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User-Centered Design

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1. Introduction and History

The design of everyday objects is not always intuitive and at times it leaves the user frustrated and unable to complete a simple task. How many of us have bought a VCR that we have struggled to used and missed recording our favorite programs because we misunderstood the instructions or had to put up with the clock blinking 12:00 because we didn't know how to stop it? Do we have to put up with designs like these? Isn't it possible to design systems that are more usable? 'User-centered design' (UCD) is a broad term to describe design processes in which end-users influence how a design takes shape. It is both a broad philosophy and variety of methods. There is a spectrum of ways in which users are involved in UCD but the important concept is that users *are* involved one way or another. For example, some types of UCD consult users about their needs and involve them at specific times during the design process; typically during requirements gathering and usability testing. At the opposite end of the spectrum there are UCD methods in which users have a deep impact on the design by being involved as partners with designers throughout the design process.

The term 'user-centered design' originated in Donald Norman's research laboratory at the University of California San Diego (UCSD) in the 1980s and became widely used after the publication of a co-authored book entitled: *User-Centered System Design: New Perspectives on Human-Computer Interaction* (Norman & Draper, 1986). Norman built further on the UCD concept in his seminal book *The Psychology Of Everyday Things* (*POET*) (Norman, 1988). In

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POET he recognizes the needs and the interests of the user and focuses on the usability of the design. He offers four basic suggestions on how a design should be:

- Make it easy to determine what actions are possible at any moment.
- Make things visible, including the conceptual model of the system, the alternative actions, and the results of actions.
- Make it easy to evaluate the current state of the system.
- Follow natural mappings between intentions and the required actions; between actions and the resulting effect; and between the information that is visible and the interpretation of the system state. (Norman, 1988, p.188)

These recommendations place the user at the center of the design. The role of the designer is to facilitate the task for the user and to make sure that the user is able to make use of the product as intended and with a minimum effort to learn how to use it. Norman noted that the long cumbersome, unintelligible manuals that accompany products are not user-centered. He suggests that the products should be accompanied by a small pamphlet that can be read very quickly and draws on the user's knowledge of the world.

Telling designers that products should be intuitive is not enough; some design principles are needed to guide the design. Norman (1988) suggested that the following seven principles of design are essential for facilitating the designer's task:

1. Use both knowledge in the world and knowledge in the head. By building conceptual models, write manuals that are easily understood and that are written before the design is implemented.

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2. Simplify the structure of tasks. Make sure not to overload the short-term memory, or the long term memory of the user. On average the user is able to remember five things at a time. Make sure the task in consistent and provide mental aids for easy retrieval of information from long-term memory. Make sure the user has control over the task.
3. Make things visible: bridge the gulfs of Execution and Evaluation. The user should be able to figure out the use of an object by seeing the right buttons or devices for executing an operation.
4. Get the mappings right. One way to make things understandable is to use graphics.
5. Exploit the power of constraints, both natural and artificial, in order to give the user the feel that there is one thing to do.
6. Design for error. Plan for any possible error that can be made, this way the user will be allowed the option of recovery from any possible error made.
7. When all else fails, standardize. Create an international standard if something cannot be designed without arbitrary mappings (Norman, 1988, p.189-201).

In 1987 Ben Shniederman articulated a similar set of principles in the form of eight golden rules (Shneiderman, 1987). Later Jakob Nielsen adapted and popularized these same basic concepts to produce heuristics for usability engineering (Nielsen, 1993, 2001).

Norman's work stressed the need to fully explore the needs and desires of the users and the intended uses of the product. The need to involve actual users, often in the environment in which they would use the product being designed, was a natural evolution in the field of user-centered design. Users became a central part of the development process. Their involvement

lead to more effective, efficient and safer products and contributed to the acceptance and success of products (Preece, Rogers, & Sharp, 2002).

2. How to Involve Users in Design?

It is necessary to think carefully about who is a user and how to involve users in the design process. Obviously users are the people who will use the final product or artifact to accomplish a taskor goal. But there are other users as well. The people who manage the users have needs and expectations too. What about those persons who are affected in some way by the use of the artifact or use the products and/or services of the artifact? Shouldn't their needs and expectations be taken into consideration in the design process? Eason (1987) identified three types of users: primary, secondary, and tertiary. Primary users are those persons who actually use the artifact; secondary users are those who will occasionally use the artifact or those who use it through an intermediary; and tertiary users are persons who will be affected by the use of the artifact or make decisions about its purchase. The successful design of a product must take into account the wide range of stakeholders of the artifact. Not everyone who is a stakeholder needs to be represented on a design team, but the effect of the artifact on them must be considered (Preece, et. al, 2002).

Once the stakeholders have been identified and a thorough investigation of their needs has been conducted by performing tasks and needs analyses, designers can develop alternative design solutions to be evaluated by the users. These design solutions can be simple paper and

pencil drawings in the beginning phase of the process. Listening to users discuss the alternative designs can amplify designers understanding of the intended purpose(s) of the artifact and may provide information that does not come out of initial interviews, observations, and needs analysis. As the design cycle progresses, prototypes (limited versions of the product/artifact) can be produced and user tested. At this point, designers should pay close attention to the evaluations by the users as they will help identify measurable usability criteria. Measurable usability criteria address issues related to the effectiveness, efficiency, safety, utility, learnability and memorability (how long it takes to remember to perform the most common tasks) of the product/artifact and users' subjective satisfaction with it. You can see how difficult it would be for designers to know or imagine all the usability criteria that are important to the users. It is only through feedback collected in an interactive iterative process involving users that products can be refined. Table 1 suggests ways to involve users in the design and development of a product/artifact (Preece, et. al, 2002).

Technique	**Purpose**	**Stage of the Design Cycle**
Background Interviews and questionnaires	Collecting data related to the needs and expectations of users; evaluation of design alternatives, prototypes and the final artifact	At the beginning of the design project
Sequence of work interviews and questionnaires	Collecting data related to the sequence of work to be performed with the artifact	Early in the design cycle
Focus groups	Include a wide range of stakeholders to discuss issues and requirements	Early in the design cycle
On-site observation	Collecting information concerning the environment in which the artifact will be used	Early in the design cycle
Role Playing, walkthroughs, and simulations	Evaluation of alternative designs and gaining additional information about user needs and expectations; prototype	Early and mid-point in the design cycle

	evaluation	
Usability testing	Collecting quantities data related to measurable usability criteria	Final stage of the design cycle
Interviews and questionnaires	Collecting qualitative data related to user satisfaction with the artifact	Final stage of the design cycle

Table 1 Involving users in the design process (from Preece et a., 2002, p.??

The discussion so far indicates the central role of usability testing in UCD, which we examine in more detail in the next section before proceeding to discuss participatory design, which is a form of UCD that has gained strong acceptance in recent years, particularly in the Scandinavian countries.

2.1 Usability Testing

Usability testing, according to Dumas & Redish (1993), aims to achieve the following five goals, to:

- improve the product's usability
- involve real users in the testing
- give the users real tasks to accomplish
- enable testers to observe and record the actions of the participants
- enable testers analyze the data obtained and make changes accordingly

Usability testing focuses on user needs, uses empirical measurement, and iterative design (Nielsen, 1994). Dumas & Reddish (1993) stress that interactive-systems designers are now aware that many pilot tests should be conducted before releasing any product to the public. An interactive system is like a play, where extensive rehearsals are expected especially close to opening night (Shneiderman, 1998). Historically usability tests are conducted in usability laboratories that are staffed by people who are experts in user-interface design and testing and

this is still the practice in large companies such as Microsoft and IBM. These laboratories are equipped with an area that allows the designers to observe the testers unnoticed. However, due to the cost of running such laboratories and the distributed nature of many systems it is increasingly common to use mobile usability testing kits that are a fraction of the cost.

Before product implementation, paper mock-ups of screen displays can be tested in order to assess the wording and layout. Many techniques are employed in usability testing, including:

- *Think aloud* techniques in which the user is asked to articulate all the steps of his / her actions.
- *Videotaping* is valuable to review what the participants did, and to show designers where the problems are in their designs (Shneiderman, 1998, p. 131).
- *Interviews and user satisfaction questionnaires* enable designers to evaluate the users likes and dislikes about the design and to gain a deeper understanding of any problems.

Typically the tests require typical users to perform typical standardized tasks in a typical task environment so that the following data can be collected:

- Time for users to learn a specific function
- Speed of task performance
- Type and rate of errors by users
- User retention of commands over time
- Subjective user satisfaction (Shneiderman, 1998, p. 135).

After the product is released, it is also recommended that evaluation be continued. The most frequent method of evaluation is interviews and focus groups. Both provide valuable information about user satisfaction and any problems with the functionality that might need rethinking. Data logging may also be performed.

2.2 Variations on usability testing

Usability testing has limitations; it does not cover all the interface features; it lasts for a few hours in the laboratory and therefore it is hard to ascertain how the product is going to perform over a few weeks or months in the real environment (Shneiderman, 1998). Furthermore, the small number of participants rarely represents the whole population (Rubin, 1994).

Mayhew (1999) suggests that the usability engineering lifecycle provides a complete approach for developing the interface that includes three phases of iterative testing. The first level evaluation is an iterative conceptual model evaluation, designed to get feedback before any code has been developed. Formal usability testing is often used at this stage. For each iteration, there should be between three to ten users, the testing should be done in the workplace, and a minimum of instructions should be provided in order to test ease of learning. The next testing stage should be done after the prototype has been coded to get early feedback about its usability. The same evaluation principles used in the first level evaluations are employed here, except, that at this second level the prototype is complete, while in the first level a paper mockup was used. The third testing phase occurs after the interface is ready, and its purpose is to evaluate the final product against the usability goals set at the beginning of development.

Web site usability testing also takes a user-centered approach, where the designer concentrates on the needs of the user (Norman, 1988). It is recommended that usability testing begin when a paper prototype has been created, and continue as the interface is coded, but in reality most Web sites are not tested before implementation. Usually testing is done with users and with experts through *expert reviews*. Experts can comment on usability issues while users can point out small problems related to tasks (Lazar, 2001). It is advisable to involve users from the target audience and to follow the same procedures as for testing software applications.

Testing can take place in a laboratory, in the workplace or at home with the designer observing the user's interactions with the system.

One problem of usability testing is that it is expensive, which has prompted development of alternative testing techniques, the most well-known of which are heuristic and discount usability testing (Nielsen, 1993). In heuristic evaluation experts inspect the application or website guided by high-level heuristics such as 'reduce load on short-term memory', and based on their knowledge of the target user population they identify problems with the design. Discount usability evaluation provides a variation on this theme in which the claim is that 3-5 reviewers identify around 80% of the usability problems. The low cost of these approaches makes them attractive to developers but there is concern about their efficacy (for a fuller discussion see Preece et al., 2002).

2.3 Participatory Design

In participatory design the users are involved in development of the products, in essence they are co-designers. The participatory design approach emerged in Scandinavia. It was born out of the labor unions push for workers to have more democratic control in their work environment (Ehn, 1989). Because cultural differences can often arise between users and designers, sometimes the users are unable to understand the language of the designers, it is recommended that the team uses prototypes, such as mockups (three dimensional paper-based representation), or a paper-based outline of the screen of a webpage, or a product (Ehn & Kyng, 1991). Other types of prototyping techniques are PICTIVE (Plastic Interface for Collaborative Technology Initiatives through Video Exploration) (Muller, 1991) and CARD (Collaborative Analysis of Requirements and Design) (Tudor, 1993). The PICTIVE prototyping method uses

low-fidelity office products, such as pens, papers, and sticky notes. The actions of the users are videotaped. CARD uses playing cards with pictures of specific items on them. PICTIVE concentrates on the detailed aspects of the system while CARD looks at the flow of the task, just as storyboarding (Preece et al., 2002).

In recent years the participatory design approach has gained momentum for designing novel systems. For example, Druin and her team have developed their own version of participatory design in which *children are design partners* for developing software for children (Druin, 200?). Preece (2000) has also developed a form of participatory design, known as *participatory, community-centered design* for developing online communities.

3. Advantages and Disadvantages of User-Centered DesignThe major advantage of the user-centered design approach is that a deeper understanding of the psychological, organizational, social and ergonomic factors that affect the use of computer technology emerges from the involvement of the users at every stage of the design and evaluation of the product. The involvement of users assures that the product will be suitable for its intended purpose in the environment in which it will be used. This approach leads to the development of products that are more effective, efficient, and safe.

It also helps designers manage user's expectations about a new product. When users have been involved in the design of a product, they know from an early stage what to expect from a product and they feel that their ideas and suggestions have been taken into account during the process. This leads to a sense of ownership for the final product that often results in higher customer satisfaction and smoother integration of the product into the environment (Preece, et. al, 1994; Preece, et. al, 2002).

If the design is not user-centered, it could lead to ill-thought out designs. When users' expectations are not met, they may get frustrated or even angry. The major disadvantage to user-centered design is that is can be quite costly. It takes time to gather data from and about users especially if you seek to understand the environment in which they will be using the products. The process requires resources, both financial and human. User-centered design teams generally benefit from including persons from different disciplines, particularly psychologists, sociologists and anthropologists whose job it is to understand users needs and communicate them to the technical developers in the team. The downside of this approach is that members of the team have to learn to communicate effectively and to respect each other's contributions and expertise. This can be time consuming and hence adds costs to the process. Management may question whether this added value is worth the cost, particularly if delivery dates are threatened (Dix, et. al, 1997; Preece, et. al, 1994; Preece, et. al, 2002). Table 4.1 summarizes these and other advantages and disadvantages of user-centered design.

Advantages	**Disadvantages**
Products are more efficient, effective, and safe	It is more costly.
Assists in managing users' expectations and levels of satisfaction with the product.	It takes more time.
Users develop a sense of ownership for the product	May require the involvement of additional design team members (i. e. ethnographers, usability experts) and wide range of stakeholders
Products require less redesign and integrate into the environment more quickly	May be difficult to translate some types of data into design
The collaborative process generated more creative design solutions to problems.	The product may be too specific for more general use, thus not readily transferable to other clients; thus more costly

4.1 Advantages and Disadvantages of User-Centered Design

4. Examples of User-Centered Design

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5. Conclusions

User-centered design (UCD) is a general term for a philosophy and methods which focus on designing for and involving users in the design of computerized systems. The ways in which users participate can vary. At one end of the spectrum involvement may be relatively light; they may be consulted about their needs, observed and participate in usability testing. At the other end of the spectrum involvement can be intensive with users participating throughout the design process as partners in the design. A variety of methods have been developed to support UCD including usability testing, usability engineering, heuristic evaluation, discount evaluation and participatory design. Quick and dirty evaluations is also important in which ideas are taken to a few representative users for their feedback early in design. Involving users in design one way or another has been shown to lead to developing more usable satisfying designs.

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To be added

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(Druin, 200?)