The Effect of Structural Design Methodology on Usability

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**A thesis submitted to the Faculty of Graduate Studies and Research
in partial fulfilment of the requirements
for the degree of Master of Arts**

Department of Psychology

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Abstract

The differences between usability rankings of UI designs created by professional and student designers using structured or unstructured design methods were investigated. Eight design teams created UI designs during 4-hour design sessions. Usability professionals, who did not know which teams created which designs, assigned the designs usability ratings. Some teams in the unstructured design condition were unable to use the structured design process correctly, and therefore the method was only partially structured. The structured design teams received higher usability scores than the teams who created their designs using partially or un-structured design processes. No significant differences were found between usability ratings received by student and professional teams. No significant relations were found between the teams' rated satisfaction with their design and design processes, and their usability ranking.

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Effect of Structured Design Methods on Usability

The user-centered design cycle involves four basic steps; identifying users, specifying user requirements, designing the interface, and testing the application (e.g., Wood, 1998). Professionals in the Human-Computer Interaction field have identified a gap, or a conceptual leap from the second to third step in the cycle (e.g., Beyer & Holtzblatt, 1993; Carroll, 1995; Wood, 1998; Constantine & Lockwood, 1999). The user-centered design process does not define how knowledge about user requirements is transformed into the design of a product. For example, we do not know how designers make decisions about which graphical elements would suit a task, or how they decide upon a navigation strategy. Many design sessions are structured so that creative decisions are only made once the design team has followed a logical sequence of steps that guide and, at times, constrain their creative process. This notion of a structured methodology to produce creative design solutions contrasts with the traditional ad hoc design approach that assumes that creativity is a magical process that occurs in the designer's head, and cannot be structured or ordered (e.g., Lawson, 1980). The purpose of this study is to compare traditional, ad hoc design methods with structured design methods to evaluate their relative contributions to the user-centered design process. This study also allows us to observe and report on design practices, in an effort to de-mystify the design process.

Review of Structured Design Methods

This section outlines some of the more popular structured design methods and describes groups of structured design practices that share similar characteristics.

Contextual design and related methods. One of the better-known user-centered

design methods, Contextual Design, consists of seven steps that require the designer to meet with customers to collect and analyze data on which to base their user interface (UI) design decisions (Beyer & Holtzblatt, 1998). There is great emphasis on creating a shared understanding of customer needs between all members of the design team.

It is the last step in their seven-step methodology that focuses on the process of design (Beyer & Holtzblatt, 1999). The team must “walk the data”, which means that they review all of the data amassed about the user to get an idea of the tasks and activities that they will need to support in their design. They then engage in a brainstorming session that is grounded in what the designers know about the customer’s work practices. Several “visions” of the solution are created. These visions are synthesized by choosing each vision’s best aspects, and integrating them into a single solution. This vision is then incorporated into a storyboard. From this storyboard, the team creates a User Environment Diagram. This diagram does not specify details about the UI, but rather lays out an architecture and workflow for the various tasks the team has decided to support. For example, in an email program, one task might be to save an email address in a directory. The diagram would specify the steps the user would need to go through to accomplish this task (i.e., specify that they want to save an address, identify the address they want to save, specify where it is saved). A UI designer uses the information gathered in the User Environment Diagram and assigns the various UI elements to support each task.

According to the authors, Contextual Design is best suited for large, complex projects, although it has been used successfully on smaller projects as well. A Contextual Design team is multi-disciplinary, and can span over several different teams working on

the development of a single project (i.e., the user interface design team and the software development team). Although Beyer and Holtzblatt refer to Contextual Design as a participatory design technique (1993), customers do not participate in every step of the design process – they are not co-designers. The Contextual Design process may require that designers take some time to learn the technique's language and explicit notation process before they can employ it as a design methodology. For example, when consolidating all the information the team has collected about the customers in what the authors describe as an Affinity Diagram, the Contextual Design method requires that different colored post-it notes must be used to convey information about the customer's work. Green post-it notes are used for a whole area of concern within a business; pink sticky notes are used for specific problems that make up that area of concern; blue sticky notes outline specific details for each problem. This very explicit type of notation works well for large teams, where lots of information must be shared in a way that does not require all players to be at every meeting. However, affinity diagrams also require some time to learn and employ, so Contextual Design may not be suitable for time-constrained projects.

Graefe (1998) has created a structured design methodology based on the principles of Contextual Design, but his method is specific in the way that the UI designer must choose the UI elements based on the User Environment Diagram. Like Contextual Design, contextual inquiries are conducted with users. From these inquiries, use cases and scenarios are developed. From these use cases and scenarios, Graefe suggests that the designer develop a conceptual model that maps out how the UI objects will behave and relate to each other. Once the designer has identified the objects,

metaphors and models from the use cases, they are transformed into paper prototypes that conform to the Windows platform standards. Widgets are chosen that allow the best representation of the tasks and behaviors of objects envisioned by the conceptual model. Prototypes start out as rough drawings, but as designers review them and more issues are resolved, the prototypes are captured as black and white drawings on the computer. These are used to conduct storyboard walkthroughs with end users to confirm the design decisions, or to provide design alternatives. A Visual Basic prototype is developed, and usability tested in an iterative fashion until the design meets the usability goals established at the beginning of the project.

Graefe's design method, although based on the principles of Contextual Design, has some major differences. For instance, once the information about users is collected, the user designers play only a minor role in the actual UI design – they serve primarily as usability test participants. Unlike Contextual Design, this is a platform-specific methodology, designed specifically for projects that are Windows-based, though there is no reason that this methodology cannot be applied to other platforms as well.

Usage-centered design and related methods. Another well-known structured design process is Lockwood and Constantine's usage-centered design process (1999). This technique uses a model-driven process to create software-based systems that are founded on user needs. This process is made up of five models, which are used to help organize the designers thinking. The role model concentrates on the responsibilities and functions of the users, and gathers this information in a collection of user roles and user role maps, which defines the interrelationships among users. The task model is based on essential use cases, which represent the goals user are trying to accomplish with the

system without actually specifying the technology and methods. The content model outlines the tools and functions that need to be represented by the system, categorizes them into useful sets, and defines the interconnectivity between them. The operational model helps the designer adapt the design to fit into the context and environment where the system will be used. The implementation model defines what the visual aspects of the design will look like, and describes each operation.

The first four models are ways of capturing information about users, their environment and the system requirements, and the last model has more to do with system design and implementation. The use of models allows the designer to focus on core concepts and enables the designer to think about the system as a whole. Constantine and Lockwood believe that they provide designers with the tools needed to capture the spirit of the design problem using abstract, technology-free descriptions.

To address the cognitive leap that happens between gathering user requirements (the first four models), and designing a usable solution (the last model), Constantine and Lockwood suggest a process called iterative innovation. Using the information gathered in the first four models, solutions to the design situation are brainstormed without considering the constraints that exist within the users' current environment, such as the documentation they use; or the practicalities that exist within real life, such as broadband issues. Then, the results of this brainstorming session undergo critical analysis. The designers explore the limitations of the proposed design based on the information they captured about the user and system requirements in the first four models. They make sure they have represented all the users of the system. They ensure that all the tasks they identified that need to be maintained are supported. They check that the tools and

operations that they identified in the content model are present in the design proposal. They make sure that the proposal can be sustained in the users' environment. They address their concerns about the proposal one-by-one until all their apprehensions have been addressed. The designers then brainstorm solutions to the limitations that were identified in the critical analysis. This process is repeated in an alternating pattern of create/constrain, until time has run out, or the design team is pleased with the resulting design solution.

This design technique differs from Contextual Design in many ways. Information about users, their roles and the tasks they need supported are gathered in both cases, but only usage-centered design divides this information into five models. Usage-centered design also makes use of some explicit notation techniques, just like Contextual Design. For example, tasks are supposed to be described as a “verb-ing Capital noun”, like “withdrawingCash.” However, unlike Contextual Design, the authors consider their notation techniques to be mere suggestions, and encourage designers to develop conventions and methods of notation that work for them. Constantine and Lockwood make it clear that they believe that the UI designer must already have a basic knowledge about UI design, and cannot make good decisions about which widgets to employ in the visual design without it. Unlike Contextual Design, usage-centered design does not require continuous user participation at every step in the design process, and does not require a multi-disciplinary team. It can be used to design all sizes and scopes of projects, and does not require a facilitator.

Another structured design methodology similar to usage-centered design is the Linn Data Technique (Nilsson & Otterson, 1998). They too believe that a thorough

investigation of user requirements must take place before any other design activities. They also believe that designers need to generate ideas in a way that increases their creativity, and helps them to abstract from concrete solutions. However, instead of directly brainstorming design ideas, like usage-centered design, the Linn Data Technique uses a process called “bubbling.” Bubbling makes use of free association about known user information to brainstorm design solutions. A key issue or goal is written on a whiteboard, and the designers then try to associate freely to the topic. For example a goal may be “regulate temperature.” Free association words might be “not too hot, not too cold”, or “always know what the temperature is.” The designers then attempt to create designs based on each of the associated words or ideas. For example, the bubble about “not too hot and not too cold” may result in a design that triggers the air or heat to go on if the temperature drops 3 degrees below the user’s desired temperature setting. Bubbling “do’s” and “don’ts” are created to help create a layout of desirable aspects of a design, as well as things to avoid. For example a “do” might be to emphasize the metric system in the display, and a “don’t” might be to not depend solely on color to identify different regions of the temperature display.

Once ideas are no longer being generated, the designers combine the design alternatives they’ve generated for each of the issues, and generate viable solutions that address the entire system. Next, a high-level design, done in rough sketches is used to compile the solutions in a manner that provides a solution that matches the information captured earlier in the process about the users’ expectations. The functional design is used to lay out UI widgets and controls, but like usage-centered design, needs to be based on a good understanding of UI design principles. Like usage-centered design, the

technique is not participatory, can be used for teams and projects of various sizes, and aside from the use of bubbles, does not require explicit notation techniques.

Participatory design. The main factor that sets participatory design techniques apart from all other structured methods is that the users not only give their input, but also act as co-designers alongside the other members of the design team (Dayton, Haslwanter, & Muller, 1997). The users help the designers define the user tasks and user model. They are a factor in the idea generation process, and also help the designers to critically analyze the design ideas that were generated to come up with viable designs that best suit their needs. They also help in the design of the prototypes and are a key aspect of testing these designs in an iterative fashion until the design works.

Participatory design methods can be extremely varied in their actual process. Some, like the Bridge method (Dayton, McFarland & Kramer, 1998), require that all of the user's tasks are broken down into component parts described by nouns and verbs (logging into a system may be broken down into the noun and verb "identify self"). These component parts are then built up again into a GUI design, allowing the designer to design something new without having to deal with the confounding details that are a legacy of the old system. Other participatory methods are less structured, like Future Workshops (Jung & Mullert, 1987). In these workshops, loosely structured brainstorming sessions between the users and designers help create visions of what future work could be like, and how to realize these visions. Other participatory design methods include Hiser Design Method (Bloomer, Crift & Wright, 1997), the original participatory design process - Scandinavian design (Greenbaum & Kyng, 1991; Kyng, 1994), Future workshops (Jungk & Mullert, 1987), and the PICTIVE technique (Muller, 1992).

Checklist-based design. Systematic Creativity is an example of a checklist-based design process used and developed by a group of workers at Intel Corporation (Salvador & Scholtz, 1996). This method makes use of some participatory sessions with users at the beginning phases of its process, although the design portion of the process does not require user participation, unlike most participatory design methods. This method was developed to specifically address the unique needs of a diverse design team that was required to produce new software products with limited time to market, unlike Contextual Design. This process is unique in that the team also has the possibility of being introduced to the design problem at any stage of product development (Salvador & Scholtz, 1998).

The portion of the method that addresses the design gap centers on a checklist of methods that are used to make certain that all goals and objectives specified by the users of the system are accounted for. In this method, designers divide all the information collected in the participatory sessions into prioritized goals (tasks) that the product needs to support, and actions and objects that will support those goals. For example, if the task is to print out a document, one action may be to select a printer from which to print, and objects could be the document and the printer. For the task of saving a document, one action might be to select the directory in which to save the document, and objects might be the document, or the directory.

Salvador and Scholtz also identify possible facilitators that can make the user's job easier, and obstacles that inhibit work. In this case, a facilitator might be that the save dialog box saves the user's preferences, so it will open in a place that makes sense to the user's workflow. An obstacle might be a badly organized file system, or poorly

labeled menu items. The design team then brainstorms to develop a metaphor, or design direction that will convey the functionality of the system to the users. For example, a metaphor widely used for the computer is the desktop metaphor, which mimics the users' work environment, and provides them with a mental model for their computer that is easily transferable from their daily lives. The metaphor or design direction that the team chooses must support all the previously defined tasks. It must also use the same actions and objects for similar tasks, to ensure consistency. For instance, if drag and drop functionality can be used to drag a file to a directory, then it should also be used to drag a document into a file folder. The proposed design direction or metaphor should also produce a design that has more facilitators and fewer obstacles than any other proposals.

Once the team has decided on a design direction or metaphor, they begin the detailed design work. The GUI components are laid out. All of the tasks are checked to make sure that similar actions are initiated in the same way and produce the same type of feedback. For example, the team must go through every detail of the task of opening a GUI object and make sure that similar GUI objects like file folders and icons both require the same action to open (a double click), and that this action is consistent across the entire interface. Using these rules as a "checklist", the designer can ensure that there is consistency in the way the tasks have been implemented across the whole design.

Systematic Creativity process provides the designers with a process-driven checklist to make sure that each task has been represented in a way that makes sense in the interface, and to ensure that widgets are applied consistently throughout the interface. It is non-participatory, and non-facilitated, and is suitable for either multi-disciplinary or heterogeneous teams of various sizes.

Mapping-based design. Mapping-based design processes use a template on which to map all of the UI widgets, to ensure that tasks and task components are being represented in the interface in exactly the same manner.

One example of mapping-based design is the Bridge method. The bridge is a three-part participatory methodology that Dayton, McFarland, and Kramer (1998) claim enables designers to quickly produce object-oriented, multi-platform GUIs according to user requirements.

Step one involves producing well-documented task flows from users' perspectives. The task flows are kept abstract – no actual system is represented. An example of a task flow for phoning a friend might be to: 1) locate the friend's contact information; 2) get a free line/dial-tone; 3) let the system know to dial the friend. Each step in the tasks is represented with a noun and a verb (locate friend's contact information). The tasks are recorded on index cards, then taped to flip chart paper, with lines of flow indicated as arrows drawn on sticky paper.

In step two, the designers and users create task objects from the nouns embedded in the task flows, for example, "friend's contact information." Each task object is written on a card, and has its attributes, as well as the actions that users can take on that object, attached to it on a sticky note. So an attribute of the friend's contact information may be their last name, and the actions that can be taken on it might be that the information can be edited or deleted. Objects that are merely an attribute of another object are eliminated (for example, "friend's contact information" becomes "contact information"). A hierarchy is created that best represents the relationships among all the task objects. The designers then place sticky notes on each of the objects to identify its parent and child

relationships. For example, a telephone number would be identified as the child and “contact information” would be identified as the parent.

Step three begins the process of mapping the hierarchy of task objects into GUI objects; widgets are assigned for each of the task objects the team has identified. Some general rules of thumb for mapping these objects apply. For instance, a parent GUI object is an interface window when open, and an icon, list item, or link when closed. When that GUI window is open, there should be a representation for the task object’s attributes. So according to these mapping rules, the task object for friend’s contact information is a GUI window that contains some representation of that task object’s attributes within the window area, like friend’s first and last name, and phone number. The GUI object can be represented as multiple windows, depending on the task at hand. For example, the friend’s phone number can be listed in a long, alphabetized list for a viewing task, or as its own window for an editing task. The way that the designers map the attributes onto graphic representations in the interface depends on whether it’s a child object, or a property. For example, a friend’s phone number is a child object of a friend’s contact information. The designer’s might choose to represent this object as a field, or a link, but the fact that the number also has the property of being long-distance will not affect the manner in which it’s displayed as an interface element. The phone number will still be displayed as a link or a field, with the long distance information merely making the field or link longer to account for the extra numbers.

Each of the GUI’s object windows is roughly prototyped on paper. Once the participatory team decides that all of the task objects and their attributes are represented

in the interface in a way that meets users' cognitive models, according to the authors "the rest are design details", and the gap has been crossed.

Another example of mapping-based design is the Delta Method - a process used by some designers in the Ericsson Corporation to help bridge the gap between user requirements and user interface design (Rantzer, 1998). Designers restructure the background requirements and user material captured in the user requirements phase, in a series of design workshops to map related tasks and objects and into "focus areas." Like the Bridge method, specific mapping rules are used that determine what objects and tasks will look like. However, this method is non-participatory, and is conducted in a series of workshops that run over the course of 2 to 3 days. Sometimes smaller projects have required less time. Like the Bridge method, this method is designed to support the work of a large multi-disciplinary team. However this approach also requires a facilitator, who is responsible for leading the flow of the session, and keeping the groups on track.

Unlike both of the mapping processes mentioned so far, the mapping design method employed by a group at Sun Microsystems is meant specifically to be non-participatory and non-facilitated (Ludolph, 1998). In fact, Ludolph implicitly states that users should not participate directly in design sessions. This process also uses mapping techniques to transform the designer's knowledge about the user requirements into a user interface design. Unlike the other two methods mentioned, it is assumed that UI designers, not a multi-disciplinary team – will do the UI design.

Summary of Structured Design Methods

It is clear from this review of structured design methods, that there is wide variety of structured design methods. The variation in the implementation of these methods may

be due to the design projects that they were created to deal with. For example, methods that were created for large, multi-disciplinary teams working on complex projects may put an emphasis on defining a common language and notation system to facilitate understanding across disciplines. Conversely, projects that are severely time limited may not be able to accommodate strict adherence to a design notation, and instead may encourage rapid, iterative brainstorming activities with lax notation practices.

Despite the variation that is apparent on the surface, all of these design methods share common elements. They all suggest that the designers partition different thought processes and actions, and designate these processes to be appropriate only for particular steps within the design method. They also allow the designers to organize information (about users, the system, etc.) so that they can easily refer back to it without increasing their cognitive load.

The structured design processes all seem to share the same five basic steps: 1) assess the users, the user environment, the business, the system requirements, etc.; 2) translate information about the users, etc. into a language that describes what the system will have to do to meet those needs; 3) generate as many solutions for the design as possible; 4) critique the ideas that were brainstormed, and apply information gathered during assessment to see if the design proposal meets the user needs defined at the beginning of the session; 5) apply UI design knowledge, and platform or system UI requirements to fill in the final design details.

Arguments Against Structured Design Processes

Many HCI practitioners believe that structure is not conducive to natural creative processes like software design.

For example, in an experimental workshop, designers were asked to create a user interface for a video picture database (Aboulafia & Nielsen, 1992). Video analysis of the workshop showed an iterative, non-linear process, where few design decisions were explicit. Instead, design decisions were made gradually, as a part of an evolving commitment to a solution that was based on intuition, imagination, and unstructured analysis.

Casady (1991), cites studies that show designers working in a non-linear, creative manner follow semantic links, constraints, and different viewpoints on the design team. He believes that design cannot be described using traditional software models: design does not involve a hierarchy of steps, and it is neither a top-down nor a bottom-up process. He believes that the design process is opportunistic.

Cohill (1991), describes design as an act of exploration that is feedback-oriented, rather than process-driven. He believes that design is circular, iterative and highly unpredictable. He also believes that design is a highly personal process that can only be learned through experience. Therefore, it should not be packaged as a set of rules or procedures to follow.

While observing hypertext designers at work, Nanard and Nanard (1995), concluded that the process of design tends to resist following formal design techniques. Instead, they describe it as incremental and opportunistic, resulting from backtracking, and erratic switching between critical design activities.

Lewis, Polson, Rieman and Wharton, (1990) say that applying current HCI models to real-world design is too difficult because not enough guidance is provided for

the wide range of issues encountered in the highly social, multi-disciplinary design environment.

Reasons for structured design processes.

Despite the observational studies that claim that designers operate in an unstructured manner, the push to apply structured design methods continues.

One reason is that studies of designers at work show that designs are not truly original. Instead, designers tend to create solutions by transferring applicable knowledge and solutions from similar, existing situations to novel ones, in a rather schematic manner (Boden, 1990; Visser, 1996; Bonnardel, 1999). This tendency to rely on previously applied solutions corresponds with a study that shows that people who must deal with large and complex problems tend to think within a very narrow and familiar subset of the solution space (Collins & Luftis, 1975). In a similar study, MacCrimmon and Wagner (1994) found that people were much better at selecting from a set of provided solutions than innovating and creating their own solution. When confronted by novel situations and problems, designers tend to apply comfortable, tried and true solutions (Cox & Walker, 1990; Paradice, Smith & Smith, 2000). However, creating innovative design is a differentiating factor that can give a business an advantage over its competitors. Clearly, the ad hoc approach to design tends not to generate novel solutions.

In contrast, structured design methods compel designers to begin their creative process by abstracting their thought processes away from concrete solutions. The designer's thinking is shifted from tangible, technological solutions, to the user's actual needs. The first phase in almost all structured design methods breaks the system into its most minimal parts: basic user actions and objects. Designers are encouraged not to

make any assumptions about how these actions and objects can be represented in the interface. From this starting point, designers rebuild the system, and brainstorm design ideas that are based on user needs, not previous system designs. The forced abstraction from concrete solutions may help designers stop thinking about the same solutions, and innovate something new, based on users' needs.

Another reason structured design methods might assist the creative process is that the nature of the method gives designers a strategy for dealing with the contradictions and constraints that are inherent in design. Designers must think innovatively and creatively to generate novel design in the brainstorming phase, but they also must explicitly check their creative thinking to apply limitations and constraints in the design and testing phases. The structured design methods enable designers to separate these two patterns of thought. When designers are in the brainstorming stage of design, they are encouraged to only think creatively – they cannot voice concerns about how the ideas will correspond with the constraints. Any technical and user limitations are only applied once the brainstorming stage has finished, and they have moved onto design. According to De Bono (1999), people solve problems more effectively when they think serially (exploring different types of thinking separately), than when they attempt to apply more than one type of thinking process at the same time. Structured design methods provide designers with a tangible mental divider that indicates when to trade the creative role for the analytical role.

Attempts to evaluate structured design methods. The first section of the Introduction described the main structured design methods. This section reviews research that attempts to evaluate the effectiveness of those methods.

Many researchers feel that the HCI community is guilty of advocating structured design methods that are untested, difficult for practitioners to use, and not always suited to real world situations (Bowers & Pycock, 1994; Lowgren, 1995; Carey, Mao, Smith & Vredenburg, 2002). According to some, we may be advocating a process to deal with a problem without fully understanding the consequences of applying a particular solution (Kellog, Maass & Rosson, 1988).

It is often assumed that a structured design method will take longer than ad hoc design. The need to evaluate the gains produced by structured design approaches is especially great given the pressure to reduce the length of the design process (Brockman & Johnson, 1998). We must be able to measure the gains to justify any design approach that may increase time-to-market, which in some industries could have an enormous impact on finances. (If structured methods do result in better design, Landay & Newman, (2000) offer the counter argument that it may be possible to develop tools that will support the process and possibly shorten the development time.)

Interview studies. Despite the fact that there have been few studies to validate specific design processes, there have been a number of studies that have attempted to understand the design process. Many of the studies have been based on interviews with designers that take place after the design process is finished (Barnard, Hammond, Jorgensen, Long & MacLean, 1983; Kellog, Maass & Rosson, 1987; Kellog, Maass & Rosson 1988; Klockner, Pankoke-Babatz & Mark, 1997; Landay & Newman, 2000).

For example, it has been noted that designers seem to engage in the same types of activities while creating solutions, regardless of the product they are working on, indicating that there is a generic design process that transcends the specific design project

(Landay & Newman, 2000). Researchers also found that designers tend to apply two different cognitive models, either representing design as a highly iterative process where design and implementation occur simultaneously and seemingly at random, or as a more structured process starting with an iterative design phase, followed by evaluation, and then implementation. (Kellog, Maass & Rosson, 1987; Kellog, Maass & Rosson 1988).

This interview research has added information that helps us shed some light on the design process. However, relying on interviews to collect data on design practice may not be the best way to investigate what really happens in a design session. Research has shown that people don't always do what they report they do. For example, in a study examining use of telephone features, study participants listed all of the telephone features that they used during their workday (Lindgaard, 1993). However, subsequent observation of the participants at work revealed that actual use of the telecom features differed dramatically from what they reported. They used only a very small sub-set of the features they said they used during the pre-observation interviews. In another study, interviews with designers using a structured design process were conducted where designers reported on their actions and the methods they used during their design process. Examination of their statements about their actions showed that designers did not comply with all the rules and procedures of the method as they had stated. Instead parts of the structured analysis process were used and mixed with other design tools and methods. (Banlser & Bodker, 1993).

These studies show that information derived from interviews with designers are useful, but cannot always be taken at face value because self-reporting is often not reliable. In such studies, it is difficult to ascertain how closely the design team followed

their declared approach, and what aspects of the design approach were correlated with the success of the final design.

Survey studies. Some researchers have attempted to understand the design process by asking designers and companies to answer survey questions about how they work and the design tactics that they employ (Gould & Lewis, 1985; Chastine, McCracken & Newstetter, 1999; Stanney, 2001; Bonollo & Lewis, 2002; Carey, Mao, Smith & Vredenburg, 2002). This investigative technique has allowed researchers, in a simple, cost-effective manner, to collect large amounts of data about how designers work. Surveys are potentially valuable in evaluating the design process of high-profile companies where data collection during the design process may have otherwise been limited or restricted.

There were many useful findings about design process garnered from this survey research. For example, one study found that designers tend to conceptualize design solutions at different stages of their user-centered design process (Stanney, 2001). While some designers only start conceptualizing design once they have amassed all of the user data, other designers start conceptualizing as soon as they are given the project's technical requirements. Designers also focus on fulfilling dissimilar needs in the design phase - some focus on user needs, others focus on market research, while other designers are either document-, process- or development-driven. Another survey found that there are major differences between the activities that novice and expert designers believe take place during the design phase (Chastine, McCracken & Newstetter, 1999). Novices tend to focus on the creative aspect of design, citing behaviors like ideation and brainstorming

as critical design behaviors. In comparison, experts refer to activities like planning, evaluation and iteration as key design behaviors.

Survey studies allow researchers to get data on large samples, but they are fraught with the same problems that exist for interview studies, and any other studies based on self-response. People cannot be expected to always report accurately on their actions, whether they are aware of the contradiction between their report and their actions or not. As well, while the survey technique gives the researcher a good tool for gathering opinion data on design philosophy, it would be valuable to see how these opinions affect and are reflected in their design practice.

Video analysis studies. Observational data has typically been gathered in a variety of ways: field studies, video analysis, observing workshops, etc. Research relying on video analysis has been particularly helpful in identifying and classifying different types of design behavior (Bush, Dayton, Mond, Muller, Nielsen & Root, 1992; Curtis, Elam & Walz, 1993; Bowers & Pycock, 1994; Carroll, Chin & Rosson, 1997; Binder, Buur & Oritsland, 2000).

Findings from this type of research shows that developers in the design stage tend to not ideate a lot of new solutions – instead they apply solutions that they have encountered in their previous experiences (Bush, Dayton, Mond, Muller, Nielsen & Root, 1992). As well, it was found that the user participant member of the team rarely articulates requirements outright in participatory design sessions, as previously thought (Bowers & Pycock, 1994). Rather, requirements are generated as a team when users talk about how the current design or design proposal might hinder work. Designers then generate ideas for solutions as a focused work-around to these problems. Investigation

also revealed that designers do follow traditional steps, however these steps are not followed in order, and merge slightly with other steps in the design process instead of having definitive start and end points (Curtis, Elam & Walz, 1993).

Video analysis is useful for capturing behaviors that designers may not be aware of, and therefore would not be able to accurately report in surveys or interviews. As well, video analysis of long-term projects avoids having to depend on designers' memories to report on what happened in the project in the past. In some cases however, video recording design sessions is not feasible, due to technical limitations, team dispersion, or even company policy. One potential disadvantage of all observational studies including video recording design sessions is that designers may not act in the manner that they ordinarily do, so the data may not reflect the designer's normal design behavior. However, the fact that there is no interaction with the researchers during the design process, and the prolonged exposure to the video process may be enough to make the designers forget that they are being observed.

Observation studies. In cases where video recording of design sessions is not possible, live observations are used to evaluate design processes (Aboulafia & Nielsen, 1992; Gasson, 2000). One advantage of observation without video recording is that the observer may pick up on subtle nuances in gesture and moods that may not be captured by cameras.

Live observational research showed that designers engage in cyclical design behavior and use various ways to approach the design problem and narrow down potential solutions. (Gasson, 2000). As well, observation of designers showed that turbulent and frequently interrupted environments, as well as incomplete task information

affect the designer's strategy (Aboulafia & Nielsen, 1992). In these situations the design process becomes opportunistic, to account for the disruptions and the fragmented task information.

Live observational studies share many of the same advantages and disadvantages with video analysis. Observation is useful for capturing behaviors that designers may not be aware of, and avoids having to depend on self-report methodologies. It also has the added benefit of being easier to apply than video analysis, and therefore, may be used in more design sessions. However, like video analysis, observation studies may affect the behavior of the designers who knows they are being watched. Additionally, observational data is only as good as the observer who collected the data. Some information may be missed in the design sessions that could have been observed later had video analysis been used.

Shortcomings of the Previous Studies

The reviewed studies all lack the capability to compare the design sessions that they studied and other design sessions. Without observing and comparing similar design projects worked on by similar teams in a similar work environment, researchers cannot make conclusive statements about the causes of differences between design sessions. Too many of the differences found between the results of these studies could be accounted for by extraneous, uncontrolled factors like the size of the team, the work environment, the project type, etc. These factors were a result of the researchers trying to compare dissimilar projects, taking place in dissimilar environments. Experimental research may be appropriate to compare the effects of structured and unstructured design methodologies on the usability of a design.

Review of the literature made it clear that research based on surveys and interview data would not be sufficient for the task of evaluating design and the effect of structured design methodologies on usability. Any comparison between the use of a structured or unstructured design methodology is best based on either video analysis, observed data, or both. As well, the research should be empirical, based on data collected in an experimental environment to ensure that all the designers were assigned the same project in the same manner, were exposed to the same environment, and had access to the same design tools. This would help to attribute any differences found between the usability of the designs to the design methodology used.

The factors that an experimental design could control for are: the size and scope of the design task, the design deliverable, the amount of time given to produce a design, the major discipline of the designers on the team, designer experience, the work environment, and the materials available to the designers. However, using an experimental design cannot possibly control for every possible factor. For example, it would have been very difficult, if not impossible to account for the way designers would react and behave towards their fellow designers. It would also be hard to judge the individuals' design capability for *this* particular project, and assign them to design teams in a fashion that would evenly distribute the design capability amongst the teams.

Purpose of Current Research

The intent of this research was to observe both structured and unstructured design sessions in a controlled setting and to explore if structured design methods resulted in a more usable product, and got higher usability rankings from expert evaluators. It was also of interest to find out if any differences existed between the groups in the satisfaction

that the designers felt with the design method used in their session or the design itself.

As well, the study looked for differences between novice and expert designers.

This experimental design study was conducted in a controlled setting to account for many of the attributes mentioned previously. However, it was impossible to account for every variable. In the case of this particular design study, it was hard just to account for people's commitment to actually showing up for their design session! Several participants missed their scheduled design session, and therefore, even size of design team could not be controlled adequately.

Hypotheses

Hypotheses evaluated in this study are summarized in Table 1. Column 1 shows the research question that I was interested in answering, column 2 shows the method of investigation used to answer the research question, and column 3 presents my hypothesis for the research question.

Table 1

Table of Hypothesis and Research Questions

Research question	Method of investigation	Hypothesis
Who was more satisfied with their design - participants in structured or unstructured design sessions?	Self-rated scores on a post-design-session survey	Participants in structured design sessions will be more satisfied with their designs than participants using unstructured design methods
Who was more satisfied with the process of their design session - participants in structured, or	Self-rated scores on a post-design-session survey	Participants in structured design sessions will be more satisfied with their design process than

unstructured design sessions?		participants in unstructured design sessions
Who created more usable designs – the teams using an unstructured design method, or a structured design method?	Expert usability analysis	The teams using a structured design method will create more usable designs than the teams using an unstructured design method
Who created more usable designs – the experienced UI designers, or the UI students?	Expert usability analysis	The experienced UI designers will create more usable designs than the UI students
Was there a difference in the time spent engaging in different design behaviors in structured and unstructured design sessions?	Observation of the design sessions and video analysis	There would be a difference in the time spent engaging in different design behaviors in structured and unstructured design sessions.

I predicted that participants who were in the structured design sessions would be more satisfied with their designs and their design processes than participants in the ad hoc design sessions (see rows 2 and 3). This is because the structured design method encourages the designers to consistently move forward in their thinking, and requires the designers to base all their design decisions on rational conclusions. Therefore designers would be more satisfied with their design because they would feel that they were always making progress with their design methodology.

I hypothesized that an expert usability analysis of the designs would find that the structured design sessions would result in more usable designs, as measured by usability rankings (see row 4). This is because the structured design method attempts to ensure that the designer's decisions are based on goals that meet the needs of the users. As well, I hypothesized that expert analysis would find that that the experienced UI designers

would create more usable design than the student designers (see row 5). This is based solely on the understanding that more experience results in the gain of more design knowledge.

In addition to these hypotheses, the nature of my experiment allowed me to explore whether or not there would be differences in the amount of time the structured and unstructured teams spent engaged in different design behaviors (see row 6). I believe that investigating differences between the amount of time spent engaging in design activities may help us to understand how structured design sessions differ from ad hoc sessions.

Method

This experiment comprised two parts. The first part involved experimental sessions where teams were required to create a solution for a user interface design problem. The second part was an expert evaluation of the designs that were created.

Design Sessions

Experimental design. A 2 x 2 completely between-groups factorial design was used for this portion of the study. The two independent variables were level of design experience, and design method.

The two levels of experience were professional UI designers, who were defined as having at least one year of professional experience in the field as a user interface designer, and students taking courses in user-centered design methodology, who have little or no user interface design experience.

The two design methods were structured and non-structured.

Participants were assigned to one of eight design teams. All of the design teams were required to create a design solution for the same design scenario. Four of these design teams consisted of experienced UI designers, and four teams were made up of the student participants. Two of the four experienced UI designer teams were required to design a solution using a structured design method, while the other two experienced UI design teams were not asked to use a structured design method. The same applied for the four student design groups – two were asked to apply a structured design method while the other two were not asked to create their design using a structured approach.

Two teams were assigned to each of the four between-groups treatments as shown in Table 2. The team numbers are listed in column 1, the designer's experience

level is shown in column 2, column 3 lists the design method the teams were assigned to, and column 4 shows the number of designers that were in each design team.

Table 2

Treatment Groups For Design Study

Task: Design a scheduling tool for a hair salon			
Team number	UI design experience level	Design method	Number of designers
Team 1	Professionals	Non-structured	2
Team 2	Students	Non-structured	3
Team 3	Professionals	Structured	3
Team 4	Students	Structured	3
Team 5	Professionals	Non-structured	3
Team 6	Students	Non-structured	3
Team 7	Students	Structured	2
Team 8	Professionals	Structured	3

Fifteen dependent variables were measured. Two subjective measures were collected from design session participants after their design sessions: satisfaction ratings for the design they created, and for the design method. The original plan was to collect four performance measures from the design sessions: time spent gaining an understanding of the problem, time brainstorming ideas, time designing solutions, and time testing the solutions against requirements and scenarios. However, video analysis of the design sessions revealed that there were 13 behaviors occurring in the design sessions that could be accounted for. In addition to the original four, performance measures were also collected for time spent evaluating ideas, defining the process, working on logistics,

understanding each other, explaining design intent, decision making, being involved in conflict, and resolving conflict. The performance measure originally referred to as “brainstorming ideas” was renamed “idea generation”, because it was observed that ideas could be generated in ways other than brainstorming.

Participants. Twelve experienced User Interface designers from the Ottawa area and 12 students from the Human-Computer Interaction psychology program at Carleton University were recruited to take part in this study. Participant selection was based on responses to a pre-test questionnaire, filled out by the participants (Appendixes A and B). However, one experienced designer and one student designer did not show up for their scheduled design sessions, so the experiment ran without them. The 11 remaining experienced designers received one hundred dollars each for their participation. The 11 student participants received a free lunch for their participation.

Materials and apparatus. The design session took place in the Cognos HCI Lab at Carleton University. The design lab was equipped with a small central table and four chairs, placed around the table. There was a one-way mirror with an observation room, from which an observer surveyed the sessions and took notes. The table was supplied with pens, markers, blank sheets of paper, scissors, glue-stick, thumbtacks and sticky notes of various sizes and colors. There was a flip chart and colored markers at one end of the table. There was also a table with a computer on it. The computer had various prototyping and graphics software, including: Microsoft Visual Basic 6.0, Macromedia Flash 5.0, Macromedia Director 8.5, Adobe Photoshop 6.0, Jasc Paint Shop Pro 7.0, and the Microsoft Office 2000 suite. The computer was connected to the Internet, a scanner and a printer.

Two video cameras that recorded onto VCRs were placed in the room to capture the interaction between the designers, as well as the flip chart and the center of the table to provide an overview of design activities.

Procedure.

Recruitment of professional UI designers. Professional participants were recruited by contacting known UI designers in the Ottawa area via email, and asking them if they would like to take part in an experiment for a Master's thesis (Appendix C). They were told that the study's purpose was to find out more about the design process, and that they would be required to participate in one four-hour design session. Designers who wanted to participate were sent the pre-test questionnaire via email, shown in Appendix A, and were asked to complete it and return it via email. The purpose of the questionnaire was to determine potential participant's years of experience in the field, their availability to take part in this experiment for the dates and times specified, what (if any) courses in structured design they had taken, their experience level with various prototyping tools, and their temperament.

Any designers who were not available for any of the time slots designated for the four design sessions were eliminated from the recruiting pool. The rest of the participants were assessed based on their responses on the pre-design session questionnaire. Instead of randomly assigning the designers to teams, my intent was to distribute the designers amongst the four possible teams so that their design experience and exposure to structured design methods were evenly spread. If possible some personality traits that might have affected their interaction with the other designers were also going to be taken into account when assigning designers to teams. The test used to

determine the personality type of the designers was included as part of the pre-design session questionnaire, shown in Appendix A (Bender, 2002). The test is based on the Meyers-Briggs Type Indicator (MBTI), a well-known and reliable personality test. Results of meta-analytic studies on the MBTI using generally accepted standards applied to instruments with continuous scores, show average overall reliabilities of .84 and .86 for internal consistency measures, and .76 for temporal stability (Ring, 1998). Designers were asked to checkmark from a list of 68, behaviors and traits they felt matched their behavior while in a team or group situation. These questions assessed the designer's level of submissiveness (or dominance) and warmth (or hostility). The designer's responses were classified as either an expressive, analytical, driver or amiable personality type. Amiable people are said to be loyal, cooperative, supportive, diplomatic and patient. Analytical people are logical, precise, serious, systematic and prudent. Drivers are efficient, independent, candid, decisive and pragmatic, while expressive people are enthusiastic, outgoing, persuasive, fun loving and spontaneous. The intention of this personality test was to assess the designer's personalities, and make sure that designer's of the same personality type who were essentially equal in the other traits (like design experience and expertise with design tools) would have been assigned to different teams.

The intended goal of the pre-design session questionnaire was to create four teams consisting of three members each, who were equivalent to the other teams based on their combined years of design experience, exposure to structured design methodology, tools, and temperament. However, because the designers' schedules were extremely varied and difficult to co-ordinate, the design teams were created based entirely on availability. In addition, since one designer did not show up for a scheduled design session, one of the

professional design teams had two members instead of three. Within one team, all three designers knew each other, and had worked in the same company, but never on the same design project. In another designer team, two of the designers knew each other, but had never worked together before. In the remaining two professional design teams, all of the designers were strangers.

Once all four design teams had been formed, teams were randomly assigned to either the two structured or two unstructured design session conditions.

Recruitment of student designers. The student design participants were recruited in a similar manner. Attempts were made to assign the students based on similar criteria (availability, exposure to structured design methods, experience with various prototyping tools and temperament), as well as one additional criterion: exposure to user-centered design courses. Students' design experience tends to be rather limited, so knowledge of their exposure to user-centered design courses helped to determine their capability as designers. However, again, due to scheduling constraints, the students were assigned to one of the four student teams based solely on availability. To make sure that the students recruited were familiar with user interface design and user-centered design, all of the students designers were recruited from the same graduate school program, which was known to teach these skills. Since this graduate program has a limited number of students, they all knew each other beforehand, although none of the students within a team had ever worked with each other on a design project before. One student designer did not show up for a scheduled design session, and therefore one student team had only two team members. The student design teams were assigned randomly to either the two structured or two unstructured design conditions.

All of the people who filled out a pre-design session questionnaire were contacted and informed of the decision to recruit, or not recruit them. Those who were chosen to participate in the study were informed of the date and time they would be required to participate, and were given directions to the location.

Design sessions. On the day of the design session, members of the team read and signed the informed consent forms (Appendix D). I began the session, following the script for either an unstructured (Appendix E) or structured design session (Appendix F).

I explained the purpose of the experiment, the design problem that the team had to address, and went through all the user needs analysis material. The designers were expected to design a scheduling tool for a hair salon. This tool would support the scheduling activities of the receptionist, and would also allow the hairdressers to view their schedules from the back of the salon.

I explained to the team what the manager's requirements were for the design (Appendix G). Two rich pictures were used to give the designers a very succinct idea of the receptionist and hairdressers' environment, needs and concerns (Appendixes H, I). A rich picture is a sketch of the user's physical work environment, with representations for the artifacts and other people that affect the users' work (Monk, 1998). The diagram is mostly pictorial, with some supporting text to label objects, and thought bubbles to indicate the stakeholders' issues and concerns. The rich pictures were supplemented by a verbal explanation of the users' jobs and the pressures that they dealt with. The rich pictures enabled the designers to quickly gain an understanding of the customer requirements without the benefit of being part of the customer needs analysis team.

I then explained two scenarios for which the designers had to design prototype user interfaces (Appendix J). The first scenario involved the receptionist scheduling a walk-in client, following the store policy of evenly distributing the walk-in clients among hairdressers. The second scenario involved a hairdresser checking the schedule for changes that had been made to his lunch schedule. These scenarios along with the manager requirements and Rich Pictures were posted on the walls of the design room so that the designers could refer to them while working.

I instructed the team that their goal was to design a completed user interface prototype, using either paper or the software prototyping tool of their choice for the two scenarios that were just described. The prototype had to be complete to the point where a user could walk through both of the tasks, and the prototype would show responses to the pre-defined scenario, for example, by showing dialog boxes open, or the reaction of a button click. The designers had to be able to explain their design intent, and demonstrate how their prototype worked to me at the end of the design session.

I answered general questions about the experiment, the lab and equipment. I also sometimes served as a scribe and hung the flip chart paper on the walls of the lab. However, I did not take part in the idea-generating process. If asked specific questions about the design, I turned the question back to the design team, and reminded them that I was not allowed to answer questions pertaining to design.

In the structured design sessions, after I read the requirements, I described the structured design process to the team while summarizing it on the flipchart. The structured design steps were: 1) identify the users and their environment; 2) identify the user tasks that the system needs to support; 3) brainstorm design directions or metaphors

that would support the users' tasks; 4) one by one, weigh the pros and cons for each design idea, based on the user and manager requirements and constraints; 5) decide on a design direction which could be an amalgamation of one or more of the design ideas generated; 6) prototype the design, using the tool of the design team's choice (paper included). After writing down each step, I asked the team if they understood and agreed with it. Once I was sure that everyone had the same understanding of the step and they were committed to applying it in their design process, I wrote down the next step.

One team needed help following the process, so I acted as their guide, prompting them to design based on the steps dictated by the structured design process. If the team felt they did not need guidance, I merely observed and interrupted the sessions only when the team had difficulty following the structured design process. When the teams started to get off track, I entered the design room, and reminded them to keep to the structured steps that they had agreed to follow. I explained how they had digressed from the process, and suggested ways to get back to the step in the structured process that they were supposed to be working on. This happened in three of the structured design sessions.

The designers were informed that, in addition to being video taped, the design sessions were observed by a research assistant behind the one-way mirror. The research assistant operated the video cameras and VCRs. She also recorded the time each time the team engaged in a new activity, as well as any comments that divulged thought patterns and processes while designing.

Once I finished reading the script that described the team's design problem and my role, I allowed the design team to proceed with their task. One half hour before time

was up, I reminded them of the time and their time restrictions, and encouraged the team to complete their prototype (if they had not already done so).

Once the time limit was up, the team members were asked to stop working on their design. I asked them to explain their design, which was presented verbally by one of the designers, and captured by the video camera. I thanked the team for their participation and asked them to fill out the post-test questionnaires which asked them to rate their satisfaction with their design and their design process (see Appendixes K and L). The survey also asked them what aspects of the session worked and did not work, and what aspects of the process they would change if they could do it again. Both the students and professional designers read the debriefing form before they were compensated for their participation (see Appendix M).

Choice of design problem. Due to the potential of fatiguing the participants, as well as difficulty getting volunteers to participate in very long sessions, the sessions were limited to four hours. The four-hour sessions enabled designers to adjust to each other's communication and interaction styles. It also gave them time to learn a structured design methodology, and produce a viable design without too much stress.

The four-hour time limit put constraints on the choice of a design problem. Since the participants did not have a lot of time to become familiar with the context, the design problem focussed on a tool that supported an experience that was familiar to everyone – getting a haircut.

The four-hour time limit also meant that the design problem itself could not be too complex. However, to have a chance to find differences between the two types of design methods, and to present a challenge to the designers, the problem also could not be too

simple. A scheduling tool for hair appointments is simple in concept, but also can include some design challenges to meet the needs of users. In this instance, some special challenges were introduced. The scheduling tool had to evenly distribute walk-in clients amongst the available hairdressers. In addition, the scheduling tool had to be designed with two types of users in mind – the receptionist who schedules appointments, and the hairdressers who need to view information in the salon.

Pilot testing of this design problem with Carleton University HCI design students and architecture students suggested that the problem was complex enough to be challenging, but also simple enough that they could produce a viable design solution by the end of the session.

Choice of structured design process. Due to the four-hour time limit, the design process used for the structured design method had to meet a number of criteria. It had to be suitable for a short design exercise; it had to be suitable for use in a small group; and it could not take long to learn and employ. As well, the design team did not have time to take part in the customer analysis step in the user-centered design process, so the structured design method had to support the quick transfer of this information.

These conditions rule out many of the structured design methods that were discussed in the Introduction. The mapping and checklist processes require too much time transforming user information into object sets, or grouping tasks and objects into focus areas before getting into ideation and design. Participatory design methods were not viable for this exercise, because it would introduce too much complexity to have the team interacting and co-designing with representative users of a hair salon scheduling system. Contextual design is most effective when the designers are part of the user needs

analysis – something that was not relevant in this simulated project. As well, the notation and language used by this process is too time-consuming to learn in a short period of time.

The structured design methodology for this study consists of a combination of features from a variety of techniques. However, it most closely approximates key aspects of usage-centered design (Constantine & Lockwood, 1999). The selected aspects of the usage-centered design process work well with small teams designing small systems. They do not require the use of complicated notation techniques or language, and do not require that the designers be present for the user needs analysis. The steps recommended by Constantine and Lockwood for the design portion of the usage-centered design process are simple, easy to understand, and can be learned and applied effectively in a short period of time.

As well as using key aspects of usage-centered design technique, one aspect of contextual design was also incorporated into the structured design process used for this study (Beyer & Holtzblatt, 1998). Designers were told that they could amalgamate different design ideas once they had been evaluated so they could use the best aspects of their ideas for the final design.

Analysis of data. The researcher assistant's recordings of comments, behaviors and times, as well as the data from the videotapes were analyzed.

The original intent of this study was to compare the my observations from the video analysis with the research assistant's observations from the live study to ensure there was some consistency in the manner in which behaviors were being categorized and timed. This was not possible because the research assistant had instructions to observe

and record only four behavior categories, based on previous studies on design session behavior: understanding the problem, brainstorming, designing, and testing the solutions. Analysis of the video taped design sessions revealed that 13 behaviors, not just four, were occurring so the criteria for analysis of the video taped data changed to enable study of the additional behaviors. Therefore, it was impossible to compare the research assistant and my data, since the research assistant had only recorded times for a small subset of the behaviors.

Design behaviors were given operational definitions, shown in Table 3, to aid in the recognition and correct categorization of actions observed on videotape.

Table 3

Operational Definitions of Observed Design Behaviors

Behavior category	Operational definition
Understanding the problem	Any actions that involve talking about user requirements, scenarios, actions, roles or tasks; design goal-setting; relating a scenario back to personal experiences; “what if” situations that explore possible scenarios; or defining parameters of the system
Idea generation	Any actions that involve brainstorming; identifying existing similar solutions; designing from first principles; talking about how to implement a design based on understanding of the problem; sketching ideas; storyboarding; writing down design ideas; or talking about design implementations
Idea evaluation	Any actions that involve listing the pros and cons of an idea; identifying situations where the idea works or doesn’t work; or “what if” scenarios that test an idea
Decision making	Any actions that involve deciding on a design direction, getting the “okay”

	from group members or voting
Design	Any actions that involve starting to put design to paper or developing it on the computer; determining the look and feel; screen layout; or deciding on widgets and details
Testing	Any actions that involve checking the design against requirements; cognitive walkthroughs; scenario run-throughs; or “what if” situations that test if the design will work
Logistics	Any actions that involve moving items around the room; moving self around the room; time checking; or dealing with, or inquiring about equipment
Process	Any actions that involve discussing how the team is going to progress; what they should be doing now, or next, or in the future; statements about where they are in the process; comments about straying from the process; or statements about dividing up the workload (who does what)
Understanding each other	Any actions that involve explaining what you mean; clarifying a point; re-iterating something; or re-stating what someone else said on your own words to make sure the understanding is clear
Design explanation	Any actions that involve communicating design intent to other team members (presentation)
Social exchanges	Any actions that involve joking, laughter, personal comments, personal inquiries, or statements about self
Conflicts	Any actions that involve disagreeing or aggressive behaviour
Resolving disputes	Any actions that involve withdrawing or avoiding confrontation, voting to settle a disagreement, compromising, making concessions, domination, taking control, or peacemaking

For video analysis, the time spent engaging in each of the 13 design behaviors was calculated by writing down the VCR playback time when the team members began

engaging in a behavior. The end time of the behavior was the start time of the subsequent behavior. The video times were then converted into the number of seconds the team was engaged in that activity. The total time spent engaged in a behavior category was tabulated by adding all the instances of that behavior during the design session. If team members on the same team were engaged in different activities at the same time (team member A was designing while team members B and C were testing the design), both times were calculated, and a note was made that the time was split between two activities.

Expert Evaluation of Designs

The second phase of the study was an expert review of the designs produced by the teams. The designs created by the design teams underwent an expert evaluation to determine their usability.

Participants. Three experts were recruited to evaluate the designs. Experts were defined as a person who has at least 10 years of experience in the HCI field, and has been involved in the review or evaluation of software, websites or hardware products. Reviewers who could be defined as an expert for the purpose of this study were contacted personally and asked if they were willing to evaluate the interfaces of eight small prototypes created in a Master's thesis experiment. The three reviewers who participated in this study had 68 years of combined experience in the human-computer interaction field.

Materials. The reviewers were given a CD containing the prototypes. The prototypes had been scanned into a computer and put in a PowerPoint slide show so that the slides represented the series of actions that the user took to complete the two scenarios. The slide packages contained instructions that communicated how the

prototype was meant to be used, according to the designers' intent. Researchers were given evaluation instructions and eight copies of a heuristic checklist for rating each of the designs (see Appendix N and O). The instructions defined how to evaluate the interfaces, including a description of the task scenarios that the prototypes were designed for.

Procedure. Reviewers were given one week to evaluate and provide a rating for the eight prototypes. Reviewers could look at the prototypes in any order they liked. Reviewers did not know which designs were created by students, and which were created by designers, and they did not know which design approach was used to create any of the designs. This prevented the reviewers from forming their own hypotheses, and subconsciously rating the prototypes accordingly. The first instruction in each evaluation was for the reviewers to look over the design. Then they carried out the two tasks that the prototypes had been designed to support. Reviewers attempted to use the tool to schedule a walk-in client as soon as possible, and with the appropriate hairdresser, according to the fair distribution of walk-in clientele. Then they attempted the second task, which was to view a rescheduled lunch break for a hairdresser.

Reviewers used the heuristics checklist to evaluate the usability of the design. These heuristics were based on a set of basic usability criteria developed by Ravden and Johnson (1989). This evaluation checklist provided structure and definitions in an attempt to ensure that all evaluators based their judgments on the same factors, using the same criteria and measurements. This process is used to give a general notion of system usability (Lindgaard, 1994).

The checklist divides the analysis of the design into nine usability criteria. The criteria that were used to evaluate the interface are: visual clarity, consistency, compatibility, informative feedback, explicitness, appropriate functionality, flexibility and control, error prevention and correction, and user guidance and support.

As shown in Appendix N, each section of the heuristic checklist began with a heading, (e.g. “Visual Clarity”), a statement explaining the general topic under evaluation (e.g. “Information displayed on the screen should be unambiguous and easy to read.”), and a list of questions (e.g. “Is important information highlighted on the screen?”), that the evaluator must consider to appraise the usability of the design. Beside each question were four checkboxes with the following labels: always, most of the time, some of the time, and never. There was also space where the reviewer could write additional comments. If the reviewer felt that a question was not relevant for the interface that was being evaluated, he or she could just write “n/a” in the comments section.

At the end of each section, the evaluators were asked to rate the prototype in terms of the particular heuristic for that section (e.g., “Overall, how would you rate the system in terms of visual clarity?”). The evaluators used a five-point scale where one was very unsatisfactory, three was neutral, and five was very satisfactory. Once the evaluators had reviewed the prototype on all nine heuristics, they added the scores. This produced the final rating for that prototype. They repeated this process until they had evaluated all eight prototypes, and had given them all a final usability rating.

Once the reviewers had completed their evaluations independently, they met to share their scores and rationale for each prototype. At the end of the meeting, all the reviewers agreed on a final composite usability ranking for the eight designs.

Results

General Comments

A main finding for this study was that the usability rankings for the designs created using a structured design methodology were higher than the rankings for the designs created using other methodologies. This finding will be discussed in more detail further on in this study.

For the rest of the quantitative data reported in this section, analysis of variance and regressions were performed, but none were significant. The failure to obtain significant results may be attributed to absence of real effects, low power associated with small sample sizes, or both. Nonetheless, it is still interesting to look at the results, as they give insight into behavior that occurs in design sessions. For example, the results tell us whether or not design teams actually followed the design method they were assigned to, what types of activities the teams engaged in, and the lengths of time they did so. They also give us insight into the types of user-interface designs that can be created within a short time period. The results of this study are especially interesting since all of the teams were assigned to the same design project, and therefore some basis for comparison exists even though not all possible variables were properly controlled. Therefore, the results presented here, though interesting, are also speculative, and are not supported by inferential statistical tests.

During one of the team sessions, technical difficulties prevented the tape from recording until an hour into the session, and that tape was later damaged during video analysis. Therefore, the percentages of time spent in various activities that were collected from the teams are reported here with the exception of one team, whose design was

ranked fourth in terms of usability. Observed data, and data regarding the finished designs from all teams are reported.

Application of the Design Methods

Although teams were assigned to either a structured or unstructured design methodology condition, not all of the teams employed the design methodology to which they were assigned. Table 4 reports the usability ranking and level of experience for each team. It also shows the comparison between the design method that was assigned to the teams and the method that was used. The usability rankings, determined by consensus of three usability experts, are shown in column 1 where one was the most usable design and eight was the least usable design. Usability rankings are used throughout the Results section to organize the results and enable comparison across all tables. Column 2 shows the design experience level of the team, column 3 shows the design method that was assigned to the team, and column 4 shows the design method that was actually employed.

Table 4

Usability Ranking, Design Experience and Design Methodology

Usability rank	Design experience	Assigned method	Employed method
1	Professional	Unstructured	Structured
2	Student	Structured	Structured
3	Student	Unstructured	Unstructured
4	Professional	Unstructured	Structured
5	Student	Unstructured	Unstructured
6	Student	Structured	Partially structured
7	Professional	Structured	Partially structured

8	Professional	Structured	Partially structured
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One hypothesis was that design produced using a structured design methodology would rank higher than design produced using an unstructured design methodology. However, not all the teams used the design method they were assigned.

Of the four teams assigned to the unstructured design method condition, the two professional designer teams elected to use a structured design approach. The two student groups assigned to the unstructured condition remained completely unstructured.

Of the four teams assigned to the structured design method condition, only one student team, usability ranked second, was able to successfully utilise the structured design method as it was intended. The other student team and both professional teams assigned to the structured method attempted to employ the method, and were successful sometimes, but overall, they employed a partially structured design methodology. These teams found it difficult to follow the structured design steps in order. Their biggest problem was stopping themselves from jumping straight into ideation once the design problem was given to them. They also experienced difficulty refraining from evaluating an idea as soon as it was proposed, instead of waiting until the idea generation phase was over.

Since only three teams used the design methodology they were assigned, findings are based on the actual method used, shown in the last column of Table 4, instead of the assigned design method. The three groups that used a truly structured design methodology were ranked first, second and fourth in terms of usability.

Teams that employed a partially structured design approach were ranked sixth, seventh and eighth. The teams that did not attempt to use any structured approach at all were ranked third and fifth.

The differences in rankings of usability of the designs produced by the structured and unstructured method teams were evaluated with two different approaches – a non-parametric test and a parametric test. The first analysis compared the mean usability ranking for designs produced by the three structured method teams (mean rank = 2.3) with the mean for the 5 non-structured teams (mean rank = 5.9). A Mann-Whitney U test with $N_1 = 3$ and $N_2 = 5$ was marginally non-significant, $p = .053$, 2-tailed.

The second analysis was a one-way analysis of variance with usability rank as the dependent variable and actual structure used (structured, unstructured, and partially structured) as independent variable. There was a significant difference among the groups on the ranking of usability of the designs, $F(2,5) = 9.62$, $p < .02$, $r^2 = .71$. To identify the differences, a multiple comparison was performed between the mean for structured groups and the mean of the combined unstructured and partially structured groups. The analysis showed that usability rank differs between those who had a structured session when compared to the mean of those who did not, $F(1,5) = 10.68$, $p < .03$, $r^2 = .68$.

Thus, teams that successfully employed a structured design methodology produced more usable designs than their counterparts, ranking first, second and fourth in terms of usability.

Usability Ranking and Experience

One a priori hypothesis was that the designs produced by the professional UI designers would be ranked higher in terms of usability than the designs produced by the

student designers. Contrary to expectations, the student teams fared quite well in comparison to their professional counterparts (see Table 4). Despite their comparative lack of design experience, the student's designs were ranked second, third, fifth, and sixth in terms of usability. The professional teams, with a mean total of almost 15 years of design experience produced designs that were ranked first, fourth, seventh and eighth in terms of usability. Although a professional team did produce the highest-ranking design, professional teams also produced the two lowest ranking designs.

Team Composition.

Columns 2-6 in Table 5 describe the composition of the design teams. Design session participants answered a pre-design session questionnaire that determined their design and educational experience, personality, and exposure to structured design methodologies through courses, literature or exposure in the workplace. Initially, this information was to be used to assign participants to design teams to control for relevant variables that might affect the team's ability to produce usable designs. However, due to participant's busy schedules, teams were created based solely on when teams of three students or professional designers could be scheduled together. Therefore, years of experience in the design field (for professional designers), years of schooling in the HCI field (for students), previous exposure to structured design methods, and personality traits were not taken into consideration when groups were formed.

Table 5

Usability Ranking, Exposure to Design, and Personality

Usability Rank	Mean design experience	Education	Personality type	Exposure to structured methods
1	4.5 years	--	Analytical Expressive	2 One designer had taken a course and applies it in his work
2	--	2 nd year MA 1 st year PhD	Expressive Expressive	2 One student had taken a course, one had taken a workshop
3	--	1 st year MA 2 nd year MA 2 nd year PhD	Amiable Amiable Expressive	3 No exposure
4	9.3 years	--	Amiable Expressive Expressive	3 One designer had read literature
5	--	1 st year MA 2 nd year MA 2 nd year MA	Amiable Expressive Expressive	3 One student had read literature
6	--	pre-MA 1 st year MA 1 st year PhD	Analytical Amiable Driver	3 One student had taken 3 courses, one has read literature
7	2.3 years	--	Driver Amiable/Expressive Amiable/Analytical	3 No exposure
8	5.3 years	--	Expressive Analytical Analytical	3 One designer had taken a course

Note. Dashes indicate the value was not measured.

Table 5 shows that, despite the fact that these factors could not be controlled, the teams were quite mixed in terms of all of these factors. All but one of the professional teams had at least one senior (more than five years of experience) and one junior (less than two years of experience) designer. As indicated in column 2, the mean design experience within each professional team was varied, ranging from 2.2 to 9.3 years; however, 20 years of the last group's total years of experience came from a single person. Column 3 shows that most student teams had participants involved in varying levels of study (undergraduate, Masters and PhD students). Personality types as shown in column 4, were varied and not more than two of the same personality types were represented in each team. Due to scheduling circumstances, two of the teams had only two members, instead of the originally intended three members, as shown in column 5. Although column 6 indicates that some teams did seem to possess members who had more exposure to structured design methodologies than other teams, this did not seem to affect whether or not they actually *used* those design methods.

Usability Ranking and Team Composition.

A team's composition did not have any effect on its design's usability ranking, shown in column 1 of Table 5. For example, the design team that had the highest mean years of professional design experience ranked fourth, while the professional team with the second lowest amount of collective design experience ranked first. The student team comprised of a first year Master's student and two second-year Master's students outranked a student team containing a first year Master's student, a second year Master's student and a second year PhD student. There were no patterns with regard to personality traits for those team members whose designs were ranked high, versus those team

members whose designs were ranked low in terms of usability. Exposure to structured design methodologies seemed to have no systematic affect on usability rank. The two highest ranking designs came from teams where at least one participant had some exposure to structured design methodologies, but exposure to structured design methodology did not guarantee higher usability rankings or that a structured design was used successfully. One other interesting finding is that the two-member teams created the highest-ranking designs (first and second).

Satisfaction With Design Methodology.

One hypothesis was that designers who used a structured design methodology would give their design method higher satisfaction ratings than designers who used an unstructured design method. Table 6 shows the relation between the designer's satisfaction with their design method and with the design method they were assigned to and the design methodology they used. Team members were asked to rate their satisfaction with the design methodology they used on a seven-point rating scale, where one was very dissatisfied, 4 was neither satisfied nor dissatisfied and 7 was very satisfied. Column 1 lists the teams in terms of usability ranking, columns 2 and 3 list the teams' assigned methodology and the methodology they used, and column 5 and 6 lists the teams' mean satisfaction ratings for their design methodology and designs.

Most team members were satisfied with the design methodology they used, giving the process they used to create their design an overall mean satisfaction rating of 5.4, as shown in the bottom row.

Table 6

Usability Rank, Design Methodology and Mean Satisfaction Ratings

Usability rank	Assigned method	Employed method	Mean method rating	Mean design rating
1	Unstructured	Structured	6.5	6
2	Structured	Structured	6	6
3	Unstructured	Unstructured	5.3	5.3
4	Unstructured	Structured	5.3	5.7
5	Unstructured	Unstructured	5	5.3
6	Structured	Partially structured	4.7	4
7	Structured	Partially structured	5	6
8	Structured	Partially structured	6	5.7
Overall mean satisfaction			5.4	5.5

There was no significant relation between the team members' design methodology satisfaction ratings and the design method condition they were assigned (structured or not). The team members who were assigned to the structured condition gave mean satisfaction ratings of 5.4, while the mean rating for team members assigned to an unstructured design condition was 5.5.

There were some minor, but non-significant differences in the ratings between teams that used a structured design method successfully, teams that used a structured design methodology unsuccessfully and teams that did not attempt to apply any structure at all. The three teams whose members successfully employed a structured design methodology (whether it was imposed on them or not) rated their satisfaction with their

design process slightly higher than the other teams, with a mean satisfaction rating of 5.9. The three teams whose members were assigned to a structured design condition, but had trouble following the process (partially structured), rated their satisfaction with their process slightly lower than the aforementioned teams, with a mean satisfaction rating of 5.2. The two teams that were assigned to the unstructured condition, and did not impose any structure on their design process at all gave the lowest mean ratings for satisfaction with their process of all the teams – a 5.1.

There did not seem to be a systematic relation between the team members' design methodology satisfaction ratings and their usability ranking. For example, the team ranked seventh, and the team ranked second in terms of usability both gave a satisfaction rating of 6 for their design process.

There was a non-significant positive correlation (.65) between the rated satisfaction with the design process, and the rated satisfaction with the design. These results are not surprising, since it is likely that designers who believe they created a good design will also be satisfied with the process they used to create the design. As well, it may be that a good design process may lead to good design.

The designers assigned to the structured condition had some interesting comments about the structured design process they were introduced to, and encouraged to use. Some of the designers felt that the structured design method did not allow them to explore the design problem freely. One of the student designers, who gave a satisfaction rating for her team's process a 3 said, "I don't like structure. I would have it (the structure) more open where ideas flowed from one thing to the next instead of holding my tongue until it was the appropriate time to talk about things."

Several other designers echoed her sentiments. “It needs more flexibility to loop and go back in the process to revisit newly defined problems.”

“I would have liked to have had the ability to switch back and forth between the steps, such as jump ahead to design for 2 minutes and then go back to the tasks.”

“I would have made the process a little more dynamic... designers often think off in tangents, following an idea. I think an improvement would be to eliminate a little of the focused thinking to explore tangents.”

However, most of the designers who used a structured process expressed satisfaction with the process. Many felt that, while the process held them back from generating designs at the beginning of their session, the clear understanding of the problem they gained through their close examination of the user’s and their tasks led to a better design in the end. Several remarked that the process prevented their team from getting off course.

“(The design process) was structured logically – it forced you to think thoroughly through each stage before moving on. We probably missed less this way and kept more on track.”

“Task-object-action analysis is a logical progression that allowed us to see common issues between scenarios and created a common terminology between developers.”

“It was thorough, and considered the problem and the users first”.

“It was somewhat structured, but not too much. We still had enough flexibility to do our own thing. I liked that we had to start by writing the tasks. This forced us to stick to the point.”

The designers who did not employ any structure in their design sessions also had positive things to say about the way their team worked together to come up with a design solution.

“I liked the free-form thinking we used, feeding off each others ideas or solutions to a similar problem to make it better. I prefer dynamic processes to structured ones.”

“We worked as a team and brainstormed – you can learn many nice ideas you wouldn’t have thought of yourself.”

However, while some of their comments indicated that they were pleased with certain aspects of the unstructured design method, designers were also able to identify some problems with their ad hoc design approach.

“Sometimes with brainstorming it is easy to get off track and focus on areas that are less important.”

“It would have been nice to have a clearer flow of the tasks.”

Satisfaction With Design.

One hypothesis was that designers who used a structured design methodology would give their design higher satisfaction ratings than designers who used an unstructured design method. Table 6 shows the relation between the designer’s satisfaction with their design, the design method they were assigned, and the design methodology they used. Team members were asked to rate their satisfaction with their design on a seven-point rating scale, where one was very dissatisfied, 4 was neither satisfied nor dissatisfied and 7 was very satisfied. The design team members were satisfied with their designs, giving their creations an overall mean satisfaction rating of 5.5, as shown in the bottom row of Table 6.

There was no significant relation between the team members' design satisfaction ratings and the design method condition they were assigned (structured or not). The team members who were assigned to the structured condition gave mean design satisfaction ratings of 5.4, while the mean design satisfaction rating for team members assigned to an unstructured design condition was 5.6.

There were also few differences in the design satisfaction ratings between teams that used a structured design method successfully (mean = 5.9), teams that used a structured design methodology unsuccessfully (mean = 5.2) and teams that did not attempt to apply any structure at all (mean = 5.3).

Design satisfaction scores were not related to the usability ranking. For example, there were three instances where all three members of the team rated their design a 6 (the highest team satisfaction score given by the eight teams). Two of these teams were ranked first and second in terms of usability, but the third team was ranked seventh. The team ranked lowest in usability gave their design a composite score of 5.7, which was slightly higher than the overall mean. The team that was the least satisfied with their design, giving a mean rating of only 4, was ranked sixth in terms of usability.

Some of this dissatisfaction is reflected in comments made about the lack of time they felt they had in a design session that was restricted to four hours.

"Basically it was a rushed design missing the touch ups. Not complete in terms of showing that we understood and made affordances for all the manager requirements."

"More time would have helped. More iteration to see what else we could do."

"I would have spent more time at each level of the process and I would have iterated more."

As well, designers expressed dissatisfaction with the amount of time spent doing activities other than design.

“I wouldn’t have changed the process, but we could have started visuals (prototyping) earlier.”

“Personally, I would have spent less time on user roles and definition.”

“I would have spent more time laying out the screen design and representing the design in prototypes.”

Observed Design Behaviour Categories.

One research question was concerned with observing the differences in the amount of time the structured and unstructured teams were occupied in design behaviours. 13 categories of behaviour were found to account for every second of all eight design sessions.

Table 7 shows the percentage of time in seconds that the design teams spent participating in each of the 13 categories of design behaviour. Column 1 shows the observed behaviour, columns 2 – 8 show the design teams listed in order of their usability ranking. The team ranked fourth in terms of usability is not shown here because their videotape could not be analysed.

The final column shows the mean percentage of time spent in a behaviour category across seven teams. The most often observed and prolonged behaviour observed amongst the groups was understanding the problem, with teams spending a mean of approximately 25% of their time in this activity. The next most common activity was idea generation, with teams spending a mean of approximately 22% coming up with ideas for designs solutions. Design took up a mean of almost 17% of the teams’ time,

while the idea evaluation phase took up a mean of approximately 11% of the design session time. The other nine activities took up the remaining 25% of the sessions, though two groups spent no time at all understanding each other, three groups spent no time resolving conflict and only three groups spent time in conflict.

Table 7

Percentage of Time Spent in Each Behaviour Category, Shown By Usability Rank

Structured method	Successfully applied			None	Partially applied			
Usability rank	1	2	4	5	6	7	8	Mean
Design behaviour	Percentage of time engaged in design behavior							
Understanding the problem	40.4	23.4	29.6	16.1	29.9	27	11	25.3
Idea generation	15	25.5	17.5	22	19.4	22.9	34.2	22.4
Idea evaluation	10.5	13.3	12.6	8.8	10.9	7.8	14.2	11.2
Design	13.5	13.4	15.6	27	8	21.7	19.2	16.9
Process	9.6	6.9	9.3	5.2	9.2	7.7	5.7	7.7
Logistics	5.9	5.3	1.6	8.1	5.3	2.6	1.8	4.4
Testing	2.3	6.2	6.5	3.7	4	2.1	7.6	4.6
Social exchanges	0.5	1.8	2.6	4.5	2.8	2.1	1.9	2.3
Understanding each other	--	0.5	2.1	0.8	0.7	2.3	--	.9
Design explanation	0.9	2	0.9	2.3	0.8	2	3	1.7
Decision making	1	1.7	1.7	0.8	0.9	1.2	1.3	1.2
Conflict	--	--	--	0.2	0.8	0.4	--	0.2
Resolving conflict	--	--	>.01	0.7	0.3	0.4	--	0.2

Note. Dashes indicate that no time was spent in that behaviour category for that team.

Where two activities happened at the same time (i.e., one designer on the team engaged

in one activity while the other team members engaged in a different activity), the amount of time spent was added to both of the behaviour categories in question.

Figure 1 shows the amount of time the seven teams that were video analysed spent engaged in the four observed behaviours that accounted for approximately 75% of the design session time. Although there were no systematic relations between teams' use of time and usability rank, it is interesting to note that the team that was ranked first spent by far the most time understanding the problem (40.4%). In contrast, the team with the design that was ranked least usable spent by far the shortest time understanding the problem (11%). However, the time the other teams spent understanding the problem did not seem to systematically affect their usability ranking. In addition to spending the least time on understanding the problem, the team with the lowest usability rating spent the most time on idea generation and evaluation. Time spent in actual design activity did not seem to be related to usability rating.

Figure 1. Percentage of time spent in top four behaviour categories. Includes values for seven teams and their mean. Teams are listed by usability rank.

Observed Behaviour Patterns.

Distribution of the time that the teams spent engaged in each of the 13 design behaviour categories was analysed. Table 8 shows the mean amount of consecutive seconds that each team spent engaged in the 13 observed design behaviour categories. Consecutive seconds refer to uninterrupted time spent engaged in a single behaviour category. For example, a design team might have generated ideas for 45 seconds, and then one of the designers might have said that they didn't think a particular idea would work. Therefore, 45 seconds were spent generating ideas, before this behaviour was interrupted by the next design behaviour, evaluating ideas. An interruption was counted, even if the designers only spent a few seconds evaluating the idea before going back to generating ideas.

Column 1 lists the 13 design behaviours. Columns 2-8 show the mean amount the design teams spent consecutively engaged in all the behaviours. Teams are listed from left to right in order of their usability rank. Column 9 is the mean amount of time spent consecutively engaged in the design behaviours across all seven teams. The bottom row of Table 8 shows the mean time spent engaged consecutively in any activity, by team.

The design teams did not spend long, continuous periods of time engaged in single behaviour categories. Instead, the teams had a tendency to jump from one type of behaviour to another. This tendency did not vary, despite the different design methods used by the teams.

The final column in Table 8 shows that the activity that teams spent the longest time engaged in without interruption was understanding the problem, with an overall mean of 83 consecutive seconds spent each time. Teams spent the least time

uninterruptedly engaging in social exchanges and decision-making, with an overall mean of 14 and 12 continuous seconds spent at each activity.

Table 8

Mean Length of Time Continuously Engaged in an Activity in Seconds

Structured method	Successfully applied		None		Partially applied			
Usability rank	1	2	4	5	6	7	8	
Behaviour	Time in seconds							Mean
Understanding the problem	186	98	76	54	66	70	33	83
Idea generation	58	26	37	34	49	34	43	40
Idea evaluation	60	20	36	29	38	25	30	34
Process	33	22	24	27	31	25	22	26
Design	55	29	60	33	34	67	42	46
Logistics	25	44	14	22	39	28	18	27
Testing	32	29	49	24	28	19	35	31
Social exchanges	9	10	22	20	11	11	14	14
Understanding each other	14	21	21	13	18	17	7	16
Design explanation	21	30	20	84	58	34	29	39
Decision making	10	9	21	12	10	13	11	12
Conflict	0	0	0	23	90	15	0	18
Resolving conflict	0	0	6	72	37	16	0	19
Mean	46	31	32	34	39	29	26	

Note: When two activities happened at the same time, the amount of time spent was added to both of the behaviour categories in question.

Observation of the design teams resulted in the identification of two repeated patterns of behavior. One pattern was very cyclical, typically involving about three behaviors with the team spending time on the first behaviors, then the second, then the third, and then going back to the first behavior. The most cyclical patterns emerged during the ideation phase. The general pattern was to generate an idea, evaluate the idea, make a decision, then generate another idea. For teams whose members designed separately and then presented their designs to team members, this pattern tended to occur as well. The designer would explain the intention of his or her design, the team would evaluate the idea, generate more ideas, and then would eventually go back to explaining their design intention.

The second pattern was oscillating, when teams would alternate between two behaviors repeatedly. The oscillating pattern tended to occur at the end of the sessions, when designers were testing their design. They would test their design against a scenario, and possibly find a scenario that required alteration of their design. They would design a solution to the problem they found, then would test their design solution again, and so on.

Collaborative vs. Individual Work.

During every design session, there were times when designers engaged in individual, rather than group, work. When this happened, one of two things was occurring. Either the designers were engaging in entirely different activities than the other members in their team (e.g., one designer was running the prototype through possible use case scenarios while the other two designers were designing), or the designers were engaged in the same activity, but were working separately (e.g., all three

designers were generating ideas on their own.). Both of these occurrences are referred to as activity splits.

Table 9 shows the breakdown of activity splits occurring over the course of team design sessions. The teams are listed in terms of their usability rank. Row 4 shows the total number of activity splits that occurred during each of the team's design sessions. Row 5 shows the mean duration of each activity split in seconds. Row 6 shows the total amount of time spent in split activities over the course of the design sessions, in seconds. Row 7 reports the percentage of time in each design session that was spent engaged in split activities.

Table 9

Breakdown of Activity Splits in Design Sessions

Structured method	Successfully applied			None	Partially applied		
Usability Rank	1	2	4	5	6	7	8
Number of activity splits in design session	4	5	10	37	1	2	16
Mean duration of activity split, seconds	27	24	55	26	104	11	22
Total time spent in activity splits, seconds	108	120	550	962	104	22	352
Percentage of time spent in splits	0.7	1	4.4	9.2	0.9	0.1	3.3

Whether or not the teams had a lot of split activities did not seem to affect their usability ranking. In addition, spending time in split activities did not seem to be more prevalent in structured, or partially structured design teams, but did seem more prevalent in the unstructured design team.

The two activities that were most common for team members to work at separately were designing and generating ideas. Five of the teams (including all three teams that used a structured design method) generated their design ideas together as a team. All of these teams engaged in group brainstorming sessions, where they built upon the ideas that were generated by their fellow designers. In the other three teams, idea generation was not always a team effort. In the team ranked third in terms of usability, the ideas were generated in a brainstorming session between two group members, while the other group member searched the web to find examples of similar software tools to generate some ideas. The team ranked sixth in terms of usability made a conscious decision to generate ideas on their own, and then present their design ideas to the other designers for evaluation. In the team ranked eighth in terms of usability, when two of the designers engaged in verbal brainstorming, one designer only participated sporadically. He would frequently withdraw from group exchanges and generate ideas on his own. These ideas were produced later in the design session and were used to generate the final design.

In the teams ranked first, second and fifth, the group members decided on a design direction and communicated the final design intent to each other well enough that the design work could be divided up amongst the members of the team to complete individually. Team members still collaborated with each other while designing, asking other members of the team for clarification or advice about elements in their design, but for the most part, they worked on their own. In all the other groups, the teams worked together on the designs, usually with one person as the lead designer who actually did the

drawing or the operating of the computer, and the other designers as the helpers who offered advice, and evaluated the design as it was created.

The designers tended to work together for the understanding the problem and evaluating ideas activities. One designer on the team ranked second in usability commented later that she and her partner would have also liked to do the design together as well but they were running out of time, so they worked separately.

One designer felt that there was too much cohesive group-work in his team. He believed that his team would have benefited from working on the solution individually and converging ideas later. "I believe the design process is better served when people present their own ideas after a couple of hours of working on the problem on their own."

Assigned and Self-Imposed Structured Design Methods

The assigned structured design process and the ad hoc structured processes were quite similar. The design process that was presented to the designers in the structured design condition was a six-step process: 1) identify the users of the system, 2) identify the tasks that the system will have to support for the specified design scenarios, 3) generate design ideas that would support the users in their tasks, 4) evaluate these ideas, checking them against requirements and scenarios, 5) decide on a design direction, and 6) prototype the design.

It is interesting to compare these steps to the steps of the two teams assigned to the unstructured condition whose designers created and followed their own structured process.

A team member in one of the groups that created their own design process described his structured design methodology as an eight-step process: 1) identify actors,

2) identify tasks, 3) detail important tasks, 4) develop design options based on tasks, 5) pros/cons for each option, 6) choose a design direction, 7) develop prototype, and 8) walkthrough task/scenario with design. With the exception of the last step, this design process maps perfectly onto the design method used by the teams assigned to the structured design process.

The other team that created their own structured design method employed a process that does not map onto the proposed design process quite as well as the first, but there are still similarities between the three processes: 1) problem identification, 2) user roles and task cases, 3) activity diagram, 4) high-level design, 5) prototype, 6) test, and 7) iterate.

With this team, there was a major difference in terms of the manner in which the design method was conceived and carried out. Instead of discussing the process and agreeing on their plan of action before they started the design session like the other designers did, this team only decided upon their next step in the process once they had finished the preceding one. During the session they began by agreeing that they should talk about the problem first. They did this in general terms. Once they finished this activity to their satisfaction, they thought about what they should do next. They agreed that they should look at the problem in terms of the user roles and tasks. Once they had finished this step of the process, they discussed and decided on the next step that they should undertake. Although this was indeed a structured design method, it was conceived and followed as the design session proceeded. Whether or not this affected their usability ranking is unknown. This team was ranked fourth in terms of usability, compared to the other two teams (ranked first and second) that used a structured design

methodology conceived and followed through from the beginning of their design sessions.

The Finished Prototype Designs

The final prototypes ended up being quite varied in terms of the ways in which they were generated, and the manner in which they were presented. There were two prototypes that were created entirely using the computer. One was done in Microsoft Power Point, and one was done using Macromedia Flash. Although they were generated on the computer, they were not interactive, but were generally in the form of screens for card flipping through the prescribed scenarios, just like any paper prototype. There were two prototypes that had elements of the interface created using the computer by creating or “borrowing” elements from pre-existing software tools, and placing them within their own paper creation. One borrowed elements from the Microsoft Windows XP look and feel to create the login screens for both design scenarios. The other team used Microsoft Word to create tables and borrowed the calendar widget from Microsoft Outlook to use in their prototype. All the other groups used paper and coloured pencils and markers to create their prototypes.

The prototypes were in various states of polish. The two computer prototypes were the cleanest looking, since they had been generated with computer-made widgets. Some of the paper prototypes were redrawn at the end of the session to make them look cleaner, while others were completed with elements and words merely scratched out, or windows drawn directly over other still-visible elements.

The look and polish of the prototypes had no bearing on the usability rank that they received. The highest rated prototype was one of the neater ones that had some

elements created by the computer. However, the second highest ranked prototype was one of the messier prototypes, drawn completely using pen and paper. The lowest ranking prototype was computer-generated, and very clean.

Uniqueness of the Designer's Solutions

The designs that came out of this exercise were all unique in some way. Each team employed a slightly different approach to solve the same problem.

Many teams used metaphors and tools found in other software packages to present the information required in their prototypes. Table 10 shows the metaphors and information presentation strategies the teams used. Column 1 lists the teams in terms of their usability ranking, column 2 lists which experience condition the teams belonged to and column 3 lists the information delivery strategy the teams used in their prototype. Columns 4-6 show which teams used the schedule book, calendar and MSN Messenger metaphors in their prototypes.

Six teams kept the “schedule book” metaphor that exists in the receptionist’s present work situation to represent information for scenario 1, and all used the schedule book metaphor for their designs for scenario 2. Two of the teams used a calendar metaphor as a means for the user to navigate through the various dates and times in their schedule. One team employed an online paging system metaphor, similar to MSN Messenger, to provide an at-a-glance awareness of hairdressers and status.

Four of the teams opted for an “object-oriented” interface, where users focus on data objects in the interface to accomplish their tasks. The other half of the teams opted for a task-based interface, where users navigated through the system and viewed information based on which task they were accomplishing. Three of the student groups

chose to use a task-oriented interface, and three of the professional groups chose to use an object-oriented interface.

Table 10

Metaphors Used and Information Presentation Strategies for Designs

Usability	Design	Information Delivery	Schedule	Calendar	MSN
Ranking	Experience	Strategy	Book		Messenger
1	Professional	Object-oriented	√	√	
2	Student	Task-oriented	√		
3	Student	Object-oriented	√		
4	Professional	Object-oriented	√	√	√
5	Student	Task-oriented			
6	Student	Task-oriented			
7	Professional	Object-oriented	√		
8	Professional	Task-oriented	√		

Even though groups did choose similar metaphors to display the design's information, all of the designs were unique. Of the six groups that chose to use the object-oriented interface with a schedule as their main metaphor, only three of the groups had the receptionist's scheduling information arranged in a similar manner – a grid pattern with the hairdressers listed horizontally across the top of the grid, and their schedules posted vertically under their names. One of the other schedule book interfaces had the information arranged in a different manner, and another did not have a view of any particular hairdresser's schedule – just an overall daily schedules with colour-coded indicators of availability for certain time slots. The last of the schedule book interfaces

presented the user with a schedule once they had entered search criteria for a walk-in client. And even those two interfaces that had information arranged in the same way did not treat this information in the same manner. The method of presenting the appointment to the user, and the way the user confirms the appointment differed.

This tendency to come up with original solutions is also evident in the manner in which teams handled the design requirements. One of the requirements was to make sure that the receptionist could distribute the walk-in clients to the hairdressers fairly, so that, at the end of the day the hairdressers would have received a fairly even distribution of the walk-in clients based on their availability. The teams handled the issue of fair distribution in four different ways. Three of the teams decided that the system should take control of the fairness issue, and just select the most appropriate hairdresser with no chance for the receptionist to override this decision. Two of the teams opted for a list of several or all the available hairdressers ordered or ranked in a manner that easily lets the receptionist know where they stand in terms of the rest of the hairdressers according to the number of walk-in clients they received. The receptionist selects the hairdresser from the ranked list. One of the teams had the system automatically make the selection for the user, but the user could also override that selection by choosing one of the other available hairdressers presented in a drop-down list. Two of the groups did not make any suggestions to the receptionist, but did give an indication of how many walk-ins the hairdressers had received that day.

Widgets for entering the search criteria to find an available appointment varied across all the teams. Designers used checkboxes; buttons; drop-down, editable fields; and radio buttons to enable data entry. Use of color was also widely varied. Several of

the designers chose to use a sort of Microsoft Windows look and feel, with menu bars and Windows-like widgets, while others chose a more web-like application, with a “home-page” motif, and navigation bar.

Discussion

There were two primary purposes of this study. The first was to find out whether the design method used to create a product would affect that product's usability. The second was to find out more about the design process. From the results of this study, it is possible to make several observations about the design process, design methods in use, and their effect on usability.

Controlling the Use of Structured Design Methods

It was not possible to control what design methods were used during the design sessions. Only three of eight teams used the design method that they were assigned to. For the remaining five teams, either designers assigned to the structured method did not use the method, or designers assigned to the unstructured design condition used a structured design methodology of their own accord.

Why the structured design method was not always used. Although designers assigned to the structured design condition claimed to understand the structured design process, and said that they would use it, for the most part, this did not happen. This finding may have some interesting implications about the design process.

One reason for the mismatch between the assigned and actual design method may be that designers may have difficulty evaluating their own design processes. Despite the fact that they clearly were not following the structured method, the designers assigned to the structured design condition may have believed that they were. In the post-design session questionnaire given to the design teams who were assigned to the unstructured design condition, the definition of a structured design method was explained, and then the designers were asked to report if they had used a structured method. In the unstructured

design sessions, it was clear that one of the designers was not able to accurately evaluate the method his team used to design the solution. This designer reported that his team used a structured design methodology, even though they did not. He even wrote down a high-level description of the structured steps that he believed his team had followed. Although components of the steps that were written down were evident in some of the team's actions, they were not followed in the sequences reported, and the reporting of the use of a structured design method was not consistent across all members of his team.

This observed behavior is consistent with research conducted by Bansler and Bodker (1993), who found that designers reported that they used a structured design methodology called Structured Analysis, but they did not. Instead, the designers made use of some of the tools from Structured Analysis, and mixed them as they needed to with other tools from design methods. As well, they did not follow the procedures outlined by the methodology as it was intended.

In a similar study conducted by Gould and Lewis (1985), designers who thought they followed recommended design principles actually did not incorporate them as part of their design process. Carey, Mao, Smith & Vredenburg, (2002) reported similar results - survey results showed that there was an inconsistency between the design procedures that companies reported they used, and the methods that the designers actually applied. Results from the literature and results from the current study demonstrate that, although designers may claim to understand structured design processes, and may think that they are using them, the developers often lack the capability to make a distinction between the proposed method and what they do.

Another reason that the designers may have not followed the structured design method, even though they said that they would was that they felt that the structured design methodology was too restrictive. This can be gleaned from comments some of the designers who did not successfully follow the structured design process made in the post-design session questionnaire.

Their comments echo the sentiments of many designers who feel that structure imposed in the design process impedes creativity. According to Nielsen & Aboulafia (1992) when we introduce too much structure in the design process we run the risk of destroying the creative phase of design. According to Berkun, (2002), the early stages of the design process should be as flexible as possible, and should avoid rigor and hierarchy to keep the mind open for fertile thoughts.

Another reason that designer may have not used the structured design process is that learning and employing new structured processes just might be difficult. Aside from the fact that the designers must generate a design for a complex problem that needs to be solved within a limited time, designers also have to learn a structured process that may not always suit their normal manner of working. This may have been just too much of a cognitive burden for the designers who were on teams that used a partially structured design method, and this may have been reflected in their inability to apply the structured method properly.

The greatest difficulty that designers seemed to have in employing the structured design methodology was during the idea generation phase. DeBono (1999) uses different coloured hats to describe serial thought processes. For instance, the black hat is used to describe analytical, critical thought processes, while the green hat is used to

describe creative, idea generating thought processes. In the idea generation phase, some designers had trouble getting into a truly green hat thought-process when they were brainstorming ideas. In DeBono's terms, they kept their black hat on, evaluating the ideas that were being generated. The designers, especially students, would typically generate an idea and immediately someone in the team would critique the idea, stating the problems that they thought might be a barrier for the idea's acceptance. In this manner, these groups were never able to get into a truly creative mode. By evaluating their ideas as soon as they were generated they effectively stopped the creative thought process. Even though all the teams assigned to the structured design condition claimed that they understood the idea generating process when it was explained at the beginning of the session, I had to intervene several times to remind them not to critique their ideas until they had reached the next step in the process.

The teams assigned to the structured design methodology also found it difficult not to generate ideas during the phase where they were supposed to be understanding user roles and tasks. Designers would talk about a task, or a user role, and this would spark an idea from one of the designers. They would state their idea, and this would prompt the other designers to either build on that idea, or critique that idea. Either way, this would take the designers off the process of understanding their problem and into the process of idea generation.

Another barrier to the designer's acceptance of the structured design methodology that was proposed may have been that they already were used to a structured design process of their own. This would make the process of employing the structured methodology more difficult – not only would they have to learn a new process, but they

would also have to abandon a method that they are already familiar with. There were no comments after the design session that indicated this was the case, and unfortunately the designers were not asked about this in their post-design session questionnaire.

Why teams used a self-imposed structured design method. Both teams of experienced designers assigned to the unstructured design condition applied and followed a structured design methodology of their own volition.

Both teams had senior designers with exposure to structured methodologies before this design session. This suggests that designers who have successfully employed a structured design method in other projects have enough confidence in the methodology to want to reuse it, and apply it in novel design situations. This notion is supported by many published accounts of industry design teams using, refining and extending structured design methodologies within their own companies (Salvador & Scholtz, 1996; Dayton, McFarland & Kramer, 1998; Ludolph, 1998; Nilsson & Otterson, 1998; Rantzer, 1998).

As well, evidence from the only team that was assigned to the structured design method and actually used it indicates that, once they successfully employ the structured design method, they enjoyed the experience and appreciated the advantages of using it. At first, this team had difficulty applying the structured method, especially in the brainstorming phase of the design process. They repeatedly assessed their ideas as they were generated, listing why each idea probably wouldn't work, and disrupting the creative process. It took intervention from me to get them back on track using the structured design method as it was intended. After the my intervention, the students were so determined to try to follow the process that they placed green sticky-notes on their

heads, as a physical reminder that they were in the “green hat” phase. Every time they felt the desire to critique an idea while they were supposed to be brainstorming, they stopped themselves and touched the green sticky-notes. In the end, these students were very successful at coming up with creative ideas, and were the only team pre-assigned to the structured condition to successfully apply the process in the manner in which it was intended. They also seemed to enjoy the process once they began to employ it consistently, and later remarked on the positive experience.

“The brainstorming part was great. I’m not sure I would have come up with as many ideas had we not been made to brainstorm before starting to design. At first, I felt like starting to design but once we started brainstorming, I didn’t want to stop.”

“The green-hat part forced us to be creative.”

Usability Ranking and Design Methodology

A main finding from this research was that the usability rankings for the designs created using a structured design methodology were higher than the rankings for designs not created using structured design methodologies. These results support the claims by advocates of structured design who say that using a structured approach increases the chance of delivering designs that meet the needs of representative users of the systems (Dayton, Haslwanter & Muller, 1997; Beyer & Holtzblatt, 1999; Constantine & Lockwood, 1999). This is because the methodological nature of structured design methods encourages a thorough consideration of users and user needs in the first step of the method. Therefore an adequate understanding of the requirements can be built upon and carried through into the next steps in the process, and throughout the project.

Structured design methodologies emphasize that this information is understood and not lost in the process of design.

Comments reported from the post-design session questionnaire filled out by some designers who successfully used structured design methods, as well as some designers who used a partially-structured design process show that they also recognized the benefits of using their particular method. They specifically made references to the fact that the process helped them to be thorough.

Design Experience and Usability Ranking

Another main finding of this research was that the student designers did not fare any worse than their professional counterparts in terms of usability ranking. This finding is very surprising, and is difficult to explain fully. It is well known that student designers can produce some very viable designs; the number of co-op students hired by high-tech companies every summer attests to this fact. However, one would assume that the experience that professional designers have would give them an edge over the students, and would lead to more usable designs being produced. The findings in this study do not support this assumption.

These findings are surprising, given the research by Gero & Kavakli (2002). They found differences in the cognitive activities between expert and naive designers. According to their findings, the novice's cognitive activity was more disorganized than the experts' design activity, and the experienced designers were three times more productive than the novice's were.

Another study that analyzed student conceptions about design found that the understanding about the steps that should take place in a design session are naïve, and do

not match the conceptual models of more experienced designers (Chastine, McCracken & Newstetter, (1999). Some of the student misconceptions lead to behavior that affects their ability to design properly. This behavior includes the tendency to fixate on a single solution, and the tendency to forget about the context of the design's environment, ignoring the design's constraints. The researchers conclude that these misconceptions inform the student's design decisions, and therefore often lead to designs that do not meet the standards of the design criteria. However, this clearly was not the case in this study.

One reason that the student designers did not produce less usable design than the expert designers may have to do with the fact that the student designers knew their fellow team members before the design sessions started, and therefore may have been familiar with each other's work interaction styles. While observing the teams, it was noted that the students seemed a little more relaxed with each other than the professional teams. They did not hesitate to state their opinions, and seemed to be able to joke casually with each other on a more personal level, and about items not necessarily related to the design session. In contrast, only one of the professional design teams knew all of their team members before the design session. In every other team, the designers were being introduced to at least one team member for the first time. However, although the students may have been familiar with their teammates on a social level, they did not have the advantage of knowing each other's interaction styles in a project situation. As well, one of the professional design teams was comprised of three designers who all knew each other, and this did not make them fare any better in their usability ranking – their design was given the lowest usability rank.

The students may have performed as well as they did because of their education and knowledge of customer-centered design processes. The students were all enrolled in a graduate-level psychology program that specialized in Human-Computer Interaction. These students were accepted to this program based on grades, as in any other graduate program, but also based on their passion and interest for Human-Computer Interaction. These students, therefore, may have a higher desire than most inexperienced designers to produce design that meets the needs of the intended users. As well, all but one of the students had taken a four-month course that taught them the skills needed to produce usable design. In comparison, the professional designers in this study only had to meet the recruiting criteria of being a professional UI designer for at least one year. No standard of excellence with regard to education in the field of HCI, design talent, or the desire to produce usable design was required.

Usability and Team Size

One surprising finding in this study was that the two teams that had only two members created more usable designs than the other teams who had three members on their team. The teams were all supposed to be the same size, but team size ended up being a variable that could not be experimentally controlled.

The reason for the better performance of the smaller teams cannot be completely explained, because there are other variables that could account for the effect. Both of the two-member teams also used the structured design methodology properly, so I cannot definitively say that the team size was the sole reason, or even part of the reason for their relative success.

However, if I were to assume that the smaller team size was part of the reason that these teams were rated higher in terms of usability than the other six teams, there could be several reasons for this. These reasons are offered for speculation and because they might be worth pursuing in future research. One of many possible explanations for the result could be that the smaller team size allowed each designer to quickly get to know the other designer's interaction style, and communicate in a way that was compatible with this style. If there are more people on the team, designers might have to repeat their communication in various ways to get all members of the team to understand the situation. This leaves more time for actually designing the project. The time spent communicating is also shortened for activities like gaining consent to go ahead with a design idea, stating preferences for one idea or another and presentation of design ideas if all the team members ideate separately.

The design problem may have also been well suited to a team of two. The designers were instructed to design for two specific scenarios involving two distinct types of users. The design deliverable had to be two interfaces. The design project may have been easier to split into two than to split into three. In fact, in the groups of three, when it came to designing the final prototypes, one of the designers was usually cast in the role of the "helper" or the "evaluator."

Satisfaction Measures and Design Methodology

Two of the objectives of this study were to determine the relation between design method and designer satisfaction rating with their design and their design process. The effect of design method was impossible to evaluate because the design teams did not always utilize the design method they were assigned. Moreover, there were no

significant differences between the ratings of the design teams who used different design methodologies. Designer teams who used either a structured design methodology, attempted to use a structured methodology, but did not do so properly, and designers who used no structured design method at all, gave both their designs, and the design processes they used similar satisfaction ratings. All of the mean ratings were moderately high, indicating that they were pleased in general with their process and design. This may be because the designers created some good solutions to a complex problem in a short period of time, often with team members they did not know and had never worked with before. Perhaps they were satisfied with this accomplishment, and their ratings reflected this regardless of the manner in which their prototype was designed.

Differences in Time Spent Engaging in Design Behaviors

Another finding in this study was that there were no differences between the amount of time spent in different design behaviors between the structured and unstructured design teams. Although there were variations in the times spent in different behaviors across all teams, the differences were not related to which design method the teams used.

The amount of time spent engaging in various activities may have been due to the make-up of the people on the team. For example, if two team members do not get along, this team will spend more time engaging in conflict and resolving conflict than other teams, regardless of the design method that they employ. This was the case in one of the student teams assigned to the structured design condition. In another case, if one of the team members does not speak the team's native language very well, then this team will

likely spend more time engaging in understanding each other than other teams, no matter what design method they use. This was the case in two of the design teams in this study.

The amount of time spent engaging in various design activities may also have to do with the way that they decide to divide up the work. For example, if one team decides to generate design ideas separately, and then present them one by one to their design team, then this team will engage in more design explanation than other teams will.

Another finding in this study was that the highest ranking team spent the most time understanding the problem, while the worst-ranking team spent the least time engaged in this activity. The team ranked last in usability spent the majority of their time generating ideas and evaluating them, but it was apparent that these activities did not result in higher usability. This is likely due to the fact that the team did not fully understand the scope of the problem and the needs of the users that they were designing the system for. Instead, they concentrated on generating many design ideas that were innovative, but not necessarily suitable for the intended users.

Patterns of Design Activities

There were no differences found in behavior patterns observed in the structured and unstructured design sessions. Teams under both design conditions displayed very sporadic and quick jumps between various categories of design behavior. This is a little surprising, since the nature of the structured design process might lead one to believe that designers following the structure would engage in only a small category of behaviors in sequence for each step of the method. This was not the case.

There is some support for the more sporadic behavior patterns observed in this study in the literature. Bansler and Bodker (1993) describe the design process as a series

of simultaneous behaviors, including negotiation of solutions, clarification of problems, cooperation, conflict, and definition of problems and solutions. The results of this study are interesting because simultaneous behaviors were observed even though these designers were following a structured design process, although according to the authors, the process was not followed properly.

Other studies that observed designers working have also seen similar behavior patterns. Aboulafia and Nielsen (1992) describe design behavior as opportunistic, and the decision making process as a pattern of gradually developing commitment based on imagination, guesswork and *unstructured* analysis. Gasson (2000) observed a cyclical design process where revisiting the same design decisions and discovering high-level design goals were common occurrences, even at the end of the design process, when it would be assumed that these activities would not take place. Lowgren (1995) describes creative design as an iterative mix between problem setting and problem solving, where design ideas are explored in parallel, and the prediction of what will happen next is impossible.

The observed behavior in this study coincides with the observed behavior in the existing literature. Despite the fact that designers employ a structured design methodology that should add stability to the design process, the behavior patterns observed in this study did not differ from the designers who used an unstructured design methodology.

Research Successes

There were some aspects of this research that worked very well. One of the biggest factors contributing to the research's success was the design problem that the

teams were required to solve. The problem could be solved in a short time frame, was complex enough to challenge their design skills, everyone could relate to it, it addressed the problems of more than one user group, and many design directions could be applied to solve it. The success of this factor was evident in the enthusiasm the teams had while working, and their positive comments about the experience after the design session. As well, the relative quality of the designs produced within the short amount of time definitely indicates that the problem was viable in terms of its scope.

Another positive aspect of the study was the presentation of the user needs information at the beginning of the design sessions. This was challenging, as most of these designers were accustomed to gathering user information themselves. The information had to be imparted quickly and succinctly, with as much detail as possible without overloading the designers with information. The use of Rich Pictures (Monk, 1998) coupled with manager requirements and scenarios enabled the designers to get quick and easily understood information about the users in the context of their work, their problems, their concerns and their daily tasks. The designers rarely needed to ask any questions about the user material presented at the beginning of the session, indicating that the presentation was adequate for their needs.

The post-design session questionnaire provided many valuable insights about the design process, and how the designer's felt about their work. It also provided quantitative measures in the form of satisfaction ratings that were very informative. For future experiments, I would also add some queries about the processes that they have used in the past (descriptions, frequency of use, comparison to the structured method used in the study, etc.). This might have helped me to understand why it was difficult for

some of the professional teams to employ the structured design methodology prescribed in this study.

Although the designers had trouble employing the structured design method, many of them had positive things to say about it, and all of them agreed at the beginning of the design session that the process seemed logical and easy to use. Therefore, despite the fact that it was not always successfully used in this study, I still believe that the structured design process that was employed in this study was appropriate for the scope of the project, with a small number of practical, easy-to-employ steps that, if used properly, would increase the usability of the design. I maintain that the reasons for not using this method had nothing to do with the structured method itself, but rather, had to do with other reasons mentioned earlier in this section.

Other aspects of the design session that went well were the location of the design sessions, as well as the materials that were provided to enable the designers to make a prototype.

Research Limitations

In doing this research, some limitations were discovered. The biggest discovery was that in this study it was not possible to control the design teams' use of design methods. No matter how many times some of the design teams were reminded to use the structured design method, and were explained how to use it properly, some of the teams were just not successful. On the other hand, there was also no way to prevent the unstructured teams from using a structured design methodology if they wished to.

One way to manage this problem might be to pre-select designers who already use ad hoc or structured methods in their everyday work, and assign them to the design

condition that matches their pre-disposition to use either structured or unstructured design methods. The benefit is that the designers will not have to learn anything new, and will likely continue working in a manner that is familiar and comfortable to them without having to have the researcher force them to use a particular design method. One drawback might be that the student designers, who have very little design experience, may not have established any pattern of use for design methods, and therefore cannot be pre-selected for one group or another. This would mean that the proposed study would not be able to compare student and professional designers. Another drawback would be that without random assignment to design conditions, there is no experimental manipulation.

Another way to manage this problem may be to have a facilitator present in both the structured and unstructured teams. Designers would state a preference for using structured or unstructured design methods, and would be assigned to teams based on this preference. The students can still state a preference for structure or not, although this may not be based on a lot of design experience. The same drawback of assigning designers according to their preference for one design method or another is that there would be no random assignment. The facilitator would make it clear at the beginning of the design sessions that the teams are only supposed to use a structured or unstructured design process, depending on which condition they were assigned to. Then the facilitator could lead the design teams through a few small, practice design exercises, for the purpose of getting the structured teams familiar with the structured method. Since this study gives researchers a good idea where people first using the structured method run into problems (i.e. green hat versus black hat, designing before understanding the

problem), the facilitator could do a better job of helping them through these parts of the process. The unstructured teams would also have a few practice runs with the facilitator, so that there would be no advantages with regard to the teams getting to know their teammates and interaction styles better. Then for the actual design session, the facilitator would leave the room and leave the designers to their own devices, since it would be unfair for the structured design session to be led through the process. This still does not guarantee that the right process will be adopted by the teams, but it does increase the chances, and it gives the researcher some opportunity to correct the designer's behavior before the design that will be rated on usability is created.

Another major setback in this study was that there were two teams where the third team member did not show up. This affected the ability to make conclusive statements about the cause of the high usability rankings for these teams. The high usability rankings could have been attributed to either the structured design method, or the fact that they had only two members on their team.

One way to control for the number of team members on each team would be to recruit one extra team member for each team. That way, if one member did not show up for their scheduled design session, there would be an extra person to take their place. If all members showed up, then the team members would be determined randomly. The extra participant would still be paid. Though this would cost more, it is only fair to compensate the extra participant for their time, since they had to book the time free in their schedule, and show up for the design session.

For the student designers, if participating in this study were part of a course credit, then the likelihood of the students showing up for their scheduled design session would be very high. This would require some cooperation from professors and the school.

Another limitation for this study was that there were not a lot of design teams to compare with each other. Therefore, in doing the statistical analyses, some correlations were quite high, but were not significant, possibly due to low power. This problem could have been easily solved by adding more teams of designers, however limitations in time to analyze the results, as well as money to pay the design participants made this not possible.

Another way to increase statistical power would be to study the effects of structured design processes on design in either professional design teams or student design teams, but not both. This would still allow the researcher to study the effects of design process on usability. And researchers could build on other designer's work, re-doing the study with different groups of design participants, and comparing their results.

Another possibility is to decrease the size of the teams to only two designers. It is apparent from the findings in this study that two-member design teams are still able to produce good designs in the same time amount as three-person design teams. In fact, in this study, the two-people design teams created designs that were rated better than those created by the three-people design teams. Although the time it takes to analyze the design sessions would not be significantly reduced, this would make the addition of several more design teams financially possible.

Another limitation in this study was the damage to one of the observation tapes, which prevented the complete analysis of one of the design teams. One way to control

for this would be to create back-ups of all the tapes so that if one of the tapes were damaged, the back-up tape could be analyzed.

Suggestions for Further Study

The experimental study of design practice allows researchers to manipulate variables to account for successes and failures in design outcomes. This allows us to explore many different facets of design to determine their value to the design process.

In this study, I wanted to assess the effect that a structured design method would have on the usability of a design. However, instead of comparing structured to unstructured design methods, it's possible to compare a certain structured design method, like Contextual Design, to another one, like the Bridge method, and see which process produces more usable design. Researchers can also look at a single structured design method, like usage-centred design, and apply it to projects of different sizes and scope to see which project type it is most effective for. This type of research would help design teams choose a structured methodology that is best suited for the project that they are tackling. Another benefit of this type of research is that it would give practitioners assurance that their design methodologies work, and they would be able to promote its corporate use.

Researchers could also take away the time limitation to this study and have designers work until they felt the design was good enough. This would determine if structured design processes do take longer than unstructured ones, as many people propose. Studies that compare different structured methods could help designers evaluate whether the relative gain in terms of usability when using a certain method would offset the possible increase in time. Researchers would have to ensure that the designers were

strongly motivated enough to finish the design until they were satisfied with it, instead of stopping the design process based on other factors, like time or boredom. It may also be the case that designers are never satisfied with their design, and want to keep iterating indefinitely. The researcher would have to provide the designers with some indication that they were done – like pre-defined usability goals, which establish a stopping point for the design session once the goals are met.

There are many other variables in the design process that would be very interesting to manipulate. For instance, we could try to determine the effects that design team sizes have on things like the usability of a design, the time they spend to create the design, and the designer's interaction patterns with one another. The results of this study suggest that it is possible that smaller teams may result in more usable designs. Researchers could also vary the size and scope of the project with varying numbers of people on the team, and see how this affects the outcomes. This would help corporations to determine how many designers would constitute the most effective design team.

Another interesting variable to manipulate would be the make-up of a design team in terms of the team member's background and skills. For example, researchers could compare the design outcomes from teams who have one engineer, one UI designer and one software developer to another team made up of a graphic designer, a UI designer and a software developer. They could also observe differences in the time they spend to create the design, their design method and their mode of interaction with one another. These mixes of teams could be observed designing projects of various scopes and sizes. This type of research could help corporations determine what mix of teams would be the most suitable for the project they are working on. It could also help determine the

various assets each team member brings to the design table, and therefore give the team a greater appreciation of their team members. It might also help the team members to understand their team-mates interaction styles, and therefore communicate more effectively together.

It would also be interesting to compare teams who use a neutral, non-designer facilitator with teams who design without any help or external leadership. The presence or absence of a facilitator may affect factors like the team's social interactions, the quality of the design produced, work allocation, and the teams' success at using a structured design methodology.

The same types of manipulations could also be used to determine what time limitations suit projects of different scopes and sizes, how constraints in terms of the nature of the deliverables affect the design process, whether design sessions broken up into smaller workshops work better than single, long design sessions, and various other lines of inquiry. The value of this work is that it can help corporations and design teams make smarter decisions about how they are going to proceed with their work.

Appendix A

Pre-test Questionnaire for Professional UI Designers

1. How many years have you been a UI designer?

2. Check the prototyping and graphics tools you are familiar with, and indicate your level of expertise:

	Beginner		Intermediate			Expert	
__Photoshop	1	2	3	4	5	6	7
__Paint Shop Pro	1	2	3	4	5	6	7
__Director	1	2	3	4	5	6	7
__Visual Basic	1	2	3	4	5	6	7
__HyperCard	1	2	3	4	5	6	7
__Flash	1	2	3	4	5	6	7
__ _____	1	2	3	4	5	6	7
__ _____	1	2	3	4	5	6	7

3. Please list all courses (if any) you have taken in a particular design methodology (e.g.: Holtzblatt and Beyer's Contextual Design, Constantine and Lockwood's Usage-Centered Design). Beside each course, please put the approximate date when you attended.

-
4. In the following lists, check those words (or phrases) that describe you best in a business or work situation.

Group A

- ☐ Reserved
- ☐ Uncommunicative
- ☐ Cool
- ☐ Cautious
- ☐ Guarded
- ☐ Seems difficult to get to know
- ☐ Demanding of self
- ☐ Disciplined attitudes
- ☐ Formal speech
- ☐ Rational decision-making
- ☐ Strict
- ☐ Impersonal
- ☐ Businesslike
- ☐ Disciplined about time
- ☐ Uses facts
- ☐ Formal dress
- ☐ Measured actions

Group C

Group B

- ☐ Take-charge attitude
- ☐ Directive
- ☐ Tends to use power
- ☐ Fast actions
- ☐ Risk-taker
- ☐ Competitive
- ☐ Aggressive
- ☐ Strong opinions
- ☐ Excitable
- ☐ Takes social initiative
- ☐ Makes statements
- ☐ Loud voice
- ☐ Quick pace
- ☐ Expressive voice
- ☐ Firm handshake
- ☐ Clear idea of needs
- ☐ Initiator

Group D

☐ Communicative	☐ Slow pace
☐ Open	☐ Flat voice
☐ Warm	☐ Soft-spoken
☐ Approachable	☐ Helper
☐ Friendly	☐ Unclear about what is needed
☐ Fluid attitudes	☐ Moderate opinions
☐ Informal speech	☐ Calm
☐ Undisciplined about time	☐ Asks questions
☐ Easy-going with self	☐ Tends to avoid use of power
☐ Impulsive	☐ Indifferent handshake
☐ Informal dress	☐ Deliberate actions
☐ Dramatic opinions	☐ Lets others take social initiative
☐ Uses opinions	☐ Risk-avoider
☐ Disciplined about time	☐ Quiet
☐ Emotional decision-making	☐ Go-along attitude
☐ Seems easy to get to know	☐ Supportive
☐ Measured actions	☐ Cooperative

5. Please check the dates and time frames when you would be available to participate in this study (remember, they are four-hour sessions)

Morning Afternoon Evening

__Tuesday March 19 th	_____	_____	_____
__Wednesday March 20 th	_____	_____	_____
__Thursday March 21 st	_____	_____	_____
__Friday March 22 nd	__n/a__	_____	_____
__Tuesday March 26 th	_____	_____	_____
__Wednesday March 27 th	_____	_____	_____
__Thursday March 28 th	_____	_____	_____
__Saturdays are a possibility	_____	_____	_____
__Sundays are a possibility	_____	_____	_____

Appendix B

Pre-test Questionnaire for Students

1. What is your student status (year and program)

2. List all of the User-Centered Design courses you have taken:

3. Check the prototyping and graphics tools you are familiar with, and indicate your level of expertise:

	Beginner		Intermediate			Expert	
__Photoshop	1	2	3	4	5	6	7
__Paint Shop Pro	1	2	3	4	5	6	7
__Director	1	2	3	4	5	6	7
__Visual Basic	1	2	3	4	5	6	7
__HyperCard	1	2	3	4	5	6	7
__Flash	1	2	3	4	5	6	7
__ _____	1	2	3	4	5	6	7
__ _____	1	2	3	4	5	6	7

4. In the following lists, check those words (or phrases) that describe you best in a business or work situation.

Group A

- ☐ Reserved
- ☐ Uncommunicative
- ☐ Cool
- ☐ Cautious
- ☐ Guarded
- ☐ Seems difficult to get to know
- ☐ Demanding of self
- ☐ Disciplined attitudes
- ☐ Formal speech
- ☐ Rational decision-making
- ☐ Strict
- ☐ Impersonal
- ☐ Businesslike
- ☐ Disciplined about time
- ☐ Uses facts
- ☐ Formal dress
- ☐ Measured actions

Group B

- ☐ Take-charge attitude
- ☐ Directive
- ☐ Tends to use power
- ☐ Fast actions
- ☐ Risk-taker
- ☐ Competitive
- ☐ Aggressive
- ☐ Strong opinions
- ☐ Excitable
- ☐ Takes social initiative
- ☐ Makes statements
- ☐ Loud voice
- ☐ Quick pace
- ☐ Expressive voice
- ☐ Firm handshake
- ☐ Clear idea of needs
- ☐ Initiator

Group C

- ☐ Communicative
- ☐ Open
- ☐ Warm
- ☐ Approachable
- ☐ Friendly
- ☐ Fluid attitudes
- ☐ Informal speech
- ☐ Undisciplined about time
- ☐ Easy-going with self
- ☐ Impulsive
- ☐ Informal dress
- ☐ Dramatic opinions
- ☐ Uses opinions
- ☐ Disciplined about time
- ☐ Emotional decision-making
- ☐ Seems easy to get to know
- ☐ Measured actions

Group D

- ☐ Slow pace
- ☐ Flat voice
- ☐ Soft-spoken
- ☐ Helper
- ☐ Unclear about what is needed
- ☐ Moderate opinions
- ☐ Calm
- ☐ Asks questions
- ☐ Tends to avoid use of power
- ☐ Indifferent handshake
- ☐ Deliberate actions
- ☐ Lets others take social initiative
- ☐ Risk-avoider
- ☐ Quiet
- ☐ Go-along attitude
- ☐ Supportive
- ☐ Cooperative

5. Please list all courses (if any) you have taken in a particular design methodology (e.g.: Contextual Design, Usage-Centered Design). Beside each course, please put the approximate date when you attended.

6. Please check the dates and time frames when you would be available to participate in this study (remember, they are four-hour sessions)

	Morning	Afternoon	Evening
☐ Tuesday March 19 th	☐	☐	☐
☐ Wednesday March 20 th	☐	☐	☐
☐ Thursday March 21 st	☐	☐	☐
☐ Friday March 22 nd	☐ n/a ☐	☐	☐
☐ Tuesday March 26 th	☐	☐	☐
☐ Wednesday March 27 th	☐	☐	☐
☐ Thursday March 28 th	☐	☐	☐
☐ Saturdays are a possibility	☐	☐	☐
☐ Sundays are a possibility	☐	☐	☐

Appendix C

Recruitment Emails

The announcement for professional designers read:

Attention All User Interface Designers!

Your participation would be appreciated for an experiment that is being conducted by a Master's student from the CURE Lab at Carleton University. We are interested in learning how people design User Interfaces. Participants recruited for this study will be required to design a software solution for an interface as part of a three-member design team. The design sessions will be video and audio taped, and will also be observed through a one-way mirror. The design session will last four hours, and designers will be paid \$100 for participating.

If you are interested in participating in this study, and would like more information, please email Alexandra Zwicker at azwix@hotmail.com, or call the CURE Lab at (613) 520-2600 ext.6628.

The announcement for student designers read:

Attention All User Interface Designer Students!

Your participation would be appreciated for an experiment that is being conducted by a Master's student from the CURE Lab at Carleton University. We are

interested in learning how people design User Interfaces. Participants recruited for this study will be required to design a software solution for an interface as part of a three-member design team. The design sessions will be video and audio taped, and will also be observed through a one-way mirror. The design session will last four hours, and designers will receive a free lunch for participating.

If you are interested in participating in this study, and would like more information, please email Alexandra Zwicker at azwix@hotmail.com, or call the CURE Lab at (613) 520-2600 ext.6628.

Appendix D

Informed Consent Form

The purpose of an informed consent is to ensure that you understand the purpose of the study and the nature of your involvement. The informed consent must provide sufficient information such that you have the opportunity to determine whether you wish to participate in the study.

Present Study: A study of understanding the design process

Research Personnel: The following people are involved in this research project and may be contacted at any time. The principal investigator is Alexandra Zwicker, Master's student, phone (613) 520-6200 ext. 6628. The principal faculty advisor of this project is Dr. R. Dillon, Psychology Department, Carleton University, phone (613) 520-2600 ext. 6629. If you have any ethical concerns about this study please contact Professor Mary Glick, Chair of Carleton University Research Ethics Committee for Psychological Research, Department of Psychology, Carleton University, phone (613) 520-2600 ext. 2664. Should you have any other concerns about this study please contact Professor Kim Matheson, Chair of the Psychology Department, Carleton University, phone (613) 520-2600 ext. 2648.

Purpose: The purpose of this study is to observe design sessions to understand the process of design.

Task Requirements: You will be required to design an interface solution as part of a three-member team. You will be asked to produce a prototype that meets that user requirements outlined in the design session, and that contains complete interface components for the required tasks. Your comments will be recorded, and the design outcomes will be evaluated by usability experts at a later date. The design session will be audio and video recorded. You will be asked to fill out a short questionnaire at the end of the design session.

Duration and Locale: The design session will last approximately four hours. The session will take place in Room 214 at the Cognos HCI Lab at Carleton University.

Anonymity/Confidentiality: The data collected in this experiment is confidential. The data will be collected such that your name is not associated with the data. The data will only be made available to the researchers associated with this project.

The Right To Withdraw: You have the right to withdraw from this study at any time without any compensation penalty.

I have read the above description of the Design Observation Study and I understand the conditions of my participation. My signature indicates that I agree to participate in the study.

Participant's Name: _____

Participant's Signature: _____

Researcher's Name: Alexandra Zwicker

Researcher's Signature: _____

Date: _____

Appendix E

Script For Structured Design Sessions

Thank you all for participating in this study. Although some of you likely know each other already, why don't we go around the table and introduce ourselves. I'm Alexandra Zwicker and I am a Master's student at the CURE lab. (*Go around table and introduce*).

As you know, the purpose of this study is to find out more about the process of user interface design. To do this, we will present you with a design problem that this group will attempt to solve within a four-hour session. One of the consent forms already notified you that we are going to be videotaping this session to make certain that we catch all of the actions and your comments. The video cameras are set up here (*point out locations for their comfort*). As well, this is a one-way mirror with a window on the other side. An observer sitting on the other side of the window will be taking notes and observing while you work.

For this session I want you to imagine that you are a consulting team. You have been asked by the owner of a hair salon to design the User Interface for a new computer system for his salon. He presently has 15 hairdressers working for him, but he is planning to expand, and wants a system built that will enable his staff to handle the extra traffic efficiently. One of his biggest complaints is that the staff bickers about appointments and lunches being allocated unfairly. He is hoping that this system will stop the bickering. (*Point to Manager Requirements*). In particular, he wants his receptionist, Jenny, to be able to quickly schedule appointments from either walk-in clients, or regular clients phoning in. Haircutting appointments are half-an hour long,

while coloring takes one hour. She must easily be able to evenly distribute the walk-in appointments among the available hairdressers. She also must be able to easily schedule the hairdresser's half-hour lunches. No more than three people are to go out for lunch at the same time. The manager will also set up a monitor in the salon area in the back so that the hairdressers can consult to check the name of their next client, and the time of their appointment, without having to run up to the front.

(Point to first Rich Picture). This is a picture of Jenny's job environment. As you can see, Jenny sits up at the front, and has to deal with the ringing phone and clients who walk in. The phone calls are usually from regulars, who request an appointment from their favorite stylist, and they also usually specify a date and time frame. Jenny tries to be as accommodating as possible. The walk-ins are usually strangers to the salon, and want to be seen as soon as possible. Jenny often has to make a tradeoff between assigning walk-ins evenly among the hairdressers, and getting the client seen as soon as possible. Jenny is under a lot of pressure from the hairdressers about lunch – they don't like to go too early, but they complain if they get sent out too late. She also has to keep track of who is in and who is out to lunch, too make sure that they come back in time. In addition to the new software that will help facilitate her scheduling duties, Jenny also has accounting and billing software on her computer.

This is a picture of Vinnie's job as a hairdresser. *(Point to second Rich Picture).* Right now, he often has to run up to the front desk to check the schedule book. He has found that if he remembers his customers' names, he gets better tips. On slow days, he'll often run out into the mall to do some personal shopping, so if he can find some free time, he'll let Jenny know when he'll be gone. He gets rather upset when an appointment

is cancelled, and Jenny doesn't have time to run back and let him know. The schedule book also lets him know when his lunch is scheduled, although due to walk-in clients, this can change over the course of the morning and early afternoon.

The manager of the salon wants to see if the user interfaces that your team designs will best suit his employee's needs. Your boss has decided to invest four hours of your time to show the manager an example of how you would design an interface for a scheduling tool. The hair salon manager and your boss have agreed to have you design a small portion of the interface. Your job will be to design a completed prototype using either paper, or the computer for the following two scenarios (*Point to scenarios*).

The first scenario is that Jenny has just greeted a walk-in client, who needs a haircut and color, and would like to be seen as soon as possible – she doesn't care which hairdresser she sees. Jenny wants to make sure that she schedules the walk-in so that the hairdressers are getting an even amount of walk-in clientele. Your interface will allow Jenny do to this. You must prototype the entire scenario, from what Jenny first sees when she first looks at her computer, to what the end screen will look like once she has scheduled the walk-in in. Make sure that all the necessary screens and interface components are prototyped so that you can walk me through the complete scenario at the end of the design session.

The second scenario is that Vinnie the hairdresser had his lunch scheduled for 11:30, but he got a walk-in client at 11:15, and he ended up working through his lunch. He wants to check the monitor in the back to see when he'll get his break. The interface that you design should allow him to see his own schedule, not the other hairdressers. Start prototyping from what Vinnie first sees when he approaches the monitor, up to

when he is able to see his changed schedule. All the interface components must be there for you to demonstrate your design at the end of this session.

The computer in this room has been equipped with Director, Visual Basic, Flash, Dreamweaver, Photoshop, Paint Shop Pro and the Windows 2000 suite. It is hooked up to the Internet, a scanner and a printer. Please let me know if you require something else and I will do my best to accommodate you.

I will remind you of the time. If you want, I can be your scribe, and write whatever you like on these flip charts so that all of you can participate fully in the design activities. As you can see, there are markers, pens, paper and sticky notes for your use – if you require something else, just let me know. I will answer any questions that you may have about the equipment in the lab, and the experiment in general, but I will not take part in any of the idea-generating process.

In addition, I will be asking you to follow a step-by-step design process. I am going to introduce you to a structured design method, and make sure that you all understand the steps, and that you all agree to the process before you commence the design session. If you like, I can stay in the design room with you and I can walk you through the design process, or I can go into the observation room and you can apply it yourselves. If I feel that you are straying too much from the process, I will come back in this room to help you get back on track. Once we've gone through the structured design steps, you can decide whether or not you'd like me to facilitate.

Let's proceed.

Appendix F

Script For Unstructured Design Sessions

Thank you all for participating in this study. Although some of you likely know each other already, why don't we go around the table and introduce ourselves. I'm Alexandra Zwicker and I am a Master's student at the CURE lab. *(Go around table and introduce).*

As you know, the purpose of this study is to find out more about the process of user interface design. To do this, we will present you with a design problem that that this group will attempt to solve within a four-hour session. One of the consent forms already notified you that we are going to be videotaping this session to make certain that we catch all of the actions and your comments. The video cameras are set up here *(point out locations for their comfort)*. As well, this is a one-way mirror with a window on the other side. An observer sitting on the other side of the window will be taking notes and observing while you work.

For this session I want you to imagine that you are a consulting team. You have been asked by the owner of a hair salon to design the User Interface for a new computer system for his salon. He presently has 15 hairdressers working for him, but he is planning to expand, and wants a system built that will enable his staff to handle the extra traffic efficiently. One of his biggest complaints is that the staff bickers about appointments and lunches being allocated unfairly. He is hoping that this system will stop the bickering. *(Point to Manager Requirements)*. In particular, he wants his receptionist, Jenny, to be able to quickly schedule appointments from either walk-in clients, or regular clients phoning in. Haircutting appointments are half-an hour long,

while coloring takes one hour. She must easily be able to evenly distribute the walk-in appointments among the available hairdressers. She also must be able to easily schedule the hairdresser's half-hour lunches. No more than three people are to go out for lunch at the same time. The manager will also set up a monitor in the salon area in the back so that the hairdressers can consult to check the name of their next client, and the time of their appointment, without having to run up to the front.

(Point to first Rich Picture). This is a picture of Jenny's job environment. As you can see, Jenny sits up at the front, and has to deal with the ringing phone and clients who walk in. The phone calls are usually from regulars, who request an appointment from their favorite stylist, and they also usually specify a date and time frame. Jenny tries to be as accommodating as possible. The walk-ins are usually strangers to the salon, and want to be seen as soon as possible. Jenny often has to make a tradeoff between assigning walk-ins evenly among the hairdressers, and getting the client seen as soon as possible. Jenny is under a lot of pressure from the hairdressers about lunch – they don't like to go too early, but they complain if they get sent out too late. She also has to keep track of who is in and who is out to lunch, too make sure that they come back in time. In addition to the new software that will help facilitate her scheduling duties, Jenny also has accounting and billing software on her computer.

This is a picture of Vinnie's job as a hairdresser. *(Point to second Rich Picture).* Right now, he often has to run up to the front desk to check the schedule book. He has found that if he remembers his customers' names, he gets better tips. On slow days, he'll often run out into the mall to do some personal shopping, so if he can find some free time, he'll let Jenny know when he'll be gone. He gets rather upset when an appointment

is cancelled, and Jenny doesn't have time to run back and let him know. The schedule book also lets him know when his lunch is scheduled, although due to walk-in clients, this can change over the course of the morning and early afternoon.

The manager of the salon wants to see if the user interfaces that your team designs will best suit his employee's needs. Your boss has decided to invest four hours of your time to show the manager an example of how you would design an interface for a scheduling tool. The hair salon manager and your boss have agreed to have you design a small portion of the interface. Your job will be to design a completed prototype using either paper, or the computer for the following two scenarios (*Point to scenarios*).

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The second scenario is that Vinnie the hairdresser had his lunch scheduled for 11:30, but he got a walk-in client at 11:15, and he ended up working through his lunch. He wants to check the monitor in the back to see when he'll get his break. The interface that you design should allow him to see his own schedule, not the other hairdressers. Start prototyping from what Vinnie first sees when he approaches the monitor, up to

when he is able to see his changed schedule. All the interface components must be there for you to demonstrate your design at the end of this session.

The computer in this room has been equipped with Director, Visual Basic, Flash, Dreamweaver, Photoshop, Paint Shop Pro and the Windows 2000 suite. It is hooked up to the Internet, a scanner and a printer. Please let me know if you require something else and I will do my best to accommodate you.

I will remind you of the time. If you want, I can be your scribe, and write whatever you like on these flip charts so that all of you can participate fully in the design activities. As you can see, there are markers, pens, paper and sticky notes for your use – if you require something else, just let me know. I will answer any questions that you may have about the equipment in the lab, and the experiment in general, but I will not take part in any of the idea-generating process.

You can take a break at any time – there is coffee or tea if you wish. So the time is now “something o’clock” – you have until approximately “something o’clock” to finish this design. At that time, I will ask you to stop designing, and walk me through your prototype for the two scenarios on the wall, and then fill out a short questionnaire. Please proceed.

Appendix G

Manager Requirements

- Receptionist must be able to quickly schedule half-hour hair cut or one-hour coloring appointments for regular clients phoning in
- Receptionist must be able to quickly find an available hairdresser for haircuts or coloring appointments for walk-in clients
- Receptionist must be able to evenly distribute the walk-in appointments among the available hairdressers
- Receptionist must be able to easily schedule the hairdresser's half-hour lunches
- No more than three people are to go out for lunch at the same time
- Hairdressers must be able to see their client and scheduling information from the monitor in the back

Appendix H

Rich Picture for Jenny's Job as Receptionist

Appendix I

Rich Picture for Vinnie's Job as a Hairdresser

Appendix J

Two Scenarios for Prototype

Scenario 1

- Walk-in client wants a cut and color as soon as possible
- Jenny needs to schedule her so that the customer is seen quickly, and so that Jenny distributes the walk-in appointments fairly amongst the hairdressers
- The design should show the interface supporting this task with ALL the interface components present; from the first screen that Jenny sees when she looks at the scheduler, to the last screen she sees once the client is scheduled

Scenario 2

- Vinnie had his lunch scheduled at 11:30, but he got a walk-in client at 11:15
- Vinnie needs to check to scheduler to see when his lunch was re-scheduled
- Vinnie can only see his own information
- Design all the interface components completely, from what Vinnie first sees when he looks at the monitor, to what he sees when he gets his new lunch information

Appendix K

Post-Design Questionnaire For Structured Teams

1. Please rate your satisfaction with the design you created on a scale of one to seven.

Very Dissatisfied			Neither Satisfied nor Dissatisfied			Very Satisfied
1	2	3	4	5	6	7

2. What aspects of the design you created do you think are the best? Why?

3. What aspects of the design you created do you think are the worst? Why?

4. Please rate your satisfaction with the process used to create your design on a scale of one to seven.

Very Dissatisfied			Neither Satisfied nor Dissatisfied			Very Satisfied
1	2	3	4	5	6	7

5. What did you like about the process used to create your design?

6. What would you have changed about the process used to create your design?

Thank-you for your participation.

Appendix L

Post-Design Session Questionnaire For Unstructured Teams

1. Please rate your satisfaction with the design you created on a scale of one to seven.

Very Dissatisfied			Neither Satisfied nor Dissatisfied			Very Satisfied
1	2	3	4	5	6	7

2. What aspects of the design you created do you think are the best? Why?

3. What aspects of the design you created do you think are the worst? Why?

4. Please rate your satisfaction with the process used to create your design on a scale of one to seven.

Very Dissatisfied				Neither Satisfied nor Dissatisfied			Very Satisfied
1	2	3	4	5	6	7	

5. What did you like about the process used to create your design?

6. What would you have changed about the process used to create your design?

7. A structured design method could be described as a set of steps or procedures that you tend to follow when you design solutions. Would you say that you used a

structured design method, or pre-determined steps to create your design solution?

Check yes ____ or no ____.

8. If you answered yes to question # 7, please list the steps that you used to create your design solution:

Thank-you for your participation.

Appendix M

Debriefing Form

Thank you very much for participating in the study. As noted before, this study attempts to observe designers creating a software solution in a controlled experimental setting in order to better understand design processes. The purpose of this study is to observe the steps designers take in their design process, and how their process may affect their satisfaction with their design outcome.

You are one of 24 participants who are involved in this study. By observing what happened within this design session, firsthand, and then later on video it will be possible to determine the steps you took in your design process, and how they affect your design outcome.

If you have any questions or comments about this study, please contact the principal investigator Alexandra Zwicker, Master's student, phone (613) 520-2600 ext. 6628. The principal faculty supervisor of this project is Professor Dick Dillon, Psychology Department, Carleton University, phone (613) 520-2600 ext. 6629. If you have any ethical concerns about this study, please contact Professor Mary Gick, Chair of the Carleton University Research Ethics Committee for Psychological Research, Department of Psychology, Carleton University, (613) 520-2600 ext. 2664. Should you have any other concerns about this study please contact Professor Kim Matheson, Chair of the Psychology Department, 520-2600 ext. 2648.

Thank you again for your participation.

Appendix N

Structured Evaluation Checklist

Section 1: Visual Clarity. Information displayed on the screen should be clear, well organized, unambiguous and easy to read.

	Never	Some-times	Mostly	Always	Comments
1. Is each screen clearly identified with an informative title or description?					
2. Is important information highlighted on the screen? (e.g. cursor position, instructions, errors)					
3. When the user enters information on the screen is it clear where the information should be entered?					
4. When the user enters information on the screen is it clear in what format it should be entered?					
5. Does the information appear to be organized logically on the screen? (e.g. menus organized by probable sequence of selection, or alphabetically)					
6. Are different types of information clearly separated from each other on the screen? (e.g. instructions, control options, data displays)					
7. Where a large amount of information is displayed on one screen, is it clearly separated into sections on the screen?					
8. Are columns of information clearly aligned on the screen? (e.g. columns of alphanumerics left-justified, columns of integers right-justified)					
9. Are bright or light colors displayed on a dark background and vice versa?					

10. Does the use of color help to make the displays clear?					
11. Where color is used, will all aspects of the display be easy to see if used on a monochrome or low-resolution screen, or if the user is color-blind?					
12. Is the information on the screen easy to see and read?					
13. Do screens appear uncluttered?					
14. Are schematic and pictorial displays (e.g. figures and diagrams) clearly drawn and annotated?					
15. Is it easy to find the required information on a screen?					

Overall, on a scale of one to five, where one means very unsatisfactory, three means neutral and five means very satisfactory, and how would you rate the system in terms of visual clarity?

Very Unsatisfactory
1

2

Neutral
3

4

Very Satisfactory
5

Section 2: Consistency. The way the system looks and works should be consistent at all times.

	Never	Sometimes	Mostly	Always	Comments
1. Are different colors used consistently throughout the system? (e.g. errors always highlighted in the same color)					
2. Are abbreviations, acronyms, codes and other alphanumeric information used consistently throughout the system?					
3. Are icons, symbols, graphical representations and other pictorial information used consistently throughout the system?					

4. Is the same type of information (e.g. instructions, menus, messages, titles) displayed in the same location on the screen?					
5. Is the same type of information (e.g. instructions, menus, messages, titles) displayed in the same layout?					
6. Is the same item of information displayed in the same format, wherever it appears?					
7. Is the format in which the user should enter particular types of information on the screen consistent throughout the system?					
8. Is the method of entering information consistent throughout the system?					
9. Is the action required to move the cursor around the screen consistent throughout the system?					
10. Is the method of selecting options (e.g. from a menu) consistent throughout the system?					
11. Are there standard procedures for carrying out similar, related operations? (e.g. updating and deleting information, starting and finishing transactions)					
12. Is the way the system responds to a particular user action consistent at all times?					

Overall, on a scale of one to five, where one means very unsatisfactory, three means neutral and five means very satisfactory, and how would you rate the system in terms of consistency?

Very Unsatisfactory

1

2

Neutral

3

4

Very Satisfactory

5

Section 3: Compatibility. The way the system looks and works should be compatible with user conventions and expectations

	Never	Some-times	Mostly	Always	Comments
1. Are colors assigned according to conventional associations where these are important? (e.g. red = alarm, stop)					
2. Where abbreviations, acronyms, codes and other alphanumeric information are displayed, are they easy to recognize and understand?					
3. Where abbreviations, acronyms, codes and other alphanumeric information are displayed, do they follow conventions where these exist?					
4. Where icons, symbols, graphical representations and other pictorial information are displayed, are they easy to recognize and understand?					
5. Where icons, symbols, graphical representations and other pictorial information are displayed, do they follow conventions where these exist?					
6. Where jargon and terminology is used within the system, is it familiar to the user?					
7. Are established conventions followed for the format in which particular types of information are displayed? (e.g. layout of dates and telephone numbers)					
8. Is information presented and analyzed in the units with which the users normally work? (e.g. hours, kilos, dollars)					
9. Is the format of displayed information compatible with the					

form in which it is entered into the system?					
10. Is information presented in a way which fits the user's view of the task?					
11. Are graphical displays compatible with the user's view of what they are representing?					
12. Does the organization and structure of the system fit the user's perception of the task?					
13. Does the sequence of activities required to complete a task follow what the user would expect?					
14. Does the system work in the way the user thinks it should work?					

Overall, on a scale of one to five, where one means very unsatisfactory, three means neutral and five means very satisfactory, and how would you rate the system in terms of compatibility?

Very Unsatisfactory
1

2

Neutral
3

4

Very Satisfactory
5

Section 4: Informative Feedback. Users should be given clear, informative feedback on where they are, what actions they have taken, whether these actions have been successful and what actions should be taken next.

	Never	Some-times	Mostly	Always	Comments
1. Are instructions and messages displayed by the system concise and positive?					
2. Are messages displayed by the system relevant?					
3. Do instructions and prompts clearly indicate what to do?					
4. Is it clear what actions a user can take at any stage?					
5. Is it clear what the user needs to do in order to take a particular action? (e.g. which options to select, which keys to					

press)					
6. When the user enters information on the screen, is it made clear what this information should be?					
7. Is it made clear what shortcuts, if any, are possible? (e.g. abbreviations, hidden commands, type-ahead)					
8. Is it made clear what changes occur on the screen as a result of a user input or action?					
9. Is there always an appropriate system response to a user input or action?					
10. Are status messages (e.g. indicating what the system is doing, or has just done) informative?					
11. Are status messages accurate?					
12. Does the system clearly inform the user when it completes a requested action? (successfully or unsuccessfully)					
13. Does the system promptly inform the user of any delay, making it clear that the user's input or request is being processed?					
14. Do error messages explain clearly where the errors are?					
15. Do error messages explain clearly what the errors are?					
16. Do error messages explain clearly why they have occurred?					
17. Is it clear to the user what should be done to correct an error?					
18. Where there are several modes of operation, does the system clearly indicate which mode the user is currently in? (e.g. update, enquiry, simulation)					

Overall, on a scale of one to five, where one means very unsatisfactory, three means neutral and five means very satisfactory, and how would you rate the system in terms of informative feedback?

Very Unsatisfactory Neutral Very Satisfactory
1 2 3 4 5

Section 5: Explicitness. The way the system works and is structured should be clear to the user.

	Never	Some-times	Mostly	Always	Comments
1. Is it clear what stage the system has reached in a task?					
2. Is it clear what the user needs to do in order to complete a task?					
3. Where the user is presented with a list of options (e.g. in a menu), is it clear what each option means?					
4. Is it clear what part of the system the user is in?					
5. Is it clear what the different parts of the system do?					
6. Is it clear how, where and why changes in one part of the system affect other parts of the system?					
7. Is it clear why the system is organized and structured as it is?					
8. Is it clear why a series of screen are sequences as they are?					
9. Is the structure of the system obvious to the user?					
10. Is the system well-organized from the user's point of view?					
11. Where an interface metaphor is used, (e.g. the desk-top metaphor in office applications), is this made explicit?					
12. Where a metaphor is					

task carried out using the system?					
10. Where task sequences are particularly long, are they broken into appropriate subsequences? (e.g. separating a lengthy editing procedure into it's constituent parts)					

Overall, on a scale of one to five, where one means very unsatisfactory, three means neutral and five means very satisfactory, and how would you rate the system in terms of appropriate functionality?

Very Unsatisfactory

1

2

Neutral

3

4

Very Satisfactory

5

Section 7: Flexibility and Control. The interface should be sufficiently flexible in structure, in the way information is presented and in terms of what the user can do to suit the needs and requirements all users and to allow them to feel in control of the system

	Never	Sometimes	Mostly	Always	Comments
1. Is there an easy way for the user to 'undo' an action, and step back to a previous stage or screen (e.g. if the user makes a wrong choice, or does something unintended).					
2. Where the user can 'undo', is it possible to 'redo' (i.e. to reverse this action)?					
3. Are shortcuts available when required? (e.g. to bypass a sequence of activities or screens)					
4. Do users have control over the order in which they request information, or carry out a series of activities?					
5. Can the user look through a sequence of screens in either direction?					

6. Can the user access a particular screen in a sequence of screens directly? (e.g. where a list or table covers several screens)					
7. In menu-based systems, is it easy to return to the main menu from any part of the system?					
8. Can the user move to different parts of the system as required?					
9. Is the user able to finish entering information (e.g. when typing in a list or table of information) before the system responds? (e.g. by updating the screen)					
10. Does the system prefill repeated information on the screen, where possible? (e.g. to save the user having to enter the same information several times)					
11. Can the user choose whether to enter information manually or to let the computer generate information automatically? (e.g. where there are defaults)					
12. Can users tailor certain aspects of the interface for their own preference or needs? (e.g. colors, parameters)					

Overall, on a scale of one to five, where one means very unsatisfactory, three means neutral and five means very satisfactory, and how would you rate the system in terms of flexibility and control?

Very Unsatisfactory
1 2

Neutral
3

4 5
Very Satisfactory

Section 8: Error prevention and correction. The system should be designed to minimize the possibility of user error, with inbuilt facilities for detecting and handling those which do occur; users should be able to check their inputs and to correct errors or potential error situations before the input is processed.

	Never	Some-	Mostly	Always	Comments
--	-------	-------	--------	--------	----------

		times			
1. Does the system validate user inputs before processing, wherever possible?					
2. Does the system clearly and promptly inform the user when it detects an error?					
3. Are users able to check what they have entered before it is processed?					
4. Is there some form of cancel (or 'undo') key for the user to reverse an error situation?					
5. Is it easy for the user to correct errors?					
6. Does the system ensure that the user corrects all detected errors before the input is processed?					
7. Can the user try out possible actions (e.g. using a simulation facility) without the system processing the input and causing problems					
8. Is the system protected against common trivial errors?					
9. Does the system ensure that the user double-checks any requested actions which may be catastrophic is requested unintentionally? (e.g. large-scale deletion)					
10. Is the system protected against possible knock-on effects of changes in one part of the system? (changes do not have unfortunate repercussions elsewhere in the system)					
11. Does the system prevent users from taking actions which they are not authorized for? (e.g. by requiring passwords)					
12. In general, is the system free from errors and malfunctions?					
13. When system errors occur, can the user access all necessary					

diagnostic information to resolve the problem? (e.g. where and what the fault is, what is required to resolve it)					
---	--	--	--	--	--

Overall, on a scale of one to five, where one means very unsatisfactory, three means neutral and five means very satisfactory, and how would you rate the system in terms of error prevention and correction?

Very Unsatisfactory Neutral Very Satisfactory
 1 2 3 4 5

Section 9: User guidance and support. Informative, easy-to-use and relevant guidance and support should be provided to help the user understand and use the system.

	Never	Some-times	Mostly	Always	Comments
1. If there is some form of help facility (or guidance) on the computer to help the user when using the system, then can the user request this easily from any point in the system?					
2. Is it clear how to get in and out of the help facility?					
3. Is the help information presented clearly, without interfering with the user's current activity?					

Overall, on a scale of one to five, where one means very unsatisfactory, three means neutral and five means very satisfactory, and how would you rate the system in terms of user guidance and support?

Very Unsatisfactory Neutral Very Satisfactory
 1 2 3 4 5

Appendix O

Usability Evaluation Checklist Instructions

1. You will evaluate 8 prototypes designed for use in a hair salon to facilitate the scheduling of customer's appointments and the communication of information to the salon staff.
2. Evaluate one design at a time. Designs are labeled with numbers, and are in random order. They have been scanned and placed into Power Point presentations. Some pages contain my instructions which clarify the designer's intent, and which tell you how to step through the task. If you have any questions regarding the designs, contact me at azwix@hotmail.com.
3. Before any questions are filled out in the evaluation form, first familiarize yourself with the system.
4. Then work through the two tasks that are showcased in these designs. The two tasks are based on the following scenarios:

Task 1: Jenny the receptionist must schedule a walk-in who wants a haircut and a colour. The walk-in does not care who she sees, but does want to be seen as soon as possible.

Task 2: Vinnie the hairdresser had his lunch scheduled for 11:30, but got a walk-in client at 11:15 and ended up working through his lunch. He needs to check the system to see what time his lunch is rescheduled for.
5. Each design has a corresponding evaluation checklist. The evaluation checklists are divided up into nine usability categories. Each category contains a number of checklist questions. To the right of the checklist questions are four columns labeled

“Always”, “Mostly”, “Sometimes” and “Never”. For each checklist question, please tick the column which best describes your answer to the question, basing your responses on the overall usability displayed for BOTH tasks.

6. You may also write any comments you have in the column labeled “Comments”.
7. If you feel that a checklist item is not relevant to the interface which you are evaluating, then write “N/A” in the comments section beside that question and move on to the next question.
8. At the end of each section, please rate the user interface in terms of the issues in that section. The ratings range from “Very satisfactory” to “Very unsatisfactory”.
9. Once you have given a rating for all nine sections, add the numbers corresponding to your ratings for each section to give that design an overall usability score, out of a possible 45 points. Record this score.
10. Set up a meeting with the other two evaluators to come up with composite usability scores for all designs.

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