

Towards an Approach for Novel Design

Nadine Ozkan, Cécile Paris and Bill Simpson-Young
CSIRO/MIS, Locked Bag 17, North-Ryde NSW 1670, Australia
Tel.: (61 2) 9325-3100; Fax: (61 2) 9325-3200
e-mail: [nadine.ozkan / cecile.paris / bill.simpson-young@cmis.csiro.au](mailto:nadine.ozkan@cmis.csiro.au)

Abstract

In this paper, we contrast the design of traditional technology with the design of new technology. Gathering from our experience, we argue that traditional HCI design techniques are not directly applicable to the design of new technology. We review some of these techniques and show how they should be adapted to be used in the context of novel design. Among others, we show that user input in the process of novel design should come at a much later stage than for traditional design. Lastly, we suggest a process for novel design where these techniques are applied and re-interpreted.

1. Introduction

The design of new technology is a complex problem which requires the anticipation of future usage patterns and context of use. Indeed, on the one hand, new technology should be designed to integrate smoothly into current work practices, and on the other, it is almost inevitable that it changes these work practices.

The human-computer interaction (HCI) literature does not specifically address novel design as a problematic different from traditional design or from re-design. Longitudinal, ethnographic studies have been the basis for novel design in some research environments ([Suchman, 1998] for example). However, such long term and focused studies are very costly, and their time frame is a hindrance for their application in industrial contexts. In addition, these studies analyse current work practices, but do not propose ways to project these findings to the future, thereby addressing novel design as a specific issue. Similarly, other techniques such as contextual design [Holtzblatt and Beyer 1995] claim to address novel design but do not do so explicitly. As to HCI techniques such as the “Wizard of Oz” prototyping, they are useful for exploring new modes of interaction or new interface types, but insufficient in cases where a system proposes functionality which is not yet available, and which is likely to impact strongly on the user’s workflow and work patterns.

From our experiences in novel design, we found that the “traditional” HCI design techniques need to be

selected, re-interpreted and adapted. This paper is a synthesis of our experience to date. We discuss the relevance of traditional techniques to novel design and how they must be adapted to different types of new technology.

2. Context and scope of our work in novel design

Working in a research organisation focused on industry needs and on the transfer of research results into industry, we are concerned with the design of prototypes for such systems and devices (collectively called tools hereafter), which our industrial clients can then take on, re-engineer for robustness and commercialise.

We consider design to be novel when it concerns tools that provide functionality not previously available in any other form (even manually), or whose introduction is likely to impact substantially work processes, practices, habits, etc. In this paper, we will contrast novel tools to what we term “traditional” tools, although we realise that sometimes, there is a fine line between them. Similarly, we refer to traditional design to mean the usual techniques applied for the design of traditional tools, and will contrast it with novel design.

In illustrating the points we make in this paper, we will refer to FRANK¹ [Simpson-Young and Yap 1996] and ISOLDE² [Paris, Ozkan and Bonifacio 1998], two research projects for the design of innovative task-driven tools. Unfortunately, we are limited by confidentiality in disclosing details of our work in some of our other projects, though these projects have also contributed to our views.

FRANK is a software system which makes it possible to make on-line searches of video archives across local-

¹ FRANK is an acronym for “Film Researchers Archive and Navigation Kit”. The FRANK project was carried out within the Cooperative Research Centre for Research Data Networks and administered by the Cooperative Research Centre for Advanced Computational Systems.

² ISOLDE is an acronym for “Integrated Software and On-Line Documentation Environment”. It is a project partly funded by Office of Naval Research (ONR), in the Programme for User Centered Direct Interaction Systems, under Grant N00014096-1-0465.

area and wide-area networks. The target users of FRANK are not only film and television researchers, but also others who are involved in the video production process and whose roles are very different from that of the researchers, such as film directors. FRANK offers two new possibilities regarding searches: Firstly, it allows the users to locate video shots archived at remote locations (which was not possible before) and in a more efficient manner than currently. Secondly, FRANK can be used for various tasks of the production process which are currently performed by different people using different systems at different stages of this process. The tasks include program shotlisting, pre-production transcription, post-production transcription, captioning and searching. FRANK uses a simple common interface for all of these tasks (though different backend functionality is often employed for different tasks).

ISOLDE is an authoring tool for technical writers, which automatically generates a specific type of on-line help from a description of the software application to be documented. The technical writer enters this description in the form of a task model. Based on this task model, ISOLDE automatically generates procedural on-line help (including hyperlinks).

3. Techniques for user requirements specifications

In this section, we briefly survey some of the techniques which are traditionally used for HCI design at the early phase of user requirements analysis. These techniques are presented in the light of their use and contribution to traditional design. This presentation will allow us to then contrast their use and contribution for novel design. We purposefully avoid reference to any specific design process or method, but instead refer to the techniques of which methods are an assemblage.

3.1 User profiling and context inquiry

Among the early activities of requirements specifications, two types of data are gathered:

1. user profiles, specifically:
 - expertise with the application domain,
 - expertise with computers in general,
 - expertise with related technologies,
 - task resolution strategy (bottom-up, top-down, etc.).
2. context of use, specifically:
 - any critical (safety, time, etc.) aspect of the environment,
 - end-user staff turnover,
 - organisational actors and the information flow among them,
 - general organisation structure type, and relationships among actors,

- current artefacts,
 - the physical layout of the end-user's location.
- (See [Holtzblatt and Jones 1993] for a detailed description of these.)

In traditional design, this information is needed to feed into the prioritisation of a system's usability objectives (see next section) and, more importantly, to closely guide design.

3.2 Task analysis and task modelling

Task analysis is the study of end-user goals and of the manner in which these goals are attained [Card and al. 1980, Diaper 1989]. Although the literature shows great variation in the definition of a task, a goal, and an operation, as well as in the purpose of task analysis, generally speaking, a task analysis is an elicitation of how people go about performing structured activities. A task model is an explicitation of this using some notation for hierarchical decomposition (see [Diaper, 1989]).

It has been our experience that task analysis can be used to guide design very closely [Paris, Balbo and Ozkan 1998]. In some cases, the system functionality, interface design and on-line help are modelled directly from the task model. In other instances, task analysis is less prescriptive and acts as useful information, in the same measure as user profiling and context inquiry.

3.3 Setting usability objectives or requirements

The data gathered above usually contributes directly to the setting of usability objectives. Several authors ([Shackel 1990] for example) have proposed sets of usability objectives - (such as learnability, rememberability, throughput, flexibility, etc.). For a specific system, setting usability objectives can involve either assigning priorities to objectives in a set or, alternatively, assigning, to each objective, metrics which must be met by the final system. Again, the usability objectives of a system directly impact design, as design decisions are taken in reference to them.

3.4 Iterative design: scenarios, storyboards, prototypes, etc.

Scenarios, storyboards and prototypes are all techniques that provide users with an initial vision of the design and allow designers to get user feedback iteratively and at varying degrees of granularity.

Scenarios, storyboards and "low-fidelity prototypes" (such as paper and pencil prototypes) are often used at the outset of a project, as a cheap and efficient way to gain feedback on initial design ideas before they are coded. The goal here is to gain an assessment of the usefulness, appropriateness and usability of a system.

Later in the development cycle, when a design is sufficiently stable to be coded, “evolving” prototypes are developed. Prototype evaluation is more precise and refined at this stage, and more informative of specific design issues. We now turn to the specific techniques of prototype evaluation.

3.5 Synthesis: design techniques for traditional tools

All the techniques presented above can be applied to varying extents and in varying orders depending on time, budget, application and preferred methodology. Nevertheless, in all cases, some user-centred design must take place for the resulting system to be appropriate and usable. In designing

Attribute of new technology	FRANK	ISOLDE
Degree of novelty		
change work practices	yes	yes
enable new tasks	no	no
new technology / novel assemblage	novel assemblage	novel assemblage
require new skills	no	yes
Range of purpose	polymorphic	task-driven
Automation of process	some functions are automated, others are not.	automated
Target user group	prosumers	prosumers

Table 1. Comparison of FRANK and ISOLDE in terms of their attributes as new technologies

traditional systems, whether for replacing existing ones or to provide new services, throw-away prototypes for experimental purposes are generally undesirable (because too expensive) and unproductive (because the technology is mature). Rather, evolving prototypes are used, and early usability input into these is crucial to the quality of the final system.

4. Our experience in novel design

In our work in novel design, we have applied the traditional techniques described above. However, we found that they were not always appropriate without adaptation. In particular, their goal, scope, order of application, and even the use of the results differed. We also found that their application in specific instances of novel design depends on the characteristics of the novel technology under consideration. This is the object of the next sub-section.

4.1 Attributes of new technology which impact design techniques

We found the following that attributes seem to have an impact on the applicability of the techniques described above:

- Degree of novelty. This comprises several questions: Will the new technology change existing work

practices? (This is clearly the case for ISOLDE, and is likely to be for FRANK.) Will it enable users to perform new tasks or get new results? (For example, ISOLDE does not allow the users to perform novel tasks. An environment for remote collaboration should enable this.) Is the technology itself new or is it a novel assemblage of existing techniques? (Both ISOLDE and FRANK are novel assemblages. The laser technology was new at the time of its introduction.) Will it require the users to learn new skills (besides the use of the tool itself)? (For example, ISOLDE requires that technical writers produce task models.)

- Range of purpose. Broadly speaking, there are here two categories of tools: Those which address one specific task, proposing a re-definition of the nature of that task and, consequently, of the tasks which are linked to it (such as ISOLDE). We call these *task-driven tools*. Secondly, there are those (e.g., e-mail systems when they were first introduced) whose main function (asynchronous, remote textual communication) can be used for a large variety of goals and whose full range of usage cannot be anticipated. We call these *polymorphic tools*.
- Degree of automation of the process. Is the process which the tool supports also automated by the tool and to what extent? (ISOLDE, for example fully

automates the text creation. A drawing tool, on the other hand, provides building blocks which must be assembled by the user.)

- Target user group. Is the target user group made up of professionals (“prosumers”) or is it the general public (consumers)?

For example, the attributes of FRANK and ISOLDE in these terms are summarised in Table 1.

These attributes of new technology can be seen as dimensions forming a space in which to place the new technology under consideration. The specific attributes of a new technology, or its place in this space, will then impact the usage and appropriateness of the requirements analysis techniques which are mentioned in section 3. We now re-examine these techniques in light of their application for novel design.

4.2 User profiling and context inquiry

In general, we found that with novel design, information on users and context should be gathered at a much coarser grain of detail than for traditional tools. Novel design should, of course, be informed design, and rest on knowledge of intended users and context of use. However, user strategy and context of use would almost certainly be affected by the introduction of the new technology, and may even become irrelevant. As a result, this information is not required in great detail. Its impact on design is therefore less direct, and, although information of this nature is valuable and should of course be gathered, it cannot be used in as prescriptive a manner as in traditional design. In terms of the attributes defined in section 4.1, this is especially true for technology which is polymorphic, which will change user practice, or which is targeted at the consumer market.

Instead of being a prescription on design, this type of information has a role of informing on the current problems with the existing technology, and on the niches of functionality which are not covered by existing technology and could be offered by new technology.

We also found that discussion with users about the new technology has shown to be of limited use. As is attested by many HCI practitioners, users are often unable to imagine the implications of design decisions. This is compounded in the case of new technology. It seems that there is inherent difficulty in stepping back from the day-to-day organisation of one’s work in order to assess it or to generalise from it. In addition, users often are unaware of technological possibilities and have difficulty relating to them. This recurring observation implies that the people best suited to feed input into novel design are often not the intended users themselves, but people who work in their periphery and who

understand the nature of their tasks. We found that the only time this is not the case, is when the new technology addresses the “prosumer” market in domains of high creativity (graphic artists, for example). In these cases, designers may have access to visionary and critical users.

4.3 Task analysis and modelling

There is a current debate in the literature about the applicability of task models to novel design (e.g., [Richardson, Ormerod, Shepherd 1998]). It is argued that, as task analysis rests on the current state of affairs, it is not useful for novel design. We believe that this position must be tempered and refined with respect to the specific characteristics of new technology, namely its purpose and its attributes among those described above.

In the case of task-focused tools that change work practices, an analysis of the current user task is not appropriate because this task is likely to change substantially with the introduction of the new tool. In the case of polymorphic tools, task analysis is difficult, precisely due to the open-ended nature of the task.

This is not to say that task analysis does not have a place in novel design. We found two uses of task analysis and task modelling, which are detailed below.

To determine the place of new technology in the workflow

For technology that changes work practices and is single-purpose, we find it important to understand its precise place in the workflow. Task analysis allows the understanding of which portions of current tasks are addressed by the new technology and which are not (but can be affected by it). In ISOLDE, for example, this analysis has led us to scope precisely the subtasks which ISOLDE supports and its domain of applicability [Paris, Ozkan and Bonifacio 1998]. Task analysis therefore helps to inform on the place of the new technology, from a work organisation perspective. This information is crucial to design, if new technology is to integrate smoothly with existing practices and tools.

To highlight the new cognitive processes imposed by new technology on end-users

Another issue with novel design which can be, albeit only partly, addressed by task analysis (or rather, by cognitive task analysis [Johnson 1992]), concerns the identification of concepts which are well-mastered by the end-users in their current task, but need to be transferred to another task with the new technology. This is especially the case for technology which changes work practices, which supports a greater range of tasks than the current technology, or which is radically new for users. For example, in ISOLDE, technical writers will need to explicitly model task decomposition, task sequencing and task iteration. These are concepts with which they are familiar, being often reflected in the instructions they write. However, ISOLDE requires these concepts to be manipulated explicitly (rather than implicitly in the instructions).

There is therefore, with some novel design, the issue of the transferability of known concepts to new tasks. A comparison between the user's current task model and the one induced by the proposed tool can help identify the concepts which require transposition and the extent of this transposition. This again informs on the scope and place of the new technology, but this time, from the perspective of cognitive activity.

4.4 Setting usability objectives or requirements

We found that traditional usability objectives are not useful at the outset of novel design. This is mainly due to their narrow focus on "usability proper" issues, which are not directly related to the usefulness of the proposed functionality and its integration in the context of use. We found, however, that it is important to set usability objectives in later stages of product development, when the value of the new technology under consideration has been established.

4.5 Iterative design: scenarios, storyboards, prototypes, etc.

We have used "low fidelity" prototypes, at early stages of development when it is not yet possible to develop an "evolvable" or realistic prototype. This early prototyping was carried out with paper or whiteboard prototypes in the case of novel systems, and with "low tech" simulations in the case of novel devices. (What we mean by "low tech" simulation here is the combination of existing technology assembled to provide similar functionality to the target device.) In the case of task-driven tools, we have asked target users to perform pre-defined tasks using the low fidelity prototype. In the case of polymorphic tools, we have asked target users to propose types of usage or tasks (rather than propose

them ourselves), and to then execute them on the low-fidelity prototype. In some cases, we have also left the prototypes with target users for several days. This allowed us to collect data on spontaneous use rather than artificial use for the purposes of observation.

We found several problems with this technique, especially in the case of polymorphic tools. Essentially, because the prototype is often quite different from a real system in terms of functionality, usability and integration in work setting, the prototyping sessions are artificial and very remote from real use. (This problem exists also for traditional technology, but is compounded in the case of new technology.) This makes the results difficult to transpose to real use.

On the other hand, we found that producing a real prototype is very useful, for all types of novel design. The semi-realistic setting allowed by such a prototype enables the future users to relate more easily the proposed functionalities with their work practices. It is important to note that, instead of being an evolving prototype, this prototype will be a throw-away prototype, whose purpose is to gain enough insight for the design of the final tool.

As to the usability evaluation of prototypes for novel design, we found it to be useful at later stages of design, rather than at the stage of the throw-away prototype. As for task modelling, this observation is not to say that early usability evaluation does not have its place in novel design. It must, however, be adapted. We found that we could usefully test "portions" of a system, for example, specific aspects of work re-design or of user interaction. In ISOLDE, for example, the usability and readability of task models for technical writers were tested [Ozkan, Paris and Balbo 1998]. These tests confirmed the appropriateness of the ISOLDE task modelling notation for technical writers. They do not, however, inform on the global use of ISOLDE.

Usability evaluation is, nonetheless, very useful at the stage of designing the final system (or the evolving prototype), as its results may very well affect the acceptability of the new technology.

5. Towards an approach for novel design

We found the most productive and realistic sequence of steps for novel design to be the following.

1. Informed application of a technological advance

Designers who are aware of technological advances must firstly understand how these could be usefully applied in specific domains or tasks. Of course, we should stress that this cannot be done without an understanding of the target users, their task and context. Only the information gathered at this point should be

much coarser grained than that prescribed by user-centred methods.

This first step therefore consists of two parallel activities:

- technological design,
- preliminary investigation of users and context of use.

2. Throwaway prototyping

Throwaway prototypes then validate the feasibility and global appropriateness of the new technology. The evaluation of throwaway prototypes cannot follow the traditional scheme of usability evaluation. Rather, evaluation should be focused on the technical viability and on the use and integration of the new technology. In parallel with the design of throwaway prototypes, task analysis may take place to inform on the place of the new technology in the workflow and on the changes in the users' cognitive processes.

3. Evolving prototyping

Once the technology has been validated in technical terms and gross usability terms, traditional evolving prototyping can take place, with tighter usability evaluation. This is also the stage where the more traditional design activities may take place: in-depth inquiries of users, context and task and the setting of usability objectives.

This method, contrasted with the methods for traditional tools, reflects the fact that the impulse for novel design originates mostly with the technology experts. This rests on the recurring observation we made throughout this paper that several techniques whose purpose is to bring early user feedback into design, are more usefully applied in later stages for novel design. Although in our early experiences of novel design, we applied user-centred methods, we found that user input at the early stages of novel design is not useful.

Our discussion has shown that this is due to several factors. The first of these is linked to the users: they often lack the ability to foresee the implications of new technology and are too often unaware of technological possibilities to initiate requirements themselves. The second factor lies with the necessity of testing and its general appropriateness before going on to specific usability issues.

In this sense, we conclude that novel design is technology-driven, rather than user-centred (as is traditional design).

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