INTERNATIONAL JOURNAL OF HUMAN–COMPUTER INTERACTION, *12*(2), 263–276

Increasing the Usability of Online Information for Older Users: A Case Study in Participatory Design

R. Darin Ellis
Sri H. Kurniawan
Institute of Gerontology
Department of Industrial and Manufacturing Engineering
Wayne State University

This article describes one of the first documented participatory design (PD) efforts specifically aimed at older users. The goal of the project was to make an existing World Wide Web (WWW) site more user-friendly for older users, specifically in terms of display format issues. A PD team was assembled from a group of community-dwelling older adults and developers from a university research lab. After the developers established the trust and confidence of the participants and developed a conceptual user model (based on a survey and previous literature), the PD team evaluated the original design. Prototypes were iteratively developed and tested by the PD team to improve problems found in the original design. Specific design improvements and general design guidelines for older WWW users are discussed.

1. INTRODUCTION

The effort described in this article is part of a program of research to address the needs of nonprofit aging-services agencies as they adapt their practices to take advantage of new technology to better serve older adults. Networked computer technology is becoming a necessary tool for many agencies to maintain their effectiveness in a rapidly evolving operating environment. For example, many funding sources now mandate some form of electronic reporting. An additional step for these agencies is to reach out directly to clients and their families via the World Wide Web (WWW). There are two main barriers to effectively reaching the client population through this medium: (a) clients must have access to the technology;

We would like to thank The National Council on the Aging and Ameritech for funding this effort through their Innovations in Communications Technology grant program. We also gratefully acknowledge the efforts of Jarrod E. Jasper, Sakthivel Mettubavi, and Rajesh Pamulapati for their technical assistance in the project.

Requests for reprints should be sent to R. Darin Ellis, 87 East Ferry Street #226, Detroit MI 48202. E-mail: ellis@iog.wayne.edu

and (b) the technology must be user-friendly and facilitate retrieval of information that is clearly presented, well organized, and relevant.

There are a growing number of options available for those who wish to take advantage of Internet-based services and information. For example, many public libraries now have access to the Internet (United States National Commission on Libraries and Information Science, 1999), as do public housing facilities with the implementation of programs such the Neighborhood Networks program (United States Department of Housing and Urban Development, 1998). The project described here began to address the access barrier, complementing and expanding an ongoing development project called the ez-Senior Information System, or ezSIS (http://www.ezsis.org). The ezSIS is an aging-services Intranet developed to provide Internet-based information technology to service agencies and the elders they work with, thereby improving communication, increasing access to information, and providing new mechanisms for collaboration. In its initial version, the ezSIS was designed with service providers in mind (Ellis, 1999; Jasper, Ellis, Jankowski, Nagarajan, & Wajahath, 1997).

The primary goal of this project was to evaluate ezSIS design features and content to plan a "virtual service center" specifically suited to seniors, which could be accessed with community-based computer workstations (e.g., in libraries, senior centers, Housing and Urban Development [HUD] neighborhood networks). We dubbed this part of the ezSIS the "Community" section. Our motivating assumption for the project was that design revisions were needed to eliminate usability problems experienced by older users; that is, older adults would not take advantage of the inherent client-side flexibility in presenting HTML documents to alleviate problems on their own. Although there is limited extant literature regarding older adults' use of alternative browser preferences, our 5 years of community service and field experience in this area provided the basis for our project. A participatory design (PD) methodology was employed to focus the development of the Community section, particularly on older users.

2. PARTICIPATORY DESIGN: BACKGROUND ON THE METHODOLOGY

PD is an approach that focuses on collaborating with the intended users throughout the design and development process, rather than designing a system "for" them. The use of PD in information systems development was pioneered by researchers from Scandinavian countries (Blomberg & Henderson, 1990; Bodker, Gronbaek, & Kyng, 1993; Ehn, 1988). The most common interpretation of the PD philosophy enunciates three premises: (a) the goal of PD is to improve the quality of life, rather than demonstrate the capability of technology; (b) the orientation of PD is collaborative and cooperative, rather than patriarchal; and (c) PD values interactive evaluation to gather and integrate feedback from intended users, thereby promoting design iteration. Another critical aspect is that the designers gain knowledge of the work context, so that the new technology explicitly incorporates the values, history, and context of the work system (Ehn, 1988). Although these concepts have been developed in the context of paid work systems, the approach generalizes easily to the work of managing one's daily life, such as the task of accessing service information.

The ezSIS development team used a six-step process adapted from Good (1992) to translate the values and principles of PD into practice. This process has also been used successfully in similar projects (Ellis, 1999; Ellis, Jankowski, & Jasper, 1998). The steps are: (a) build bridges, (b) develop user model, (c) map possibilities, (d) develop prototype(s), (e) elicit and integrate feedback, and (f) continue the iteration. The first three steps are performed in preparation for rapidly proceeding through the latter three steps, which comprise design and feedback elicitation iterations.

2.1. Preparing for Participatory Design

Build Bridges

This step involved identifying key groups of end-users and forming a participatory design team of intended users and developers. The goal of this step was to open lines of communication between intended users and the developers.

The key end-user population was identified as older adults living in the greater Detroit metropolitan area, particularly those who live in HUD senior housing and similar senior-oriented residential facilities. This served to focus our efforts for the purposes of constituting a PD team and facilitated development of a user model (see following section).

The next step was the constitution of the PD team. The PD team included seniors from the community as just described and the developers (i.e., members of Ellis's research lab). The entire team varied in number from 10 to 15 people over the course of the project, including 7 to 10 community seniors and 3 to 5 developers. The developers were chosen from a multidisciplinary perspective, to include members with backgrounds in cognitive psychology, computer engineering, human factors engineering, and gerontology.

The pool of potential older participants was generated based on contact with the management of 16 independent-living senior residential facilities. All of these facilities were either in the planning or implementation stages of their own computer centers. Building managers were able to identify individuals who had helped or expressed interest in the computer center development process.

Trust and capability of the participants are two characteristics required for successful PD (Ellis, 1999; Ellis et al., 1998). Trust is important to make sure that everyone is comfortable contributing to the process. Some level of capability is required to recognize design limitations and potential solutions. To build trust and capability, the technical team offered a 12-week workshop (24 hr in total) on WWW usage. This initial investment allowed the participants to get to know the developers on a personal basis, in a context where they were receiving something of value.

Older participants. At the end of the 12-week skills workshop, the older participants were asked for their participation in the PD process. The scope of their participation, the scope and goals of the design project, and background information on PD were all provided in detail. All of the skills workshop participants chose to partici-

pate. As mentioned earlier, only 7 to 10 older participants were present at any one team session. The older participants ranged in age from late 60s to late 70s. They came from diverse socioeconomic backgrounds: Education varied from partial high school to college degree. Income data were not specifically requested, but some of the housing units rented at market rate, whereas others were government-subsidized low-income sites, indicating a range of income. Four of the participants were men. Two of the participants dropped out early because of health concerns. The remaining participants did not indicate the presence of any health conditions that would interfere with their participation. In addition to already having received free computer training, the participants were provided with free transportation and lunch on the team meeting days; no other compensation was provided.

Develop User Model

A user model is a representation of the users' needs, capabilities, and limitations that is used to guide design decisions. Traditionally, PD calls for ethnographic techniques in this regard (e.g., Good, 1992). Typically, ethnographic techniques call for job shadowing and other participant–observer methods in the natural setting of the activity targeted by the PD process. However, finding seniors who were actively using the WWW to seek out service information proved very difficult. As an alternative, the developers constructed a user model using two main sources of information: (a) a survey of the key end-user group, and (b) the literature.

Survey. The survey was distributed to all 16 senior housing sites associated with the key end-user group. A total of 1,599 surveys were distributed, and 318 were returned (a 20% overall response rate). The demographic data indicated a mean age of 77.4 years, mean educational level of 12.5 years (*M*s of 10.7–14.7 years across sites). The respondents were primarily women (81%) and not married (82%). About 20% indicated that they had used a personal computer before. Nearly 54% indicated that they had no computer knowledge, 24% indicated very little knowledge, and 19% indicated "some knowledge" or more. No one indicated that he or she was an expert. In response to questions regarding different applications (e-mail, games, word processing, WWW, making cards and banners), WWW usage was perceived as the least fun and the hardest to learn.

Literature review. The developers also reviewed the literature with respect to older computer users to flesh out the user model. There are several relevant cognitive, perceptual, and motor changes that occur with increased age (Czaja, 1997), and design features that may be sensitive to age differences need to be carefully considered.

Older adults generally take more time to perform most motor and cognitive tasks. In screen design, this means that fast-moving objects should be avoided (textual or graphical). For example, scrolling speed should be adjustable and set so that

an older viewer will realize that the screen has changed. Some notification should be given that the screen has changed when this occurs (Morris, 1994).

Vanderplas and Vanderplas (1980) compared the effects of several typefaces on reading efficiency in adults 60 to 83 years of age; the results indicated that 12- to 14-point font sizes yielded superior performance by the older adults. Morrell and Echt (1997) suggested that although font typeface has not received an enormous amount of empirical attention in the aging literature, the finding of the studies supports the idea that typeface choice affects reading performance for older participants. The finding suggested that Helvetica (a sans serif typeface) improved reading performance. Morrell and Echt also suggested color schemes, font thickness, physical spacing, justification, and line width. When the selection of text with a mouse is necessary, font-size selection plays an even bigger role. Walker, Millians, and Worden (1996) found that there is a critical minimum target size below which older adults cannot effectively use the mouse. The result was evident even for experienced users. A similar result was found by Kelley and Charness (1995), who described the difficulty in fine positioning caused by the age-related decline both in vision (particularly spatial) and in "moving and clicking" coordination.

The use of output devices that feature high display resolution can help older users to identify screen objects with less effort. Czaja (1988) strongly suggested, in particular, maximizing the displayed resolution of screen objects. Morrell and Echt (1997) suggested several ideas to increase the degree of contrast, such as increasing the contrast of focal objects, complemented by careful use of color, texture, and size variations. Many researchers (Czaja, 1997; Fozard, 1990) have noted that caution must be exercised with respect to the use of color coding, because there is some decline in color discrimination abilities with age, particularly in shorter wavelengths such as blues and greens. With particular regard to contrast, although the results have been mixed, some research has shown dark text on a light background to be more efficient for older adults (Murch, 1987; Tobias, 1987). Snyder (1988) noted that negative contrast may minimize distraction from glare, which older adults are particularly sensitive to.

Memory function declines somewhat with normal aging. Older adults experience particular difficulty with tasks that place demands on working memory resources. When using computer software, older adults may have problems recalling things such as a specific WWW page location (i.e., Uniform Resource Locator, or URL), previously followed links, or the current location in a particular WWW site (Mead, Spaulding, Sit, Meyer, & Walker, 1997). Recall takes more cognitive effort than does recognition; therefore, well-designed visual cues such as text links, buttons, and icons could significantly support older users. Graphical cues are useful in providing users with a sense of current location. Proper organization and amount of information on a screen are important because of the age-related decline in visual search skills and selective attention. Older adults have difficulty processing complex or confusing information and are more likely to pay attention to irrelevant information. Highlighting important information and using perceptual organization such as grouping would help older adults to access the necessary information more effectively (Czaja, 1997).

User model summary. Taken together, the literature and survey gave the developers on the PD team some awareness of the issues faced by older users. Specifically, the survey indicated that the older group targeted by the project was largely uninitiated to computers in general and did not know what to expect from the WWW. The literature provided some useful information on the specific design parameters that would need to be explored.

Map Possibilities: Specifying the First Prototype

This stage of preparation brought the PD team together for the first time; in this stage, the remaining information necessary to start the prototype iteration process was gathered. User perceptions of future information-seeking practices were mapped out with Futures Workshop exercise (Bodker et al., 1993; Greenbaum & Kyng, 1991). The Futures Workshop idea was originally developed to assist citizens' groups with limited resources in presenting their ideas to public policy decision-making bodies (Jungk & Mullert, 1987). This practice is reported to enhance the sense of shared responsibility between developers and users as they attempt to shed light on design problems, to generate a viable vision for the future design, and to discuss how to reach that future. This technique elicited problems with the current design and generated requested features and potential usage scenarios to guide the development of prototype design improvements.

The Community section's original design (see Figure 1) consisted of a group of resources that had evolved organically; that is, site managers had simply added material as it happened along without following an overall plan. Material included

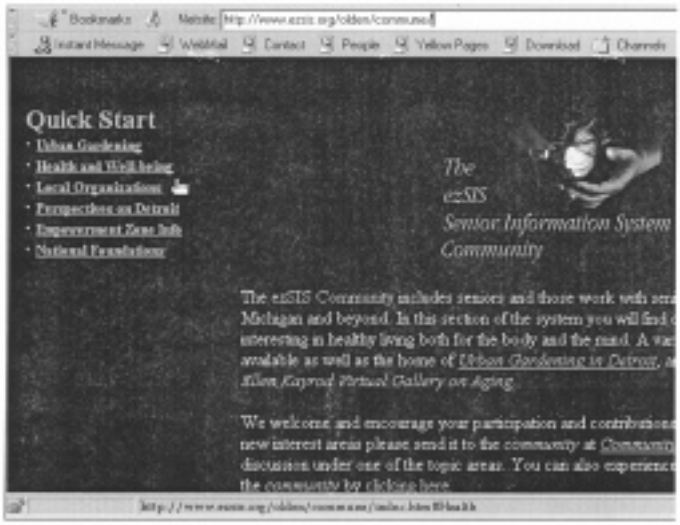

FIGURE 1 Original design of the ez-Senior Information System Community page aimed at older users.

lists of service agencies, information on Detroit, lists of grant-making foundations of interest to service providers, health information from different sources, and special interest material such as a subsection on urban gardening issues. The site design used a small (set to "size = –1") Times Roman font (approximately 10-point size using standard browser preferences) in positive contrast (white letters on a black background). The color blue was used intermittently as a technique for text emphasis. Links that had not been followed were colored aqua, and followed links were bright red. Links were generally either embedded in narrative or placed in unordered lists.

The overall site organization in the original design consisted primarily of long, multiple-topic pages. The distribution of topics across pages was not clearly guided by the topics' relation to one another. The primary navigation tool was a "Quick Start" menu placed in small text in the upper left-hand corner of the home page. This list consisted of small text in the original color-typeface scheme, presented in an unordered list. The links led to either specific sections of large pages (using a named anchor reference) or to separate pages. All of the top-level navigation choices led to pages hosted on the ezSIS server.

The participants were unambiguous in their critique of the site. They reacted most strongly to the color scheme, unanimously and immediately declaring the positive contrast unacceptable. Several participants made references to other sites with negative contrast that "looked nice" and were "easy to read." The team critiqued other aspects of the color scheme, indicating their confusion with the use of blue for emphasis and aqua for unfollowed link text. Link placement and size were problematic for some of the participants. They also reacted strongly to the text size, stating that it was too small. In terms of the site organization, the original design was confusing for the participants. In particular, participants felt that they lost track of their location in the overall site because of the named anchor tags. Additionally, they expected separate pages for distinct topics.

2.2. Design Iteration With PD

The Iterative Cycle: Develop Prototypes, Elicit Feedback, and Implement Changes

Prototyping is a technique used by developers to explicitly convey their ideas to intended users (Wilson & Rosenberg, 1988). Users change their expectations (and thereby change the product requirements) as a result of their experience with a prototype. By prototyping, an information system's requirements are refined very early in the development process. Whereas traditional methods of prototype development can occur in a vacuum, PD calls for a prototyping method proposed by Bodker and Gronbaek (1991). This method, called *cooperative prototyping,* allows users and designers to participate actively and creatively in developing a prototype. Cooperative prototyping was possible because of the flexible nature of HTML documents and WWW browsers. Different features and design parameters were explored using a large-screen (31-in. diagonal) personal computer connected to the

Internet in a conference room. The PD team interactively engaged in a cycle of page viewing, discussion and comment, reformatting, further viewing, and so on using an HTML editor and browser; this cycle was similar to the methods proposed by Gartner and Hanappi-Egger (1999).

For eliciting and interpreting user feedback, we used observation and open-ended discussion during four formal prototype evaluation sessions with actual users. The first session evaluated the first iteration of the new interface, which was based on information from the User Model and Futures Workshop (see previous sections). The subsequent sessions took place at approximately 1-month intervals and evaluated the improvement in each design iteration. Each session consisted of approximately 1.5 hr of hands-on use. The first half of the session was generally left to unstructured browsing, leaving the second half for group discussion. Feedback was recorded with a combination of notes and video recording.

3. RESULTS: THE EVOLUTION OF THE DESIGN

Despite the fact that none of the users specifically asked for the font typeface to be changed, the developers on the team decided to test the typeface guideline (i.e., to use a 14-point sans serif font). To minimize the number of combinations to test, the developers chose to develop five new design alternatives that captured a range of possible configurations. Each alternative used a different sans serif typeface (Lucida Sans, Franklin Gothic Book, Franklin Gothic Medium, Arial, Century Gothic), with several variations in size across pages. Each page was also given a different set of negative contrast colors (a light background with dark hues for text, emphasized text, and the various link colors). These alternatives were presented to the participants for extended viewing in one of the feedback sessions. After the participants became familiar with all the alternatives, the follow-up discussion focused on each of the dimensions of the design. A light yellow background was preferred, with standard black Arial font raised to "size = +1" (approximately equal to a 14-point font with standard browser settings). Text emphasis and link colors were chosen but were refined further in subsequent feedback sessions. The final colors were a light yellow background (#FFFFCC; note that the colors are denoted in hexadecimal RGB format), black text (#000000), dark blue unfollowed links (#000099), lighter blue active links (#3333FF), and dark magenta followed links (#330033). Colors chosen for the text on the graphic images for the navigation buttons were made identical using a common image editing tool.

Site organization was also reviewed with the PD team. In particular, parts of each feedback session were devoted to evaluating alternative topic organization and potential navigation tools. Evaluation of the topic and page organization revealed an interesting trade-off: The older adults on the PD team liked the idea of having fewer (larger) pages; however, the standard scroll bar slider was not a very powerful cue to indicate the presence of off-screen information. Additionally, the act of clicking a link was deemed easier than scrolling down a page, in terms of the motor skill required. Therefore, although longer pages were preferred (albeit only where conceptually appropriate), the PD team actually reported more trouble with them. For the

final page organization, designers first separated topics onto their own pages and then examined pages to make sure that page content did not break (i.e., with white space) in a way that could falsely indicate the bottom of the page. During the PD process, the team decided to add content on topics deemed relevant that were missing from the original design. This resulted both in adding more ezSIS pages and in pointing to content off the server itself. To manage the larger content of the new design, several prototype features were developed and evaluated, including using navigation pop-up menus and targeting content to new browser windows. None of the proposed content management features was acceptable for one simple reason: The users all browsed in a single window in full-screen mode. Launching a new window, either for presenting new content or navigation tools, disturbed users' strategy for keeping track of their browsing session.

As mentioned earlier, the navigation bar on the original home page was a bulleted list of links in the upper left-hand corner of the page, with link text tagged "size = –1." In an early usage-based feedback elicitation session, the older participants were observed having trouble with this navigation tool. After analysis of the session's videotape, the difficulties were summarized into four primary problem areas. First, the links were simply too small and difficult to select with the cursor. Second, there was virtually no dead space in the vertical direction between items. This led to the frustrating phenomenon of not only missing the target but also accidentally selecting an adjacent link. Third, the older users found that the standard feedback indicating that a navigation action is available (i.e., the cursor's changing from arrow to pointing hand) did not provide high-quality visual feedback. Finally, the link names were found to have considerable variation in their descriptive accuracy and information content. There was a consensus among the users that links needed to be more informative; however, the group did not agree on how this goal could best be accomplished. For example, several participants thought that adding a description next to the links would clutter the page, and therefore there was no consensus on the potential benefit of expanding the link text language.

The design iterated through several versions, incrementally addressing these concerns (see Figure 2). The final version used graphic buttons (180 pixels W × 22 pixels H) in the color scheme discussed in the previous section. By increasing the size of the targets in this manner, the new design improved the Fitt's Law index of difficulty for the items by a factor of 2 (see MacKenzie, 1992, for a review of Fitt's Law research). To increase the dead space around links, a line break tag was used between each of the images. JavaScript was used to add feedback to the link buttons with the "onMouseOver" event: When users touched the links, the image swapped to a similar image, appearing to rise up in three dimensions and to light up with a triangle pointer on the end and a lighter shade of text color. The total effect gave unambiguous feedback that the link was "clickable" without adding to the users' perception of clutter or complexity. All of the new link features (button size, placement, and feedback) were tested with multiple alternatives to heuristically arrive at the most desirable combination. The use of layers, the "visible" property of which was keyed to the onMouseOver event, allowed the developers to add additional text to better explain the content associated with each link without cluttering the page's default content.

FIGURE 2 Redesigned ez-Senior Information System Community page with features discovered, evaluated, and implemented using participatory design.

For the last of the feedback sessions, we focused on general display configuration issues that could potentially make all Web sites easier to use. The purpose of this final exercise was to determine the best overall display configuration. Four screen configuration alternatives were evaluated. The configurations were changed using the Display control panel in Windows 95. They were varied in terms of the Display Properties—Appearance by using the Windows-Standard and Windows-Standard (extra large) schemes, and in terms of the Display Properties—Settings by using two "screen area" resolutions (low: 640 × 480 pixels, and high: 1,024 × 768 pixels). Each participant was presented with randomly paired screen configurations displayed side by side. Overall, we identified eight elements that our participants considered important to interface design throughout the PD process. These elements were the ease of making menu selection; the ease in clicking on icons; the ease in clicking on links; the ease of using window controls (scroll, resize, minimize, maximize, and close); body text readability; body text legibility; system text legibility; and graphics size and legibility. For each of these elements, participants were queried for their rating on a scale using nine discrete semantic ratings (bipolar from *absolutely prefer A* through *no preference* to *absolutely prefer B*). Analysis of the ratings suggested that the participants preferred low-resolution to high-resolution screens across all rated elements but that the font size preference shifted when screen resolution changed: "Windows-Standard (extra large)" was preferred when screen resolution was high but was not preferred at low resolution.

4. DISCUSSION

The presentation and organization of information on the WWW is incredibly flexible. Users are given a large degree of control over the way they navigate and view information. Although this is generally viewed as a benefit to users, the trade-off in the current context is that flexibility increases complexity. This is particularly detri-

mental to the older user population; whether because of lower levels of experience or because of declining problem-solving and information-processing abilities, the older adults in this project did not take advantage of client-side features. Throughout the design process, the participants focused on changing the inherent visibility and legibility page parameters such as font size, font typeface, and color schemes. After 12 weeks of training, including a good deal of hands-on experience, the users did not typically remember that they could override page formatting with browser settings. Even the more advanced users, who knew they could override the parameters on hard-to-read pages, were reluctant to do so. Two common reasons were given. First, our users tended to rely heavily on toolbar buttons (reducing the apparent complexity of the interface); therefore, changing browser preferences through the menus was not easy enough, and hotkeys (such as Ctrl-]) were difficult to remember. Note that the participants were using Netscape Navigator, which does not currently have a toolbar button for changing font properties. Second, the act of changing preferences, especially color scheme and font typeface, is persistent. That is, the effect carries forward through other downloaded pages until the settings are changed back. Our participants relied on the consistent look and feel of pages to give them a sense of "where" they were. With persistent, difficult-to-toggle preferences, key transitions between linked sites could be missed. This leads to an unambiguous conclusion: The users who are most vulnerable to an inadequate WWW design may also be the ones least likely to override it with their own preferences.

4.1. Summary of Design Recommendations

The PD process facilitated a trial-and-error approach to minimizing usability problems. Some of the general principles that were extracted, largely supported by empirical literature cited earlier, include the following:

- Use a sans serif font, such as Arial or Helvetica. The literature generally supports the contention that older users perform better with these fonts, and our users found them to be both more appealing and subjectively easier to read than the serif font (Times New Roman) that was present in the original design. This observation is consistent with the findings of Morrell and Echt (1997).
- Use dark type on a light background (commonly referred to as "negative contrast" or "positive image"), emphasizing high contrast. We make this recommendation based on our experience with this group of users, despite the fact that the literature is mixed with regard to the positive–negative contrast issue (Murch, 1987; Snyder, 1988; Tobias, 1987).
- Make sure that links (a) are placed where they are easy to see, (b) are fairly large (the size settled on by the PD team here was 180 pixels × 22 pixels for a graphic button), and (c) have plenty of dead space around them to prevent accidental selection. This confirms and extends the suggestions of Czaja (1997) and Kelley and Charness (1995).
- Plan screen sizes to fit in lower resolution display settings, at least 800 × 600 and perhaps even 640 × 480 for monitors up to a 17-in. screen size. Plan for users to

browse with a single maximized (full-screen) window, and minimize the use of links and references to new browser windows. These findings have not been explicitly mentioned in the literature to date.

4.2. Insights From Participatory Design With Older Adults

For the group of older adults in the PD project, it was important to feel supported and respected as a partner in the effort. The technical team worked very hard to avoid behavior that could be viewed as exploitative, patriarchal, or patronizing. There was initially a tendency on the part of some (generally the less confident or experienced users) to not express opinions discordant with the views of more experienced users or to ask the technical team members their opinion first. Empowering all the seniors to have and express an opinion was very important. Supportive statements and open-ended probing in the PD sessions helped created a positive environment for expression and exploration. This pattern of behavior is similar to our experience with PD in work settings. There were a few differences, though. In the workplace, there are issues of interpersonal (supervisor–employee relationships) and organizational (competing system functionality requirements) power dynamics. We did not have to deal with these issues. Individuals did, as mentioned earlier, vary in their willingness to contribute. Also, as in any social situation, people assumed different roles within the group. These issues arose within the PD sessions, though, and were not implied at the outset. A second difference in working with this group was that they did not view us as consultants or salespeople there to convince them to adopt a new system. They viewed participation in the project as a service to other current and potential older WWW users.

The PD team sessions were social occasions for the seniors involved. Many came in pairs or larger groups. Sessions were held in the morning, and the entire group had the opportunity to have lunch together afterwards. Placing the PD activity in a larger social context for the seniors was a key to maintaining their interest in participating. The less socially engaged participants (i.e., those who came alone or who did not stay for lunch with the group) were less engaged in the design process, both in terms of missing sessions and in the level of contribution in sessions that were attended. Thus, the incentive that we provided developed better teamwork in addition to being a respectful "thank you." The keys to success in this project can be boiled down to the following rules: (a) invest in the relationship to develop trust, (b) communicate the importance and relevance of the project to the participants, and (c) engender a culture of partnership and mutual respect.

5. CONCLUSIONS

PD was used to arrive at an improved user interface for a relatively modest collection of material in a short period of time. Although the lessons gained in this project came from one design exercise, the high level of agreement among our participants (in spite of their diverse backgrounds) and the general agreement with the literature

lends support to the notion that our findings are firm and generalizable. When design choices are needed in the areas covered by our exercise, notwithstanding additional trade-offs that we did not deal with here, we feel confident that following our guidelines will lead to success in other settings.

It is unclear to what extent these guidelines will be useful to designers of sites with much broader scope and higher information density. In those situations, organizational and structural issues come much more into play. More research is needed with regard to navigation patterns of older adults and their relative success with and acceptance of sites with various architectures. With regard to specific within-page design issues, our guidelines should be generally applicable.

Finally, a note on the value of the scientific literature on older computer users: A common complaint levied against empirical human performance research is that lab results are rarely carried through to the point of becoming concrete design recommendations. As many developers have found in other efforts, our review of the literature on older computer users resulted in a list of guidelines that varied widely in their applicability and specificity. However, the project team's familiarity with the intended user group and their context of use, as well as the ability to quickly iterate through a series of principled design changes, allowed even vague guidelines to be implemented at a level of detail not available from the literature alone. Although deriving guidelines from empirical literature and designing with them in a vacuum may not necessarily be effective, even an abstract conceptual guideline can be successfully implemented when (as in PD) there is a way to quickly test multiple design interpretations.

REFERENCES

Blomberg, A. L., & Henderson, A. (1990). Reflections on participatory design. In *Proceedings of CHI'90: Human factors in computer systems* (pp. 353–359). New York: ACM.

Bodker, S., & Gronbaek, K. (1991). Cooperative prototyping: Users and designers in mutual activity. *International Journal of Man–Machine Studies, 34,* 453–478.

Bodker, S., Gronbaek, K., & Kyng, M. (1993). Cooperative design: Techniques and experience from the Scandinavian scene. In D. Schuler & A. Namioka (Eds.), *Participatory design: Principles and practices* (pp. 157–175). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Czaja, S. J. (1988). Microcomputers and the elderly. In M. E. Helander (Ed.), *Handbook of human–computer interaction* (pp. 581–598). New York: Elsevier.

Czaja, S. J. (1997). Computer technology and the older adults. In M. E. Helander, T. K. Landauer, & P. Prabhu (Eds.), *Handbook of human–computer interaction* (2nd ed., pp. 797–812). New York: Elsevier.

Ehn, P. (1988). *Work-oriented design of computer artifacts*. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Ellis, R. D. (1999). Introducing information technology to the aging-services network through cooperative design: An intranet for collaborating service agencies. *New Technology in the Human Services, 11*(3), 2–7.

Ellis, R. D., Jankowski, T. B., & Jasper, J. E. (1998). Participatory design of an Internet-based information system for aging services professionals. *The Gerontologist, 38,* 743–748.

Fozard, J. (1990). Vision and hearing in aging. In J. E. Birren & W. Schaie (Eds.), *The handbook of the psychology of aging* (3rd ed., pp. 150–170). New York: Academic.

Gartner, J., & Hanappi-Egger, E. (1999, March/April). Bringing participatory design to practical application: The interrelation between LCD projection, facilitation, and participatory design. *Interactions, 6*(2), 13–22.

Good, M. (1992). Participatory design of a portable torque-feedback device. In *Proceedings of CHI'92: Human factors in computer systems* (pp. 439–446). New York: ACM.

Greenbaum, J., & Kyng, M. (Eds.). (1991). *Design at work: Cooperative design of computer systems*. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Jasper, J. E., Ellis, R. D., Jankowski, T. B., Nagarajan, R., & Wajahath, S. (1997, August). Using cooperative design to introduce ORDBMS-driven Intranet applications to collaborating social service agencies. In G. Salvendy, M. J. Smith, & R. K. Koubeck (Eds.), *Designing of computer systems: Cognitive considerations* (pp. 97–100). Amsterdam: Elsevier.

Jungk, R., & Mullert, N. (1987). *Future workshops: How to create desirable futures*. London: Institute for Social Inventions.

Kelley, C. L., & Charness, N. (1995). Issues in training older adults to use computers. *Behaviour & Information Technology, 14,* 107–120.

MacKenzie, I. S. (1992). Fitts' law as a research and design tool in human–computer interaction. *Human–Computer Interaction, 7,* 91–139.

Mead, S. E., Spaulding, V. A., Sit, R. A., Meyer, B., & Walker, N. (1997). Effects of age and training on world wide web navigation strategies. In *Proceedings of the Human Factors and Ergonomics Society 41st annual meeting* (pp. 152–156). Santa Monica, CA: Human Factors and Ergonomics Society.

Morrell, R. W., & Echt, K. V. (1997). Designing written instructions for older adults: Learning to use computers. In A. D. Fisk & W. A. Rogers (Eds.), *Handbook of human factors and the older adult* (pp. 335–361). New York: Academic.

Morris, J. M. (1994). User interface design for older adults. *Interacting With Computers, 6,* 373–393.

Murch, G. M. (1987). Colour graphics—blessing or ballyhoo? In R. Baecker & W. A. S. Buxton (Eds.), *Readings in human computer interaction: A multidisciplinary approach* (pp. 333–341). Los Altos, CA: Morgan Kaufmann.

Snyder, H. L. (1988). Image quality. In M. Helander (Ed.), *Handbook of human–computer interaction* (pp. 437–474). Amsterdam: Elsevier.

Tobias, C. L. (1987). Computers and the elderly: A review of the literature and directions for future research. In *Proceedings of the Human Factors Society 31st annual meeting* (pp. 866–870). Santa Monica, CA: Human Factors and Ergonomics Society.

United States National Commission on Libraries and Information Science. (1999). *Moving toward more effective public Internet access: The 1998 national survey of public library outlet Internet connectivity*. Washington, DC: Author.

United States Department of Housing and Urban Development. (1998). *About neighborhood networks* [Online]. Available: http://www.hud.gov/nnw/nnwabout.html.

Vanderplas, J. M., & Vanderplas, J. H. (1980). Some factors affecting the legibility of printed materials for older adults. *Perceptual and Motor Skills, 50,* 923–932.

Walker, N., Millians, J., & Worden, A. (1996). Mouse accelerations and performance of older users. In *Proceedings of the Human Factors and Ergonomics Society 40th annual meeting* (pp. 151–154). Santa Monica, CA: Human Factors and Ergonomics Society.

Wilson, J., & Rosenberg, D. (1988). Rapid prototyping for user interface design. In M. Helander (Ed.), *Handbook of human–computer interaction* (pp. 859–889). Amsterdam: Elsevier.