ABSTRACT
Usability is an important and determinant factor in human-computer systems acceptance. Usability issues are still identified late in the software development process, during testing and deployment. One of the reasons these issues arise late in the process is that current requirements engineering practice does not incorporate usability perspectives effectively into software requirements specifications. The main strength of usability-focused software requirements is the clear visibility of usability aspects for both developers and testers. The explicit expression of these aspects of human-computer systems can be built for optimal usability and also evaluated effectively to uncover usability issues. This paper presents a design science-oriented research design to test the proposition that incorporating user modelling and usability modelling in software requirements specifications improves design. The proposal and the research design are expected to make a contribution to knowledge by theory testing and to practice with effective techniques to produce usable human computer systems.

Author Keywords
User-centred software requirements, user modelling, usability modelling

ACM Classification Keywords
Human-Computer Interaction (HCI)

INTRODUCTION
Design science is described as an inventive or creative problem solving activity (Venable, 2006, p.1), and focuses on how to develop and produce artefacts and artificial systems having desired properties (Carlsson, 2005). According to Simon (1988), the distinction between natural science and design science or the science of the artificial is that the former is concerned with how things are and the latter is concerned with how things ought to be to attain goals. In a much cited paper, March and Smith (1995) describe ‘build’ and ‘evaluate’ as two fundamental design science processes and four types of products in design science: constructs, models, methods, and instantiations. According to their definitions, constructs or concepts form the vocabulary of a domain, a model is a set of propositions or statements expressing relationships among constructs, a method is a set of steps used to perform a task, and an instantiation is the realisation of an artefact in its environment. The reporting of design science concepts by March and Smith further developed by a number of authors recently (Au 2001; Ball 2001; Hevner and March 2003). Hevner et al. (2004) claim that design activities are central to the information systems (IS) discipline and present a conceptual framework for understanding, executing, and evaluating IS research combining behavioural science and design science paradigms. Figure 1 shows research as addressing both the rigour required of research and the practical environment of use.

Figure 1. Information Systems Research Framework (Hevner et al. 2004, p.80).

Peffers et al. (2006) presented a design science research process for information systems research consisting of six process elements: problem identification and motivation, objectives of a solution, design and development, demonstration, evaluation, and communication.

Human-Computer Interaction (HCI) is a discipline primarily focusing on design, evaluation, and implementation of interactive systems. Accordingly, design science research is appropriate for HCI as well as IS.

In this paper, we present a design science-oriented research design in HCI to test the impact of user modelling and usability modelling on software requirements. We also explain how we developed our research design based on design science principles.

RESEARCH DESIGN
The aim of the research design is to test whether systems design quality is improved when functional specifications are explicitly enhanced with user modelling and usability modelling. As with all design research, there are
methodological issues to be addressed, but first, we started discuss the proposed research design.

Research Process
We take the functional specification for an existing system and present it to a designer who produces a user interface design. We then give the designer User and Usability Specifications and invite him/her to refine the design on the basis of the added information. The two designs are evaluated against the usability criteria and compared to detect the differences. This process is repeated with a number of designers. Results are aggregated to see where, and in what ways, the designers’ work differed and how the differences might have impacted on the quality of their design. Our proposed research design is illustrated in Figure 2.

Issues with the Proposed Research Design
There are many issues to be addressed if these steps are to be reasonably rigorous in Hevner's terms (see Figure 1).

The project is based on the assumption that the more information people have, the better the work they do, so the information supplied to participants needs to be taken into account at each stage of the process. Functional specifications often contain unstructured comments about the users and context of use.

This project will present user and usability information formally for the design of Interface 2, so the information relating to user and context of use needs to be removed from the functional specification. Aim of this separation is to ensure that designer doesn’t have relevant information about user and context of use in the functional specification and, this separation of information goes some distance towards isolating the sources of design decisions.

Designers will have tacit user and usability models that are expressed in their first interface design. Whether these mental models are similar across designers or not becomes less of an issue if the user and usability information is presented independently of the functional specification because it is the difference between the two designs that is important, not the quality of the designs per se.

A number of designers will participate in the research. The final number will be limited by funds and designer availability but at least 6 people will participate. The strength of the results will be limited by the low number of participants. This will be problematic if the results are mixed, but less so if they show a strong trend.

Tester bias is an issue that is addressed by the formality of the usability model. This model is the usability test protocol and is being designed to be prescriptive. There is a world of contextual judgement about usability and testers will no doubt make comments outside the formal test instrument. These comments will be used to inform the results, but not strictly as part of the comparison of interfaces.

It is intended that the proposed research design would prove interesting enough to be reused and refined in other interface research settings.

USER AND USABILITY SPECIFICATIONS
An important aim of HCI is to gain a detailed understanding of cognitive, perceptual, and motor components of user interactions with human computer systems (Olson and Olson, 2003). The two models to be used to develop a detailed understanding and to elaborate the functional specification are the user and usability models. These models will be formally designed as specifications.

Conceptual User Model
User interface design is based on user models and descriptions derived from studies of able-bodied users (Keates, Clarkson and Robinson, 2005). A user model is a representation of information and assumptions about
users (Kobsa, 1995, pp.155-157) and can be viewed from three perspectives: modelling user knowledge, modelling user plans, and modelling user preferences (Kobsa, 1993). Modelling user knowledge involves the accurate estimation of users’ background knowledge, skills, and experience. Modelling user plans aims to investigate the sequence of user tasks required to achieve user goals. Modelling user preferences primarily focuses on users’ information needs and preferences.

The attributes of a user model are context dependent and vary across the application domains, but there are certain user attributes, which we consider as quite important in relation to a user model. We propose user model consists of eight user attributes and the Figure 3 illustrates the conceptual user model.

![Figure 3. Conceptual User Model.](image)

In Norman’s terms, design model is the conceptualization that the designer has in mind and Norman (1998, pp.189-190) argues that a user model can be used to improve the usability of computer interfaces and ideally the user model needs to match the design model. This is a part of the proposition to be tested.

In the proposed research a user model of the existing system is created through the process of user interviews, and observations and persona development. The result will be a specification of the model for use in this specific research, but also a more general pattern for the specification of user models.

**Conceptual Usability Attribute Model**

In International Standards Organisation (ISO) terms, “usability” has been defined as the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use (ISO 9241-11, 1998, p.2). There are many definitions of usability and its attributes published in the literature, and some of the important usability attributes are: Learnability (Dix et al. 2004, pp. 260-270), Memorability (Nielson, 1993, p.31), Functional Correctness (Brink et al. 2002, pp. 2-3), Efficiency (Nielson, 1993, pp. 30-31), Error Tolerance (Nielson, 1993, pp. 32-33), Flexibility (Dix et al. 2004, pp. 260-270), and Satisfaction (Nielson, 1993, pp. 33-37; ISO 9241-11, 1998, p.6).

Figure 4 uses an Ishikawa diagram (fishbone diagram) to illustrate the conceptual usability attribute model and its measurable criteria. It shows that usability is a combination of seven usability attributes: Efficiency, Functional Correctness, Error Tolerance, Learnability, Memorability, Flexibility, and Satisfaction, and each usability attribute is governed by several usability related measurable aspects of the system or product. For example, the usability attribute “Efficiency” can be measured, based on the evaluation of three components: E1- Task completion in a minimum time, E2- User tasks are not misleading, and E3- No workarounds are needed.

![Figure 4. Conceptual Usability Attribute Model and Measurable Criteria](image)

As with the user model, the usability model will be created by examining the existing system in situ. The measures of the usability attributes will be established. The result will be a specification of the usability model for use in this specific research, but also a more general pattern for the specification of usability for developers and testers.

**ENHANCED REQUIREMENTS SPECIFICATION**

It has been proposed that user interactions with a system need to be designed based on a conceptual user model and a conceptual usability model similar to Figure 3 and Figure 4 to ensure optimal usability and positive user experience. User modelling will ensure that user interactions match user needs and expectations, users’ existing knowledge and experience, user goals and tasks, users’ physical attributes, cultural factors, and users’ attitudes to the system. Usability modelling will ensure that user interactions are efficient, functionally correct, error tolerant, learnable, memorable, and satisfying.

The addition of the two models described above to the functional specification produces an enhanced specification. The research described will compare the designs resulting from the enhanced specification with those produced from only the functional specification to test the proposition that enhances specification produces more testable designs that are better suited to their environment.

In terms of ‘design science’ by Peffers et al. (2006) and Hevner et al. (2004), the investigation into the context of
use of the existing system is primarily to analyse the environment to identify the problem and to establish objectives of a solution or the need. In other words, it is the relevance of the need of the environment to the body of the research (see Figure 1). This need is fulfilled by user modelling, usability modelling, and design and development of artefacts in the form of constructs, models, methods, or instantiations. Artefacts will be used in simulations and experimentations to demonstrate the capability of artefacts to provide solutions to the problem or the need. Evaluation is the comparison of the objectives of a solution to actual observed results from use of the artefacts in the demonstration. Communication is the research findings to inform the problem, the artefacts, its utility, the rigor of its design and its effectiveness. These models will be formally designed as specifications.

**CONCLUSIONS**

In this paper, we have outlined a research design to integrate user-centred design approaches into interface development through enhanced requirements specification. There are three kinds of contributions to be made from this research. First, evidence as to the impact of user and usability specification on design. Second, techniques for the practical specification of these specifications. Third, a reflection on the ‘design science’ research approach.

If the research shows that this technique makes no difference to design quality, then it casts doubt on the common wisdom that user and usability modelling help in the design process. On the other hand, if the research shows that enhanced specifications make a distinct improvement in design quality the implications for practice may be considerable. In particular, the user-centred specifications will be a value-added aid to the build phase of a software development process. Developers will be able to incorporate usability aspects effectively into systems for optimal usability and testers will be able to test systems effectively and efficiently to uncover functionality issues as well as usability issues. Such approaches will ensure that any system that goes “live” will be with no or minimal usability issues hence minimising the usability-related issues in end products and enhancing the positive user experience.

**REFERENCES**


