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USER-CENTERED DESIGN

The design of everyday objects is not always intuitive, and at times it leaves the user frustrated and unable to complete a simple task. User-centered design (UCD) is a broad term that describes design processes in which end users influence how a design takes shape. Developers consult users about their needs and involve them at specific times during the design process, typically during requirements gathering and usability testing. Some UCD methods involve users much more completely; recognizing users as partners with designers throughout the design process.

History

The term *user-centered design* originated in the 1980s in the research laboratory of the cognitive psychologist Donald Norman at the University of California at San Diego (UCSD) and became widely used after the 1986 publication of *User-Centered System Design: New Perspectives on Human-Computer Interaction*, which Norman edited with the psychologist Stephen Draper. Norman built further on the UCD concept in his 1988 book *The Psychology of Everyday Things* (*POET*). (The book was reissued in 2002 as *The Design of Everyday Things.*) In *POET* Norman recognizes the needs and the interests of the user and focuses on the usability of the design. He offers four basic suggestions regarding design:

- Make it easy to determine what actions are possible at any moment (make use of constraints).
- 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, 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 use the product as intended, with a minimum of time spent learning how to use it. Telling designers that products should be intuitive is not enough, however. Norman suggested that the following seven principles of design are essential for facilitating the designer's task. These seven tasks are subordinates of the four basic principles mentioned above, and they help to ensure that the designer has a list of guidelines that is intuitive to follow:

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.
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 1998, 189–201)

In 1987 the computer scientist Ben Shneiderman articulated a similar set of principles in the form of eight golden rules. Later the engineer Jakob Nielsen adapted and popularized these same basic concepts to produce heuristics (problem-solving techniques) for usability engineering.

Norman stressed the need to explore users' needs and desires and the product's intended uses fully. Involving 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 led to more effective, efficient, and safer products and contributed to the acceptance and success of products.

How to Involve Users in Design

It is necessary to think carefully about who a user is and how to involve users in the design process. Obviously the people who will use the final product or artifact to accomplish a task or goal are users, but there are other users as well. The people who manage the users have needs and expectations too, as do the people who are affected by the product or artifact's use, and those who use the by-products (either services or other products) that the product or artifact produces. Ken Eason, who studies the effect of information technology on organizations, has identified three types of users: primary, secondary, and tertiary. Primary users are those who actually use the artifact; secondary users are those who will occasionally use the artifact or those who use it through an intermediary; tertiary users are those who will be affected by the use of the artifact or make decisions about its purchase. For a product design to be successful, it should take all three levels of user into account.

Once the stakeholders have been identified and a thorough investigation of their needs has been conducted, designers can develop alternative design solutions that users may then evaluate. 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 or artifact) can be produced and user tested. At this point, designers should pay close attention to users' evaluations, as the evaluations will help identify measurable usability criteria in the areas of effectiveness, efficiency, safety, utility, learnability, and memorability (how long it takes to remember to perform the most common tasks). Evaluations will also reveal users' satisfaction with the product or artifact. It is only through feedback collected in an interactive, iterative process involving users that products can be refined. The discussion so far indicates the central role of usability testing in UCD, which we examine in more detail in the next section before discussing participatory design, which is a form of UCD that has gained strong acceptance in recent years.

Usability Testing

Usability testing should make a product more usable, involve actual users and real tasks, and generate results that testers can observe, record, and analyze. Usability testing focuses on user needs, relies on empirical measurement, and employs iterative design. Designers of interactive systems are now aware that many pilot tests should be conducted before releasing any product to the public. In this section the discussion is limited to design of

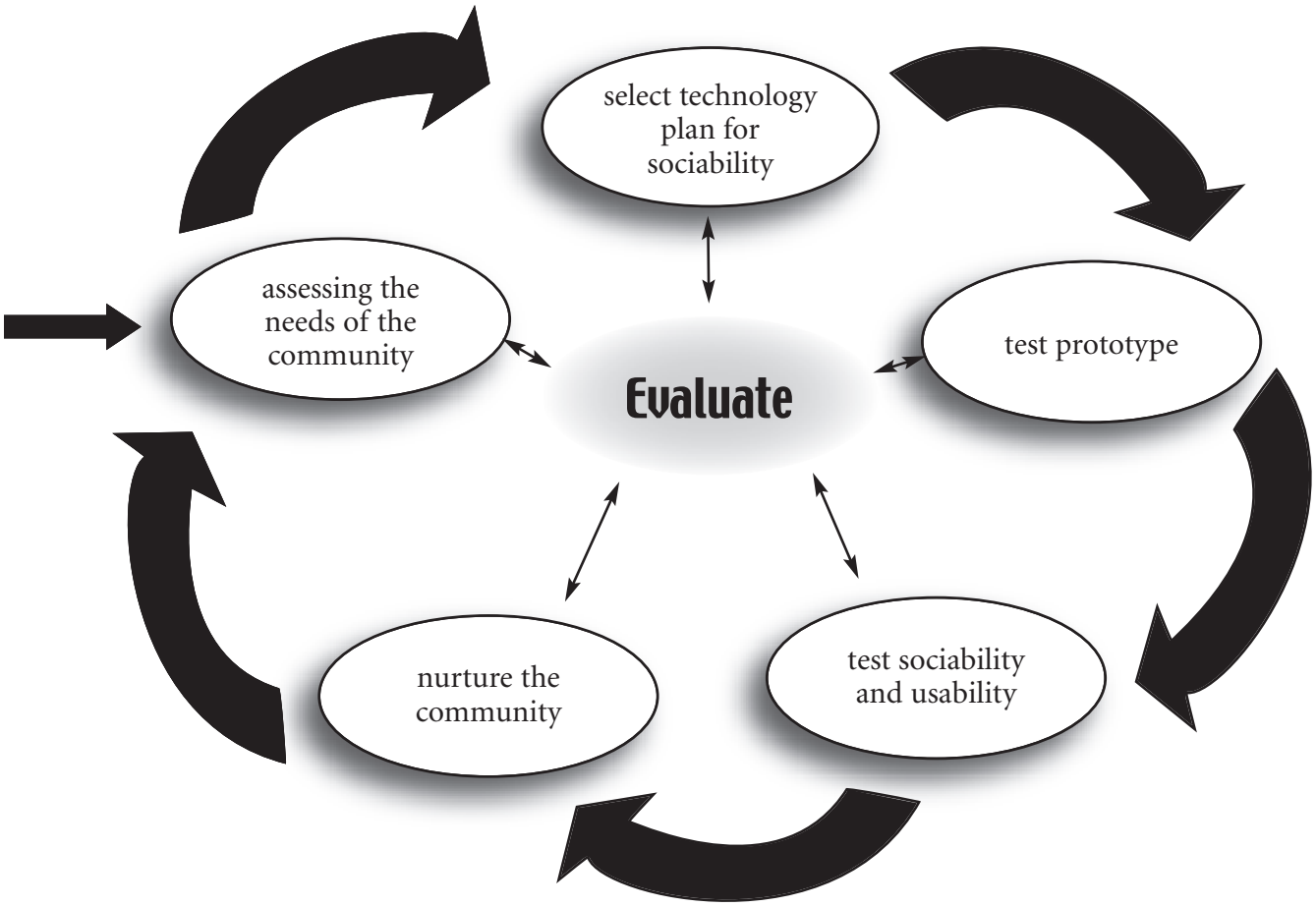

FIGURE 1. *The circular nature of participatory design*

computer-related systems. Shneiderman has observed that an interactive system is like a play: Extensive rehearsals are expected, especially close to opening night. Historically, usability tests are conducted in usability laboratories staffed by experts in user-interface design and testing. These laboratories are set up so that designers can observe the testers unnoticed. While large companies such as Microsoft and IBM still rely on usability laboratories, the cost of running such laboratories and the distributed nature of many systems make it increasingly common for developers to use mobile usability testing kits instead—at a fraction of the cost.

In computer design, before product implementation, paper mock-ups of screen displays can be tested in order to assess the wording and layout. Techniques that are employed in usability testing include thinking aloud (the user is asked to articulate all of his or her actions), videotaping the users in action, and interviewing the users or having them fill out questionnaires to gain insight into how well they liked the design under investigation.

Generally usability tests require typical users to perform typical, standardized tasks in a typical task environment so that the designers can learn how long it takes users to learn a specific function, how fast they perform the task, the type of errors they make, and at what rate they make errors.

After the product is released, it is wise to continue with evaluations. The most common methods for evaluating products after they have been released are interviews and focus groups. Both provide valuable information about user satisfaction and any problems with the product's functionality that might need rethinking. Data logging may also be performed.

Variations on Usability Testing

Usability testing has limitations: It does not cover all the interface features, and because it lasts for only a few hours in the laboratory, it does not reveal how the product is going to perform over long periods of time in the real environment. Furthermore, the small number of participants rarely represents the whole population of users.

The cognitive psychologist Deborah Mayhew recommends the usability engineering lifecycle as a complete approach to developing a human-computer interface. It 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 done 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 takes the place of the paper mock-up. 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.

Website usability testing can also take a user-centered approach. 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 websites are not tested before implementation. Usually testing is done with users and with experts through expert reviews. Experts can comment on overall usability issues while users can point out small problems related to tasks. 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 with usability testing is that it is expensive, which has prompted development of alternative testing techniques, the most well-known of which are heuristic (guidelines for evaluation) and discount usability testing. 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; the claim is that three to five reviewers identify around 80 percent of the usability problems. The low cost of these approaches makes them attractive to developers, but there is concern about their efficacy.

Participatory Design

In participatory design, users are in essence co-designers. The participatory design approach emerged in Scandinavia, born out of labor unions' push for workers to have more democratic control in their work environment. Because of cultural differences that may exist between users and designers (for example, users sometimes may be unable to understand the language of the designers), it is recommended that the team uses prototypes, such as mock-ups or paper-based outlines of the screen of a webpage or of a product. Prototypes are especially important given cultural differences, since they allow for hands-on work and transcend words. Other types of prototyping techniques are PICTIVE (Plastic Interface for Collaborative Technology Initiatives through Video Exploration) and CARD (Collaborative Analysis of Requirements and Design). The PICTIVE prototyping method uses 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. They allow the designer to map a layout of the product using a picture of each item to be included in the design. PICTIVE concentrates on the detailed aspects of the system, while CARD looks at the flow of the task.

In recent years the participatory design approach has been used for designing novel systems. For example, Allison Druin (2002), a scholar in the field of information studies, and her team have developed a version of participatory design in which children help develop children's software. Jenny Preece, a scholar of information systems, has developed a form of participatory, community-centered design for developing online communities. In 2003 the scholars Chadia Abras, Diana Maloney-Krichmar, and Jenny

Preece created an online community for a doctoral program using participatory design.

Advantages and Disadvantages of User-Centered Design

The major advantage of user-centered design is that it makes possible a deeper understanding of the psychological, organizational, social, and ergonomic factors that affect the use of computer technology. 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 safer.

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 is true if the small percentage of users involved in testing is a true representation of the users in the target population. This leads to a sense of ownership of the final product that often results in higher customer satisfaction and smoother integration of the product into the environment. If the process is not user-centered, it could lead to ill-thought-out designs. When users' expectations are not met, users may get frustrated or angry.

The major disadvantage of 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 people from different disciplines, particularly psychologists, sociologists, and anthropologists, whose jobs are to understand users' needs and communicate them to the technical developers in the team. The downside to this approach is that members of the team have to learn to communicate effectively and to respect one another's contributions and expertise. This can be time consuming and hence adds costs to the process. Management may question whether the added value is worth the cost, particularly if delivery dates are threatened. Fortunately, the concept of user-centered design is broad, and therefore flexible. As discussed above, certain types of user-centered design are less expensive than others. Given that involving users in design has been shown to result in more usable, satisfying designs, we expect that, despite its costs, user-centered design will continue to be popular.

Chadia Abras, Diane Maloney-Krichmar, and Jenny Preece

See also Cognitive Walkthrough; User Modeling

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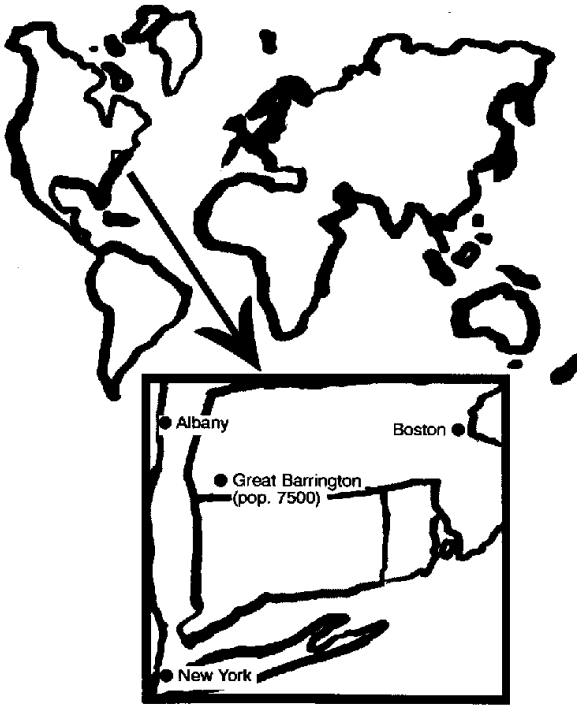

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