patterns to design high-fidelity prototypes of a realistic size.

6.3.3 Static Features of Guidelines and patterns

It is recommended that studies based on the usefulness of different formats and ways of presenting content in guidelines and patterns be conducted. Such studies would investigate whether different pattern formats and ways of presenting pattern content would be more useful in usability evaluation. Such studies should incorporate the effect of designer experience in a collaborative setting.

6.3.4 Collective Structures of Guidelines and patterns

It is recommended that studies of the usefulness of different pattern and guideline collection interfaces and content be conducted, as the current research has shown that pattern collection content and interfaces affects the usefulness of a pattern collection.

6.4 Conclusions

Several findings were established for the use of patterns for design and redesign, compared to guidelines (Section 6.2.1). The designs of the Guideline and Pattern

Groups were of good quality. There was no statistical difference between the two group's designs, although the Pattern Group's redesigns were better than those of the Guideline Group. The Pattern Group experienced pattern use for design more positively than the Guideline Group's experience of guideline use.

It was recommended that patterns be used for early design and early stage activities as well as later physical design, as this would produce better conceptual models and physical designs. Patterns should be used in preference to guidelines because of the better designs produced. Guidelines could be used as a fall-back resource if development time was highly constrained, as patterns have a higher initial design overhead than guidelines. Designers should be encouraged to experiment with the use of design notes, leading to conceptual models, when using patterns in early stage design activities. The lack of understanding of pattern languages requires that designers be taught how to use pattern languages to search for patterns required for a particular design efficiently. Finally, it was recommended that designers should use modern guideline collections, as these have features that support guideline selection.

A number of findings were made for the use of patterns for evaluation, compared to guidelines (Section 6.2.2). The numbers, types and explanations of usability issues and good design features detected and the differences between the issue sets detected by guidelines and patterns were noted. There was no difference in evaluation effectiveness between guidelines and patterns.

It was recommended that guidelines and patterns should be used together for evaluation in IxD, as they complement each other. Using patterns for UPI and heuristic evaluation together reveals more serious usability issues than using one or the other. Patterns can be used effectively to provide effective downstream utility in usability reports. It was important to use multiple inspectors during UPI, to compensate for the evaluator effect. HE should be used in preference to UPI, if time constraints apply to evaluation. This is because patterns were designed primarily for design, rather than evaluation, and their verbose format is less efficient to use than the terse format of guidelines. Finally, it was recommended that designers experiment with alternative pattern formats (bulleted points, for example) for evaluation.

The findings of static features and collective structures of patterns were discussed and recommendations made (Section 6.2.3).

It was recommended that patterns should be used in preference to guidelines, as the designs were likely to be better due to the innate advantages of patterns. Multiple IxD pattern collections should be used to cover design context more completely and to learn the shortcomings of particular pattern collections. Finally, it was recommended that pattern collections with more usable interfaces should be identified and used in preference to other collections.

Recommendations for future research were made, based on the set of general questions formulated in Table 3.4, Section 3.5.3 (Section 6.3). Studies incorporating two conditions of designer experience (novice and experienced designers) and the alternative collaboration condition (collaborative design) were seen as particularly important.

The recommendations focused on modes of pattern and guideline use, static features of guidelines and patterns, and the collective structures of guidelines and patterns. It was recommended that the efficiency, effectiveness and satisfaction of comparative design, evaluation and redesign, incorporating the effect of designer experience, be studied.

The usefulness of different formats and ways of presenting content in guidelines and patterns for designers having varying degrees of experience requires investigation. It is possible that non-standard pattern formats improve design activities and usability evaluation. Finally, studies of the usefulness of different pattern and guideline collection interfaces and content are required, as revealed by the current research.

Chapter 7 provides an overview of the entire thesis.

Chapter 7: Conclusions

7.1 Introduction

Chapter 6 made recommendations for the theory and practice of pattern and guideline use in interaction design (IxD) and future research in this area. This chapter presents the conclusions arising from the research (Research Objective 8, Section 1.3.2). The summary of the research findings, a discussion of problems encountered and a summary of the contributions made by the research are discussed.

7.2 Summary of Research Findings

The aim of the research was to determine how useful IxD patterns are when used as physical design and usability evaluation aids in IxD, as compared to design guidelines. Several existing studies have focused on different aspects of this research (Section 1.2). There were a number of issues that these studies did not address. These issues included comparing guidelines and patterns using experimental groups, the redesign activity and the effect of design aid properties and structures on design and evaluation. Eight research objectives were identified in Section 1.3.2.

The literature review of guidelines and patterns showed that patterns differ from guidelines in their clear design context, solution process description, rich set of examples and value-centeredness. Recent guideline collections were found to have acquired some of the properties of patterns. Pattern languages can be used to generate complete designs with less effort than using guideline collections. A comparison scheme for guideline and pattern properties was devised, which demonstrated that patterns were equivalent to general guidelines in terms of design context.

Several findings were established for the use of patterns for design and redesign, as compared to guidelines. The designs and redesigns of the Pattern and Guideline Groups were determined to be of high quality, with the Pattern Group designs and redesigns being slightly better. There was no significant statistical difference between the new designs of the Pattern and Guideline Groups, but the redesigns of the Pattern

Group were statistically better than those of the Guideline Group. Better designs resulting from pattern use were predicted from the literature review (Section 3.3.7). The Pattern and Guideline Group's subjective experience of using the different design aids was statistically equivalent. The Pattern Group rated their subjective experience of using patterns for design and redesign more highly than the Guideline Group, possibly due to the known advantages of patterns and pattern languages, compared to guidelines.

Patterns should thus be used for early conceptual design and later physical design, as this could produce better conceptual models and physical designs. Guidelines should be used if development time is highly constrained, as pattern-based design has a higher initial overhead than guidelines while the patterns are being learned. The use of design notes while designing with patterns could lead to improved conceptual models. Designers need to be taught how to use pattern languages to search for required patterns, as the pattern language concept is not intuitive. Designers are encouraged to use modern guideline collections such as Koyani, Bailey and Nall's guideline collection (2006) as these have features that supported guideline selection.

A number of findings were made for the use of patterns for evaluation, as compared to guidelines. Participants were able to use guidelines and patterns to identify a comparable number of usability issues and good design features and explain them in terms these design aids. Guidelines and patterns were found to identify different sets of issues and features, with low overlap. This was partially due to the differences between the design advice of the different guidelines and patterns. The issues identified by the participants using guidelines and patterns corresponded to the issues identified by the expert review, illustrating the effectiveness of guidelines and patterns for heuristic evaluation. Guideline- and pattern-aided inspection exhibited similar characteristics to other analytical evaluation methods such as heuristic evaluation and cognitive walkthroughs, including a strong evaluator effect.

Guidelines and patterns could thus both be used for evaluation in IxD, as they were found to complement each other. Using patterns and heuristics together would result in a better coverage of usability issues. Pattern use would provide effective downstream utility for designers and developers in usability reports, since patterns

incorporate the steps required to generate good designs. Multiple inspectors should be used when using guidelines and patterns for heuristic evaluation, to compensate for the evaluator effect. Heuristic evaluation using guidelines is suggested in the event of time constraints, because patterns were designed primarily for design rather than evaluation. Designers should first identify and review relevant guidelines and patterns and then design products using these design aids (design aid-based review and design). Designers need to be taught how to use pattern languages to search for patterns efficiently, so as to improve pattern identification. Such teaching is required because pattern languages were found not to be an intuitive concept. Finally, it was suggested that guideline collections that better support guideline selection be used (e.g. Koyani, Bailey and Nall's guideline collection (2006)).

A number of findings were made in respect of the static features and collective structures of patterns. Patterns were experienced as useful and easy to remember. However, patterns may not cover all design problems and their format may need modification to serve certain purposes. No statistically significant difference was found between subjective measures of the static features and collective structures of guidelines and patterns (Section 5.6.2). The pattern name, description, problem, solution, context of use and examples of pattern use were experienced as useful. The format of patterns made design solutions consistent and predictable. The logical grouping of patterns by site genre and page type and the links to related patterns made it easy to find patterns. The usability and the content of a pattern collection partially determined its usefulness.

Several recommendations were made regarding the static features and collective structures of patterns. It was suggested that guidelines and patterns should be used as IxD aids, noting that the designs obtained using patterns were likely to be better. Using multiple pattern collections would ensure a better coverage of the design context. Pattern names, pattern description, problem, solution, context of use and examples were regarded as important and could be used by designers to produce better designs. Grouping patterns by site genre and page types and using pattern language links to related patterns was seen as useful.

There are several research questions requiring further investigation. A study could be conducted incorporating two conditions of designer experience (novice and

experienced designers) and the condition of collaborative design. This would enable designer experience in a collaborative setting to be studied. There are a number of specific research questions to be investigated; for example, whether patterns enable experienced designers to produce physical designs and usability evaluations more efficiently than using guidelines. Saponas *et al.* (2006) maintain that patterns could support more complete, detailed design. Thus research should be done on the design of high-fidelity prototypes of real-world products using patterns.

The usefulness of different formats and ways of presenting content in guidelines and patterns requires further investigation. It is possible that different pattern formats and ways of presenting pattern content would be more useful for heuristic evaluation. Finally, the usefulness of different pattern and guideline collection interfaces and content also needs further investigation. The usability of pattern collection content and interfaces can affect the usefulness of a pattern collection.

In summary, patterns were determined to be as useful as guidelines as design and evaluation aids, when used by novice designers in the domain of B2C E-commerce websites. Patterns were found to more effective than guidelines when used for redesign. The difference in effectiveness between guideline and pattern use for design and evaluation, compared to the use of these aids for redesign could possibly be due to the content of patterns. This requires further research.

7.3 Discussion of Problems and Limitations

This research has a number of limitations. The empirical study focused on novice designers, and did not incorporate experienced designers. Collaborative design was not investigated. The mismatch between pattern and guideline design advice (incomplete overlap) was a confounding factor. Pattern and guideline use was studied embedded in parts of an IxD lifecycle. Studying the use of these aids throughout a complete IxD lifecycle would have provided a more realistic context for the research. A factorial experimental design, in which two groups employed both guidelines and patterns, would have provided a richer comparison of the different aids.

7.4 Summary of Contributions

This empirical study made a number of contributions to the understanding of guidelines and patterns as physical design and usability evaluation aids and suggestions for future research in this area:

1. A comparison scheme for guideline and pattern properties, based on a guideline property classification scheme, was devised.
2. A definition of the usefulness of guidelines and patterns as IxD aids was formulated (Section 3.5).
3. A general research agenda for guidelines and patterns as IxD aids was identified, extending that of Dearden and Finlay (2006).
4. Guidelines were determined to be as effective as patterns as new design aids in IxD, but patterns were determined to be more effective than guidelines when used as redesign aids. The quality of the Pattern Group's new designs and redesigns was slightly better than the Guideline Group's designs. Patterns should thus be used for early conceptual design and later physical design, as this could produce better conceptual models and physical designs.
5. It was established that the pattern language concept is not intuitive. The use of pattern languages to simplify pattern selection and application in pattern-based design and evaluation must thus be explicitly taught and practised with designers.
6. A B2C E-commerce heuristic evaluation form for measuring the quality of designs and redesigns was developed.
7. Guidelines were determined to be as effective as patterns as evaluation aids in IxD. Both guidelines and patterns can thus be used as evaluation aids in IxD.
8. Guidelines and patterns were found to display similar characteristics when used for evaluation as those obtained in the comparative usability evaluation (CUE) studies conducted by Molich *et al.* (2004: 65-74). It can thus be concluded that the effectiveness and efficiency of using guidelines and patterns is also partially subject to the evaluator effect.
9. The previous point implies that teams of four or five inspectors should collaborate in using guidelines and patterns for heuristic evaluation.
10. Mismatches were found between guideline and pattern design advice. These mismatches suggest that designers should use guidelines and patterns as

complementary IxD aids, since they will identify more design issues and good design features and create better designs by doing this than if they used only one of these aids.

11. Most novice designers first identified and reviewed particular patterns or guidelines and then used them for design or evaluation. This suggests that novice designers should be taught to follow this intuitive procedure.
12. Pattern collections differ in the quantity and quality of their design advice and the usability of their interfaces. These differences can affect designer performance in design and evaluation.

Considering the literature review, empirical study and discussion presented in this thesis, it may be concluded that IxD patterns are as useful as design guidelines when used as physical design and evaluation aids in IxD.

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Appendix A: Heuristic Evaluation of Porcupine Ceramics Website

Application:	Porcupine Ceramics	**Evaluator Name:**	**NLO Cowley**
ID:	http://www.porcupine.co.za	**Evaluation Date:**	**01/03/2004**

Meaning of Severity Rating Values Used Below:
NA = Not applicable; 0 = No problem; 1 = Negligible problem; 2 = Minor problem; 3 = Moderate problem; 4 = Serious problem.

#	Heuristic	Severity Rating						Suggestion(s) for Correcting the Problem(s)
		NA	0	1	2	3	4	
1	**Visibility of System Status:** The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.				X	X X X X		Most Popular/Top Selling product list not provided. Product hierarchy not explicitly accessible on home page, because name of category page list ("Collection") is confusing. Active category page number, total number of items in set, visited and unvisited page links not indicated. Shopping cart contents not visible at all times (only when browsing category pages and at checkout). Product availability information not provided.
2	**Match Between System and the Real World:** The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.					X X X		Home page does not state that the function of the website is B-C E-commerce in raku ceramics. Prices are only in ZAR; currency conversion for international customers is not supported. Checkout process is confusing.
3	**User Control and Freedom:** Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.				X	X X X	X	No product search facility on category pages The quantity of an item in the shopping cart can not be (explicitly) set. Shopping cart contents not visible at all times (only when browsing category pages and at checkout). Once submitted, there is no way to edit one's Registration Form details. No order tracking system.

4	**Consistency and Standards:** Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.						X X X	Non-standard terminology for shopping cart components used. Secure connections for information transfer and payment not provided. No explanation of why sensitive customer information is required.
5	**Error Prevention:** Even better than good error messages is a careful design that prevents a problem from occurring in the first place.				X X			Hyperlinks not underlined/in standard colour format. Product cost components not completely specified on product pages. Product cost components not completely specified on product pages.
6	**Recognition Rather than Recall:** Make objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.					X		Shopping cart contents not visible at all times (only when browsing category pages and at checkout).
7	**Flexibility and Efficiency of Use:** Accelerators – unseen by the novice user – may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.						X	Add and remove item functionality of shopping cart severely restricted and non-standard.
8	**Aesthetic and Minimalist Design:** Dialogues should not contain information that is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.							
9	**Help Users Recognize, Diagnose and Recover from Errors:** Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.						X	No assistance with forgotten password provided.
10	**Help and Documentation:** Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.					X X X	 X X	No guarantee policy provided. No guidance on how to shop online on site. Insufficient contact mode information provided on Contact page. No privacy policy provided. Help link points to empty page.

#	**Comment**
	Very attractive website that is not a true E-commerce website (no on-line ordering or purchasing). Easy to use but has
	a number of usability issues in the areas of the shopping cart, product pages, trust and customer service.

Appendix B: Project Information and Informed Consent Form

2004 UPE UI Design Patterns Evaluation Project
Project Information and Informed Consent Form

You have been selected as a research participant in the 2004 UPE Usability Patterns Evaluation Project, as a member of the 2004 Electronic Commerce 4/5 (WREC411/501) class. The research is being conducted at UPE by Mr Lester Cowley (csanlc@upe.ac.za), 504 2326) and Prof Janet Wesson (csajlw@upe.ac.za). Dr Lynette Barnard, your WREC411/501 lecturer, has kindly agreed to this research being done under the auspices of WREC411/501.

The Project aims to understand how to measure the usability of user interface (UI) design patterns and how designers and developers use them in designing the interfaces of applications.

We invite you to participate in and support this important research, in order to advance the frontiers of scientific knowledge.

If you decide to participate in the Project, three WREC411/501 E-commerce assignments will be given to you to do as an individual (i.e. not in a group) over the next three weeks. You will do one assignment per week. You will use either UI design patterns or E-commerce design guidelines while doing these assignments. As you complete each one, you will submit your answers for evaluation and the marks obtained will go towards your class mark for the WREC411/501 module. While doing the assignments, you will gather data for the Project through your activities. We expect the part of the Project in which you will participate to require about twelve hours. We may request additional participation from you in the form of interviews.

If you decide NOT to participate in the Project, non-Project WREC411/501 E-commerce assignments will be given to you to do as an individual (i.e. not in a group) over the next three weeks. These assignments will be equivalent in difficulty and work volume to the Project assignments and will take about the same amount of time to do. The marks obtained for them will go towards your class mark for the module.

If you decide to participate, you will do the following:

- Complete a pre-questionnaire.
- Use patterns or guidelines to evaluate an existing E-commerce site.
- Use patterns or guidelines to redesign an existing E-commerce site.
- Use patterns or guidelines to design a new E-commerce site.
- Keep a diary of your experiences while using patterns or guidelines.
- Complete a post-questionnaire.

The data collected will be used only for the purposes of the Project and will not be distributed to or viewed by anyone not associated with the Project. It will be processed and used to write scientific reports and papers. No one will be able to identify you personally by reading these reports and papers. There are no known risks associated with participating in the Project.

We are happy to answer any questions you may have about the Project and your role in it. As a participant, you have certain rights, which are listed below.

Your rights as a participant are as follows:

1. You have the right to withdraw from the Project and withdraw your data at any time for any reason. If you decide to withdraw, please inform the researchers immediately.
2. At the conclusion of your participation, you may view your data, if you so desire.

You are requested not to discuss the details of your participation in the Project with people who are not participants. You are also requested not to give such people access to the project resources made available to you.

We greatly appreciate your time and effort in participating in the Project.

Your signature and your personal and contact details below indicate that you have read this Project Information and Informed Consent Form in its entirety and that you voluntarily agree to participate. Make sure that you keep a copy of this Form for your records.

Full first names, followed by surname: _____

Signature: _____

E-mail address: _____

Contact telephone number: _____

Date: 10 May 2004

Appendix C: Pre-Test Questionnaire

2004 UPE UI Design Patterns Evaluation Project	
Pre-Test Questionnaire	
	Instructions (please read carefully)
1.	Complete ALL items that are relevant to you.
2.	Where appropriate, write responses in BLOCK CAPITALS in the spaces provided and choose options by circling the selected options.
3	Some items are statements or questions that you must rate or answer by circling a number on a scale from 1 to 5, or NA (Not Applicable).
4	If you circle an "Other" option, write the information required in the space to the right of the word "Other:".
5.	Hand the completed questionnaire to a researcher.

	Date completed	/ 10 / 05 / 2004 /

A.	**Biographical Data**	
	Complete the following items relating to SOME OF YOUR PERSONAL DETAILS.	
1.	Surname	
2.	Initials	
3.	Title	/ Mr / Mrs / Miss / Ms / Dr / Prof / Rev /
4.	Age	Years
5.	Nationality	/ South Africa / The Netherlands / Other: /
6.	Gender	/ Male / Female /
7.	Main language spoken	/ English / Afrikaans / Xhosa / Dutch / Other: /
8.	Post-school educational qualification(s)	
9.	Institution where studying/employed	/ UPE / Satama / Other: /
10.	Degree registered for in 2004/Job title	

B.	**Computing Experience**
	This section records your practical experience of computing as a designer, a developer, or both. • A **DESIGNER** is a person who specifies the way that users interact with an application, chooses the interface components, and lays them out in a set of views. • A **DEVELOPER** is a person who writes the application code for the interfaces and internals of systems. • If you are a UPE Computer Science and Information Systems student, you might have experience of both roles. • In some software companies, an employee is either a designer or a developer. In other software companies, an employee can do both jobs.

Please turn over the page and complete the rest of the items.

B.1	**If you have experience as a DESIGNER, complete the following items relating to YOUR PRIOR EXPERIENCE OF DESIGNING.**		
1.	How long have you been designing?	Years	
2.	How experienced a designer are you?	/ Novice / Intermediate / Expert /	
3.	How many interfaces have you designed for systems?		
4.	How do you design interfaces? (What design methodology and design aids do you use?)		
5.	What design software do you use?		

B.2	**If you have experience as a DEVELOPER, complete the following items relating to YOUR PRIOR EXPERIENCE OF DEVELOPMENT.**		
1.	How long have you been developing?	Years	
2.	How experienced a developer are you?	/ Novice / Intermediate / Expert /	
3.	How many systems have you developed?		
4.	How do you develop systems? (What development methodology and development aids do you use?)		
5.	What programming/scripting language(s) do you use?		

Please turn over the page and complete the rest of the items.

C.	**Complete the following items relating to YOUR EXISTING KNOWLEDGE OF UI DESIGN PATTERNS.**	
1.	Do you know what a UI design pattern is?	/ Yes / No /
2.	If you know what a UI design pattern is, give your definition of it.	
3.	Have you previously used UI design patterns?	/ Yes / No /
4.	If you have used UI design patterns, name them and their authors (where known).	

D.	**If you have USED UI design patterns to design systems, complete the following items relating to YOUR EXPERIENCE OF USING UI DESIGN PATTERNS.**

D.1	**Complete the following items relating to the USABILITY OF UI DESIGN PATTERNS. (NA = Not Applicable.)**						
1.	You were able to create a design faster using patterns, compared to using other design aids. (Work more efficiently.)	Strongly Disagree				Strongly Agree	
		1	2	3	4	5	NA
2.	You were able to create more candidate designs for a system using patterns, compared to using other design aids. (Work more efficiently.)	Strongly Disagree				Strongly Agree	
		1	2	3	4	5	NA
3.	You were able to reach final designs of system components faster using patterns, compared to using other design aids. (Work more efficiently.)	Strongly Disagree				Strongly Agree	
		1	2	3	4	5	NA
4.	The designs that you created using patterns were better, compared to those created using other design aids. (Work more effectively.)	Strongly Disagree				Strongly Agree	
		1	2	3	4	5	NA
5.	It was more satisfying to use patterns to create a design, compared to using other design aids. (Work with more satisfaction.)	Strongly Disagree				Strongly Agree	
		1	2	3	4	5	NA
6.	Describe HOW you used UI design patterns to design systems.						

Please turn over the page and complete the rest of the items.

D.2	**Complete the following items relating to YOUR EXPERIENCE OF GENERAL PROPERTIES OF UI DESIGN PATTERNS. (NA = Not Applicable)**						
1.	You used patterns a lot when thinking about design activities. (Using patterns as a personal design language.)	Strongly Disagree				Strongly Agree	
		1	2	3	4	5	NA
2.	You used patterns a lot when you talked about designing to other designers. (Using patterns as a shared design language.)	Strongly Disagree				Strongly Agree	
		1	2	3	4	5	NA
3.	The format (components and layout) of patterns affected how useful they were to you.	Strongly Disagree				Strongly Agree	
		1	2	3	4	5	NA
4.	Based on your experience of pattern use, you will want to use patterns as a design aid in the future.	Strongly Disagree				Strongly Agree	
		1	2	3	4	5	NA
5.	What aspects of the format (components and layout) of patterns were useful to you?						
6.	What aspects of the format (components and layout) of patterns were NOT useful to you?						

Please check that you have completed ALL items that are relevant to you.
Hand the completed questionnaire to a researcher.
Thank you very much for your participation.

Appendix D: Assignment 1 (Patterns)

Assignment 1: Heuristic Evaluation (Pattern Group)

1. Goals

The goals of this assignment are to perform a heuristic evaluation of an E-commerce website and to evaluate the content of UI design patterns used in the heuristic evaluation.

2. Duration

This assignment should take between two and four hours to do.

3. Tasks

Working as an individual (i.e. not in a group), do a heuristic evaluation of the usability of the Porcupine Ceramics website (http://www.porcupine.co.za/), using the UI design patterns in two well-known pattern repositories, the Amsterdam Pattern Collection and the Design of Sites Pattern Browser. See below for a screenshot of the Porcupine Ceramics home page (Figure 1).

Sign up for a free one-year access license to the Design of Sites Pattern Browser at http://www.designofsites.com/pb/register.html.

Local copies of the Amsterdam Pattern Collection and the Design of Sites Pattern Browser have been provided for you to use for speed of access. The local copy of the Amsterdam Pattern Collection is stored on the Post Graduate Server at http://postgrad/amsterdam collection/. The local copy of the Design of Sites Pattern Browser is stored on the Post Graduate Server at http://dos/. You have been given read-only Internet browser access within the boundaries of the UPE campus for a period of one month to these local copies. Screenshots of the home pages of these pattern repositories appear below (see Figures 2 and 3).

Heuristic evaluation forms part of the usability engineering lifecycle. The aim of heuristic evaluation is to identify usability problems in an application, so that these problems may be corrected in an updated version of the application.

To do heuristic evaluations using UI design patterns is difficult at first, but becomes easier and easier as one becomes familiar with the patterns and the process of using them.

You should first scan the pages and the site structure of the website to form a general impression of the appearance and behaviour of the site.

Next, study patterns in the repositories that seem relevant to features of the site to become familiar with their content (look at their names, what problems they solve and internal links to related patterns). Form an impression of the connections between related patterns. The process of learning the patterns takes some time.
Critically evaluate the website using the pattern content, looking for missing or sub-standard features at various levels of abstraction that make the website less usable. Note that such features have a static appearance (or form) and a dynamic behaviour (interactivity) and you should consider both of these aspects. Several features may interact and thus influence each other. Also look for features that work well.

You may find usability problems that are not covered by any pattern in the repositories that you have studied. Record information about these problems, as this may help researchers discover new patterns.

It is very important to make notes of what you observe in the Project Diary as you work, to capture details while they are still fresh in your mind.

The researchers suggest that the patterns listed below will help you find the major usability problems in the Porcupine Ceramics website and that you start off by using them. It will improve the depth and quality of the heuristic evaluation to look for additional patterns and employ them as well.

From the Amsterdam Pattern Collection:

- Shopping experience
- Shopping cart
- Product Page
- Paging
- Login
- Register
- Form
- Input Error Message.

From the Design of Sites Pattern Browser:

- Patterns in the Personal E-Commerce section
- Patterns in the Advanced E-Commerce section.

Keep a detailed record of your experiences in your Diary while you are doing the heuristic evaluation. Write what you are doing (your processes), your observations, opinions, ideas, criticisms, suggestions, etc. Provide detailed information, and not just a few words or blank spaces. Draw diagrams and pictures and paste or staple in printouts and photocopies if you wish. List the names and sources of all the UI design patterns that you used (naming the source is necessary to distinguish between patterns with identical names that occur in the two sources). You will use the information that you wrote down to draw up the heuristic evaluation report.

Required:

1. Draw up the heuristic evaluation report from your Diary notes as follows:

1.1 Write down the potential usability problems that you found. For each usability problem:

- Give a brief description of the problem.
- State whether there is a UI design pattern that covers the problem or not.
- If there is such a pattern, give its name and source and comment on whether it gives adequate guidance on how to solve the usability problem.

1.2 List the features that you found to be well designed (this is unusual in a heuristic evaluation). For each good design feature:

- Give a brief description of the feature.
- State whether there is a UI design pattern that covers the feature or not.
- If there is such a pattern, give its name and source and comment on whether it gives adequate guidance on how to achieve a good design for the feature.

4. Submission of Assignment 1

Hand the heuristic evaluation report to a researcher at the WREC411/501 lecture on Monday 17 May 2004 for evaluation.

Keep the Diary. You will use it while you are doing Assignments 2 and 3.

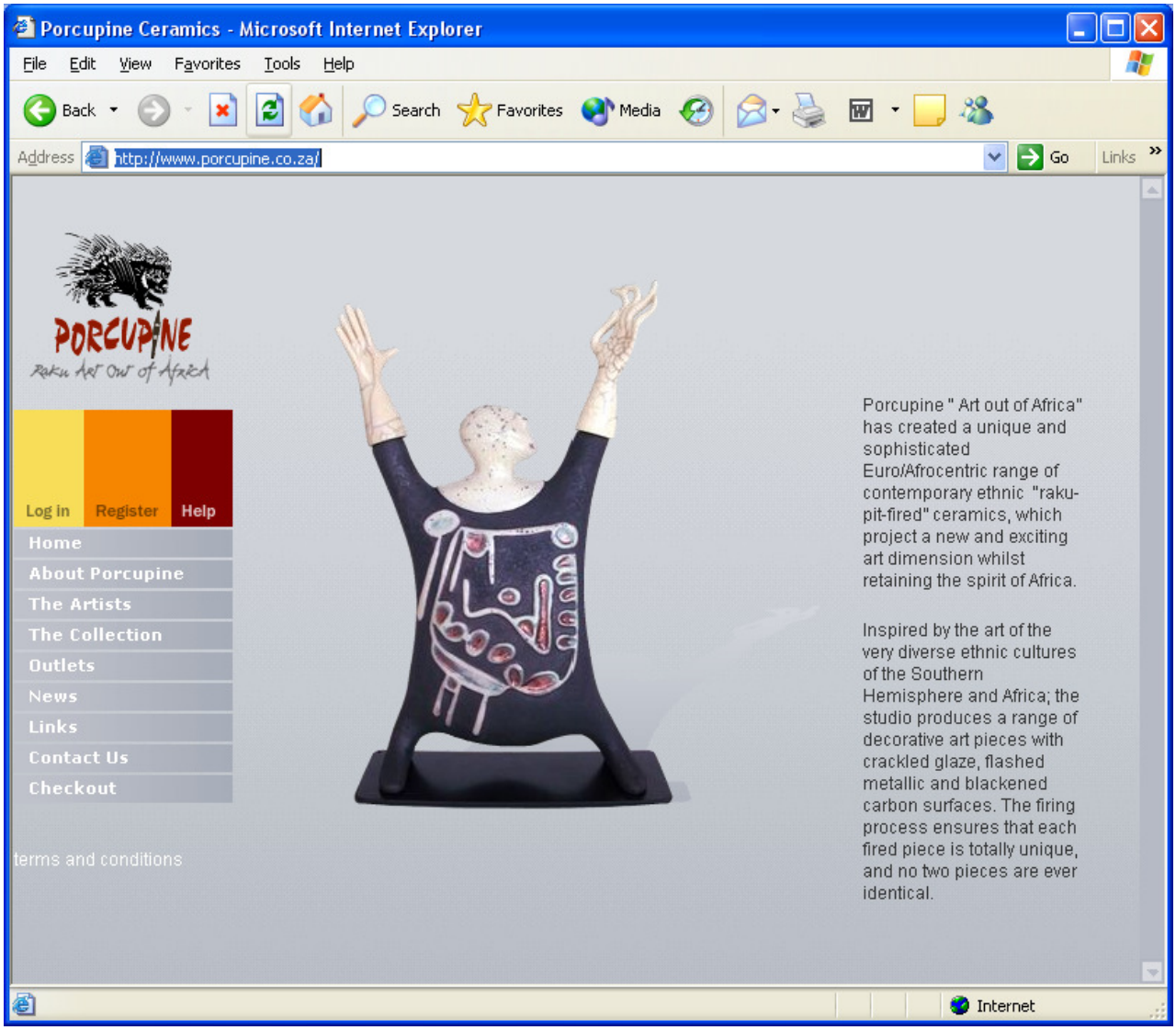

Figure 1. Home Page of the Porcupine Ceramics Website

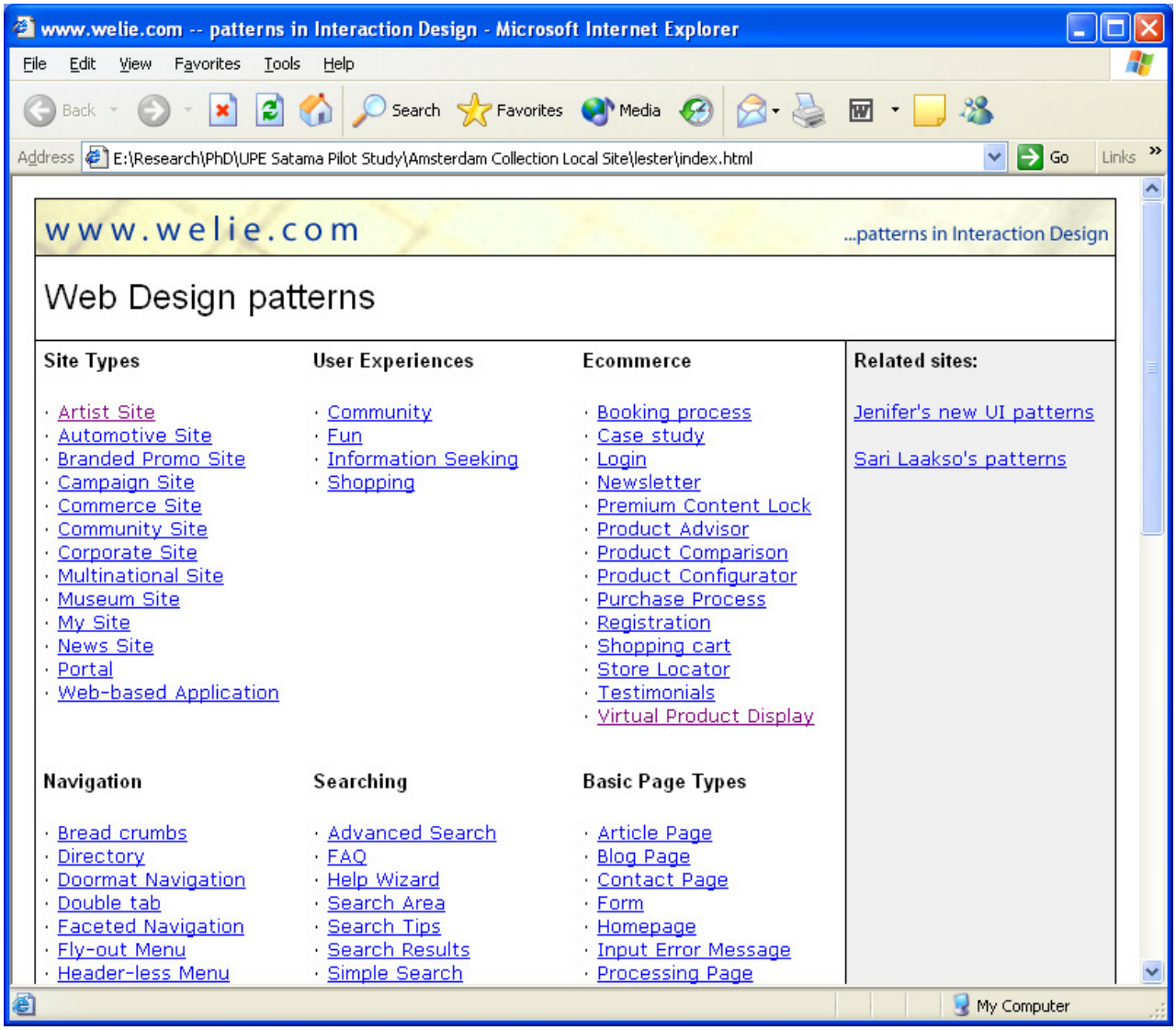

Figure 2. Home Page of the Amsterdam Pattern Collection

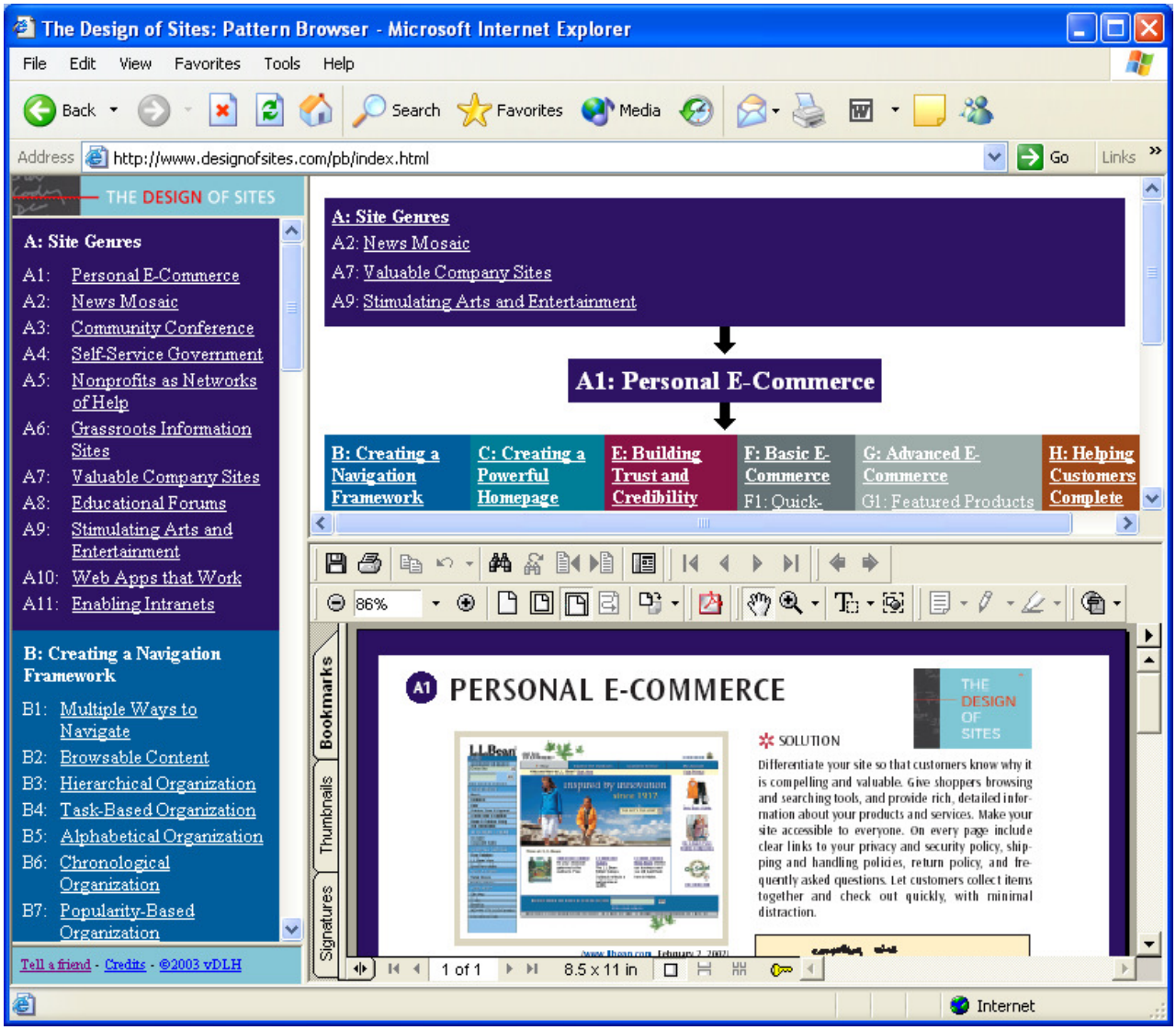

Figure 3. Home Page of the Design of Sites Pattern Browser

Thank you very much for your valued participation.

Appendix E: Assignment 1 (Guidelines)

Assignment 1: Heuristic Evaluation (Guideline Group)

1. Goals

The goals of this assignment are to perform a heuristic evaluation of an E-commerce website and to evaluate the content of E-commerce design guidelines used in the heuristic evaluation.

2. Duration

This assignment should take between two and four hours to do.

3. Tasks

Working as an individual (i.e. not in a group), do a heuristic evaluation of the usability of the Porcupine Ceramics website (http://www.porcupine.co.za/), using Dr Lynette Barnard's E-commerce design guidelines. See below for a screenshot of the Porcupine Ceramics home page (Figure 1).

A local copy of Dr Barnard's guidelines has been provided for you to use. The local copy is stored on the Post Graduate Server at http://postgrad/guidelines. Access to this local copy is restricted.

Heuristic evaluation forms part of the usability engineering lifecycle. The aim of heuristic evaluation is to identify usability problems in an application, so that these problems may be corrected in an updated version of the application.

To do heuristic evaluations using guidelines is difficult at first, but becomes easier and easier as one becomes familiar with the guidelines and the process of using them.

You should first scan the pages and the site structure of the website to form a general impression of the appearance and behaviour of the site.

Next, study guidelines that seem relevant to features of the site to become familiar with them. Form an impression of how related guidelines are grouped together in categories. The process of learning the guidelines takes some time.

Critically evaluate the website using the guidelines, looking for missing or sub-standard features at various levels of abstraction that make the website less usable. Note that such features have a static appearance (or form) and a dynamic behaviour (interactivity) and you should consider both of these aspects. Several features may interact and thus influence each other. Also look for features that work well.
You may find usability problems that are not covered by any of Dr Barnard's guidelines. Record information about these problems, as this may help researchers discover new guidelines.

It is very important to make notes of what you observe in the Project Diary as you work, to capture details while they are still fresh in your mind.

The researchers suggest that the guidelines listed below will help you find the major usability problems in the Porcupine Ceramics website and that you start off by using them. It will improve the depth and quality of the heuristic evaluation to look for additional guidelines and employ them as well.

Categories from Dr Barnard's E-commerce design guidelines:

- Customer support
- Shopping cart & placing order
- Product Pages
- Category pages.

Keep a detailed record of your experiences in your Diary while you are doing the heuristic evaluation. Write what you are doing (your processes), your observations, opinions, ideas, criticisms, suggestions, etc. Provide detailed information, and not just a few words or blank spaces. Draw diagrams and pictures and paste or staple in printouts and photocopies if you wish. List the names and categories of all the guidelines that you used. You will use the information that you wrote down to draw up the heuristic evaluation report.

Required:

Draw up the heuristic evaluation report from your Diary notes as follows:

1.1 Write down the potential usability problems that you found. For each usability problem:

- Give a brief description of the problem.
- State whether there is a guideline that covers the problem or not.
- If there is such a guideline, give its name and category and comment on whether it gives adequate guidance on how to solve the usability problem.

1.2 List the features that you found to be well designed (this is unusual in a heuristic evaluation). For each good design feature:

- Give a brief description of the feature.
- State whether there is a guideline that covers the feature or not.
- If there is such a guideline, give its name and category and comment on whether it gives adequate guidance on how to achieve a good design for the feature.

4. Submission of Assignment 1

Hand the heuristic evaluation report to a researcher at the WREC411/501 lecture on Monday 17 May 2004 for evaluation.

Keep the Diary. You will use it while you are doing Assignments 2 and 3.

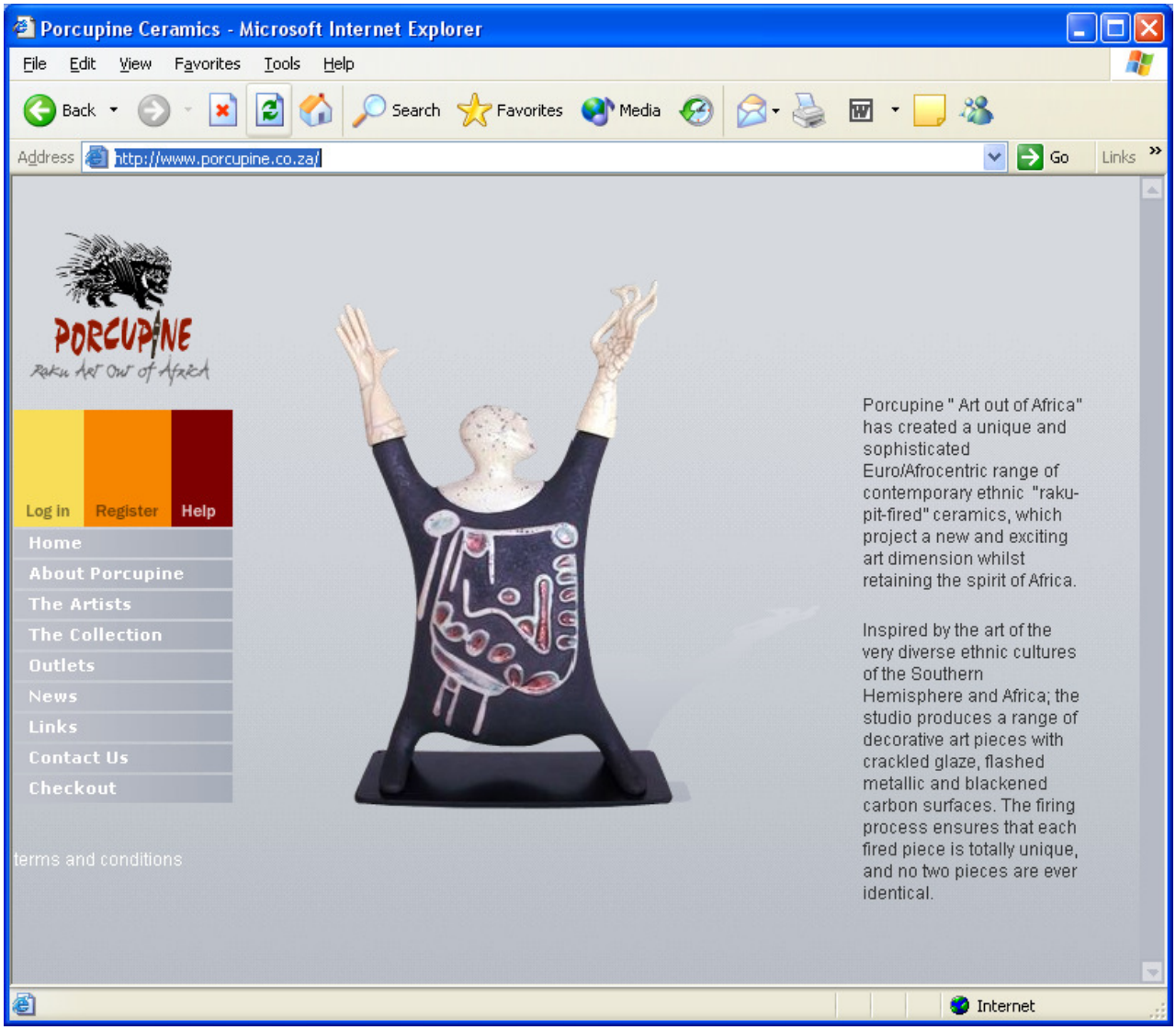

Figure 1. Home Page of the Porcupine Ceramics Website

Thank you very much for your valued participation.

Appendix F: Assignment 2 (Patterns)

Assignment 2: Redesign of Existing E-Commerce Website (Pattern Group)

1. Goals

The goals of this assignment are to redesign the E-commerce web site that you evaluated in Assignment 1, and to evaluate the content of UI design patterns used in the redesign.

2. Duration

This assignment should take between four and six hours to do.

3. Tasks

Working as an individual (i.e. not in a group), redesign the Porcupine Ceramics website (http://www.porcupine.co.za/). Use the heuristic evaluation report that you did for Assignment 1 and the UI design patterns in the Amsterdam Pattern Collection and the Design of Sites Pattern Browser to correct the usability problems that you found in Assignment 1.

Do not redesign every page in the site. This would be far too much work for one assignment (there are numerous product pages, for instance). Redesign all the *types* of pages (e.g. home page, product page, sign-in/new account page, etc.) required to make the Porcupine Ceramics website usable, showing an example of each.

The researchers suggest that you document your redesign as a site (or navigation) map and a collection of wireframes that describe the web pages.

A site map is the familiar diagram made up of web page thumbnails and links joining them, which is used to design the overall structure of a web site before designing the individual web pages. See Figure 1 below for an example of a site map.

A wireframe is a skeletal rendering of a web page that only shows the layout of the page and not the aesthetics (look and feel, colours, fonts, etc.). A graphic designer can create a mockup for this, which adds the aesthetics. See Figure 2 below for an example of a wireframe. If you wish to learn more about wireframes, visit http://www.mojofat.com/tutorial/step4.html and http://www.synthis.com/products/adalon/generators/other/wireframes/index.jsp. Wireframes are popular among web designers and information architects.

You may use computer tools like Microsoft Visio, Microsoft Visual Basic or Adobe Photoshop to create the site map and wireframes, or you may draw neat sketches of the site map and the wireframes by hand.

Keep a detailed record of your experiences in your Diary while you are doing the redesign. Write what you are doing (your processes), your observations, opinions, ideas, criticisms, suggestions, etc. Provide detailed information, and not just a few words or blank spaces. Draw diagrams and pictures and paste or staple in printouts and photocopies if you wish. List the names and sources of all the UI design patterns that you used (naming the source is necessary to distinguish between patterns with identical names that occur in the two sources). You will use the information that you wrote down when you create the site map and the wireframes for the redesign.

Required:

1. Redesign the Porcupine Ceramics website as described above, producing a site map and wireframes.
2. Write a report that analyses the usefulness of the *contents* of the patterns that you used to redesign the Porcupine Ceramics website to solve the usability problems that you identified in Assignment 1. For each usability problem:
    - Give a brief description of the problem.
    - State whether there is a UI design pattern that covers the problem or not.
    - If there is such a pattern, give its name and source and comment on:
        - Which parts of the pattern were useful in solving the usability problem and which parts were of little or no use.
        - What information was missing from the pattern that you think is important for applying the pattern to solve the usability problem.

4. Submission of Assignment 2

Hand the redesigned site map and wireframes, and the pattern usefulness report to a researcher at the WREC411/501 lecture on Monday 24 May 2004 for evaluation.

Keep the Diary. You will use it while you are doing Assignment 3.

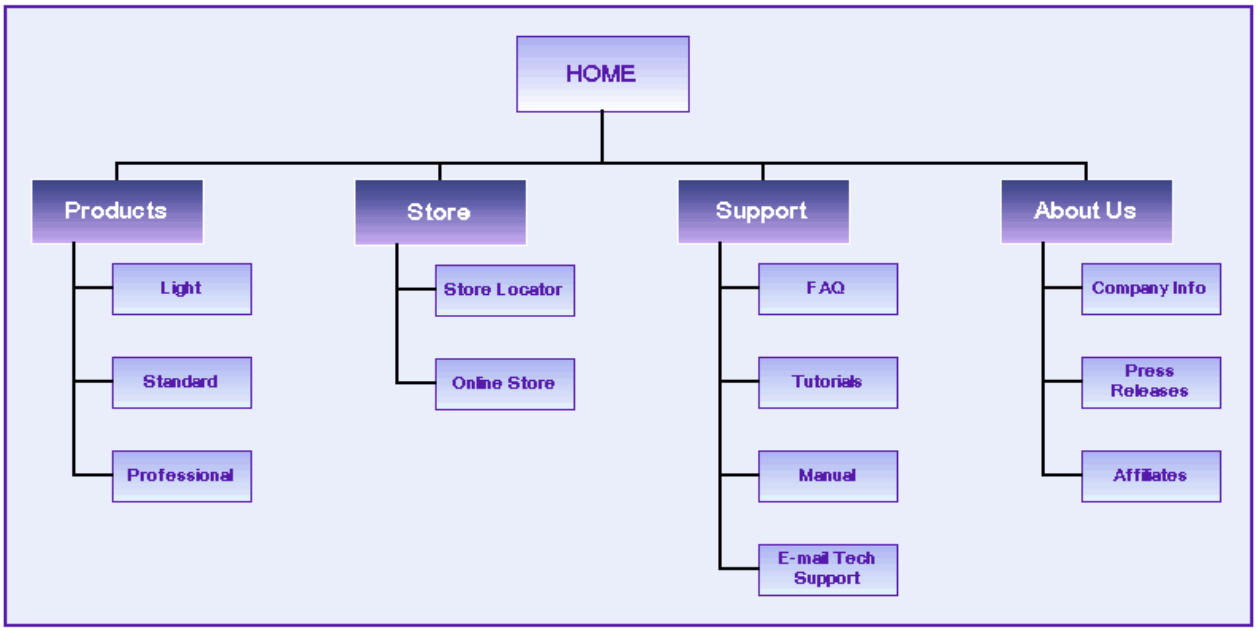

Figure 1. Example of a site map for a web site

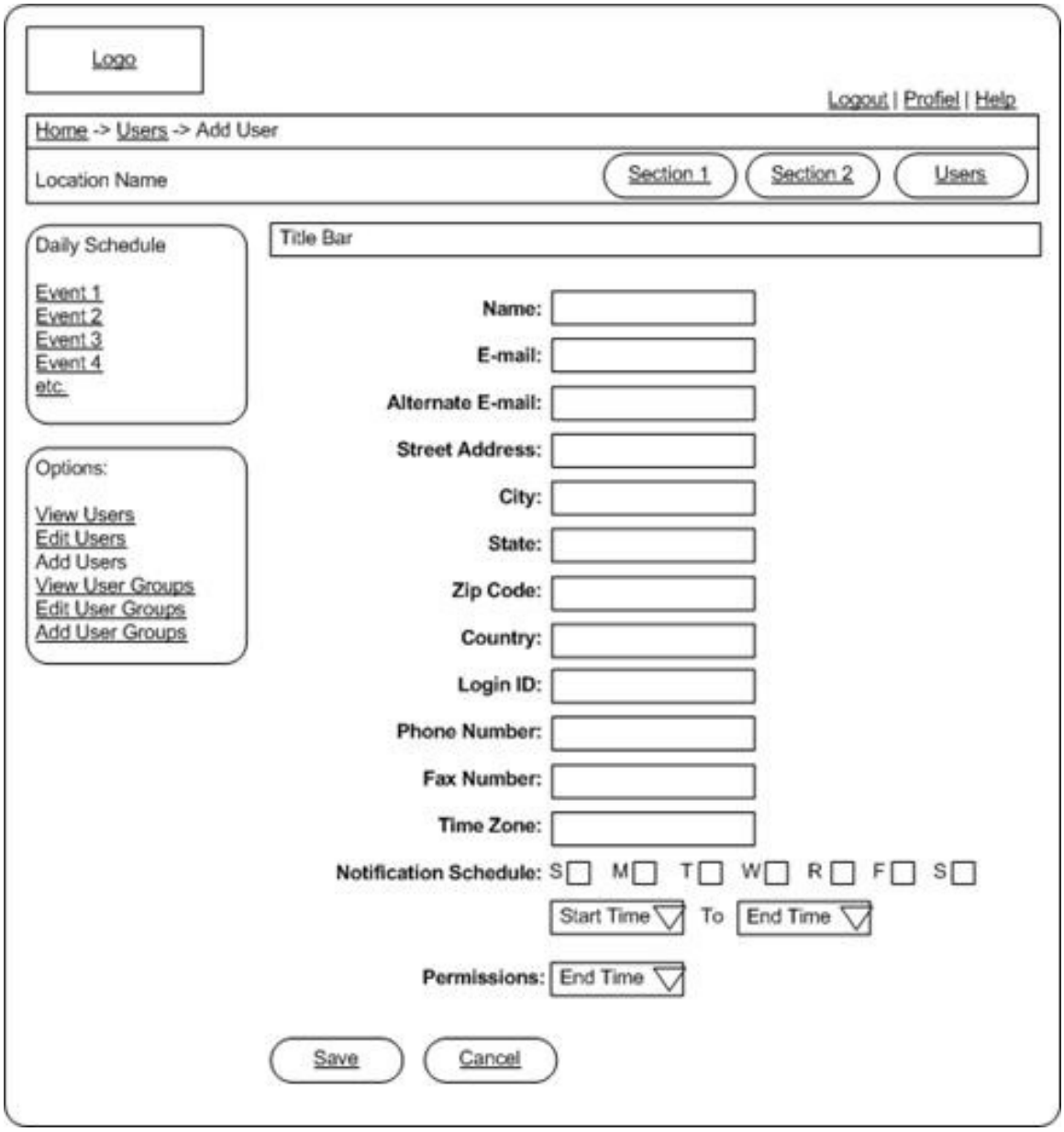

Figure 2. Example of a wireframe of a web page

Thank you very much for your valued participation.

Appendix G: Assignment 2 (Guidelines)

Assignment 2: Redesign of Existing E-Commerce Website (Guideline Group)

1. Goals

The goals of this assignment are to redesign the E-commerce web site that you evaluated in Assignment 1, and to evaluate the E-commerce design guidelines used in the redesign.

2. Duration

This assignment should take between four and six hours to do.

3. Tasks

Working as an individual (i.e. not in a group), redesign the Porcupine Ceramics website (http://www.porcupine.co.za/). Use the heuristic evaluation report that you did for Assignment 1 and Dr Lynette Barnard's E-commerce design guidelines to correct the usability problems that you found in Assignment 1.

Do not redesign every page in the site. This would be far too much work for one assignment (there are numerous product pages, for instance). Redesign all the *types* of pages (e.g. home page, product page, sign-in/new account page, etc.) required to make the Porcupine Ceramics website usable, showing an example of each.

The researchers suggest that you document your redesign as a site (or navigation) map and a collection of wireframes that describe the web pages.

A site map is the familiar diagram made up of web page thumbnails and links joining them, which is used to design the overall structure of a web site before designing the individual web pages. See Figure 1 below for an example of a site map.

A wireframe is a skeletal rendering of a web page that only shows the layout of the page and not the aesthetics (look and feel, colours, fonts, etc.). A graphic designer can create a mockup for this, which adds the aesthetics. See Figure 2 below for an example of a wireframe. If you wish to learn more about wireframes, visit http://www.mojofat.com/tutorial/step4.html and http://www.synthis.com/products/adalon/generators/other/wireframes/index.jsp. Wireframes are popular among web designers and information architects.

You may use computer tools like Microsoft Visio, Microsoft Visual Basic or Adobe Photoshop to create the site map and wireframes, or you may draw neat sketches of the site map and the wireframes by hand.

Keep a detailed record of your experiences in your Diary while you are doing the redesign. Write what you are doing (your processes), your observations, opinions, ideas, criticisms, suggestions, etc. Provide detailed information, and not just a few words or blank spaces. Draw diagrams and pictures and paste or staple in printouts and photocopies if you wish. List the names and categories of all the guidelines that you used. You will use the information that you wrote down when you create the site map and the wireframes for the redesign.

Required:

1. Redesign the Porcupine Ceramics website as described above, producing a site map and wireframes.

2. Write a report that analyses the usefulness of the gudelines that you used to redesign the Porcupine Ceramics website to solve the usability problems that you identified in Assignment 1. For each usability problem:

- Give a brief description of the problem.
- State whether there is a guideline that covers the problem or not.
- If there is such a guideline, give its name and category and comment on:
    - To what degree the text of the guideline was useful in solving the usability problem.
    - What information was missing from the guideline that you think is important for applying the guideline to solve the usability problem.

4. Submission of Assignment 2

Hand the redesigned site map and wireframes, and the guideline usefulness report to a researcher at the WREC411/501 lecture on Monday 24 May 2004 for evaluation.

Keep the Diary. You will use it while you are doing Assignment 3.

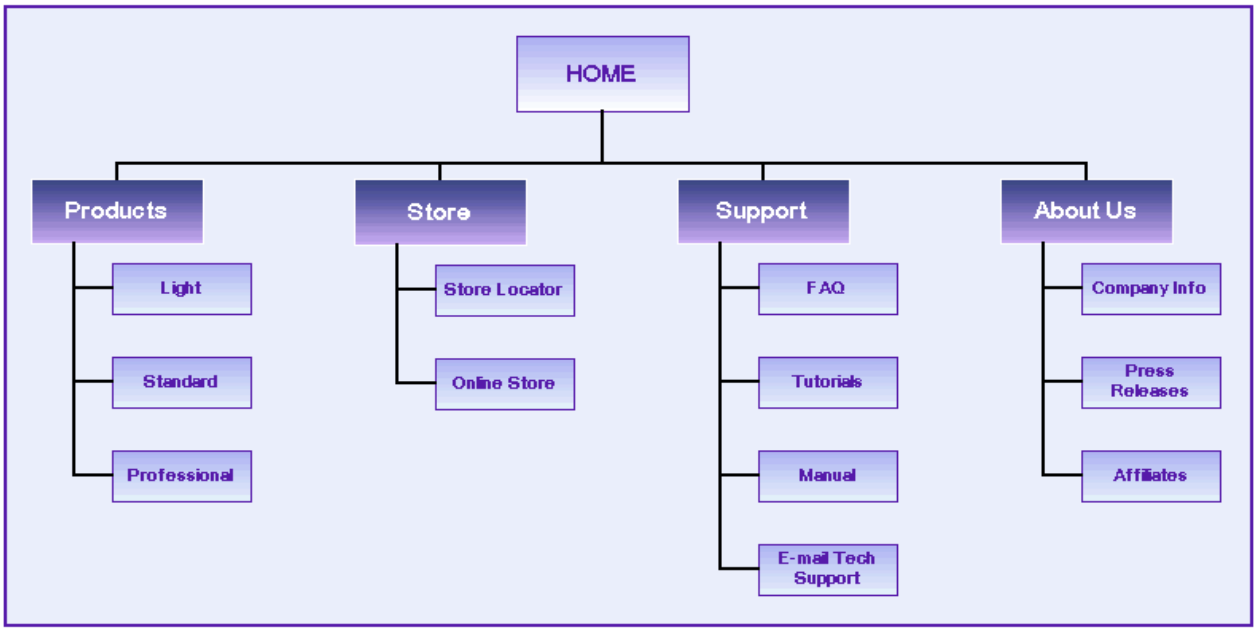

Figure 1. Example of a site map for a web site

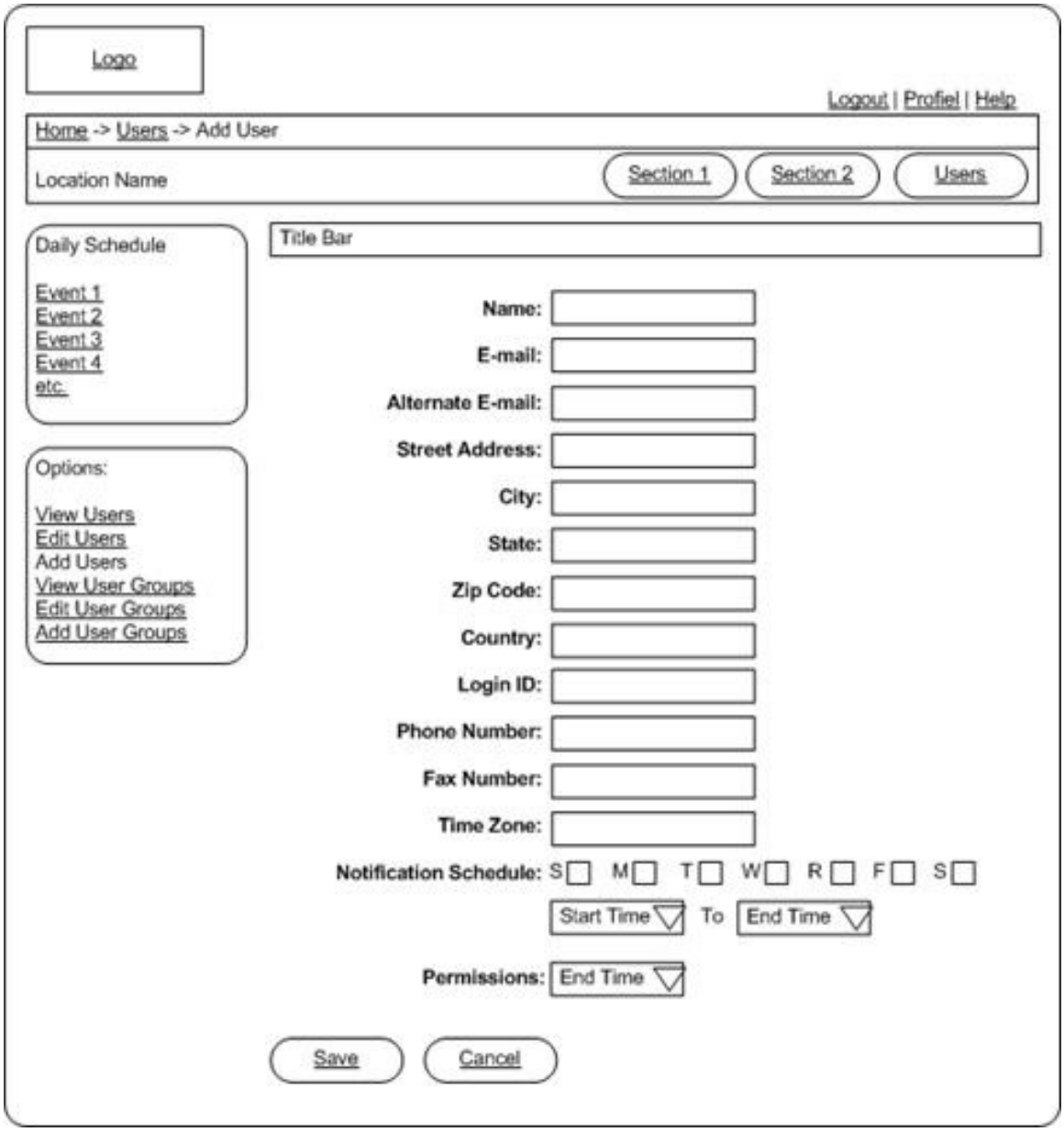

Figure 2. Example of a wireframe of a web page

Thank you very much for your valued participation.

Appendix H: Assignment 3 (Patterns)

Assignment 3: Design of New E-Commerce Website (Pattern Group)

1. Goals

The goals of this assignment are to design a new E-commerce web site using patterns, and to evaluate the form (configuration) of UI design patterns used in the design.

2. Duration

This assignment should take between four and six hours to do.

3. Tasks

Consider the following scenario:

Cover Up is an upholstery factory in Port Elizabeth that manufactures and sells stylish and comfortable upholstered furniture—sofas, chairs, headboards for beds, etc. Five master upholsterers (the owners) and twenty assistants work in the factory, manufacturing upholstered furniture to order. It has been selling these products to Port Elizabeth customers for three years. Customers are singles and couples and you will find PCs with Internet access in their homes. They are all keen Web surfers and emailers. The customer profile is as follows:

- Males, over 25, well off. They look for comfort in products. They prefer modern furniture designs. They like bargains.
- Females, over 25, well off. They are "arty" (interested in interior decorating, graphic arts, music, etc.). They prefer fashionable, modern furniture designs that harmonise with the rest of their decor. They prefer quality to low prices.

Cover Up has a printed colour catalogue of the different types and designs of upholstered furniture (about fifty different items falling into seven different categories) that it manufactures and sells, and customers can browse through this and choose products to order. Customers can also discuss custom designs with one of the master upholsterers. Customers who have ordered a piece of furniture can visit the factory to see how work is progressing on their order.

Sales are good, but Cover Up has reserve manufacturing capacity and would like to expand its customer base within South Africa beyond Port Elizabeth, targeting the same type of customer that it has at present, but also making a start with selling directly to small corporate customers (B&Bs and boutique hotels).

The owners are not very computer-literate, but they want to use Internet marketing and E-commerce to expand the customer base of the business. They want to tell prospective customers about Cover Up and what its vision is, and how beautiful and well made their products are. They want to sell their products online through their proposed web site (although potential customers could send email, telephone or send faxes if they wanted to).

Customers must be able to view the available items, their description and cost (excluding VAT) and order the ones that they want. VAT is charged on orders placed by non-corporate customers (corporate customers must provide a VAT number and an order number). A 10 % delivery charge is charged on the total amount of an order (excluding VAT). Cover Up will start manufacturing the items on receipt of the order. Customers who have placed an order must be able to visit the website to see how work is progressing on their order. On

completion, the customer is sent an email, the payment is processed and the order is despatched for delivery.

Site2See, your well-known web design company, has been asked to design a web site for Cover Up by the owners of the factory.

Working as an individual (i.e. not in a group), design the Cover Up website (which will be located at http://www.coverup.co.za/). Use the UI design patterns in the Amsterdam Pattern Collection *and* the Design of Sites Pattern Browser. *This is very important—you must use patterns from both pattern collections.*

Do not design every page in the site. This would be far too much work for one assignment. Design all the *types* of pages (e.g. home page, product page, sign-in/new account page, shopping cart page, etc.) required for the Cover Up website, showing an example of each.

The researchers suggest that you document your redesign as a site (or navigation) map and a collection of wireframes that describe the web pages, as you did in Assignment 2. Refer to Assignment 2 for an example of a site map and a wireframe.

You may use computer tools like Microsoft Visio, Microsoft Visual Basic or Adobe Photoshop to create the site map and wireframes, or you may draw neat sketches of the site map and the wireframes by hand.

Keep a detailed record of your experiences in your Diary while you are doing the design. Write what you are doing (your processes), your observations, opinions, ideas, criticisms, suggestions, etc. Provide detailed information, and not just a few words or blank spaces. Draw diagrams and pictures and paste or staple in printouts and photocopies if you wish. List the names and sources of all the UI design patterns that you used (naming the source is necessary to distinguish between patterns with identical names that occur in the two sources). You will use the information that you wrote down when you create the site map and the wireframes for the design.

Required:

1. Design the Cover Up website as described above, producing a site map and wireframes.
2. Write a report that describes:
    - How you searched for patterns to help you do the design,
    - How you used the patterns to do the design (the process steps that you followed).
    - The degree to which the *form* (the way in which the content is structured or laid out) of the patterns was useful (this is why you must use both the van Wielie and Design of Sites patterns), commenting on:
        - The way in which the patterns are grouped in each of the collections and how this affected your search for suitable patterns.
        - The degree to which the various parts (pattern name, examples, problem, solution, etc.) of the patterns and the order or arrangement of the parts was useful in solving design problems.
        - Whether the patterns can be improved by changing their form (changing the order, adding new parts or removing existing parts).

4. Submission of Assignment 3

Hand the following to a researcher by Friday 25 June 2004 for evaluation.

- The site map and wireframes for the Cover Up website
- The pattern form report
- The Diary that you kept while doing Assignments 1 to 3.

You will be given a Post-Questionnaire to complete when you hand in the documents.

You are welcome to submit the documents before the final date if you wish to.

Thank you very much for your valued participation.

Appendix I: Assignment 3 (Guidelines)

Assignment 3: Design of New E-Commerce Website (Guideline Group)

1. Goals

The goals of this assignment are to design a new E-commerce web site using patterns, and to evaluate the form (shape) of the E-commerce design guidelines used in the design.

2. Duration

This assignment should take between four and six hours to do.

3. Tasks

Consider the following scenario:

Cover Up is an upholstery factory in Port Elizabeth that manufactures and sells stylish and comfortable upholstered furniture—sofas, chairs, headboards for beds, etc. Five master upholsterers (the owners) and twenty assistants work in the factory, manufacturing upholstered furniture to order. It has been selling these products to Port Elizabeth customers for three years. Customers are singles and couples and you will find PCs with Internet access in their homes. They are all keen Web surfers and emailers. The customer profile is as follows:

- Males, over 25, well off. They look for comfort in products. They prefer modern furniture designs. They like bargains.
- Females, over 25, well off. They are "arty" (interested in interior decorating, graphic arts, music, etc.). They prefer fashionable, modern furniture designs that harmonise with the rest of their decor. They prefer quality to low prices.

Cover Up has a printed colour catalogue of the different types and designs of upholstered furniture (about fifty different items falling into seven different categories) that it manufactures and sells, and customers can browse through this and choose products to order. Customers can also discuss custom designs with one of the master upholsterers. Customers who have ordered a piece of furniture can visit the factory to see how work is progressing on their order.

Sales are good, but Cover Up has reserve manufacturing capacity and would like to expand its customer base within South Africa beyond Port Elizabeth, targeting the same type of customer that it has at present, but also making a start with selling directly to small corporate customers (B&Bs and boutique hotels).

The owners are not very computer-literate, but they want to use Internet marketing and E-commerce to expand the customer base of the business. They want to tell prospective customers about Cover Up and what its vision is, and how beautiful and well made their products are. They want to sell their products online through their proposed web site (although potential customers could send email, telephone or send faxes if they wanted to).

Customers must be able to view the available items, their description and cost (excluding VAT) and order the ones that they want. VAT is charged on orders placed by non-corporate customers (corporate customers must provide a VAT number and an order number). A 10 % delivery charge is charged on the total amount of an order (excluding VAT). Cover Up will start manufacturing the items on receipt of the order. Customers who have placed an order must be able to visit the website to see how work is progressing on their order. On

completion, the customer is sent an email, the payment is processed and the order is despatched for delivery.

Site2See, your well-known web design company, has been asked to design a web site for Cover Up by the owners of the factory.

Working as an individual (i.e. not in a group), design the Cover Up website (which will be located at http://www.coverup.co.za/). Use Dr Lynette Barnard's E-commerce design guidelines.

Do not design every page in the site. This would be far too much work for one assignment. Design all the *types* of pages (e.g. home page, product page, sign-in/new account page, shopping cart page, etc.) required for the Cover Up website, showing an example of each.

The researchers suggest that you document your redesign as a site (or navigation) map and a collection of wireframes that describe the web pages, as you did in Assignment 2. Refer to Assignment 2 for an example of a site map and a wireframe.

You may use computer tools like Microsoft Visio, Microsoft Visual Basic or Adobe Photoshop to create the site map and wireframes, or you may draw neat sketches of the site map and the wireframes by hand.

Keep a detailed record of your experiences in your Diary while you are doing the design. Write what you are doing (your processes), your observations, opinions, ideas, criticisms, suggestions, etc. Provide detailed information, and not just a few words or blank spaces. Draw diagrams and pictures and paste or staple in printouts and photocopies if you wish. List the names and categories of all the guidelines that you used. You will use the information that you wrote down when you create the site map and the wireframes for the design.

Required:

1. Design the Cover Up website as described above, producing a site map and wireframes.
2. Write a report that describes:
    - How you searched for guidelines to help you do the design,
    - How you used the guidelines to do the design (the process steps that you followed).
    - The degree to which the *form* (the way in which the content is structured or laid out) of the guidelines was useful, commenting on:
        - The way in which the guidelines are grouped in each of the categories and how this affected your search for suitable guidelines.
        - The degree to which the content in the guidelines and the way in which it is arranged was useful in solving design problems.
        - Whether the guidelines can be improved by changing their form (changing existing content, removing existing content or adding new content).

4. Submission of Assignment 3

Hand the following to a researcher by Friday 25 June 2004 for evaluation.

- The site map and wireframes for the Cover Up website
- The guideline form report
- The Diary that you kept while doing Assignments 1 to 3.

You will be given a Post-Questionnaire to complete when you hand in the documents.

You are welcome to submit the documents before the final date if you wish to.

Thank you very much for your valued participation.

Appendix J: Project Diary (Abbreviated)

2004 UPE UI Design Patterns Evaluation Project
Project Diary

A.	**Information and Instructions (please read carefully)**
1.	The purpose of this Diary is to enable you to record your experiences of using patterns or guidelines during your participation in the Project.
2.	Complete items B and C below by writing responses in BLOCK CAPITALS in the spaces provided and choosing options by circling the selected options.
3.	**It is very important for the research that you do the following:** • Work as an individual and do not copy what other participants are doing. • When you start to work for a period of time (a session), write the date, the starting time and what assignment you are doing in the Diary. • While you work, write what you are doing (your processes), your observations, opinions, ideas, criticisms, suggestions, etc. in the Diary. • Provide detailed information, and not just a few words or blank spaces. • Draw diagrams and pictures and paste or staple in printouts and photocopies if you wish. • Staple additional pages if required to the end of the Diary. • When you end a session, write the ending time in the Diary.
4.	Keep all your Diary pages safe and in order and hand them to a researcher at the end of your participation when requested.

B.	**Date completed**	/ / / 2004

C.	**Biographical Data**	
1.	Surname	
2.	Initials	
3.	Title	/ Mr / Mrs / Miss / Ms / Dr / Prof / Rev /

Please turn over the page and continue recording work information.

D.	**Work Record**		
	Assignment 1	**Date:**	**Time:**
	Work Done:		

Please turn over the page and continue recording work information.

D.	Work Record		
	Assignment 2	**Date:**	**Time:**
	Work Done:		

Please turn over the page and continue recording work information.

D.	Work Record		
	Assignment 3	**Date:**	**Time:**
	Work Done:		

Staple additional pages behind this page, if required.

Appendix K: Post-Test Questionnaire (Patterns)

2004 UPE UI Design Patterns Evaluation Project	
Pattern Use Post-Test Questionnaire	
	Instructions (please read carefully)
1.	Complete ALL items.
2.	Where appropriate, write responses in BLOCK CAPITALS in the spaces provided and choose options by circling the selected options.
3	Some items are statements or questions that you must rate or answer by circling a number on a scale from 1 to 5, or NA (Not Applicable).
4.	Hand the completed questionnaire to a researcher on or by Friday 25 June 2004.

	Date completed	/ / 06 / 2004 /

A.	**Biographical Data**	
	Complete the following items relating to SOME OF YOUR PERSONAL DETAILS.	
1.	Surname	
2.	Initials	
3.	Title	/ Mr / Mrs / Miss / Ms / Dr / Prof / Rev /

B.	**Complete the following items relating to YOUR GENERAL KNOWLEDGE OF UI DESIGN PATTERNS.**		
1.	Do you know what a UI design pattern is?	Yes	No
2.	If you know what a UI design pattern is, give your definition of it.		

Please turn over the page and complete the rest of the items.

C.	**Complete the following items relating to YOUR EXPERIENCE OF USING UI DESIGN PATTERNS.**

C.1	**Complete the following items relating to your experience of using UI design patterns to FIND USABILITY PROBLEMS IN AN EXISTING SYSTEM: (NA = Not Applicable)**						
1.	Using the patterns in the pattern collections enabled rapid identification of usability problems in the existing system.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
2.	Using the patterns enabled more rapid identification of usability problems than using other methods.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
3.	Using the patterns to find usability problems identified a significant number of problems.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
4.	Using the patterns to find usability problems was more effective in identifying problems than other methods.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
5.	It was enjoyable to use patterns to find usability problems.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
6.	It was more enjoyable to use patterns to find usability problems than using other methods.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
7.	Describe HOW you used the UI design patterns to find usability problems in the existing system.						
8.	Which of the two pattern collections (Van Welie or DoS) did you prefer to use when finding usability problems? Give reasons for your answer.						

Please turn over the page and complete the rest of the items.

C.2	**Complete the following items relating to your experience of using UI design patterns to REDESIGN AN EXISTING SYSTEM TO CORRECT USABILITY PROBLEMS IDENTIFIED EARLIER: (NA = Not Applicable)**						
1.	Using the patterns in the pattern collections enabled rapid correction of usability problems identified earlier in the existing system.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
2.	Using the patterns enabled more rapid correction of usability problems identified earlier than using other methods.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
3.	Using the patterns enabled usability problems identified earlier to be successfully corrected.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
4.	Using the patterns enabled usability problems identified earlier to be more successfully corrected than when using other methods.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
5.	It was enjoyable to use patterns to correct usability problems identified earlier.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
6.	It was more enjoyable to use patterns to correct usability problems identified earlier than using other methods.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
7.	Describe HOW you used the UI design patterns to redesign the existing system to correct usability problems identified earlier.						
8.	Which of the two pattern collections (Van Welie or DoS) did you prefer to use when redesigning the existing system to correct usability problems identified earlier? Give reasons for your answer.						

Please turn over the page and complete the rest of the items.

C.3	**Complete the following items relating to your experience of using UI design patterns to DESIGN A NEW SYSTEM: (NA = Not Applicable)**						
1.	Using the patterns in the pattern collections enabled a design to be rapidly created.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
2.	Using the patterns enabled a design to be more rapidly created than using other methods.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
3.	Using the patterns enabled several possible designs to be created.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
4.	Using the patterns enabled more possible designs to be created than using other methods.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
5.	Using the patterns enabled a good design to be created.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
6.	Using the patterns enabled a better design to be created than using other methods.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
7.	It was enjoyable to use patterns to design a new system.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
8.	It was more enjoyable to use patterns to design a new system than to use other methods.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
9.	Describe HOW you used the UI design patterns to design the new system.						
10.	Which of the two pattern collections (Van Welie or DoS) did you prefer to use when designing the new system? Give reasons for your answer.						

Please turn over the page and complete the rest of the items.

C.4	**Complete the following items relating to your experience of the FORMAT AND CONTENT of the UI design patterns and the pattern collections: (NA = Not Applicable)**						
1.	The format (the parts and layout) of the patterns make them useful.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
2.	Some parts of the patterns could have been left out, without affecting their usefulness.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
3.	The content (the information embodied in the parts) of the patterns make them useful.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
4.	Some of the content of the patterns could have been left out, without affecting their usefulness.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
5.	The categories into which the patterns were grouped made them useful.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
6.	The links to related patterns in the pattern collections (making the patterns into a pattern language) were useful.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
7.	What aspects of the FORMAT of the UI design patterns were USEFUL?						
8.	What aspects of the FORMAT of the UI design patterns were NOT USEFUL?						
9.	What aspects of the CONTENT of the UI design patterns were USEFUL?						
10.	What aspects of the CONTENT of the UI design patterns were NOT USEFUL?						

Please turn over the page and complete the rest of the items.

11.	What aspects of the CATEGORIES, into which the UI design patterns were grouped, were USEFUL?
12.	What aspects of the CATEGORIES, into which the UI design patterns were grouped, were NOT USEFUL?
13.	Which of the two pattern collections (Van Welie or DoS) did you prefer? Give reasons for your answer.

C.5	**Complete the following items relating to your GENERAL EXPERIENCE of using UI design patterns: (NA = Not Applicable)**						
1.	Familiarising yourself with the patterns in the pattern collections was a quick process.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
2.	Familiarising yourself with the patterns in the pattern collections was easy to do.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
3.	Familiarising yourself with the patterns in the pattern collections was enjoyable.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
4.	You used patterns a lot when thinking about design activities.	Strongly Disagree				Strongly Agree	
		1	2	3	4	5	NA
5.	You used patterns a lot when you talked about designing to other participants.	Strongly Disagree				Strongly Agree	
		1	2	3	4	5	NA
6.	Based on your experience of pattern use, you will want to use patterns as a design aid in the future.	Strongly Disagree				Strongly Agree	
		1	2	3	4	5	NA

Please check that you have completed ALL items.
Hand the completed questionnaire to a researcher.
Thank you very much for your participation.

Appendix L: Post-Test Questionnaire (Guidelines)

2004 UPE UI Design Patterns Evaluation Project	
Guideline Use Post-Test Questionnaire	
	Instructions (please read carefully)
1.	Complete ALL items.
2.	Where appropriate, write responses in BLOCK CAPITALS in the spaces provided and choose options by circling the selected options.
3	Some items are statements or questions that you must rate or answer by circling a number on a scale from 1 to 5, or NA (Not Applicable).
4.	Hand the completed questionnaire to a researcher on or by Friday 25 June 2004.

	Date completed	/ / 06 / 2004 /

A.	**Biographical Data**	
	Complete the following items relating to SOME OF YOUR PERSONAL DETAILS.	
1.	Surname	
2.	Initials	
3.	Title	/ Mr / Mrs / Miss / Ms / Dr / Prof / Rev /

B.	**Complete the following items relating to YOUR GENERAL KNOWLEDGE OF E-COMMERCE DESIGN GUIDELINES.**		
1.	Do you know what an E-commerce design guideline is?	Yes	No
2.	If you know what an E-commerce design guideline is, give your definition of it.		

Please turn over the page and complete the rest of the items.

C.	**Complete the following items relating to YOUR EXPERIENCE OF USING DESIGN GUIDELINES.**

C.1	**Complete the following items relating to your experience of using design guidelines to FIND USABILITY PROBLEMS IN AN EXISTING SYSTEM: (NA = Not Applicable)**						
1.	Using the design guidelines enabled rapid identification of usability problems in the existing system.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
2.	Using the design guidelines enabled more rapid identification of usability problems than using other methods.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
3.	Using the design guidelines to find usability problems identified a significant number of problems.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
4.	Using the design guidelines to find usability problems was more effective in identifying problems than other methods.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
5.	It was enjoyable to use design guidelines to find usability problems.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
6.	It was more enjoyable to use design guidelines to find usability problems than using other methods.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
7.	Describe HOW you used the design guidelines to find usability problems in the existing system.						

Please turn over the page and complete the rest of the items.

C.2	**Complete the following items relating to your experience of using design guidelines to REDESIGN AN EXISTING SYSTEM TO CORRECT USABILITY PROBLEMS IDENTIFIED EARLIER: (NA = Not Applicable)**						
1.	Using the design guidelines enabled rapid correction of usability problems identified earlier in the existing system.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
2.	Using the design guidelines enabled more rapid correction of usability problems identified earlier than using other methods.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
3.	Using the design guidelines enabled usability problems identified earlier to be successfully corrected.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
4.	Using the design guidelines enabled usability problems identified earlier to be more successfully corrected than when using other methods.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
5.	It was satisfying to use design guidelines to correct usability problems identified earlier.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
6.	It was more satisfying to use design guidelines to correct usability problems identified earlier than using other methods.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
7.	Describe HOW you used the design guidelines to redesign the existing system to correct usability problems identified earlier.						

Please turn over the page and complete the rest of the items.

C.3	**Complete the following items relating to your experience of using design guidelines to DESIGN A NEW SYSTEM: (NA = Not Applicable)**						
1.	Using the design guidelines enabled a design to be rapidly created.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
2.	Using the design guidelines enabled a design to be more rapidly created than using other methods.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
3.	Using the design guidelines enabled several possible designs to be created.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
4.	Using the design guidelines enabled more possible designs to be created than using other methods.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
5.	Using the design guidelines enabled a good design to be created.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
6.	Using the design guidelines enabled a better design to be created than using other methods.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
7.	It was satisfying to use design guidelines to design a new system.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
8.	It was more satisfying to use design guidelines to design a new system than to use other methods.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
9.	Describe HOW you used the design guidelines to design the new system.						

Please turn over the page and complete the rest of the items.

C.4	**Complete the following items relating to your experience of the FORMAT AND CONTENT of the design guidelines: (NA = Not Applicable)**						
1.	The format (the parts and layout) of the design guidelines make them useful.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
2.	Some parts of the design guidelines could have been left out, without affecting their usefulness.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
3.	The content (the information embodied in the parts) of the design guidelines make them useful.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
4.	Some of the content of the design guidelines could have been left out, without affecting their usefulness.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
5.	The categories into which the design guidelines were grouped made them useful.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
6.	What aspects of the FORMAT of the design guidelines were USEFUL?						
7.	What aspects of the FORMAT of the design guidelines were NOT USEFUL?						
8.	What aspects of the CONTENT of the design guidelines were USEFUL?						
9.	What aspects of the CONTENT of the design guidelines were NOT USEFUL?						

Please turn over the page and complete the rest of the items.

10.	What aspects of the CATEGORIES, into which the design guidelines were grouped, were USEFUL?
11.	What aspects of the CATEGORIES, into which the design guidelines were grouped, were NOT USEFUL?

C.5	**Complete the following items relating to your GENERAL EXPERIENCE of using design guidelines: (NA = Not Applicable)**						
1.	Familiarising yourself with the design guidelines was a quick process.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
2.	Familiarising yourself with the design guidelines was easy to do.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
3.	Familiarising yourself with the design guidelines was satisfying.	Strongly disagree				Strongly agree	
		1	2	3	4	5	NA
4.	You used design guidelines a lot when thinking about design activities.	Strongly Disagree				Strongly Agree	
		1	2	3	4	5	NA
5.	You used design guidelines a lot when you talked about designing to other participants.	Strongly Disagree				Strongly Agree	
		1	2	3	4	5	NA
6.	Based on your experience of design guideline use, you will want to use design guidelines as a design aid in the future.	Strongly Disagree				Strongly Agree	
		1	2	3	4	5	NA

Please check that you have completed ALL items.
Hand the completed questionnaire to a researcher.
Thank you very much for your participation.

Appendix M: B2C E-Commerce Heuristic Evaluation Form

Participant ID:		**Evaluator Name:**	
Design Aid:	[Patterns] / [Guidelines]	**Evaluation Date:**	

Meaning of Severity Rating Values Used Below:
NA = Not applicable; 0 = No problem; 1 = Negligible problem; 2 = Minor problem; 3 = Moderate problem; 4 = Serious problem.

#	Heuristic	Severity Rating						Suggestion(s) for Correcting the Problem(s)
		NA	0	1	2	3	4	
1	**Visibility of Website Status:** The website should always keep users informed about what is going on, through appropriate feedback within reasonable time.							
2	**Match Between Website and the Real World:** The website should speak the users' language, with words, phrases and concepts familiar to the user, rather than website-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.							
3	**User Control and Freedom:** Users often choose website functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.							
4	**Consistency and Standards:** Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.							
5	**Error Prevention:** Even better than good error messages is a careful design that prevents a problem from occurring in the first place.							
6	**Recognition Rather than Recall:** Make objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the website should be visible or easily retrievable whenever appropriate.							
7	**Flexibility and Efficiency of Use:** Accelerators – unseen by the novice user – may often speed up the interaction for the expert user such that the website can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.							
8	**Aesthetic and Minimalist Design:** Dialogues should not contain information that is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.							
9	**Help Users Recognize, Diagnose and Recover from Errors:** Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.							
10	**Help and Documentation:** Even though it is better if the website can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.							

#	Heuristic	Severity Rating						Suggestion(s) for Correcting the Problem(s)
		NA	0	1	2	3	4	
11	**Formalising Objectives:** The website should assist customers to formalise their objectives by means of Home Page features like a B2C site purpose description, new products, top sellers, special offers and a FAQ. The category hierarchy should be visible on the Home Page.							
12	**Searching and Refining Results:** The website should assist customers to search for products and refine search results by means of features like category pages, category navigation functionality and a search facility.							
13	**Using Target Information:** The website should assist customers to use target information by means of features like product pages, product descriptions, product specifications, product images and product reviews.							
14	**Decision-making:** The website should assist customers to make decisions with confidence and trust in the website by means of features like a secure network connection, secure payments, a security policy, a privacy policy, product prices, a product comparison tool, shipping method/cost information, a return/exchange policy, customer service information, and information about the company.							
15	**Ordering:** The website should assist customers to place orders by means of features like a shopping cart (SC) that shows items, VAT, delivery and total costs, and allows customers to add items to the SC, change the numbers of items in the SC, delete items from the SC, clear the SC and continue shopping from the SC, check out pages that allow customers to enter the shipping address, billing address, payment options, and receive an order confirmation email, a registration page that allows registration (private or corporate) and changing registration data, and a login page/facility that supports registration if not registered and help if a password is forgotten.							
16	**Using Customer Service:** The website should assist customers to use customer service by means of features like a customer service page that supports order tracking and return/exchange, and a customer support/contact us page that provides multiple means of contact.							
	General Comments on Website							
#	**Comment**							