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A NEW METHOD IN USER-CENTERED DESIGN: COLLABORATIVE PROTOTYPE DESIGN PROCESS (CPDP)

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ABSTRACT

To build upon user-centered design methods, we used a collaborative and multi-modal approach to involve users early in the design process for a website. This article presents our methods and results and addresses the benefits and limitations of the Collaborative Prototype Design Process (CPDP), including ways in which this new method can be implemented. The CPDP is an innovative approach to user-centered website design that emphasizes collaboration, iterative testing, and data-driven design. The CPDP balances the power and needs of users with those of designers and, thus, enables design teams to test more tasks and involve more users. We divided our initial team into three independent design teams to separately profile users, test usability of low-fidelity paper prototypes, and then create and test usability of resulting wireframes. After completing the user-centered design and usability testing, the three teams merged to analyze their diverse findings and create a final prototype.

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INTRODUCTION

User research, prototyping, and iteration that allows for both structure and innovation early in the user-centered design (UCD) process balances the power and needs of users with those of computer software designers and writers [1]. Design is "the art of making products that serve people," according to Richard Buchanan [2, p. 34]; however, designers and technical communicators frequently struggle to accomplish a user-centered design because, as Rettig points out, UCD is difficult when "you aren't your user" [3, p. 23]. Some design teams have attempted to accomplish UCD through methods such as brainstorming and expert evaluation [4-7]. Other teams have used design methods that involve actual and representational users—those who can test and react to realistic scenarios [8-10]. However, even if users participate in the design process as early as the prototyping stage, the product may still suffer from obstructions common to teamwork (e.g., groupthink, brainstorming problems, domineering personalities, and cognitive tunneling). To prevent these obstructions, designers have tested a multiple-team approach, which allows them to benefit from efficient time management and numerous perspectives and roles in the testing and design process [5, 10-12]. Although an excellent innovation, the multi-team approach is not well tested, and designers who use a multi-team approach tend to limit themselves to a traditional design process.

A common approach to UCD for websites is for a design team to profile users and create a prototype, followed by a wireframe and then the final design. Working with prototypes enables designers to more clearly identify the users' priorities [13] because when testing begins with a working product rather than a prototype, teams tend to focus on identifying their own design issues rather than on creating a UCD [12]. Many design experts recommend paper prototyping because of its simplicity, fast turnaround, and ease of use for the team and the user [10, 13-15]. When a design team begins with a low-fidelity but representative prototype, the team can easily alter the design to reflect the users' needs and abilities [16, 17], save money on the design process [18], identify design issues early in the process [10], strengthen the team and obtain quality design results [13], and shift from analysis to design [19].

In the prototype stage, the most important issue is to capture the vision of the final product [6, 20], a vision which paper prototyping can achieve. But despite its well-documented benefits, design teams often resist such a seemingly unstructured method. Designers are also frequently unwilling to involve the user at an early stage of design because they "sometimes worry that having to alter their work in response to user feedback will limit creativity" [11, para. 13]. Thus, most users are involved in the design process too late to influence the final product—an obvious shortcoming when a team is designing for interactivity.

PURPOSE

In our project, we were tasked with the website design for an annual educational seminar. Building upon UCD processes while also attempting a novel concept, our team of designers (with a combined total of more than six decades of design experience) elected to use a multi-modal approach to involve users early in the process. Primarily, we were interested in collecting data from potential users, thus involving them as codesigners. The process, which we named the Collaborative Prototype Design Process (CPDP), involved one team of 12 designers that divided into three independent design teams to separately:

- identify the user group,
- develop and test three independent paper prototypes for the same website,
- evaluate and interpret data,
- create three wireframes of a website,
- test those wireframes for usability with representative samples of users,
- gather and analyze data per team and collaboratively across teams, and
- merge designs to create one final, user-driven prototype of the website.

The CPDP is diagramed in Figure 1.

In the CPDP, users completed more tasks than they would with one team because each of the three design teams created its tasks independently. Teams tested similar tasks against multiple paradigms, and multiple wireframes resulted in more design solutions. Once the three teams merged their findings, they created a final product that synthesized the most usable design features from three different wireframes.

In this article, we provide the methods we used, present our results and analysis of the process, and suggest benefits and limitations of the CPDP and ways that other design teams can implement this new method.

MATERIALS AND METHODS

Our goal was to create a website that provided information to a user group about an annual seminar. Previously, the seminar organizers and attendees accessed several separate sites for necessary information. To avoid groupthink, problems with brainstorming, domineering personalities, and cognitive tunneling, our design team decided to implement the CPDP.

The CPDP involves four distinct stages (see Figure 1):

1. defining the user group(s),
2. developing and testing paper prototypes,
3. developing and testing wireframes, and
4. developing a final prototype for testing.

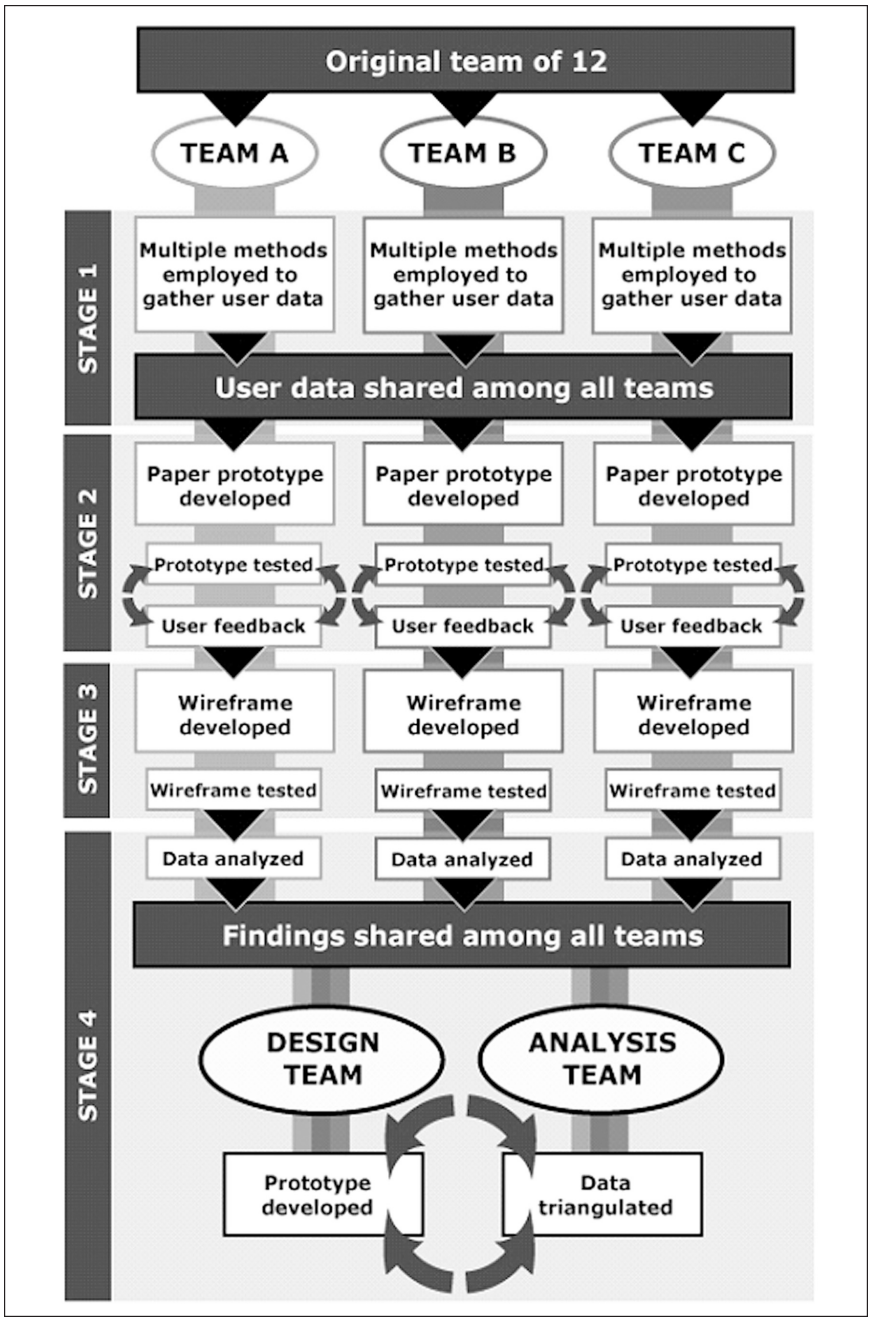

Figure 1. The Collaborative Prototype Design Process (CPDP).

As Friedman states, "[m]oving from a general theory of design to the task of solving problems involves a significantly different mode of conceptualization and explicit knowledge management than adapting the tacit knowledge of individual design experience" [21, pp. 153-154]. To address these needs, our design team integrated three separate design groups for the initial design and testing stages. During the four stages, our separate design teams did not interact, unless noted in our methodology.

Stage One: Defining User Group

We sought to create a website for a group of doctoral students who attend an annual two-week education seminar. The students are a diverse group who are distance learners from three countries. Each spring, the group meets for two weeks to study, collaborate, and plan for their next year of study. Students are diverse in age (26-58 years), in gender (with a ratio of two females to one male), and in working situation (some students are university faculty and some are working as communicators in the marketplace).

In our website design, three teams conducted independent surveys and interviews to gather information about the users and later shared this information with the other teams. By gathering information separately and then sharing findings, we established a better understanding of who our users were, what tasks they might need to perform on the website, and how they typically perform those tasks. Recognizing that "identifications of users' characteristics and groups is an iterative process, and user descriptions evolve when real data are gathered from users" [22, p. 1], we used different data-gathering techniques over two days to define our user group.

One demographic survey was sent to all members of the primary user group via an electronic mailing list and Twitter. This survey was followed by a series of interviews conducted to clarify and verify user characteristics and the tasks users would need to perform on the website. A final printed survey was administered to gather specific data on the social-networking preferences of the user group. (Members had previously received or sought information about annual seminars from multiple and diverse online sources, including a social networking page at www.Ning.com and e-mail and Twitter updates from other participants and seminar administrators.) In the course of data collection, the three design teams identified two primary user groups: users who had previously attended the seminar and users who had never attended but would in the following year. Due to time and distance constraints, we tested one user group: those attendees who had previously attended the annual seminar.

Stage Two: Developing Testing Paper Prototypes

After determining a representative user group, three four-person design teams—Teams A, B, and C—each created a low-fidelity paper prototype of the seminar

website. Teams did not interact during this stage so as to minimize teams influencing each other; each team created an independent design on which to test the representative users. We chose to begin with paper prototypes because their advantages include low cost and low investment in terms of design time [13], and they are easier to change than is a high-fidelity website [10, 23]. We wanted to test at least two iterations of our proposed site, and the low-fidelity prototype would yield more data with minimal investment.

To ensure minimal resource investment, each team used easy-to-find supplies. Each team tested individual low-fidelity prototypes on two users from the user group. Team A chose to use a whiteboard with erasable markers to create its low-fidelity prototype (see Figure 2). The team began with an outline of a homepage and several blank pages in the prototype. During user testing, one team member spoke, encouraging each user to talk about his or her expectations, while another team member wrote on the board and on sticky notes to document what the user said. The other two team members silently documented the conversation on a laptop.

Team B used poster paper and multicolored sticky notes on which they documented what the users wanted (see Figure 3). One team member encouraged users to move things around and speak aloud, while a second team member wrote on the paper prototype. The other two team members silently documented the conversation on a laptop.

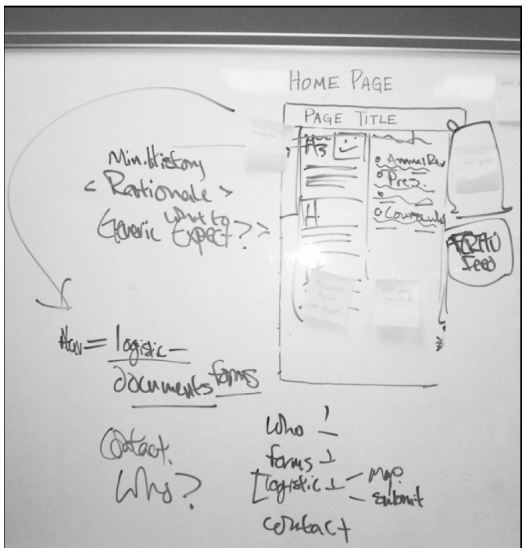

Figure 2. Team A's paper prototype: whiteboard technique.

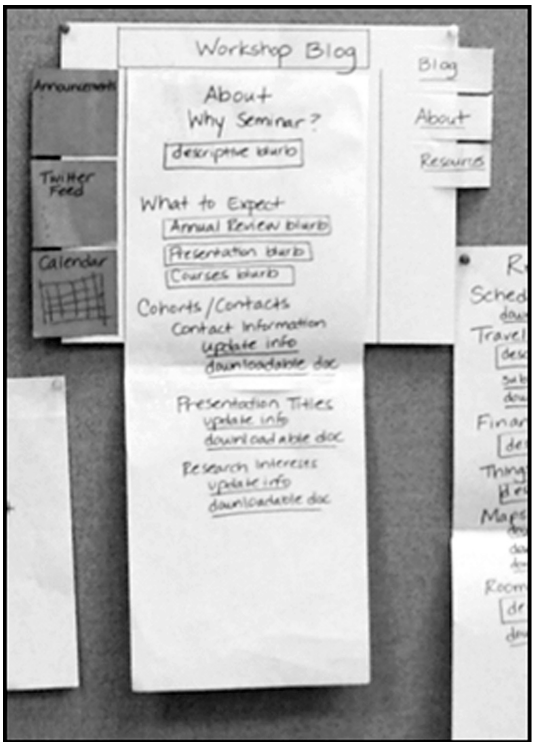

Figure 3. Team B's paper prototype: poster technique.

Team C began with a paper diagram of the website and used multi-colored sticky notes to document user comments during the paper prototype stage (see Figure 4). While two team members documented the conversation, one team member wrote notes on sticky notes and placed them on the paper prototype, and one team member encouraged the user to explain his/her thinking process.

After assessing their surveys and prototype designs, each team created a task list and a script for usability testing. Tasks were based on the user group surveys and the areas of importance that were identified. Because all members of our design team were also part of the user group, the teams conducted a second test of their prototypes with a member from another team, using these task lists and scripts based on the responses from each of their first paper prototype tests.

During the paper prototype testing, all three teams used Boren and Ramey's speech-discourse version of Think-Aloud Protocol (TAP) [24]. In TAP, users speak aloud as they test a product to share their thought processes, opinions, and decisions. When users participated in TAP, the design teams were able

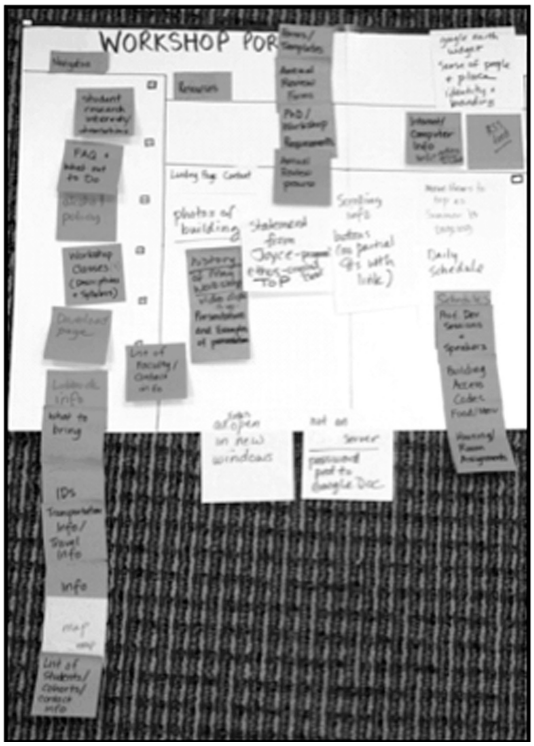

Figure 4. Team C's paper prototype: sticky-note technique.

to follow how the user successfully or unsuccessfully used the prototype and therefore could identify more information than just the user's activities.

By providing each team with the opportunity to test users but in separate situations and with differing methods, we increased the iterations of testing to allow us to investigate the usability of our designs from multiple perspectives. As a result, we increased the feedback we received and thus believe we were able to better involve users in the initial design and wireframe testing and thus to create a more usable design in the end.

Stage Three: Developing and Testing Wireframes

Based on the feedback that the teams received during the paper prototype tests, each team constructed a wireframe. Of the three wireframes, two were constructed in Microsoft PowerPoint and one was constructed in Adobe Dreamweaver. While the wireframes were being constructed, the three design teams administered individual prescreening surveys to determine which users would best

represent the user group. Because the seminar user group has a ratio of two females to every male, the sample did not exceed that gender ratio. Each team selected its own three representative users.

Each design team established user tasks to test on its wireframe. Testing a website with sample users performing a set of pre-determined tasks is generally considered to yield the most reliable and valid estimate of its usability. With these tasks, we aimed to examine the extent to which the website would support the users' needs. Our design teams brainstormed and designed tasks to simulate "real-life" situations that users would encounter while using the final website. Teams were not limited to the same tasks because the goal was to find some commonality in tasks without having possible representative tasks dissolve into groupthink. The three teams chose a total of 13 tasks, with overlapping or recurring tasks as illustrated in Figure 5. Of the 13 tasks, the Venn diagram below

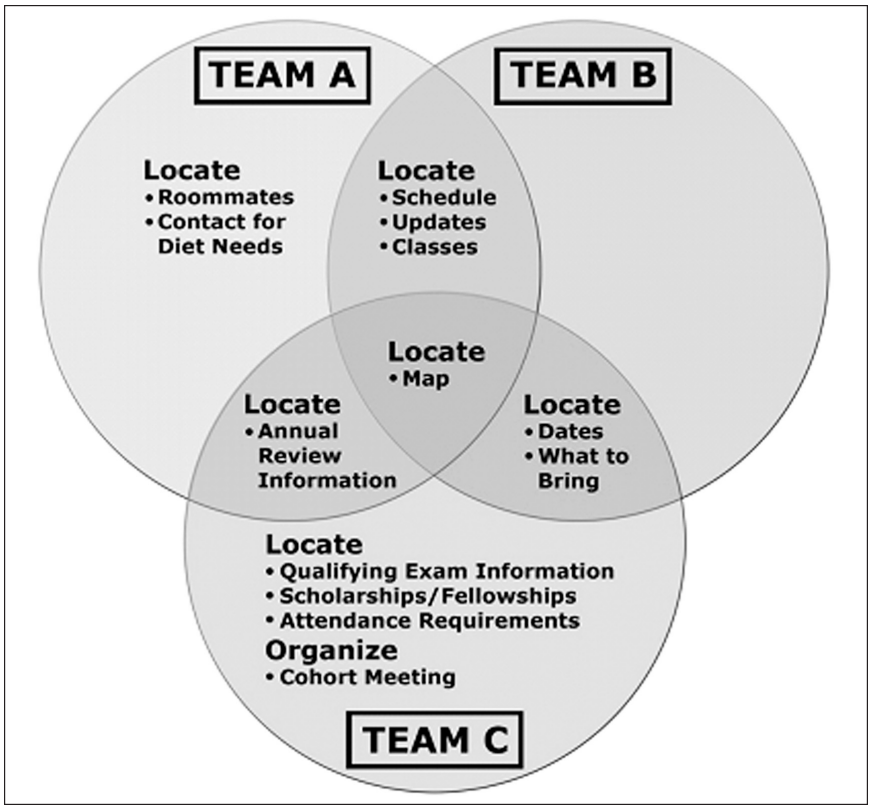

Figure 5. Overlapping website tasks uncovered by three design teams during usability testing.

shows that six tasks were used by two teams, and one task—to locate a map of the seminar site—was chosen by all three teams. Two tasks were unique only to Team A, while four tasks were unique only to Team C. The different tasks tested by each group were important when wireframe testing was complete because these tasks gave richer user-centered feedback to the designers than if only one team had tested their team's specific tasks.

Multiple methods were employed by the design teams to garner as much information about the usability of the wireframes from the users as early in the production process as possible. The three teams used a variety of facilitation methods: TAP, Active Intervention, and Retrospective Recall. TAP [24], as previously defined, is a method in which the user speaks throughout the test to explain his or her thoughts and justifications for actions in relation to the tasks. During Active Intervention, a protocol defined by Dumas and Redish, one member of the team sits with the user during the test and prompts him or her with open-ended questions to encourage the user to explain his or her thought processes [25]. In Retrospective Recall, the user completes the tasks in the test, and then one team member questions the user about his or her experiences during the test.

At the start of each testing cycle, participants completed a demographic pretest to ensure that each user fulfilled the characteristics of the average seminar user. The facilitator then explained the facilitation method (TAP, Active Intervention, and/or Retrospective Recall) that would be used during the test. After the test, each user completed a posttest to evaluate the testing process; however, the pretests and posttests did not address the user tasks.

The usability tests were conducted in a professional usability laboratory made up of two rooms that are divided by a one-way mirror. During each usability test, teams recorded audio, visual, and screen-capture data on a desktop computer in the observation room using cameras that were mounted on the ceilings and desktop computer in the testing room. A wide variety of data were collected, including user comments, task starts and completions, and task errors. All three groups used TechSmith's Morae software to facilitate coding; however, each team coded its markers with different scales: Team A used the Dumas-Redish Scale, Team B used the default Morae markers, and Team C used Boren and Ramey's TAP. This decision was not intentional; rather, each team decided on error-marker scales based on their individual member preferences for analysis.

Although the user group that we tested was diverse and representative, their feedback was consistent. While testing the medium-fidelity wireframes, users communicated their preferences about aspects of website communication; in fact, all three teams found that user preferences were mostly unanimous. Of the preferences that users either shared or diverged upon, the design teams had either not considered those preferences or had regarded those options as unlikely. Three teams provided more user feedback than we had expected.

Stage Four: Developing Final Prototype Testing

Each team independently analyzed its data from the usability tests of its wireframe, and then the three teams merged as one team to report results and talk through a preliminary analysis of those results. Again, by having teams separately create and evaluate wireframes, we were able to expand the iterative quality of our testing, thus providing more opportunities for users to evaluate drafted designs during the process and integrating more perspectives into the creation of the final design. Furthermore, by structuring the process so that three teams tested three different wireframe prototypes, we were able to ensure that the final prototype design was truly user-centered, rather than the result of the design teams' personal preferences. Once each team reported its findings, the merged 12-person design team reorganized into two groups: design and analysis. We selected one member of Teams A, B, and C to represent each of the original teams in our new groups for seamless access to data and experience generated in the previous design stages. By redistributing our teams into new groups, we were able to take advantage of various strengths. The design group took the data that the teams collected in wireframe testing and created an iteration of the wireframe to create a final prototype of the website. The analysis group worked on triangulation of the data from each team's report to ensure that the design group incorporated all findings into the final design. During the next two days, the design and analysis groups met informally several times to share developments and validate findings and then synthesized the results to create an optimal design for the final prototype.

RESULTS

Working independently on the same website design, three design teams generated distinctly different results throughout the CPDP, starting with the low-fidelity paper prototypes (see Figures 3, 4, and 5). The teams then combined their initial qualitative feedback and directly translated that data into medium-fidelity wireframes. Medium-fidelity prototypes are not sketchy and temporary, as are our low-fidelity prototypes, nor are they as detailed as high-fidelity prototypes; yet, they are still easy and cost-effective to change. For example, when a user selects a website link in one of our wireframes (which are shown in Figures 6, 7, and 8), the link works for the tasks that the teams are testing, but links that are unnecessary for testing are not active. Based on user screening tests, teams carefully considered the different paths users might take to complete tasks and ensured that links for those paths were active. These medium-fidelity prototypes—pictured in Figures 6, 7, and 8—were tested for usability, and those tests generated important qualitative and quantitative data that we will discuss further in our analysis.

The purpose of design is to create a product that our users can use for a specific purpose. However, if we had sought to create one option and tested its usability with users, we would have limited our opportunity to test the variety of tasks that we covered with three teams. In addition, we would have decreased some of the creative elements that different teams tested by limiting what users saw. These tasks and creative elements would have been decreased to testing one prototype that was created as a result of groupthink. Instead, we created three parallel designs and allowed our users to test all three of those designs to provide us with feedback on what worked and did not work; we exponentially increased our usability testing. We do not consider this three separate usability tests because our users and our purpose were the same. Instead, we consider this a multi-faceted usability method that gives the designers more time and feedback from users and then allows them to integrate the best of the designs into the final product.

Team A created a medium-fidelity prototype in Adobe Dreamweaver. Team A's prototype is shown in Figure 6. Team B created a medium-fidelity prototype in Microsoft PowerPoint (see Figure 7). Team C created a medium-fidelity prototype in Microsoft PowerPoint also (see Figure 8).

During the wireframe testing, recurrent thematic elements emerged from each analysis:

- Users want an interactive, authoritative calendar as a focal point of the website. The tasks associated with one supplementary calendar had the highest error rates and dwell times and twice the anticipated number of mouse clicks. The calendars in all three wireframes did not sufficiently meet even the basic needs of users.
- Users tended to leave the site when seeking current information. For example, users instinctively attempted to navigate outside of the wireframe when searching for "the most current" announcements.
- Users liked placement of updates in a blog on the home page because the information was easy to find and authenticate. The three users who specified that they liked the blog format completed the tested task with one mouse click, indicating familiarity and comfort.

These and other findings led to an almost unanimous desire from users for

- prominent display of a calendar, with comments such as "the schedule could be dynamic" and "emphasize calendar";
- timeliness of information, with comments such as "updates should be timely and from an authority" and "if I pull up a file like this, it couldn't be updated quickly";
- authority of information, with comments such as "I would go to the official site" and "I wouldn't go looking for forms here"; and

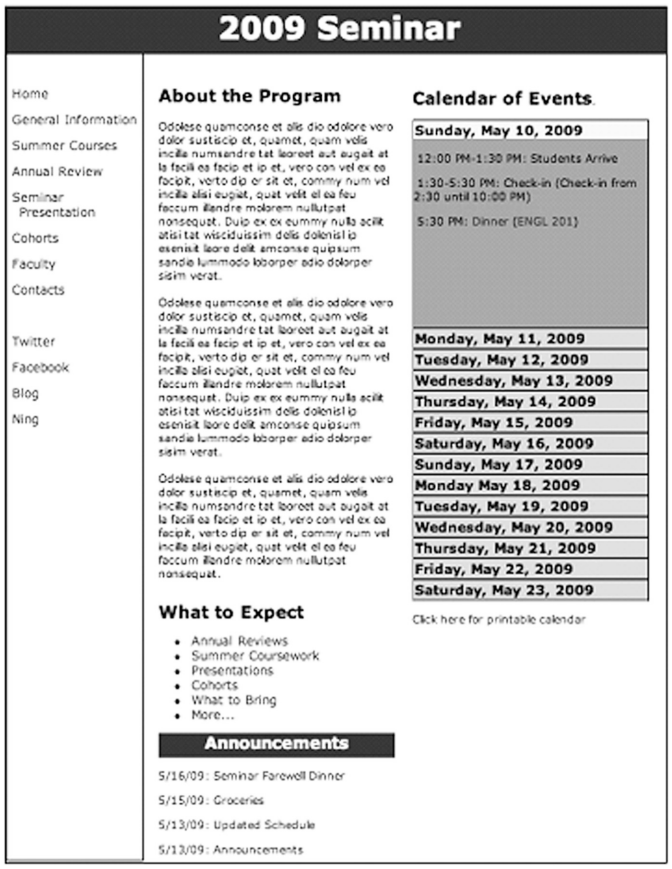

Figure 6. Team A's wireframe.

- continuity with existing websites, rather than elimination of them, with comments such as "Twitter is the only [source] with immediacy" and "I don't see any reason to get rid of Facebook [as a source of information for the seminar]."

The final prototype, which integrates the notes from the analysis group and the work of the design group from the merged group of 12 designers, is shown in Figure 9. To create the final prototype, the design group integrated the users' comments and requests, the usability test results, and the paper prototype results. By combining the successful elements of each wireframe, we were able to create a website design that more closely meets the users' needs and expectations.

Figure 7. Team B's wireframe.

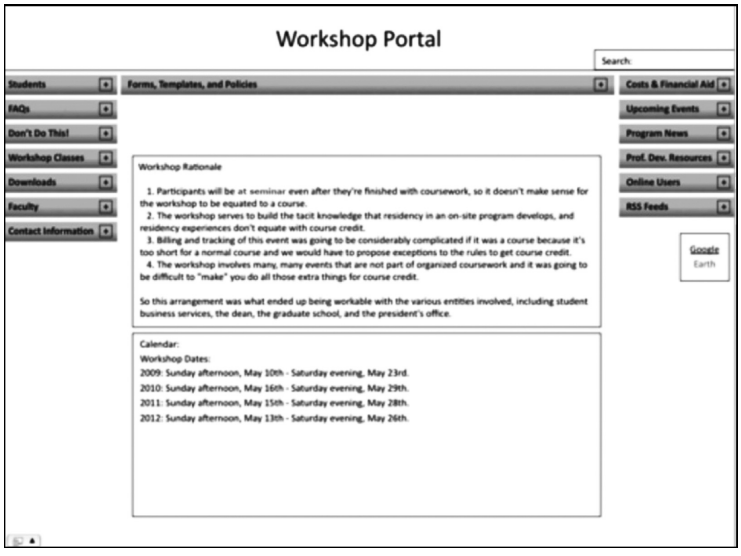

Figure 8. Team C's wireframe.

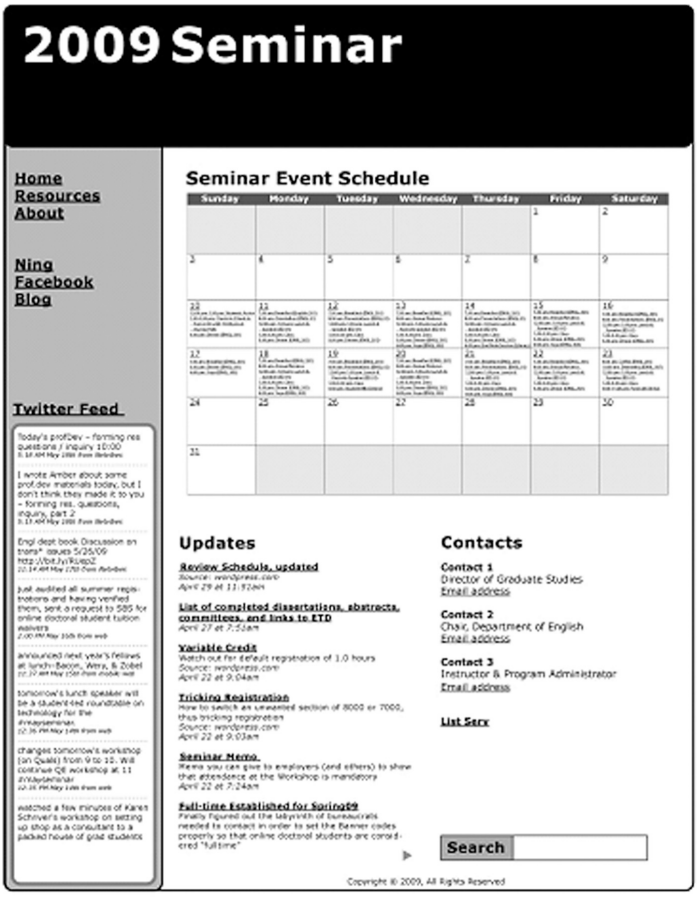

Figure 9. Final prototype.

ANALYSIS

We found that the CPDP demonstrated much utility and success in its initial inception. The process proved very useful because of the collaborative efforts that we used during the CPDP as well as the multiple team efforts and design processes that maximized user input at an early stage of the website design. During the paper prototyping and wireframe testing processes, the three design teams were able to identify the most important problems with our designs, which allowed the designers to make necessary changes early in the design process. Without this combination of prototype testing and independent development, we would have been less successful in identifying all of the major issues that we uncovered

during the design process, and this failure in usability testing would have resulted in serious complications after product release.

A primary benefit of the CPDP is the minimization of groupthink. As Irving Janis has noted, groupthink often results in poor decision-making [26]. Therefore, rather than gathering all designers around a table and choosing one option for the entire group, we allowed for individual creators to test different designs to meet the same purpose. Users completed more tasks in our tests because we created tasks independently in three groups. We also tested similar tasks against multiple prototypes, and our multiple wireframes resulted in more design solutions.

By minimizing the potential pitfalls of groupthink, the CPDP created a UCD. Ultimately, more user needs were uncovered and addressed during low- and medium-fidelity usability testing than would have been discovered if we had tested during high-fidelity or end-user prototype testing. For example, the tasks created for testing the usability of wireframes included 13 unique tasks that addressed a wider spectrum of user needs than the typical six to eight tasks that a single usability test would address. Tasks varied in their relevancy: for example, one task enabled our users to locate information that >80% of our users need (directions), while another task directed users to find information that <15% of our users need (dietary concerns).

Because of the CPDP, our design team gathered more information and data than existing processes would have allowed, and we were able to triangulate our information and data between the independent design Teams A, B, and C. All three teams worked toward the same goal and tested different paper prototypes and wireframes. The CPDP exposed a greater variety of user concerns because those concerns were articulated in multiple representative tasks. The CPDP truly encapsulates UCD.

Because each team worked independently, three different solutions to these problems emerged: three medium-fidelity wireframes became the subject of usability testing. As a result, our final prototype, which emerged from our use of the CPDP, was a combination of three designs and thus a richer solution, which was more meaningful to the user group. For example, the calendar design in each wireframe was tested as a completely different concept: Team A used a drop-down menu, Team B used a monthly calendar, and Team C used a list. As a result of user feedback and navigation difficulties during usability testing, we decided to change the calendar's overall design and move the calendar to a location where the majority of users found the information most useful. If our design team had created only one design, we would not have benefited from the feedback that the two other designs provided.

Similarly, each wireframe contained differences in page headings and menu items, and user feedback during usability testing identified the headings and menu items that users found most useful. Because users expressed concern about whether data was official and timely, the design group incorporated date and time stamps as well as a signature of the information source into the final

design prototype. Again, each wireframe contained differences in the design, wording, and location of information, but by testing three wireframes, the design team was able to gather more user information about user needs for the final prototype.

Although flexible, the CPDP incorporates both low- and medium-fidelity prototyping; therefore, designers may discount it as a valid method. However, with three potential design solutions, revised through multiple iterations, the CPDP uncovers greater user needs than does a process that tests only one paper prototype, only one wireframe, or a high-fidelity design later in the design process. Because of limited time and money investments, low-fidelity (paper prototypes) and medium-fidelity (wireframes) testing by our design team produced significantly more data from users at a very early stage in the design process. The CPDP allows users to focus on substantive suggestions about layout, navigation, and content rather than cosmetic elements about color, font, or button design. The CPDP allows users to become codesigners, to consider multiple design possibilities, and to make more suggestions early in the process of creating a product.

The greatest limitation of the CPDP is that the process requires more people than an individual designer or a small design team would normally require. In our situation, our original design team included 12 experienced designers, and once we divided into teams, we created three teams of four designers each. A usability testing team may not have the luxury of this many designers. The CPDP may have other limitations, such as time and manpower. The initial time spent with users is high during the paper prototype stage. An additional limitation is team coordination and management, which is necessary when working in several groups and using multiple prototypes. As with any design process, user input must not be circumvented. Designers could easily bypass one of the stages of the CPDP, potentially ignoring valuable user input.

CONCLUSION

As designers have become more interested in and receptive to usability and iterative prototyping, more efficient and effective design models are needed, particularly user-centered processes that involve users early in the design. Our new process, the CPDP, offers all the benefits of UCD along with additional benefits, such as decreased cost and time, increased user comments and suggestions, and multiple prototypes that enable more usability testing of more design options. Our evaluation of the CPDP determined that this collaborative, multimodal process is effective and could be easily replicated. We would encourage such replication.

Although we acknowledge that CPDP currently has some limitations, we would argue that these limitations are offset by the user-centeredness of this process. Multiple design characteristics are identified early in the process, and the information can be included as soon as the paper prototype phase. Bringing

in users at this point allows them to participate as codesigners in the entire design process, and it also offers designers the ability to test multiple options or approaches. Thus, the CPDP attempts to balance the power and needs of users with those of designers. The CPDP enables design teams to test more tasks and involve more users. The CPDP also enables designers to independently verify and triangulate trends in the users' abilities to successfully complete tasks. Future research opportunities include applying this technique to more diverse and multiple user groups. This process could also be used online to allow virtual teams to test the CPDP process.

The CPDP adds to the UCD community by building on current approaches to design teamwork. This new process also offers a potential management model for large-scale design teams. The model could enable companies with multiple sites to test local users and then coordinate analysis and design, reinforcing the value and practice of centering multiple users and designs in the development process. Furthermore, the CPDP could be applied to large-scale writing projects in which multiple parties work in an iterative manner to produce user-centered texts—the kind of projects common to technical communicators. Because the CPDP offers the benefits of iterative testing, user-centeredness, and multiple means of data collection, the process could be utilized in any large-scale technical project that requires an economical, yet still richly detailed, means of identifying and fulfilling user needs.

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