Designing a User-Centric Web Site for Handheld Devices: Incorporating Data Driven Decision Making Techniques with Surveys and Usability Testing

Authors: Suzanna Conrad, Digital Initiatives Librarian, California State Polytechnic University, Pomona, skconrad@cpp.edu; Julie Shen, Business and Computer Science Librarian, California State Polytechnic University, Pomona, jshen@cpp.edu

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Abstract

Cal Poly Pomona University Library launched its first mobile Web site in 2007. The continuous development of our mobile Web sites has mostly been informed by feedback from library staff rather than from student users. As mobile devices and tablets become more prevalent among college students, it is crucial to gain a better understanding of students' mobile and tablet usage patterns so that more decisions are data-driven and based on user expectations. This article details the findings from a study assessing the usability of our library's Web site for tablets and mobile devices, which includes survey feedback and three rounds of usability testing.

Keywords: data driven decision making, user-centric Web site design, mobile usability testing, tablet usability testing, multi-criteria decision making, MCDM

Introduction

User feedback is important in Web interface development. This includes mobile Web sites, which are increasingly being utilized by library users. The emergence of responsive Web design allows for the possibility for Web programmers to create one Web site that can be used on computers as well as handheld devices. To determine whether a responsively designed Web interface would be suitable for our library users, we decided to gather user feedback.

Questionnaires and usability testing can both be effective methods of collecting user experience data to inform Web development. In our research, we used both a survey and a round of usability testing to collect initial data for a Web redesign project, and then we tested our design with two additional rounds of usability testing.

The development of Cal Poly Pomona's University Library Web site had followed a similar pattern for years: the homepage and main navigational pages remained stagnant, with major changes occurring only when the campus Web templates were overhauled. Over time, the homepage evolved into a repository of links pointing to the Library's expanding menu of services. User testing focused on validating design decisions and was restricted to a small group of expert users, which included librarians and library staff representing various units within the Library as well as occasional student assistants who were already familiar with the Library's services. The Library also had a mobile Web site, which was created in 2007. However, the script to redirect mobile users was never activated, and it was never publicized, and therefore it remained largely under-utilized.

In 2013, the University's Web site underwent its latest design overhaul, which embraced a responsive Web design that functioned both on traditional desktop computers as well as mobile devices. Responsive Web design, a term that became more widely used after a 2010 article from Web designer and developer Ethan Marcotte, is the concept that a responsive Web site will be displayed similarly or consistently across devices with varying screen sizes. Responsive Web design requires maintenance of only one Web site that is optimized to expand or shrink to fit the device on which it is viewed; therefore if a responsive Web site is maintained, often the need for a separate mobile representation is nullified.

With the Library's Web site scheduled to be transitioned to a new content management system that featured a responsive design during 2014, we saw this as a unique opportunity to gather feedback from students to inform an iterative process of redesigning and testing. We were awarded funding for this research through the Cal Poly Pomona University President's Research, Scholarship, and Creative Activities grant program, which covered a period of January 2013

that these examples will satisfy the needs of their users.

To fulfill this goal, this study had three primary objectives. First, we wanted to determine what preferences our users had for accessing library resources on their handheld devices. Second, we developed an evaluation matrix for rating Web sites from other university libraries. This evaluation matrix, which incorporated feedback from a survey to determine the importance and weight of services, allowed us to directly compare the services our students were requesting to the services on another library's Web site. Third, we conducted usability testing on Library mobile Web sites to evaluate whether users were actually satisfied with their experiences on those sites. All three of these objectives supported our goal of incorporating user feedback for better data-driven decision-making.

Literature Review

Web Usability Defined

What is usability? The International Organization for Standardisation (1998), a group that authors standards to ensure that products are consistently produced according to a certain quality, defines usability in ISO Standard 9241-11 as “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use.” This ISO Standard is frequently referenced as a guideline in library Web site usability testing (Genuis 2004). In *Usability 101: Introduction to Usability*, Jakob Nielsen (2012) mentions five components, two more than the ISO standard, which make an interface usable: learnability, efficiency, memorability, errors, and satisfaction. In a comparison between LIS research and actual practices in the field, Yu-Hui Chen, Carol Anne Germain, and Abebe Rorissa (2011) define usability as the following:

Usability means that a system has visible working functionality familiar to its users, maximum readability, and useful content that is supported by its environment and aligned with context of use. In addition a usable system accommodates the cognitive capacity and various needs of its users, so that they can easily understand, effortlessly learn, and dynamically interact with the system as well as its content, resulting in a satisfactory experience with a high level of productivity (621).

The last part of this definition is more specific than other definitions of usability due to its focus on user perceptions and experiences. Frequently, measures of usability, such as usability testing, are conducted by expert users or the designers themselves, rather than through interactions with users. The pitfalls of expert users designing Web sites without significant feedback from users is not a new topic in LIS literature. Yong-Mi Kim (2011) highlights how user-centered design can be inhibited by “institutional forces;” rather than determine what the users themselves need, often Web designers consult other Web sites to assess the quality of those Web sites and to determine what elements to include (99). Yu-Hui Chen, Carol Anne Germain and Huahai Yang (2009) acknowledge the potential issue with Web committees determining design function and features in that they may not always meet users’ needs and expectations. Additionally, Web designers are not always aware of the problems or issues with their Web sites. Collecting user feedback and considering the user during the design process can help designers honestly assess the success of their interface.

User Centered Design Defined

The Usability Professionals' Association (2013) defines user-centered design as “an approach to design that grounds the process in information about the people who will use the product.” These users may have very diverse needs. For instance, students are not the only users of library Web sites; library staff are also frequent users (Turnbow et al. 2005). In addition, consortial sites need to serve both institutional members as well as the consortium overall (Bossaller et al. 2008). Nina McHale (2008) cites the importance of understanding why users visit the library Web site so that design can be more user-centric (140). However, the “librarian knows best” attitude frequently prevails at many institutions. Yunchen Huang and Lesley Strawderman (2009) recognize this issue:

Partly due to the non-profit characteristics of the library system, libraries have extensively relied on what they believed was good for their customers and tended to structure their holdings and services around their belief rather than studying customers' needs and behaviors, as most business organizations are focusing on (193).

The library is losing the struggle against other information service providers. Back in 2005 Pamela Harpel-Burke stated, “libraries are no longer competing solely with bookstores but with the entire Internet,” and urged libraries to adapt their standards to suit the commercial Web design standards to which their users are accustomed (206). More recently, Kim (2011) reasserts this need to focus on the users' needs during the design process, because so many users are utilizing commercial Web sites that do not have the same depth as library Web sites (104). If users are not taken into account during the design process, libraries are only making it harder for users to find library resources, creating usability problems that result in “user failure” (Kress et

al. 2011, 156).

Mobile Usability

There is a wealth of literature on Web usability, including analysis of library Web site design. On the other hand, mobile usability -- especially tablet usability -- has only recently been addressed in the scholarly literature. James Hahn (2010) focuses on students' usage of a particular app on the iPod Touch and claims that search behaviors on mobile devices mirror desktop behaviors. Baker Evans (2011) surveys expert users about mobile usage and upcoming trends they identified that would take advantage of mobile technology. Hyejung Han and Wooseob Jeong (2012) examine the gap between users' needs and academic libraries' mobile offerings through an extensive survey. Many studies detail results from some form of mobile or e-reader usability testing (Aaltonen et al. 2011; Bowman 2012; Hegarty and Wustemann 2011; Miller et al. 2013; Paterson and Low 2011; Pendell and Yeh 2012; Tidal 2013;). Paterson and Low (2011) have the most comparable approach in terms of the goals of their research project to our research project: students completed a survey outlining their current mobile expectations and then participated in focus group testing on a number of mobile sites from other academic libraries, as the institution had not yet developed their own mobile site. Angela Dresselhaus and Flora Shrode (2012) conducted an online survey to determine actual mobile device usage, the purposes students had for using these devices, and their interest in accessing mobile services. None of these studies address a plan to target handheld devices in general; either they discuss usage of e-readers, tablets or usage of mobile devices.

Assessing Usability: Multiple-Criteria Decision Making (MCDM) & the Pugh Matrix

In this study, we were interested not only in usability and user-centered design, but also in incorporating more reliable and user-based decision-making processes to determine what to evaluate and test. Multiple-criteria decision making (MCDM) is a problem-solving method by which a decision can be reached despite varying and sometimes conflicting criteria (Yoon and Hwang 1995). It is often used in designing Web sites (Akincilar and Metin 2014; Cebi 2013; Cyr 2013; Huang and Huang 2010; Hu 2009; Tsai et al. 2010). A common feature of MCDM is the use of an evaluation matrix (Ball 2003; Cervone 2009; Damm 2012; Nicholson 2004; Yoon and Hwang 1995). Such matrices have been frequently employed by corporations to evaluate products and software (Brynko 2009; Pugh 1991). In particular, the Pugh Matrix allows products to be evaluated according to a set of requirements to determine which solution would best fit actual needs (Pugh 1991, 77). In addition, it acknowledges the importance of weighting certain objectives and includes weights for establishment of priorities (98). Christopher Hoyle and Wei Chen (2009) see the Pugh Matrix as a means to “compare alternative design concepts against customer requirements, with evaluations made relative to a base or favored concept” (272). Tay Hock (1997) cites the Pugh Matrix as a method to provide a rationale for decisions reached during the design process (194). Other researchers compare the Pugh Matrix to a number of other alternative procedures and determine that it results in superior outcomes overall (Frey et al. 2009). The Pugh Matrix has been used in engineering product development since its inception. Henri Défossez and Hassan Serhan (2013) discuss its usage in the development of orthopedic implants. It has also been used by librarians; H. Frank Cervone (2009) identifies benefits in using the Pugh matrix for complex decision making for the development of a digital library. There are, however, some caveats to using the Pugh Matrix for product evaluation. Christopher Hoyle and Wei Chen (2009) point out that the matrix is not a “comprehensive enterprise-level decision

tool” in that it helps make decisions “while considering product requirements, without consideration of uncertainty, customer demand, or enterprise profitability” (273).

Methodology

The methodology for this research was guided by the literature on usability, user-centric design, and data driven decision-making. We acknowledge that when tasks performed during usability testing are chosen by librarians, they are geared toward services that librarians deem to be important, which may neglect the students’ perspective. In 2006, Karen Schneider asserted that “the user is not broken.” This concept served as a guiding principle for our project. In addition, many previous usability studies focus on one type of usability tool to assess an interface. We wanted to use student feedback throughout an iterative process so that the feedback from one phase of the project would be used in a subsequent phase of the project. The phases of the project were as follows:

1. Implementation of an exploratory survey;
2. Development of an evaluation matrix to rate Web sites from other university libraries followed by an evaluation period in which the matrix was used;
3. Usability testing round one: testing of mobile Web sites from other university libraries;
4. Usability testing round two: testing of two mobile Web sites developed by our team; and
5. Usability testing round three: testing of the responsively designed mobile Web site in production.

Phase 1: Survey

For the first phase of this project, an online survey was conducted from February through March 2013. This 22-item exploratory survey included demographic questions as well as open- and close-ended questions (see Appendix 1). Participants were asked about smartphone and tablet ownership, data plan subscriptions, and current usage or interest in using certain types of services, including library services, on mobile phones and tablets on a Likert scale of current patterns or likelihood of using certain services. Participants were incentivized with the chance to win one of three \$10 gift cards and were recruited via sample email lists provided by the Office of Institutional Research & Academic Resources at Cal Poly Pomona as well as through promotional channels including campus email newsletters, digital signage, paper flyers, Web site banners, Web site news updates, and via social networking. While the survey was open to participation from anyone on campus, our marketing channels were geared toward student users and thus resulted in the higher response rate from students. Within the survey, participants were asked whether they would be interested in participating in individual usability testing. During the two-month survey period, 284 valid responses were received, 279 of which were from undergraduate (94 percent) and graduate students (6 percent). This percentage breakdown mirrors Fall 2013 enrollment at Cal Poly Pomona of 20,942 undergraduates (93 percent) and 1,558 postbaccalaureates (7 percent).

Phase 2: Development of an Evaluation Matrix and Evaluation Period

Based on the survey results from phase 1, we created a Web site evaluation matrix that reflected the interests of our students. We selected the library services that students showed the most interest in using on mobile devices or tablets and weighted them on a point system relative to student interest. For example, group study room reservations were weighted at 40 points due

to high interest in this service and computer workstation reservations were weighted at 10 points due to lower interest in this service. These weighted services were then incorporated into a Web site evaluation matrix based on the Pugh Matrix. The matrix allowed us to evaluate each weighted service on a Web site individually, but it also allowed us to look at each Web site as a whole in terms of evaluative functions and characteristics, such as responsiveness, performance or speed, and design or attractiveness. Figure 2 contains a sample section of the matrix for an evaluation of the pre-existing Cal Poly Pomona mobile Web site.

Evaluation Matrix			
	Project Weight	CPP library mobile	
		http://www.csupomona.edu/~library/m/	
Location of website/app		Averages	Points
Tested on (i.e. web browser such as Chrome, Firefox, or tested on a device)			
Working functionality (rate from 0-5, see rating key for more information)			
Reserving group study rooms	80	0.80	64
Search for books and media	80	4.00	320
Search for articles and journals	80	3.60	288
Search for eBooks	80	4.00	320
Maps & directions (where items are located, maps of library, GPS instructions)	60	4.00	240
Computer availability maps	60	0.00	0
Computer reservation system	20	0.00	0
Access course reserves	40	1.00	40
Working functionality	500		1272
	45.05%		
Speed of function (rate from 0-5, see rating key for more information)			
Reserving group study rooms	40	1.67	67
Search for books and media	40	5.00	200
Search for articles and journals	40	5.00	200
Search for eBooks	40	4.67	187
Maps & directions (where items are located, maps of library, GPS instructions)	30	5.00	150
Computer availability maps	30	0.00	0
Computer reservation system	10	0.00	0
Finding out library hours	30	5.00	150
Access course reserves	20	1.33	27
View events calendars	20	5.00	100
Find contact information for library staff/faculty	10	5.00	50
Speed of function	310		1130
	27.93%		
Technical functionality (rate from 0-5, see rating key for more information)			
Is the site responsive?	100	4.33	4
	9.01%		400
Type of scripting, technology (i.e. HTML, jQuery Mobile, Drupal, WordPress iTunes app)			
General performance (speed of network) (rate from 0-5, see rating key for more information)	100	4.67	5
	9.01%		467
General design / attractiveness (rate from 1-5, see rating key for more information)	100	2.60	2
	9.01%		233
TOTAL	1110	3502	

Figure 2: Sample of evaluation matrix

The Web site evaluation matrix included five major rubrics. Under “Working functionality,” a Web site was rated for ease of use of its various functions, e.g., how easy it was to make a group study room reservation once a student found this function. For each function

evaluated under this rubric, we developed a rating key with a description for each score. For example, a computer availability map received a higher score when a user could find an available computer's location on a map, rather than just see a total number of available computers.

"Working functionality" accounted for 45 percent of a Web site's overall rating. A listing of all five rubrics with weighted percentages is in Table 1.

Five Rubrics for Product Evaluation Matrix	
Working functionality	45%
Speed of function (findability)	28%
Responsiveness of the site	9%
General performance	9%
General design/attractiveness	9%

Table 1: Five Rubrics for Product Evaluation Matrix

"Speed of function" reflected the findability of a function, e.g., how long it took a student to find a group study room reservation form. The scores under this rubric reflected the number of seconds or minutes it took to find a function, and a rating of zero meant either a function was non-existent or not found after five minutes. Each evaluator used a stopwatch to time how long it took to find a function. Some functions, such as finding library hours or contact information, were only rated under this section. "Speed of function" accounted for 28 percent of a Web site's overall rating.

"Responsiveness of the site," "General performance," and "General design and attractiveness" each respectively accounted for 9 percent of the total rating. Responsiveness of the site was a subjective rating from one to five that reflected how well a Web site adjusted to the device from which it was viewed. General performance was tracked over three separate sessions

and referred to the amount of time it took Web site features or search results to load. General design/attractiveness was a subjective rating from one to five, with five being the most attractive.

The score for a given Web site was computed based on average scores from all of the evaluators, who consisted of three students at various stages of their academic careers, one Web developer, and two librarians. First, the average score for each function in a rubric was multiplied by its weighted total. For example, if the group study room function received a “1.67” and had a weight of 40, its score was 67. Subsequent functions under a rubric were calculated similarly with their rating multiplied by the weight. All scores for all functions in a rubric were then added together. Then the scores for all of the rubrics were added together for a total score.

In creating a list of best practice library Web sites to evaluate using our matrix, we included mobile and responsive Web sites from the other twenty-two California State University campuses, from scholarly literature on library and information science topics, and from reviews or announcements on the Internet regarding library mobile Web sites. Additionally, we searched in the iTunes App Store and the Google Play Store for apps from academic institutions and libraries. The initial list included over 130 mobile or responsive design Web sites and over 40 apps. Then we eliminated any Web sites that either hid search results behind a password or lacked many of the functions that had been highly weighted by Cal Poly Pomona students in the initial survey. This narrowed our list down to 45 Web sites and apps, which is substantially more than normally recommended by Pugh’s methods. However, in the interest of not arbitrarily excluding Web sites in order to reduce numbers, all remaining 45 sites were evaluated. All six evaluators reviewed all 45 sites using the evaluation matrix.

Phase 3: Usability Testing on External Web Sites

Three points of evaluation were important during all rounds of usability testing: to determine if users are successful in their resource discovery, to ascertain how quickly they are able to find the resources they are seeking, and to understand how satisfied they are with the general experience. Based on the final scores from the evaluation matrix, the top three external sites were selected for the first round of usability testing with student testers. Because none of these sites had all of the functions that our students expressed interest in using based on the survey feedback, we asked our student testers to complete different usability tasks on each site (See Appendix 2). For instance, on one Web site only the group study reservation system was tested.

Ten students were recruited based on their survey response in phase 1 indicating their willingness to participate in usability testing. . Students' hands and voices were filmed and recorded as they tested a variety of devices, including an iPad 4, an iPad Mini, a Google Nexus 7" tablet, a Samsung Galaxy 7" tablet, a Kindle Fire, an Android HTC Sensation 4G, and an iPod Touch (as a substitute for an iPhone). All of the students had prior experience with at least one device and were encouraged to use a familiar device during testing. Before and after testing, participants completed a pre- and post-questionnaire. Each participant received a \$15 gift card.

Phase 4: Usability Testing on Two Cal Poly Pomona Mobile Web Sites

Based on feedback and observations collected by testing mobile Web sites from other university libraries, Cal Poly Pomona University Library redesigned its mobile Web site to incorporate more of the functions that Cal Poly Pomona students were seeking. Two versions were developed -- a mobile Web site written in jQuery UI and a responsively designed site -- to determine if students would react differently to mobile sites vs. responsive sites. Participants were asked to perform a set of tasks similar to the previous round of testing, with the addition of

a few tasks that required Cal Poly Pomona test logins to evaluate additional functionality on our mobile Web site (see Appendix 3). Furthermore, the new mobile sites featured a search engine in beta that indexed articles, books, and the Library Web site in a three-column results screen. Ten participants were recruited for this second round of testing, with each receiving a \$15 gift card. Participants used the same devices from the first round of usability testing. Each participant completed a pre- and post-questionnaire before and after testing.

Phase 5: Usability Testing on the New Responsive Web Site

In Spring 2014, after the launch of our new responsive Web site, a third round of usability testing was conducted with five randomly selected students who each received a \$10 gift card for participating. Because the grant funding had been expended at this point, this last round was funded by the Library, thus the difference in the number of testers and the amount of the incentive. This site was live at the time of testing, and participants repeated the usability tasks from the second round (see Appendix 3). The new combined search engine indexing articles, books, and the Library Web site was live at this point. Again, the students used the same devices to test the new responsive Web site and were given a pre- and post-questionnaire before and after testing.

Findings & Discussion

Phase 1: Survey

The exploratory survey we conducted provided a number of details about our student population. It should be noted that these results are not intended to be generalizable, rather apply specifically to the needs and preferences of our student population. More detailed results from our survey are included in Appendix 4.

Only 1 percent of students did not own a mobile phone, and of those that did own a mobile phone, 82 percent owned a smartphone. Tablet ownership was less common; only 41 percent of students owned a tablet. Due to the diversity of mobile devices, we asked smartphone owners about the operating system of their smartphones (and not about their specific device). The leading operating systems were Mac OS and Android, with a small percentage of Windows 8. Most users paid for a data plan as part of their mobile contract (74 percent) with only 23 percent not paying for data and 3 percent not sure if they paid for data; 37 percent of participants had unlimited data plans.

At the time of this study, there were a number of dominant tablet models on the market, so participants were polled regarding specific types of devices used. Usage of these devices was more split amongst various manufacturers: Apple iPad/iPad mini (51 percent), Amazon Kindle (18 percent), Google Nexus (9 percent), Samsung Galaxy (8 percent), Barnes & Noble Nook (5 percent), and others (9 percent). Only 51 percent had 3G or 4G capable tablets that could be used on mobile networks; 40 percent did not have these models and 9 percent were unsure if they had these models.

Participants were asked how likely they were to use mobile library services on their phones and tablets. Tablets were preferred with 65 percent reporting that they were likely to or very likely to use library services on their devices; only 56 percent were likely or very likely to use the same services on their mobile phones.

For those who owned mobiles or tablets or both, we also asked about their current usage of both campus services and library services on their devices. Among participants who owned mobile phones, 71 percent frequently accessed campus services from their mobile phones daily or weekly, but only 23 percent accessed library services from their mobile phones daily or

weekly. Similarly, 66 percent of tablet owners used their tablets to access campus services daily or weekly, while only 32 percent accessed library services as frequently.

Participants were also asked if they preferred a Web site that was optimized to fit to their screen size: 74 percent preferred Web sites that fit their device; only 8 percent responded that they preferred to scroll around on a full version of a Web site; 17 percent were comfortable with either alternative; and 1 percent reported that they did not understand the question.

Participants were asked to check all services they would be interested in using in mobile or tablet form. They were not asked to rank or put the services in order of importance. The results were tabulated and prioritized based on the total number of checked instances for each service. On mobile phones, participants were most interested in speedy access to information such as library hours, computer lab hours, and reserving group study rooms. They were slightly less interested in research tasks such as searching for articles or journals, searching for books or media, or finding eBooks on their mobile phones. Tablet users, on the other hand, were more likely to be interested in services relating to research; in fact, the top services checked for usage on a tablet included searching for books or media, searching for articles and journals, and searching for eBooks. Participants expressed interest in using both types of devices to find hours, reserve group study rooms, renew checked out items, and look up computer availability.

The services that consistently appeared in the top ten according to participants' interests were included as the services to evaluate on external mobile Web sites. More information on how these services were ranked is included in the next section.

Phase 2: Development of an Evaluation Matrix and Evaluation Period

An evaluation matrix was an effective means to create a ranked list of Web sites that were appropriate for our students to test. By using this matrix, we were able to create a shortlist

of three exemplary Web sites from other academic libraries. Each of these Web sites had specific strengths that were helpful during usability testing. This matrix can be used in the future to evaluate our own future iterations of our Web site.

There were a few limitations encountered in using this Pugh Matrix to rank Web sites. The matrix was extremely complicated for student evaluators to understand. When a student evaluator first began using the matrix to evaluate the external sites, extensive training was required. After the student completed the first few evaluations, we checked in frequently to confirm that they were rating the sites consistently. Additionally, the evaluation matrix reflected only Cal Poly Pomona student needs and not all university student needs, because the criteria reflected feedback from the initial survey.

We did find the matrix helpful for ranking Web sites as subjectively as possible, but some inadequacies could be improved for further usage. For example, the time taken to find a function on a Web site was described in minutes, and it would have been more realistic if it had been calculated in seconds. In hindsight, it seems unlikely that students would take up to five minutes to find a function. Rather, a student might give up and resort to Google or another non-library resource. For this reason the weights applied to “findability” in the matrix may also have been too low. Even if a function works in a superior manner, if it cannot be found in a reasonable amount of time, it may negate the effects of the superior function.

Phase 3: Results from Pre-/Post-Questionnaires during Usability Testing

Our pre-interview questionnaire consisted of four questions: undergraduate/graduate student, major/college, frequency of using the Library Web site, and whether or not the Cal Poly Pomona University Library currently had a mobile Web site. The last question was asked to gauge student awareness of the Library’s mobile Web site. During phase 3, the first round of

usability testing, nine testers were undergraduates and one was a graduate student. Students from a wide variety of disciplines were represented. Of these students, 50 percent used the Library Web site frequently (more than once a week); and 80 percent were unaware of the Library's mobile Web site.

In the post-interview questionnaire, students were first asked whether the three Web sites they tested were easy to use and whether the words were understandable. Students indicated their agreement with statements such as "Overall, I found this Web site easy to use" using a Likert scale. On another page, students were asked to select their favorite Web site and provide explanations for their preference. Students were also asked to indicate their least favorite Web site. Finally, six Web sites from libraries that had not been tested were displayed as images. Two of the Web sites displayed were responsive Web sites and four were designed as mobile Web sites.

Overall, students preferred the Web sites where they had the easiest experience completing the usability tasks. This held true for ease of use, understandability of the words, as well as their choice of favorite and least favorite Web sites. In terms of preferences for responsive vs. jQuery mobile sites, students had various preferences that did not lead to a clear conclusion.

Phase 4 & 5: Results from Pre-/Post-Questionnaires during Usability Testing

The same pre-questionnaire questions were asked for phases 4 and 5 of the project (usability testing rounds 2 and 3). Students reported undergraduate/graduate student status, major/college, frequency of Library Web site usage, and awareness of a mobile Library Web site. All students were undergraduates in both of these rounds, from a variety of disciplines. In phase 4, 60 percent reported that they used the Library Web site more than once weekly vs. 50

percent in phase 5. In both phases, 60 percent of students either assumed that a Library mobile Web site did not exist, or were unaware if one existed.

In both phases 4 and 5, students were asked (1) whether the Library mobile Web site was easy to use, (2) whether the words on the site were easy to understand, and (3) if the images and text on the screen were clear enough to complete the task at hand. Students were also asked open-ended questions about what they liked and disliked about the Web site and if anything was missing from the Web site.

We saw improvements in user experience between the last two phases of usability testing: specifically student testers using our launched and live site reported a better user experience than those who had completed testing on test sites. Slight improvements were seen in self-reported post-questionnaire answers on (1) ease of use and (3) if the images/ text assisted with completing the task: in phase 4, students stated that they either “agreed” or “neither agreed nor disagreed” that the site was easy to use and images/text were understandable. In phase 5, students’ average rating was that they “agreed” that the Web site was easy to use and that the images/text were helpful. In both phases, participants agreed that (2) the words on the Web site were understandable.

Phases 3, 4 & 5: Observations from Usability Testing

We noted a number of interesting behaviors in every round of usability testing. First, users repeated unsuccessful behaviors. In one instance, a student looked for computer availability maps by searching for “available computers” using a search box that only indexed books and articles. A moment later, the student searched for “computers” in the same search box and received similar results only indexing library materials, not services.

A second similar behavior was frequently observed in student testing sessions: students

resorted to search when browsing (or even a first search) was unsuccessful. Multiple students searched for keywords related to a library service after not finding links from main pages, drop-down menus, or pages lower in the Web site structure. Some expressed frustration when they were looking for such services only to find books, and responded with comments such as “why is it giving me books? That’s not what I’m trying to find.” In phases 4 and 5, a combined index improved search experiences. However, if the relevant sites were not indexed -- many had not been indexed during phase 5 -- the results are only as good as the comprehensiveness of the indexing.

Search engine silos on lower level pages that indexed a subset of our resources, such as the library catalog, the FAQ, and research guides were generally misunderstood. Users who navigated to these lower level pages searched with the intention of searching the entire library Web site, including academic resources from databases. More often than not, they were unable to find what they were looking for.

Users noted no major difference in experiences or reactions to mobile vs. responsive Web sites; users seemed more concerned with functionality and ability to complete the task than how the Web site fit their device. Any preferences for jQuery or responsive Web sites seemed to be more related to personal graphic design preferences than functionality.

Unsurprisingly, users did not understand many instances of library jargon on Web sites. When looking for computer availability maps, a few clicked on “e-resources,” and some clicked on “digital commons.” One clicked on “media services.” The term “subject librarian” was particularly troubling for users. Many students were unaware of what a subject librarian was and often looked for tutors or advisors. When attempting to reserve a study room, one student looked under “course reserves,” having spotted the word “reserves.” Furthermore, many students had

problems with the concept of the “library catalog;” based on their behaviors, they were not entirely sure what the library catalog indexed. Some students thought the library catalog was an all-encompassing index that would include library Web site results. Others thought articles were also available in our library catalog, which currently only includes resources such as books, journals, and media.

Additionally, the alphabetical list of databases can at times be confusing to users. Users in all rounds of usability testing were asked to find general resources such as books and articles about a specific research topic. In every round, a few users navigated to the A-Z databases pages and expected to find specific keywords for a research topic listed on this page, rather than database names in alphabetical order.

We calculated the average number of attempts students made to find a service. After approximately three attempts a student would give up. We believe the actual average number of attempts made would be significantly lower for a student browsing the Web site outside of the test environment; many of the student testers may have been more persistent in their searching because they were (1) being recorded, (2) being viewed by a group of library staff, and (3) receiving a gift card for their participation.

It was challenging to provide consistent navigation for test sites due to the proliferation of vendor sites linked to the library homepage. Many of these services were integrated in such a manner that users were unaware that they had left the library Web site. This was especially confusing for users who clicked “Home” or another navigational button to try to return to the mobile test site and were instead forwarded to the current live mobile Web site. Users therefore expected consistent navigation such as consistent home buttons or menus.

In the last stage of usability testing, users tested the live responsive Web site that

included a template with global campus navigation. The global campus navigation included two menus at the top of the page that linked to main campus services. This feature was both positive and negative for users testing the Web site. In the last round of testing, two out of the five users navigated away from the library Web site and tried to complete the usability task on department pages or general campus information pages. Those two users, however, were both able to navigate back to the library Web site without being instructed to do so because of a global navigation link for the library.

We also encountered challenges during the redesign project in providing certain services we deemed important for students to test and eventually be able to use. For instance, we were very interested in a responsive version of our group study reservation system. However, the resources were not available to implement a responsive version within the time constraints of this project. Similarly, computer availability maps were tabled for later implementation and investigation by campus IT.

Our student testers encountered two significant challenges when trying to find library resources: having more than one search box on a page as well as search boxes that did not index library Web sites and resources comprehensively. Based on observations in usability testing, it became clear that users were accustomed to Google-like search interfaces with exhaustive indexing. Students consistently reverted to search when all other strategies failed. This led to the conclusion that an effective search engine with comprehensive indexing could offer an alternative to other possible user interface issues. Additionally, many vendor services siphon users off into new portals that appear to be seamless but may not really be experienced as such. Additional research on the representation of search and universal navigation on vendor and external pages is warranted.

Even with an all-inclusive search box, however, users still had issues understanding certain vocabulary and jargon on a Web site. While a search box can serve as a backup to browsing problems, effective vocabulary that is understandable by the average user will assist with overall design issues. Also, while jargon is often clarified in instructional sessions in academic libraries, whether the use of the jargon is justified or can be effectively clarified is a topic worthy of further research.

Certain issues on the Web site were corrected by the last round of usability testing; however, there were still a few students who had trouble completing some of the tasks. Most of the randomly selected students in this round were freshmen or students who had never used the library Web site. In the future, it may be worthwhile to conduct research on these students so that the Web site can be more usable by students with no prior experience. Additionally, developing personas for different types of users to determine how to serve a diverse student population may be an alternative to address some of the issues encountered by new library users.

Conclusion

Certainly, the processes we used during our study helped our iterative design process. Getting user feedback via a survey was informative and helped support prioritization decisions for what features should be prominent and available on a new mobile Web site. Our use of an evaluation matrix helped reduce bias when looking at external Web sites that we could use as best practice examples. Usability testing was extremely valuable for justifying or nullifying design decisions, as we were able to observe how our students actually interact with our library Web site. While this multi-phased approach was time intensive, the learning gleaned from the various phases allowed us to make more confident data-driven decisions. We have also learned

the importance of continuing these kinds of iterative processes. This study specifically focused on mobile and tablet usage; however, observations and learning also applied to the desktop Web site. The data collected during all phases of this study have informed discussions and helped get buy-in from campus IT and library staff, who might not otherwise have supported some of the changes.

Our students have only begun to realize the benefits of our decision to center our mobile Web design efforts around their specific needs. Our efforts have only touched the tip of the iceberg in terms of all the things that we as researchers can learn about the way our students behave, not only on our mobile Web sites but on our desktop Web sites as well. We are attempting to offer a consistent user experience by displaying a responsive Web site with all available online library services. As our Web site evolves, we hope to continue to collect as much data about user experiences as possible in order to create the kinds of Web experiences our students expect.

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Appendix 1: Survey

Effectiveness of Resource Discovery on University Library Mobile Sites

Please answer the following questions to the best of your ability. If you are uncomfortable answering one of the questions, please skip to the next one.

1. Are you a:
 - a. Cal Poly Pomona Undergraduate Student
 - b. Cal Poly Pomona Graduate Student
 - c. Cal Poly Pomona Faculty or Staff
 - d. Other:
2. What is your email address? *Please enter your Bronco email address for a chance to win a \$10 Cal Poly Pomona Foundation Gift Card (only available to Cal Poly Pomona students):* _____
3. Do you own a mobile phone?
 - a. Yes
 - b. No

Please review and answer the following questions regarding your mobile phone usage and contract.

4. Do you own a smartphone? *A smartphone is a cellular telephone, which can access the Internet and includes built in applications.*
 - a. Yes
 - b. No
 - c. I don't know
5. If you own a smartphone, what operating system is running on your smartphone?
 - a. Windows (e.g. Nokia Lumia, HTC Windows, etc.)
 - b. Mac OS (e.g. iPhone)
 - c. Android (e.g. Samsung Galaxy, Nexus, HTC One X+, Motorola, etc.)
 - d. I don't know
 - e. I don't own a smartphone
 - f. Other:
6. Do you pay for a data plan as part of your mobile phone contract? *or, do you have a plan included in your contract that allows you to access Internet services on your phone?*
 - a. Yes
 - b. No

- c. I don't know
- 7. If you have a data plan, how much data is included with your monthly contract?
 - a. 500 MB or less
 - b. More than 500MB and less than 2GB
 - c. More than 2GB and less than 5GB
 - d. More than 5GB but not unlimited
 - e. Unlimited
 - f. I don't know
 - g. I don't have a data plan
- 8. How often do you use your mobile phone to access campus services such as BlackBoard, BroncoDirect, financial aid, class listings, check the campus calendar, finding on-campus jobs, etc.?
 - a. Daily
 - b. Weekly
 - c. Monthly
 - d. Once a quarter
 - e. Once a year
 - f. Never
- 9. How often do you access library services from your mobile phone? *Library services may include checking the catalog for books, searching for articles, looking up directional information in the library, checking your library account, etc.*
 - a. Daily
 - b. Weekly
 - c. Monthly
 - d. Once a quarter
 - e. Once a year
 - f. Never
- 10. How likely are you to use library services on your mobile phone?
 - a. Very likely
 - b. Likely
 - c. Not very likely

Tablets & E-Readers

- 11. Do you own either a tablet or an e-reader? *This could include such devices as an iPad, an iPad Mini, a Kindle Fire, etc.*
 - a. Yes
 - b. No

Tablets & E-Readers Further Questions

Please review and answer the following questions regarding your tablet or e-reader.

12. What kind of tablet or e-reader do you own?

- a. Apple iPad
- b. Amazon Kindle
- c. Barnes & Noble Nook
- d. Microsoft Surface
- e. Samsung Galaxy
- f. Google Nexus
- g. Sony Xperia
- h. Asus Transformer Pad Infinity
- i. Motorola Xoom
- j. Other:

13. Is your tablet or e-reader either 3G or 4G capable?

- a. Yes
- b. No
- c. I don't know

14. How often do you use your tablet or e-reader to access campus services such as BlackBoard, BroncoDirect, financial aid, class listings, check the campus calendar, finding on-campus jobs, etc.?

- a. Daily
- b. Weekly
- c. Monthly
- d. Once a quarter
- e. Once a year
- f. Never
- g. I don't own a tablet or e-reader

15. How often do you access library services from your tablet or e-reader? *Library services may include checking the catalog for books, searching for articles, looking up directional information in the library, checking your library account, etc.*

- a. Daily
- b. Weekly
- c. Monthly
- d. Once a quarter
- e. Once a year
- f. Never
- g. I don't own a tablet or e-reader

16. How likely are you to use library services on your tablet or e-reader?

- a. Very likely
- b. Likely
- c. Not very likely
- d. I don't own a tablet or e-reader

Library Services

Please review and answer the following questions regarding what kinds of services you'd like to see from the library for mobile devices.

17. Please check the library services below that you would be likely to use or access with your mobile phone:

- a. Search for articles and journals
- b. Search for books and media
- c. Search for eBooks
- d. Access course reserves
- e. Text call numbers to your phone
- f. Reserve a group study room
- g. Rate or review items you found in the library so that others can read your recommendations
- h. Read reviews from others of items found in the library
- i. Share items you've found in the library with others
- j. See a map of available computers in the library
- k. Find your way around the library using GPS
- l. Locate the shelf where an item is housed
- m. View maps of the library
- n. View the library's calendar of events
- o. Find contact information for library staff
- p. Find out the upcoming library hours
- q. Find out the upcoming 24/7 computer lab hours
- r. View your patron information and library account (to review charges, items borrowed, reserved, requested, etc.)
- s. Request an item that is currently loaned to another patron
- t. Renew items you've checked out
- u. Get general alerts about your library account, e.g. due dates, renewal notices, etc.
- v. Other:

18. Please check the library services below that you would be likely to use or access with your tablet or e-reader:

- a. Search for articles and journals
- b. Search for books and media
- c. Search for eBooks
- d. Access course reserves
- e. Text call numbers to your phone
- f. Reserve a group study room

- g. Rate or review items you found in the library so that others can read your recommendations
- h. Read reviews from others of items found in the library
- i. Share items you've found in the library with others
- j. See a map of available computers in the library
- k. Find your way around the library using GPS
- l. Locate the shelf where an item is housed
- m. View maps of the library
- n. View the library's calendar of events
- o. Find contact information for library staff
- p. Find out the upcoming library hours
- q. Find out the upcoming 24/7 computer lab hours
- r. View your patron information and library account (to review charges, items borrowed, reserved, requested, etc.)
- s. Request an item that is currently loaned to another patron
- t. Renew items you've checked out
- u. Get general alerts about your library account, e.g. due dates, renewal notices, etc.
- v. Other:

19. When you're browsing a webpage using your mobile phone or tablet, do you like the website to be optimized to fit your screen size? *If the page is optimized to fit your screen size, you don't have to scroll around on the page, rather the page fits your specific device screen.*

- a. Yes, I like it when the website fits my device
- b. No, I would prefer to start on the main library website and scroll around for information
- c. It doesn't matter to me either way
- d. I don't understand the question

20. What, if any, mobile services would you like to see the library offer?

21. Would you be interested in participating in usability tests to test mobile devices and tablets?

- a. Yes
- b. No

22. Comments: *Please let us know if you have further comments or input.*

Appendix 2: Usability Tasks Round 1

Between each task, we will load the appropriate website for you to test with.

1. Attempt to reserve a group study room for 4 people to study for the next hour at James Branch Cabell Library.
2. You want to use a computer in the library right now. Find an available computer in the library.
3. Search for the book “Marketing Management” by Philip Kotler.
4. You are doing a research paper on project management. Locate three resources on this topic including books and articles.
5. Is the Alderman Library open this Sunday?
6. Find Room 567 in the Alderman Library.

Appendix 3: Usability Tasks Round 2 & 3

1. Attempt to reserve a group study room for 4 people to study for the next hour at Cal Poly Pomona University Library.
2. Locate the book “Marketing Management” by Philip Kotler.
3. You are doing a research paper on project management. Locate three resources on this topic including books and articles.
4. Is the Library open this Sunday?
5. Find room 4134 in the library.
6. Attempt to renew a library book you’ve checked out.
7. Find the contact information for your school or major’s subject librarian.

Appendix 4: Survey Analysis

Status of Participant

Figure 3

Do you own a mobile phone?

Figure 4

Do you own a smartphone?

Figure 5

If you own a smartphone, what operating system is running on your smartphone?

Figure 6

Do you pay for a data plan as part of your mobile phone contract?

Figure 7

If you have a data plan, how much data is included with your monthly contract?

Figure 8

How often do you use your mobile phone to access campus services such as BlackBoard, BroncoDirect, financial aid, class listings, check the campus calendar, finding on-campus jobs, etc.?

Figure 9

How often do you access library services from your mobile phone?

Figure 10

How likely are you to use library services on your mobile phone?

Figure 11

Do you own either a tablet or an e-reader?

Figure 12

Figure 13

Is your tablet or e-reader either 3G or 4G capable?

Figure 14

How often do you use your tablet or e-reader to access campus services such as BlackBoard, BroncoDirect, financial aid, class listings, check the campus calendar, finding on-campus jobs, etc.?

Figure 15

How often do you access library services from your tablet or e-reader?

Figure 16

**How likely are you to use library services on
your tablet or e-reader?**

Figure 17