Live from the Stacks: User Feedback on Mobile Computers and Wireless Tools for Library Patrons

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ABSTRACT

Digital library research is made more robust and effective when end-user opinions and viewpoints inform the research, design and development process. A rich understanding of user tasks and contexts is especially necessary when investigating the use of mobile computers in traditional and digital library environments, since the nature and scope of the research questions at hand remain relatively undefined. This paper outlines findings from a library technologies user survey and on-site mobile library access prototype testing, and presents future research directions that can be derived from the results of these two studies.

KEYWORDS: DL case studies, evaluation, human-computer interaction, mobile and ubiquitous computing

INTRODUCTION

Traditionally, the scope of digital library research has been technical and administrative in nature, focusing on cataloging, tracing, storing and disseminating large quantities of various types of digital information in a manner that addresses key privacy, security and intellectual property questions.

While these research questions are pressing and necessary, resolving these questions alone may not necessarily result in information systems that meet the needs and demands of end-users. Increasingly, DL researchers are discovering the benefit of integrating user, task and context models in an effort to make DL technologies more effective in actual usage situations.

Integrating user and usage context models into systems design is especially relevant as digital libraries move away from traditional hard-wired, desktop/office technologies towards mobile, field-based solutions accessible through ubiquitous wireless network connections. Mobile technologies potentially create a wide variety of uses and limitations that differ significantly from desktop technologies. While mobile technologies may offer users more flexibility with respect to information access, mobility may also increase the ambiguity and complexity of the context of use, creating limitations and challenges that are more easily accounted for in static, controlled environments. The rapid pace of innovation confuses issues even further. It is difficult to implement and test services in an environment where technologies may become obsolete in months. Taken together, these ambiguities make it difficult to fall back on existing human-computer interaction and usability literature.

These rapid changes in the sociotechnical system of mobile DL technologies need to be accounted for in the design of effective DL solutions. Our research aims to investigate this rapidly changing information access environment in an effort to inform effective designs that meet the needs of users while supporting innovation in technical and administrative practice. This paper outlines the need for user-centered design in mobile computing and digital library research and presents results from two preliminary studies aiming to solicit user feedback regarding mobile computing technologies in a library setting. The paper concludes with a look at the limitations of these studies and our plans for future research in mobile digital libraries.

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MOBILITY AND HUMAN-COMPUTER INTERACTION: A CHANGE OF FOCUS TOWARDS USER ACTIVITIES IN NATURAL CONTEXTS

The importance of usability studies in computer and information science is not new. GOMS (goals, operators, methods, selection rules) models, for example, has been in place since the early 1980s and has gone through many successive iterations in the meantime[6]. This model provides software engineers with quantifiable data and computationally relevant models of user information processing that can be used to pinpoint inefficiencies in existing systems and provide baseline measures to compare alternate iterations of a product.

GOMS tends to focus on formal derivations of user mental models and measurements of individual user performance in discrete, bounded tasks. While GOMS-based models are effective tools to create abstract models of user behavior and predict potential future behavior, HCI professionals have found such formal models limited in uncovering information about actual actions and interactions in naturalistic contexts of use. Complementary models based on the analysis of human activity have filled this void and raised new research questions. Activity theory [9,12] has been used to inform a more holistic and multidimensional understanding of computer use within real-world contexts. In such models, technological artifacts are situated in a larger context of social norms, community expectations, labor management issues, and relationships among objects and subjects of study [9]. This turn towards more complex, interdependent models of user expectations is mirrored in contemporary technology studies research, which posits that all technological artifacts are, at their core, products of socially constructed, situated processes [18,19]. In both theoretical models, technical systems are reframed as inherently sociotechnical [15], directly merging social technical contexts into one interdependent environment.

As the scope of human-computer interaction research has expanded, so has the availability of alternate research methods. While quantitative measures of user interaction (e.g., timed interaction studies, measures of physiological responses) are effective in evaluating discrete simple tasks in controlled environments, such methods are less effective in investigating complex, dynamic environments in which a multitude of uncontrollable exogenous variables may directly or indirectly impact user behavior. Qualitative and goal-directed methods such as ethnographic field research [17], joint application design [2], and contextual inquiry [5] have proven effective in uncovering a more robust understanding of user tasks and behavior in more naturalistic contexts. This is not to suggest that quantitative, formal methods cannot contribute to a richer understanding of this context, however. Indeed, the quality of our collective understanding of user behaviour and usage context will likely be enhanced through mixed-method evaluation and research designs [1]. Privileging one set of methods to the exclusion of others will inevitably lead to narrow and partial worldviews that are more artifacts of methodology than faithful representations of the world.

Researchers in the digital library community have noted the need for DL development to include such multifaceted, user-centered approaches [3,11] and have begun to integrate user feedback into the design process [7,14]. We argue that such a focus on user context and activity is especially relevant when mobile computing technologies are the focus of attention.

Mobile computing technologies have forced some rethinking of existing practices in human-computer interface design and interaction research. It is arguable that the WIMP (windows, icons, mouse, pointer) graphical user interface pioneered by Xerox PARC, commercialized by Apple and made ubiquitous by Microsoft has been stale for a good deal of time, and has constrained future design innovation [10]. Mobile computing challenges the status quo by forcing designers to make accommodations for a new set of abilities and limitations brought forth by small and lower-fidelity screens, small amounts of memory and storage, slow network connectivity, and alternative forms of input. Successful designs (e.g., the Palm Computing System) tend to be simple, elegant, stable and functional, albeit within a tightly constrained range of potential usage contexts. Designing within the limitations of these "information appliances" requires a solid and broad understanding of user behaviors and tasks in order to be effective in practice [13].

While mobility constrains the quality and quantity of tasks that can be performed, it makes an accurate picture of usage context more difficult to determine. Traditional human-computer interaction research has not only been constrained by the hegemony of the WIMP interface, but also by the relatively static nature of the usage domain - the individual desktop workstation, primarily located in an office or other professional environment [4]. Moving from this well-understood and stable context to a more dynamic environment greatly increases uncertainty for designers wishing to model usage context. The technical infrastructure must not only support a given range of tasks, but be able to do so in a variety of shifting physical and social contexts[16].

Functional mobile digital library environments will inevitably be built around robust and stable technical infrastructure. Designing effective mobile digital libraries, however, will require an equally robust social and administrative infrastructure that can support the needs, tasks and environments in which the system will be used.

Physical libraries provide an excellent environment to test these emerging concepts and challenges. Innovations in mobile information access and retrieval can be tested in a familiar physical context and be built around existing user tasks. Physical libraries are also generally well equipped to support computer networking, and the bounded nature of

the environment makes it easier to set up wireless network testbeds. The remainder of this paper outlines two complementary efforts that investigate issues raised by mobile and digital library technologies through situating these tools in the familiar setting of physical libraries.

DETERMINING KEY TASKS: THE MOBILE LIBRARY TECHNOLOGIES SURVEY

Given the complexity of the research questions involved in investigating mobile and wireless access to digital libraries, our group determined that a survey of user views and expectations regarding digital library technologies would be an appropriate foundation on which to build a more comprehensive research plan.

Our group drafted a library user survey for dissemination among students of two undergraduate courses in the Department of Communication at Cornell University. The initial draft of the survey was submitted to senior undergraduates enrolled in a human-computer interaction course. Their responses and feedback were used to streamline the instrument to ensure that it would be accessible, relevant and easy to complete. We believe that this process of iterative design was essential in obtaining a data set that contained no missing data and only two written comments noting confusion regarding specific items in the survey.

Students were invited to participate in the survey over a two week period. Participation in the survey was voluntary; however, students who did participate were eligible to receive extra course credit for their assistance. This method yielded 50 respondents representing a wide variety of disciplines and experience. This unexpected breadth of respondents resulted from the fact that both courses targeted were common electives in other programs in the College of Agriculture and Life Sciences. As a result of this, there was a perfect split among social science/humanities and natural/physical respondents and a close split among junior and senior undergraduates (54% to 46%, respectively).

The survey was designed to solicit student feedback regarding existing and potential computing technologies in a library setting. We were not surprised to discover that existing online resources were popular among undergraduate users. In a ranked scale of nine existing services, online indices and online full texts were nearly twice as popular with users as paper-based books and journals, despite the fact that all of these services were used in the past year by at least 86% of respondents. What was especially interesting was the poor ranking of the online book catalog, which placed a distant fifth in preference despite being used by four-fifths of respondents. Negative reactions to Cornell's antiquated NOTIS database, which is due for replacement at the end of the 1999-2000 school year, was a likely factor here.

Uncovering information about future mobile library technologies was done through two related batteries of questions. The first posed comparable questions regarding various technologies and tasks and asked respondents to evaluate their importance in both in-library and outside-of-library contexts. Mean scores on a one-to-five scale were matched using a paired-sample T-test to test for significant differences among the inside/outside questions. The results generally point to an appreciation of mobile technologies within the library context. Retrieving information from scanning barcodes on materials, handheld scanners in the library stacks, and accessing library maps while on site were seen as valuable services within the library. Despite earlier suggestions that the online catalog was not particularly useful, the catalog was singled out as the most important feature and the one most valuable outside the library context. This discrepancy and additional comments given in open-ended questions further suggests that users find the catalog unwieldy and difficult to access both in-house and remotely. Two tools - online synchronous communication with reference librarians and annotation of library records - received a lukewarm reception both inside and outside the library context.

The second set of questions outlined four potential usage scenarios in which a hypothetical user's activities were described. We felt that the use of scenarios would help provide some background and context for what we expected would be an inexperienced audience - an expectation that proved to be true, as only three users had claimed any previous experience with personal digital assistants, mobile tablets, or laptops in a library setting. The usage scenarios are as follows:

1. Person **A** enters the library and proceeds to the main desk. From the desk, she signs out a binder-sized mobile computing device that she will use while searching for information. The device allows her to search the on-line catalog from all locations in the building, interact with others presently on the network (including library personnel), send electronic mail, take notes on items that she has found, and record the notes in a private space on a library computer when done.
2. Person **B** is reading under a tree when he stumbles across a reference in a book. He wonders whether the library has that particular resource. **B** pulls out his laptop computer and accesses the library's online database through a wireless connection. He downloads the appropriate information to his bibliographic database, and makes a note to himself to retrieve that resource on the way home.
3. Person **C** is conducting research in conjunction with person **D**, who is located at a different department on campus (or somewhere else in the world for that matter). While at the library, person **C**'s mobile/ wireless computing device gives her the ability to send emails to—or even "chat" in real-time with—**D** as soon as she encounters references and resources she thinks **D** might be able to use for their joint research.

4. Person **E** enters the library and proceeds to the main desk. From the desk, he signs out a hand-held scanner the size of a large calculator. This scanner allows him to scan text and graphics from books, journals, and other printed materials in the library into an electronic format stored within the scanner. The stored scans can then be printed or transferred to **E**'s disk or laptop computer for use in electronic documents—like word processing documents or Web pages—upon returning the scanner to the main desk.

Following each of these scenarios, users were asked four identical questions asking whether these tools or services would assist their research and whether they would be willing to make a financial commitment (either through purchase or through a $80/year increase in student fees) to sustain the systems described. Questions and mean responses from each scenario follow in Table 1 below.

Table 1: Mean scores on scenario questions
(1=Strongly Agree, 5=Strongly Disagree)

a) This system would be useful for my own library research.
S1: 1.78 **S2**: 2.12 **S3**: 2.14 **S4**: 1.48
b) I would conduct more library research if this system were implemented.
S1: 2.18 **S2**: 2.44 **S3**: 2.48 **S4**: 1.88
c) I would be willing to have student feeds increased $40 a term to support such a system.
S1: 3.24 **S2**: 3.28 **S3**: 3.58 **S4**: 2.40
d) I would be more likely to purchase or lease a mobile computing device to gain access to such a system.
S1: 3.22 **S2**: 3.04 **S3**: 3.12 **S4**: 2.58

Respondents noted a clear strong preference for scenarios 4 and 1, followed by more moderate but statistically significantly positive support for scenarios 3 and 2 respectively. When asked whether the systems described would encourage them to conduct more library research, the same order and significant deviation from the midpoint was noted, although respondents were more likely to agree than strongly agree in each case.

What was especially telling was the discrepancy between willingness to use mobile technologies and willingness to support the necessary infrastructure financially. Respondent enthusiasm significantly declined when either technology purchase or student fee increases were suggested. The most marked decrease was noted in scenario 1 - the library mobile computer was the second-least likely to be supported by student fees and the least likely to be purchased, despite being noted as quite popular and useful in principle. Scenario 4 - in-stacks handheld scanning - was the only scenario to receive a muted but nevertheless significant willingness to pay - all other scenarios were marginally but not significantly rejected with respect to the pocketbook.

This finding would be of special concern for library administrators who are investigating ways and means of supporting future DL infrastructure costs. While interest in innovative ideas may appear to be high in user surveys and focus groups, this interest may dissipate if a significant monetary cost is attached to the service. That said, solutions with a strong base of support may be financially supported by the user community at large - suggesting that these solutions may be the least controversial to implement at first.

TESTING TASKS IN A QUASI-NATURALISTIC CONTEXT: FIELD TESTING MOBILE LIBRARY TECHNOLOGIES

Based on the findings from the above survey and continuing research activities in the field of mobile computing technologies, a prototype mobile computer similar to that described in scenario 1 above was tested with students at Cornell University. We developed a prototype suite of software tools designed to run on the Windows CE-based Vadem Clio, a scaled-down laptop that allows both keyboard and pen interaction, has a nine inch monitor-shaped display and could be connected to the network via a wireless Ethernet connection.

The functionality of the prototype included: 1) access to the online catalog; 2) access to a prototype MyLibrary suite being developed by Cornell's Personalized Electronic Services Working Group; 3) a mapping device that directed you to the book in the stacks; 4) live chat to the reference desk; and 5) a portable Hewlett Packard hand scanner (similar to scenario 4 above) that connects to the mobile computer via infrared ports. A screen shot of the suite can be found in Figures 2 and 3 at the end of this paper.

Fourteen test users from a senior-level Communication course were invited to a small, specialty library and were briefed on the specific hardware and prototype tools available in the test. Users were asked to complete a series of reviews and tasks of the specific functionality, including searching for a book on the online catalog, locating the book using the interactive map, scanning and loading pages of text, sending messages to a library staff member using the chat feature, and reviewing the MyLibrary suite. Our

research team collected user responses to the prototype system via a short prepared survey and recorded one-on-one interviews with library staff and student library patrons.

Figure 1: The mobile prototype in action.

As interactions with the network were controlled and monitored by research staff, it cannot be concluded that this study was naturalistic in the purest sense of the word. However, conducting this study on-site did provide some insight on how the use of these technologies are influenced by the context of use, and users were encouraged to experiment with the mobile computer within the bounds of its prototypical base of functions. As such, we feel justified in labeling this effort quasi-naturalistic, especially in comparison to the more standard but abstract approach outlined above in our discussion of the survey.

The study yielded very informative user insights, especially when compared to the survey results. As could be predicted from the survey, users expressed enthusiasm for the prototype in particular and the concept of mobile digital library technologies in general. Users were especially enthusiastic about the ability to access the online catalog remotely from the stacks. Users could see themselves using such a function in order to overcome the common frustration of having to leave the stacks in order to look up references using the online catalog. Users were less satisfied with the on-line map, although some did suggest that such a function might be more useful within a larger library.

The online chat to staff at the reference desk was well received, despite the fact that this service ranked sixth of nine in terms of use and importance in the earlier survey. It was suggested by one user that the online chat function would make it easier and thus more attractive to ask questions of library staff, who are usually centrally located away from the stacks and work areas, where reference questions are most likely to be formulated. This suggests that ubiquitous mobile access may increase communication between library staff and patrons, who may be reluctant to leave their current context to ask questions that are not immediately important to their work.

Exposure to the dynamics of using mobile computers and scanners in the stacks tempered expectations and enthusiasm somewhat. Many users complained that the unit was difficult to use while simultaneously holding books and other materials. Users suggested that the library provide harness devices or carry bags to help carry such devices through the stacks. Others noted that the small size of the unit made it difficult to use the keyboard, which is slightly smaller than a desktop keyboard.

The scanner was generally seen as an effective complement to library research. However, some users suggested that they would still prefer to use traditional photocopiers for large copying tasks. A librarian tester noted that while digital documents would be appealing, the scanner would only likely be used to scan short passages or visuals in a few key pages. Continued user preference for paper-based documents vs. digitized documents may be a factor here. - scanned documents are likely to be printed before read, thus adding an extra step to the process of information access.

LIMITATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

Findings in the above two studies are best seen as preliminary steps in a much broader effort to understand user tasks and contexts in a mobile digital library environment. We are continuing to solicit user opinions regarding these technologies using instruments similar to those described above. Future iterations of these instruments will continue to target key hypotheses that have emerged from these initial efforts.

For example, it would be interesting to investigate how monetary commitment will impact user rankings of existing library services. Library administrators are acutely aware of the costs involved in providing access to online indices, especially those that include substantial full-text articles. It remains to be seen whether these services are so important to users that they would be willing to cover part or all of the costs of licensing access to intellectual property. Our survey also did not deal with time, another scarce resource. Time was likely a factor in the noted reluctance to retreat from the library stacks in order to ask questions of reference librarians or check the library catalog. We hypothesize that users are willing to support most services in principle, but that only the most essential or beneficial services will stand the test of financial and time commitment. A broader sample within our university community and similar communities elsewhere would also prove to be very useful in future research.

In the short term, we will be conducting more in-context user studies using the mobile computing prototype suite of tools described above. Other potential avenues for research include continued iterative testing of the MyLibrary system. This system will provide ready access to more

traditional library services such as interlibrary loan, holds and recalls - a feature that was a noted useful application in both our survey and in-context research efforts.

A key challenge will be to create an atmosphere that is more conducive to natural patterns of use while being accessible to research and evaluation. Two future projects aim to address these issues using different but complementary tools. A recent equipment and research support grant from Intel has provided our group with access to laptop computers and wireless Ethernet connections. Students in selected classes will be granted the right to use their own personal computers for coursework and research activities, under the mutually agreed upon condition that their activities will be monitored using anonymous user tracking software operating in the background. While this still creates a somewhat contrived usage context at first, we hypothesize that most users will eventually forget about the tracking software and use their machines in a largely unfettered fashion.

It is ironic to note that the provision of digital library services still depends a great deal on the arrangement of physical space. User input regarding floor maps, carrying around extra equipment, accessing research librarians, and collaborating with group members can be traced to arrangements of space within traditional libraries that tend to privilege individual use of a small number of physical resources simultaneously. Physical constraints to access and communication may prove to be less salient in a digital library environment. Our continuing project with Cornell University Libraries and the architecture firm Shepley, Bulfinch, Richardson, and Abbott will investigate the redesign of physical spaces to encourage effective collaboration and communication among library users.

Perhaps our most challenging task ahead is to be able to reframe all the above in such a way that it can inform existing and future DL research. Thankfully, our research group is aligned with a number of complementary projects headed by representatives from the Division of Computing and Information Science, Cornell University Libraries, and other interested parties. These existing links provide access to alternative ways of conceptualizing these key issues while giving our group the ability to present our research questions and findings as relatively equal partners. That said, there are considerable differences in opinion and priorities among groups [8] that need to be appreciated, if not resolved, in order for equitable mutual communication to be truly effective.

Negotiating such a complex set of interrelated questions is by no means a small task, but it is an essential one. Effective digital libraries will require a strong technological foundation that is both informed by and supports user behaviors, actions and contexts. Mobile computing technologies add a particular spin to DL research and tend to reopen previously dormant debates concerning user behavior and interaction. It is our hope that a concerted effort in mobile digital library research will immediately and routinely incorporate user input and experience to help shape systems that are both innovative and practicable.

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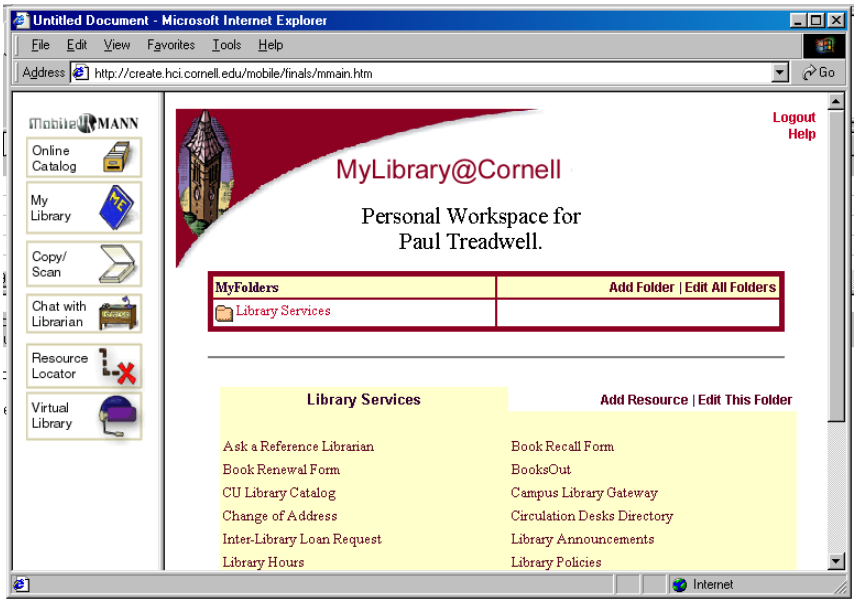

Figure 2: Mobile prototype demonstration screen running MyLibrary.

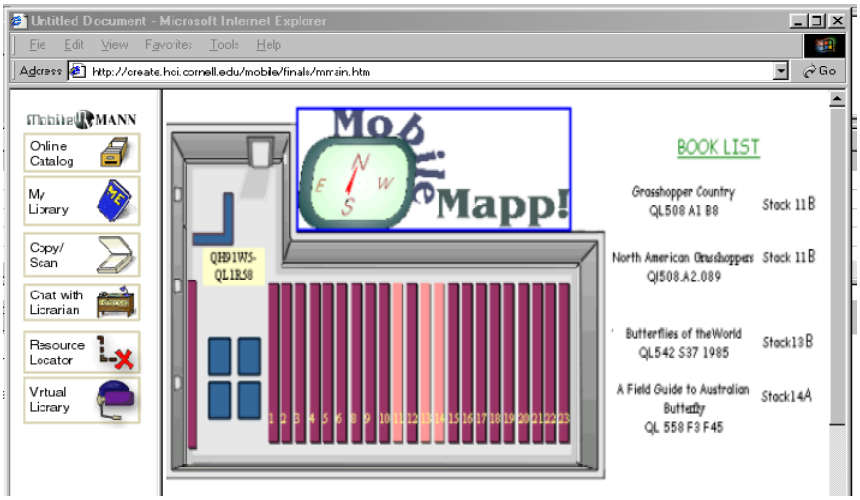

Figure 3: The mobile library stacks map.