

Evaluation of Digital Libraries Systems' Usability and Performance through User Perception

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With the proliferation and availability of information on the Internet, libraries are competing in the digital world to maintain their position as a trusted and accessible information resource. The volatility of electronic environments necessitates digital libraries to identify, measure, and communicate their worth. By comparing the criteria established as important to digital library users in the *University of Wisconsin, Milwaukee* study (UOWM)(2006) to the results of the *Digital Renaissance Foundation* study (DRF)(2008) and the *Universities Study, Guangzhou, China* (Guangzhou)(2011), this paper's purpose is to evaluate users' perceptions of digital libraries' usability and performance and to identify areas for improvement and advancement. Based on a review of previous user research and system evaluation studies, best practices, and current technological trends, the paper's goal is to determine an appropriate evaluation model for future research and possible systems solutions. As returning users boost digital libraries use and validate the goals and funds spent on development, the results can provide collection management departments, technology designers, and funders of all sized digital libraries the motivation to assess their viability and to build efficient, effective, and competitive digital libraries to preserve their value as the primary knowledge management system by the global community.

Literature Review

While there is currently no one clear definition of a digital library, the Digital Library Federation (DLF) defines digital libraries as:

“... organizations that provide the resources, including the specialized staff, to select, structure, offer intellectual access to, interpret, distribute, preserve the

integrity of, and ensure the persistence over time of collections of digital works so that they are readily and economically available for use by a defined community or set of communities...”(DLF Web Site, 2004)

Additionally, a digital library has the infrastructure architecture to support and preserve the cultural context and user perspective of the collection, both paper and electronic, and to provide access to multi-lingual and multi-cultural holdings, material otherwise inaccessible to the global community. Digital can mean material born digital, emails or Web sites, or converted from analog to digital, e-books, photographs, or newspapers.

Large quantities of capital have been spent building digital libraries. However, user research studies and systems evaluations have lagged behind development, focusing on traditional library metrics of existing use patterns and assessing technical aspects of the system’s design. As the Internet became more prevalent, governmental and financial pressures coincided requiring libraries to reassess their performance criteria. At the same time, the US Digital Library Initiative Phase I, the D-Lib Working Group on Digital Library Metrics (2001) convened to address an appropriate set of metrics to evaluate and compare the effectiveness of digital libraries and component technologies in a distributed environment (p. 5), although actual definitions and evaluations of projects did not come to fruition (Saracevic, PDF). While uniform definitions of evaluation metrics for consistent measurement tools and reporting standards are still an open issue, there are some that seem to apply globally and will help understand further discussion in this paper. Users are the citizens of the world regardless of age, ethnic group, etc., who locate content in all subjects and formats from any location for what ever they need, according to the US President’s Information Technology Advisory Committee (PITAC) (Chen, 2004, p. 2). Usability is defined by the International Standards Organization (ISO) as “the extent to which a

product can be used by specific users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use” (Jeng, 2005, p, 47) or by Nielsen’s five usability attributes: learnability, efficiency, memorability, low error rate or easy error recovery, and satisfaction, both are universally acceptable (p. 47).

Research focused increasingly on user profiles, usability studies, and digital libraries’ performance, although most have been western-oriented. The Perseus Digital Library Project marked the beginning of usability studies as it evaluated users’ ability to learn the system, how hypertext tools influence use, the system’s performance and accuracy, content and acquisition policy, and the impact of the digital library on users and their communities (Marchionini, 1998, p. 96). The results of the study led to the creation of Marchionini’s (1998) information seeking behavior model which recognizes the user controls, and is central to the search process, and therefore an understanding of the cognitive and behavioral processes used during a search is important to develop electronic systems from a user-centered perspective with the casual user in mind (p. 5). Studies continued to determine what users want, systems problems, and areas for improvement and implemented a variety of assessment tools such as: focus groups, iterative design process in the University of California Berkeley Electronic Environmental Library Project, Web hits, users logs, database analysis, satisfaction surveys, usage as compared to a control group in the Alexandria Digital Earth Prototype, and content of the system as compared to other systems (Xie, 2006).

As more research results were collected, it became apparent users wanted access to information from anywhere. Many international conferences and initiatives assembled in support of international collaboration and to define universal information access protocols. The Division of Information and Intelligent Systems in the Directorate for Computer and Information Science

and Engineering sponsored the International Digital Libraries Collaborative Research and Applications Test Beds (National Science Foundation, 2002) which awarded multi-country, multi-team projects to create systems in multiple languages, formats, media, and social and organizational contexts. Its goal was “to advance the creation and access to Internet based digital content” (p. 5). To achieve this, various meetings were held to determine usability standards, resulting in a worldwide consensus that Dublin Core will be used for compatible description of digital objects (Fox, 1999) as well as other agreements. The Digital Library Evaluation Forum of the DELOS Network of Excellence, supported by the European Community, developed holistic evaluation criteria. The DELOS-National Science Foundation Working Group’s interdisciplinary research model is based on the triangular relationship between people, content, and technology with applications and use in the center of the triangle. DELOS recommends research between the three points of the triangle, such as people to technology and the center, to develop technologies that will enhance the way people create and access content (Fuhr, Hansen, Mabe, Micsik, & Sølvsberg, 2001; Chen, 2004).

Up to this point, the studies share a common fact; they occur after a digital library is built. An innovative approach to user research studies and systems evaluations is the UOWM study’s premise to create evaluation criteria from the user’s point of view by identifying what users feel is important in a digital library and the problems they encounter with existing digital libraries (Xie, 2006). This is very similar the Gap Model of Service Quality used in the business sector. To evaluate users’ satisfaction, evaluation tools measure the performance gap between customers’ perceptions of expectations and importance of service delivered and the company’s perception. This model posits customers are the best judges of service quality; therefore organizations should include customers in the assessment process to understand the value of and

way to improve service (Parrasuram, Zeithanl, & Berry, 1985, p. 45). As libraries provide more user-centered services, some users will search the collection for specific purpose while others will search for entertainment or no purpose, uninterested or casual users (Kessler, 1996).

Libraries serve both users in a fast paced, budget conscience environment so an evaluation of services and resources by both addresses issues and realigns institutional goals and decisions to design the digital library to meet their needs.

Case Studies

University of Wisconsin-Milwaukee (UOWM) study

In 2003 and 2004, 48 undergraduate and graduate students participated in a study using open-ended self-administered surveys to develop a set of criteria, as well as the reasoning behind the selection, that they consider essential to evaluate a digital library's performance (Xie, 2006, p. 437). After becoming familiar with one of the large, existing digital libraries, participants then applied the set of criteria they created and reported problems incurred. Collection quality and usability resulted in the highest areas of importance. Service quality, system performance efficiency, and user opinion solicitation complete the remaining important criteria. After general content, collection quality criteria important to participants in descending order were scope, authority, accuracy, and completeness. Participants reported the ability to make their own judgment on authority, accuracy, currency, and copyright was important however many libraries do not maintain a collection update schedule (p. 444). Within usability, general usability, interface usability, and navigation were closely tied as important criteria. Participants indicated digital libraries that show the link from the library to its mission statement and that keep their users upmost in their minds were the most important criteria in service quality. Usability appeared again along with intuitive interface design, easily identifiable home page, more

browsing options, and efficient information retrieval with increased precision over recall as important system performance criteria. The ability to offer opinions through customer surveys or feedback forms was a highly rated criteria under user opinion solicitation (p. 440). Unexpectedly, the areas the participants valued were many of the same important criteria identified by previous user research and systems evaluation studies. Participants stated problems typically experienced with current digital libraries were the lack of intuitive interfaces, search features that were hard to control or did not support Boolean operators, lack of a help feature or site directory to locate information, and no output features such as print, save, etc. In addition, responses highlighted areas that were not considered by researchers in other studies such as provide and advertise services unique to the digital library; collect feedback both actively by tracking user satisfaction and passively by providing clearly visible contact information; offer community areas to exchange ideas or make announcements as can be done in a traditional library; reach out to local communities, and expand user base (pp. 443-446).

Digital Renaissance Foundation (DRF) study

In 2005, Italy's *Digital Renaissance Foundation's* (DRF) study measured onsite users' expectations and perceptions of three cultural institutions' digital libraries services: Mediteca Toscana, Humanities Library of the University of Florence, and the Library Museum of the History of Science. The study also assessed the current state of digital libraries in Italy to determine best practices in collaboration and interoperability; DRF was established to encourage cooperation between various organizations to share and promote the use of new technologies. As the user is critical to the assessment of a digital library, the study was designed from the user's point of view with the premise to justify the construction and maintenance of a digital library in that it must significantly add value over a traditional library (Tammaro, 2008, pp. 131-132). By

combining the elements, the study sampled a broad range of experienced digital collection users from undergraduate and graduate students at the University of Florence, professionals with post bachelor degrees at the History of Science, and students aged 19 to 25 at Mediteca. All users gave highest satisfaction for speed and virtual, 24 hour access to many resources. Areas that needed improvement were staff assistance, user education, online tutorials, and a new category, promotion and publicity of resources and services. Other important areas of improvement for the participants were an online public catalog (OPAC) design with easier findability features and the ability to give design input (p. 136).

Universities in Guangzhou, China study

From May to August 2009, undergraduate and graduate students from three Chinese universities were surveyed to measure their use of the digital library at their respective universities. Each university has an extensive digital library and the subjects were from a variety of disciplines. Of the 400 surveys sent out, 152 undergraduate and 129 graduate surveys were returned collecting quantitative and qualitative data including open-ended questions (Ziming, & Lili, 2011, p. 230). Both groups reported the convenience of remote 24-hour access, speed of delivery, and the availability to a number of resources the three most determining factors as to why to use the digital library. The students responded that the digital library saves time in their research. This result is unique to the *Guangzhou* study because Chinese students use digital libraries more readily than their Western counterparts and tend to look up quick facts in a digital library first as compared to US students who first search Wikipedia. Undergraduates responded that they expect Internet search engine performance to occur in all electronic resource interfaces and were satisfied that they didn't have to worry about material availability. Graduate students said they appreciated earlier access to publications (pp. 231-234). Undergraduates responded that

detering factors to using the digital resources are the ability to retrieve information from the Internet, digital libraries are difficult to use, and no human help. While graduate students said their deterrents are the lack of reliable materials and no access to older materials, so like undergraduates, they resort to conducting their research on the Internet. Qualitative and open-ended responses expanded on their perceptions of the digital libraries: extends the breath of materials and reduces library visits to some extent. Overall, graduate students used and appreciated the digital library more than the undergraduates. Both groups agreed that more use equates to higher satisfaction as familiarity, trust, and credibility are developed (p. 235).

Analysis and Discussion

The UOWM study provides a critical perspective on user research studies as it aids in understanding user expectations to accurately measure gaps in digital libraries' performance and moves forward the efforts to create global evaluation criteria. Analysis of the studies to the criteria determined in the UOWM study could discover digital libraries' strengths, weaknesses and areas for improvement. Although all three studies identified their sample population from frequent users of digital resources, the responses provide a baseline to determine the gap between user expectations and system performance for all users. Designers should keep in mind that the definition of research lies with the user. As users are not defined by their geography and anyone can use a digital library, non interested or casual users need to be included in future evaluation and design surveys as different users have different needs (Wade, p. 19) All three studies concluded that prior to the creation or renovation of a digital library, users should be identified and included in the design process.

Usability

Usability is user focused. Digital libraries' design should be simple and understandable like the Internet, putting the user in control of the search parameters. If the design is easy to navigate then it is easy to learn and remember how to use, two of Nielsen's five usability attributes. Study participants expected to access digital libraries through multiple entry points and navigate easily with intuitive search features to facilitate their research goals. They expected to find pages and materials represented in consistent layouts combined with strong cataloging and classification systems. These expectations reflect interface design best practices advocated in human-computer interaction (HCI) to keep users engaged (Marchionini, 1998, p. 18; Parandjuk, 2010, pp. 125- 28).

Even though these were relatively recent studies and participants were familiar with digital libraries in general prior to testing, it is surprising the participants' encountered poor interface designs, especially as best practices in Web site design are published every year and can be transferable to digital library design. The *Guangzhou* study results may be due to the fact that China's digital libraries initiatives have lagged behind (Hongqing & Zimmerman, 2003; Liu, W., 2003; Liu, W. & Zhang, 2008, p. 157). It is challenging to construct a digital library that is current and customizable for diverse communities. Reviewing the important criteria outlined in the studies, there are features and services that digital libraries could consider incorporating to meet users' needs. Well-designed information architecture encourages findability from the Internet. Findability encompasses aspects of information architecture, user interface design, accessibility, and search engine optimization (SEO). Strong meta elements describing the library Web site could link the library to the user's Internet search terms resulting in the Web site appearing in the first 10 results. For instance, when performing a Google search for the term

Leonardo, meaning Leonardo da Vinci, the Museum of Science in Boston, Massachusetts' 1997 Leonardo exhibition is listed fourth in the results.

Although considered as internal search functions, multi-language, natural language, and image-based navigation are features digital libraries could consider adding to their Web interface design. Users can select the language feature to translate text or the page enabling the user to type the query, as they would say it naturally, to retrieve results (Kessler, 1996). The user would not have to know the primary language of the site nor Library of Congress Subject Headings or Booleans operators as the architecture intuitively translates the query for optimal results. Best practices suggest having multiple domains to optimize findability by language, however multi-language capabilities can be expensive. Depending on how many languages the library serves, the library would have to balance service to languages to offered. The National Library of China (NLC) and Peking University Library (PKL) have separate domains for the Chinese and English version of their Web sites. An Internet search in English for NLC or PKL presents their English domain as the second and first results, respectively. Both sites have the Chinese translation feature located in the upper right-hand corner of the Home Page.

Image based navigation is another feature a digital library could consider adding to replace languages not served or to facilitate access to their collection. One of NLC's partners, the World Digital Library (WDL), is an example of best practices for multi-language and image navigation. Like PKL, WDL's English site appears as the first result in an English language Internet search. When selected, its interface is a map of the world with one image per continent as entry point. The user can change the Web site's language by selecting one of the seven supported languages from the pull down menu at the top of the page. This features remains in place on every page of the site. When selecting the image, the system retrieves the title of the

work, its description in an easy to read layout, hypertext links from key points in the description to corresponding pages in the collection, and a scroll of thumbnail images of material in the collection related to the item. Another entry point on the Home Page is the hyperlinked text next to the image stating the number of images in the collection for the continent. Also, the user can click and drag the date indicator on the world history timeline located at the base of the page to the appropriate era of the users' search. The manipulation changes the image on the continent and the number of items in the collection that correspond to the era and the continent selected. As suggested by best practices, these easily recognizable and navigable interfaces put the user in control. Further consideration could be given to include an image search similar to Google's allowing users to click and drag an image from their desktop, link to an image's URL, or upload an image to the digital library's search input field to search the collection for the item.

Another search feature not considered in the studies is voice recognition search to empower users who may be visually or physically impaired. Designers could mimic or subscribe to Google's Voice Search on Desktop, a mobile app that can support 27 languages and dialects. Additionally, designers could consider offering a spoken word version of the collection similar to WDL's. On the item's catalog page, WDL offers a Listen to this page feature. By clicking the Listen-button, the add-on enables the user to see synchronized highlighting of the text that is currently being read, on a word by word depending on the language the user selected.

Collection quality

So it is not necessarily a question of improving the collection, but placing it where users are to attract them to search the collection. As more digital libraries employ findability best practices, they must anticipate changes in search engine capabilities and design features that will make their system work for the user. Meta tags of collection material deep links the catalog to

the user's search terms as experienced when using Google Book Search. A book entry in the list of retrieved results will provide a link "Find in a library" that intuitively jumps the user to WorldCat, a library content network, from which the user can select the closest library and view its OPAC for availability (Brenner & Klein, 2008).

Once located, the collection's scope, authority, accuracy, completeness, and currency are vital to establish the value and reliability of a library. Without high quality, the digital collection cannot support the needs of many users. Participants responded that functionality issues encountered when using OPACs or online databases result in a perception that the collection's quality is poor (Tammara, 2008). Digital libraries could consider addressing this by instituting a search tool based on visual data analysis. By replicating humans' natural ability to interpret relations between data, the tool expresses the attributes of the search term in a diagram where the search term is in the center connected by spokes of a flexible wheel to all related terms, labeled in natural language, around it. The diagram and the catalog page could be easily translated into the user's language with one click. In addition, there is the option for the user to contribute tags, ratings, create a separate personal collection as well as participate in member forums. This function allows for the ability of the system to know the user's likes and dislikes, like LibraryThing, solving respondents desire to experience the serendipity of locating a resource by browsing (Ziming & Lili, 2011). Humans have always employed these tactics through face-to-face communication or by phone so social media tools answer the respondents' desire for virtual spaces for collaboration. Also, user-generated metadata or tagging can increase findability as natural language changes over time and names for items change within cultures (Kessler, 1996).

Because respondents indicated they related the value of a digital collection's scope and authority to a traditional library, it is important for designers to separate user-generated material

from library-generated material to maintain accuracy and reliability (IFLA, 2010). Open source or Web 2.0 applications allows for next generation features to be easily applied. Prior to implementing Web 2.0, digital libraries could determine potential security risks as well as the technical knowledge needed and staff resources required to maintain the applications, especially if the institution does not have an IT department.

Lastly, designers could consider building an easy to locate collection update schedule statement and copyright information to assist users to make their own material currency and validity judgments. The update schedule was not retrievable for NLC, PKL or WDL, however WDL does have a last updated date in the lower right-hand corner of each cataloged item's page. Only PKL follows best practices in Website development by placing the copyright dates, the date the Web site is active and last updated, on the bottom of each page. NLC provides a link to the library's overall copyright policy statement as a hyperlink on the bottom of every page. As PKL's and NLC's collections are in Chinese, confirmation is difficult for non-Chinese speakers to make validity judgments on objects in the collection.

Service quality

When executed properly, this criterion can differentiate digital libraries from search engines. Although the respondents may have drawn on their traditional library experiences as a benchmark against which to evaluate this criterion, their comments urge digital libraries to remember their function as educator, facilitator of the exchange of ideas, community bulletin board, and cultural center. Internet searching has influenced search patterns making a 'Google generation user', natives and older generations (IFLA, 2010). As of June 2009, Google had 88 % share of the web search query market in Italy (Bonfils, 2010) while in December 2010, Google had 66% share of the US market (Comscore, 2011). In the first quarter of 2011, Google

controlled 19.2 % of the market in China while Baidu, China's search engine, had 75.8 % (Chen, L., 2011). Google generation users scan, do not read, the first ten results of an Internet search. Because of this, their digital library information literacy will be low. Information literacy is a set of abilities requiring individuals to "recognize when information is needed and have the ability to locate, evaluate, and use effectively the needed information" (ALA Web site, 2000). Without the experience using analytical search strategies such as Boolean operators or Library of Congress Subject Headings in digital collections, users will become frustrated because of their inability to navigate to the appropriate resource (IFLA, 2010). Librarians help people learn by identifying resources not previously identified by the user, coaching, and asking questions and this role must be incorporated in the digital library's design. The Contact Us and help links are clearly labeled and easily located on NLC's, PKL's, and WDL's sites, however NLC's and PKL's help page is in Chinese. Conversely, WDL employs best practices because its help page is easily translated using the language menu at the top of the page and all help features such as tutorials, screenshots, and contact forms are in the designated language. Whether it is FAQs, user education modules or lectures, online tutorials or live assistance, these features have to be easily accessible and maneuverable, reliable, and accurate to build trust in a system that puts their users first, resulting in returning customers.

In addition, digital libraries have to identify and highlight their special services that cannot be found elsewhere (Xie, 2006). Borrowing from the business sector, it is important to have a business strategy that uses the Web site as the virtual face of the library and serves as a discovery tool with meta elements pulling users to it. Forty-two percent of US adults use social media to follow favorite retailers for special deals, new product news, and promotions (Bell, Web log, 2011). Social media reflects the human tendency of involving group discussion and

individual input so it can be used for two traditional marketing purposes: word-of-mouth advertising to push events or services and secondly, to build a base of library advocates who will support the digital library in good and bad times (Bell, Web log, 2011). However, libraries must commit to update the pages a minimum of once per week or the social media site content will be perceived as irrelevant and untrustworthy, an extension of the collection.

A unique promotional approach is based on the reasoning that not everyone in China has a mobile device, but everyone has access to a television. So, the National Digital Library of China's (NDLC) five-year goal is to broadcast through television over a dedicated channel NLC's catalog, events such as the Weijin Lecture series, recommended books, classics, or children's reading materials (Meng, Q, personal communication, June 22, 2011). Although this initiative may not be easily replicated in other countries, it is attainable due to China's political and financial support and the national upgrade to digital television.

System performance efficiency and user opinion solicitation

Many of the suggested usability improvements can also apply to system performance. Further efforts to streamline database interfaces, combine text with multimedia, and multiple language capabilities have improved accessibility. Additionally, libraries added mechanisms to increase precision such as Google's PageRanking or highlighting text. The National Science Digital Library, Chinese Academy of Sciences (NSLC) indicated they are changing their mission from a digital library to a knowledge service by adding ilibrary, a mashup toolkit (Zeng, Y., personal communication, June 21, 2011). A mashup performs as it sounds; it combines data from two or more sources to create a new service from one search box. This service advances the principle of universal access and improves the collection quality when tied to other collections. It

also competes favorably with Google's new mashup service called What Do You Love (Schroeder, 2011).

As system performance evaluations progress, there are suggested methods to complement the passive 'Contact Us' form or links to the institution's email address. One method passively tracks users' search patterns to identify weak links or confusing design patterns (IFLA, 2010, p. 76). As users are familiar with social media and online public forums, digital libraries are slowly offering more interactive feedback collection venues. By participating, users have a vested interest in the success of their information resource and anticipate action or response to be taken quickly; a slow or no response will negatively affect the user's perception of the library's quality.

Conclusions and Recommendations

As envisioned in *As We May Think* (Bush, 1945), the Internet has led the information explosion. Digital libraries are constantly developing and changing to remain competitive. Although decisions on copyright, censorship, bridging the digital divide, net neutrality, and digital library evaluation guidelines are pending, global collaboration continues to overcome political differences between countries to diversify collections and provide universal access. Digital libraries are a combination of digital and traditional materials with developed information systems to preserve and organize information to ensure its ready access. As they transform into knowledge management systems, consideration could be given to expand digital libraries to realize social media's full potential of interactivity. Although user-generated material will need to be delineated from library-generated, social media's design matches the Google generation's collective, bottom-up, communication style and exemplifies the associated ways of indexing information, linking articles, and enabling access to other users as envisioned by Bush (1945).

One possible product available to perform these interactive tasks is ProQuest's Summon Service. Nie (2011, June 15) indicated that, by the end of year, PKL will replace their current federated search engines with Summons. Based on Software as a Service (SaaS) in which software and data are centrally hosted on the Internet or cloud computing, Summon performs intuitive and fast searches that mimic the Web browsing experience within the mash up of subscribed partners. The service is applicable to all types of collections and includes 'Marketing Your Library tool kit' (Serials Solution Web site, 2011). Although each feature is fee related, the collection broadens and the fees reduce as more member libraries join. Another option, Blacklight, is a free, open source OPAC that allows anyone to search and browse collections online. Currently, Blacklight can index, search, and provide faceted browsing (Blacklight Website, 2011).

Regardless of the investment of time and materials to build and maintain a digital library, it will have little perceived value if materials are not accessed because users are unaware of its existence or find it difficult to use. The user base must be identified and partnerships developed to serve existing users and to engage new users. Once identified, users' motivations and behaviors cannot be assumed so continuous evaluation will remain a priority. Future research using the criteria from the UOWM study may help to develop global evaluation metrics to include the early involvement of existing and potential users in the design process. In rapidly changing fiscal environments, libraries can remain viable by locating the appropriate investment avenues to improve resources and services to meet users' needs and to create a valuable, dynamic space, serving the global community as its primary source of information.

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