

Developing Multi-Method, Iterative, and User-Centered Evaluation Strategies for Digital Libraries: Functionality, Usability, and Accessibility

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Usability, functionality, and accessibility testing of digital library information services and products are essential for providing high quality services to users. This paper details a long-term, evolving effort to develop meaningful

evaluations for assessing digital libraries. The authors of this paper have been engaged in a multi-year study to determine appropriate evaluation techniques, tools, and methodologies for the Florida Electronic Library (FEL) and other digital libraries. The evaluation protocols and approaches have been designed over time and iteratively through assessment efforts of the research team of other digital library initiatives and with multiple versions of the FEL. As such, this paper examines the process of developing, applying, and refining appropriate evaluation methodologies for the networked environment of libraries, as well as the implications of these methodologies.

The approach taken in the research described herein relies on a combination of evaluation strategies applied iteratively to assess libraries from the perspective of patron needs. A number of specific methods, as shown in this paper, can be readily developed to provide such evaluations. The following goals guide the presentation in this paper of the development through time of the methods and instruments created, tested, refined, and operationalized in functionality, usability, and accessibility testing by the researchers. The goals of this paper are to: 1) demonstrate the potential roles of multiple, iterative evaluation strategies in the development and refinement of digital libraries; 2) detail the methodologies that focus on how the services meet the needs of users; and 3) encourage further discussion of the uses of these multiple evaluation approaches in assessing these libraries.

Introduction

This paper details a long-term, evolving effort to develop meaningful evaluations for assessing digital libraries. The authors of this paper have been engaged in a multi-year study to determine appropriate evaluation techniques, tools, and methodologies for the Florida Electronic Library (FEL) and other digital libraries. The evaluation protocols and approaches have been designed over time and iteratively through assessment efforts of the research team with multiple versions of the FEL and of other digital library initiatives. As such, this paper examines the process of developing, applying, and refining appropriate evaluation methodologies for the networked environment of libraries, as well as the implications of these methodologies.

The networked environment is an important means through which libraries provide access to information and in which individuals seek information. In light of the still expanding usage of the Internet, digital libraries stand to play an increasingly significant role in the way in which patrons expect to receive library services, including the ability to search and retrieve content from library catalogs,

web pages, and licensed resources. Digital libraries “give us opportunities we never had with traditional libraries or even with the web” (King, et al., 2004, p. 123).

With the growing importance of the provision of online services and resources, there is a need to establish methods by which to evaluate and measure the performance of library websites, the information they contain, and the services they deliver against set standards. Evaluation can play both a formative role, helping to continually refine and update goals, objectives, and services; and a summative role, helping to ascertain whether the goals and objectives are being met (Ryan, McClure, & Bertot, 2001; Thompson, McClure, & Jaeger, 2003). Evaluation can also provide insight into whether a program is more effective and efficient as a physical program or as a technology-driven program (Hallfors, et al., 2000). As identified in ensuing sections of this paper, all of these issues have implications for the evaluation of digital libraries.

A number of studies sought to create frameworks for researching or assessing a library’s networked environment (i.e., Bishop, et al., 2003; Borgman, 2003; King, et al., 2004; Marchionini, Plaisant, & Komlodi, 2003). The approach taken in the research described herein relies on a combination of evaluation strategies applied iteratively to assess libraries from the perspective of patron needs. Additionally, from a methodological standpoint, the right combination of multiple approaches is very important. Multi-method approaches “may offer the best chance for innovative evaluation methods in the networked environment” (McClure & Bertot, 2001, p. xvi). To focus specifically on evaluating libraries from the perspective of needs of patrons, the researchers employed a combination of functionality, usability, and accessibility methods.

Functionality, usability, and accessibility testing of digital library information services and products are essential for providing high quality services to a broad and diverse population of users. A number of specific methods, as shown in this paper, can be readily developed to provide such evaluations. In this paper, specific goals guide the presentation of the development through time of the methods and instruments created, tested, refined, and operationalized in functionality, usability, and accessibility testing by the researchers. The goals of this paper are to: 1) demonstrate the potential roles of multiple, iterative evaluation strategies in the development and refinement of digital libraries; 2) detail the methodologies that focus on how the services meet the needs of users; and 3) encourage further discussion of the uses of these multiple evaluation approaches in assessing these libraries.

Functionality, Usability, and Accessibility in the Digital Library Context

Functionality, usability, and accessibility are methodologies that provide different data regarding the ability of a digital library to meet the needs of users. More specifically:

- Functionality testing determines the extent to which a digital library, in whole or in part, is able to perform desired operations (e.g., basic search, multiple languages).
- Usability testing determines the extent to which a digital library, in whole or in part, enables users to intuitively use a digital library's various features.
- Accessibility testing determines the extent to which a digital library, in whole or in part, provides users with disabilities the ability to interact with the digital library.

Rather than focus strictly on technological aspects, this combination of methodologies places emphasis directly on how well the digital library serves its community of users on the whole (see Table 1 below). Such methodologies account for key points of library service from the perspective of providing service where: 1) information and services must be comprehensible for all users; 2) features and functions necessary to provide library services must be present and always operate properly; and 3) the needs of a diverse population of users within a library's community, which includes those with special access needs must be considered.

Table 1: Methods for evaluating Digital Libraries.

Method	Purposes	Selected Resources
Functionality	<ul style="list-style-type: none"> • Assesses whether the digital library (or component) actually works in the manner it is intended and provides the results it is meant to deliver. • Can be used to make comparisons between separate, comparable programs with similar goals. 	Bertot, 2002; Bertot, et al., 2003; Wallace, 2001.
Usability	<ul style="list-style-type: none"> • Assesses how users react to and interact with the program. • Can allow the user to express personal impressions of the resource, such as satisfaction, utility, value, helpfulness, benefits, frustration, and self-efficacy. 	Dalrymple & Zweizig, 1992; Hert, 2001; Sweeney, Maguire, & Shackel, 1993.
Accessibility	<ul style="list-style-type: none"> • Assesses how well systems allow users with disabilities to have equal or equivalent use of information and services. • Measures often tied to the suggested accessibility guidelines of the World Wide Web Consortium or the guidelines of Section 508 of the Rehabilitation Act (29 U.S.C. § 794d). 	Jaeger, 2002; Nadler & Furman, 2001; Section 508 of the Rehabilitation Act; World Wide Web Consortium, 1998.

Moreover, the combination of all three of these techniques provides a composite picture that is far more comprehensive and robust than any of these evaluation strategies can provide individually. Further, by employing this combination of approaches in an iterative fashion, evaluations of digital libraries can be used to continually refine and improve the services of these libraries. More specifically, this multi-method approach to evaluating the digital services and resources of libraries enables researchers, library managers, and funding agencies to understand the extent to which:

- A library's networked environment meets desired user system features – e.g., search and retrieve functions, information

- access displays (for immediate download, location and availability, format, language);
- The design of the library is intuitive and overall enables users to navigate with ease; and
- Users with various disabilities (e.g., visual, auditory, mobility) can engage services and resources for information seeking and retrieval processes.

Together, therefore, this combination of evaluative data provides multiple and powerful perspectives on the operation and use of a digital library.

Evaluation Protocols

The research team engaged in multiple research efforts over time to develop functionality, usability, and accessibility protocols. These studies took place over a period of three years, from 2002 to 2004, and involved multiple digital library initiatives in the states of Texas and Florida (see Bertot, 2002; Bertot, et al., 2003; McClure, Snead, & Bertot, 2004; Snead, et al., 2004). Not all the studies used all three approaches; in some cases, an individual study served as the basis for the development of a particular protocol (i.e., accessibility). In the end, however, the functionality, usability, and accessibility protocols were developed, pre-tested, and refined through a multi-project iterative process. The purpose of developing these specific protocols is two-fold: 1) to broaden the kinds and types of data collected; and 2) to address the growing complexity of digital libraries by evaluating the various components of libraries using a variety of evaluative means.

As complex entities, digital libraries in general consist of three key components: 1) an online catalog; 2) digitized library content, generally made available through a library's website; and 3) licensed resources. Additionally and in this context, digital libraries are increasingly making use of federated search systems that enable users to search and retrieve material across all three of these resource types. Thus, it is necessary to engage in a multi-evaluation effort using functionality, usability, and accessibility testing that looks across these different resource types and search interfaces. This multi-evaluation approach using these three methods provides a broader, richer collection of data than focus strictly upon technological aspects of a digital library's components can provide.

Functionality Protocol Development

Functionality is a relatively new and evolving concept in terms of digital libraries and has not yet been widely studied in relation to them. For this work, the researchers define functionality as the extent to which the information and services of a digital library perform the desired operations and provide the content that they are designed to provide.

Moen & Murray (2002) developed functional requirements for the Library of Texas (ZLOT) initiative. At that time, the researchers and the State Library of Texas were trying to determine the feasibility of the functional requirements findings compared with the current library search and retrieval technology marketplace. The results of this study “identified three levels of functional requirement priorities for four Resource Discovery Service components: Virtual Catalog (VC), Search and Retrieval Interface (SRI), Search Interface (SI), and Retrieval Interface (RI)” (Bertot, 2002).

Based on the functional requirements identified by Moen & Murray, Bertot (2002) developed a functionality protocol that enabled the ZLOT study team to look across multiple vendor federated search system products. More specifically, the protocol (see Table 2 below):

- Focused on selected functions and features;
- Attempted to determine the extent pilot projects meet specific system requirements; and
- Provided selected assessments of the extent projects accurately search and retrieve individual library OPACs.

Results of the study allowed presentation of data retrieved in two ways: 1) A Functional Requirement Capability Index through which points for each functional requirement (and its subcomponents) were summed from evaluators and then divided to create an indicator for percent of requirements met; and 2) A Functional Requirement Ability Index through which *functional requirements met* per prototype were summed and then divided to provide indicators of the full extent functional requirements were met, as specified by the Moen & Murray report. These two indexes, therefore, allowed the researchers to look across multiple vendor systems and determine the extent to which their systems met the LOT functional requirements.

Over a period of two years, study teams from the Information Institute at Florida State University built on this functionality protocol by initially testing and evaluating four different existing Florida digital library pilot programs. These programs were selected as representative of different operational models of virtual catalogs to provide data to developers of a future virtual catalog component

of the Florida Electronic Library (Bertot, et al., 2003). Testing and evaluation also occurred on the model eventually selected and developed as the virtual catalog model for the Florida Electronic Library (Snead, et al., 2004). Additional functionality testing occurred within the FEL setting of a single federated search interface product currently under development as part of the portal component of the FEL (Snead, et al., 2004).

Usability Protocol Development

Usability testing measures the quality of the experience a user has when interacting with a website, including factors of ease, efficiency, memorability, and satisfaction (Usability.gov, 2004). Studies that have evaluated digital libraries from that perspective of users have predominantly employed the methodology of usability (i.e., Battleson, Booth, & Weintrop, 2001; Campbell, 2001; Norlin & Winters, 2002; Van den Haak, De Jong, & Schellens, 2003, 2004).

Members of the research team developed the initial usability instrument while evaluating a project called the Public Library Geographic Database (Thompson, McClure, Ott, & Snead, 2004) as part of an Institute of Museum and Library Services grant awarded jointly to the Information Institute and the GeoLib Program of the Florida Resources and Environmental Analysis Center (FREAC) at Florida State University. Usability testing was conducted through several phases within the usability lab setting, and the usability instrument was refined throughout the course of the research (McClure, Snead, & Bertot, 2004).

For purposes of the 2004 FEL study, the study team employed a broad meaning for usability, using a selection of usability methods including policy analysis, website management and organization, technical assessment, and/or user satisfaction. The scope of the usability analysis specifically addressed the usability of the tested online interfaces for librarians and other library users, who participated in the testing within a lab setting. Some examples of primary questions used to frame the usability lab evaluations include:

1. Were the basic navigation and identification tasks intuitive?
2. Was data presented within each interface logical, clear, and easy to understand?
3. Did each interface perform as users expected it would?

4. Could the data obtained from the testing be useful for library planning, policy development, training purposes, and decision-making purposes?
5. What are some specific recommendations to make each interface more useful?
6. What are some specific recommendations to improve each interface?

These and other guided questions were used to assess the experience of the user from the user perspective as to usability and usefulness of the interfaces being assessed.

The protocol was portable and could be administered in multiple settings. Indeed, the study team engaged in usability testing in the Information Institute's usability lab as well as at three library sites. This approach resulted in a flexible, yet comprehensive usability protocol that could be used to engage users of digital libraries in the lab setting and in more natural settings.

Table 2: Examples of Instrument Criteria and Descriptions.

Instrument	Criteria	Description
Functionality	<ol style="list-style-type: none"> 1. Ability to group 2. Limiting 3. Search options 4. Refine searches 	<ol style="list-style-type: none"> 1. Prior to search, user can delimit <i>pending results' listings</i>, and group results by item characteristics (type, format). 2. User can limit search by library (e.g. specific library, group of libraries, type of library, etc.) 3. User can perform both basic and advanced search; also user can search by subject, author, keyword, title, etc. 4. Once results are retrieved, users have the ability to focus and reduce number of items retrieved.
Usability	<ol style="list-style-type: none"> 1. Navigation 2. Content Presentation 3. Labels 4. Search process 	<ol style="list-style-type: none"> 1. Ability to traverse a site using available navigation site tools, e.g. back buttons, links. 2. Content presented in logical manner that is clear and easy to understand 3. Toolbars, buttons, icons, drop-down features are sensibly presented and labeled 4. Search features enhance location and retrieval of relevant materials.
Accessibility	<ol style="list-style-type: none"> 1. Alternate forms of content 2. Color independent 	<ol style="list-style-type: none"> 1. Users with visual or auditory disabilities are given access to all content through provision of alternate, equivalent formats. 2. Users with color deficits and other visual disabilities can access all content; site does not rely on specific colors to convey content.

Accessibility Protocol Development

An information technology is accessible to persons with disabilities when “it can be used in a variety of ways that do not depend on a single sense or ability” (Nadler & Furman, 2001, p. 14). As such, a digital library should present its information and services in a manner that does not prevent any users with disabilities—visual, auditory, mobility, cognitive, learning, and others—from using part or all of the content.

In developing the accessibility instrument, the research team generally followed the suggested guidelines of the World Wide Web

Consortium (“W3C”) (1998). The team, however, applied the principles of these guidelines in light of the specific requirements of Section 508 of the Rehabilitation Act when performing accessibility evaluations. As the Section 508 requirements were designed for government websites, these practical requirements have considerable utility when evaluating digital library sites, which are often a function of local or state governments. The combination of these two standards creates a lens that combines both accessibility principles and specific government-oriented requirements for evaluation. Deriving criteria specific for accessibility from these standards was seen as critical by the research team to use in assessing digital library components in federated search systems for individuals with disabilities (see Table 2).

The research team originally developed initial accessibility criteria of the FEL for inclusion within the functionality instrument used in Bertot, et al. (2003). Initially, the research team viewed accessibility as functionality criteria; however, after applying the criteria within the functionality assessment and interpreting results, it was determined that this approach limited the collection of potentially rich and descriptive data. Restricting accessibility testing to functionality seemed to limit the application of the assessment and weaken interpretation of results via the standards from which the original criteria were derived, from W3C and Section 508. Thus, the team revised and enhanced the initial accessibility protocol.

The goal of testing the three pilot programs with a newly revised and expanded accessibility instrument was to provide a better and more comprehensive understanding of accessibility issues for users with a range of disabilities, including visual impairments, hearing impairments, learning disabilities, and mobility impairments. An example of the broadened application is the inclusion within results of a suggestion line for addressing identified issues that correspond directly to specific sections within the W3C and Section 508 that accompanies each testing question. The results offer guidance for addressing these suggestions by identifying related resources within the W3C website or the Section 508 website.

Conclusions and Future Directions

By combining these three methodologies, the researchers found that they were able to create a rich and robust evaluation of digital libraries, accounting for needs of diverse user populations. These methodologies can provide detailed evaluations of the extent to which information and services are comprehensible for all users, the extent to which the features and functions necessary to provide library functions operate properly, and the extent to which the digital library meets the needs of a diverse population of

users within a library's community.

These methodologies also present a number of issues that researchers and practitioners should consider when evaluating digital libraries:

- Evaluation design, planning, and execution are essential to fruitful evaluation efforts (Bertot & Davis, 2004; Carvalho & White, 2004). A key part of good design is tailoring the evaluation to fit the particular circumstances and to fit information needs of the primary audiences for the study and address a real, known need (Feinstein, 2002; Mathison, 2001; Patton, 1997).
- There are multiple evaluation approaches, tools, and techniques to employ in the evaluation of digital libraries. These can range from measures of performance and outputs (e-metrics) to measures that focus on users such as service quality, outcomes, functionality, usability, and accessibility (Bertot, 2003; Bertot & McClure, 2003a, 2003b; Bertot & Snead, 2004; Jaeger, 2002; McClure, et al., 2004; Snead, et al., 2004). Given the approaches available to digital library evaluators and managers, it is important to select the most appropriate evaluation approach or approaches that best meet their informational needs.
- One evaluation technique may not meet the informational needs of researchers or digital library managers. It is more likely the case that there is a need to engage in multiple evaluation techniques to yield a comprehensive picture of a digital library's impact(s) on its user community.
- The combination of functionality, usability, and accessibility testing enables a suite of user-centered design evaluation data that describe the operation of a digital library and its features; demonstrate the ability of users to intuitively navigate through the digital library and take advantage of the library's features; and determine whether users with various types of disabilities can truly interact with the digital library and its contents. The robustness of these combined evaluation approaches far outweighs the informative value of either approach conducted separately.

The protocols and methods aimed at the evaluation of digital libraries, and the implementation of such protocols and methods, will need to continue to evolve over time to meet the changing digital library landscape, goals and objectives of specific digital libraries, and evaluation needs of researchers and practitioners.

In future research on these methodologies in relation to digital libraries, topics that merit further exploration include:

- Exploring ways to further integrate functionality, usability, and accessibility testing into basic evaluation activities;
- Ascertaining how functionality, usability, and accessibility testing can be tailored to best localize the needs of individual digital libraries;
- Comparing ways to report findings to determine which reporting methods best facilitate implementation of evaluation findings;
- Exploring data quality issues, such as reliability and validity, as they pertain to these methodologies;
- Raising awareness of the importance of these methodologies and finding ways to counter the perception that these methodologies are unduly expensive or time-consuming;
- Providing means for users to have a voice in the evaluation of libraries in terms of functionality, usability, and accessibility;
- Establishing performance benchmarks by which to measure the effectiveness of these functionality, usability, and accessibility methodologies;
- Determining if other methods of testing might compliment or significantly enhance the use of functionality, usability, and accessibility methodologies; and
- Finding ways to better incorporate these methodologies and their importance into the curricula of Library and Information Science degree programs.

Research on such issues will provide a better understanding of the ways to make these approaches more useful and will raise awareness of these issues for library professionals, library students, and digital library users. Ultimately, by enacting multi-method user-centered approaches to assessing digital libraries, researchers and practitioners can ensure that investments in digital libraries are returned through extensive use of resources by a community with diverse information seeking needs.

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