

# Three looks at users: a comparison of methods for studying digital library use

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## Abstract

The Variations and Variations<sup>2</sup> digital music library projects at Indiana University provide a valuable test-bed for user studies. We have used user satisfaction questionnaires, session logging, and contextual inquiry to study digital music library usage by music students. This paper describes our approach with each method and offers a comparison of cost, advantages, and disadvantages of each methods. The comparison can help digital library practitioners choose amongst or combine field-study methods based on their objectives and constraints.

## Introduction

Usability has been a continuing topic of interest in the digital library (DL) community. In 1995 the US National Science Foundation sponsored "How We Do User-Centered Design and Evaluation of Digital Libraries: A Methodological Forum" (Bishop, 1995). Two more recent examples of such workshops are the JCDL 2002 workshop, "Usability of Digital Libraries" (Blandford & Buchanan, 2002) and the Fourth DELOS workshop, "Evaluation of Digital Libraries: Testbeds, Measurements, and Metrics" (Borgman, 2002), which, although not exclusively concerned with usability issues, included papers on user-centred topics.

Two general, comprehensive books about digital libraries each offer a chapter pertaining to usability: "Usability and Retrieval Evaluation" (Lesk, 1997) and "User Interfaces and Usability" (Arms, 2000). However, although both chapters emphasize fitting the DL interface to the user, neither suggests users be consulted or studied. Both take what may be called a "weak" approach to user-centred activity. Weak user-centredness believes it is adequate to base design upon ergonomic principles gleaned from prior studies or upon best practices. Strong user-centredness believes one's own users, tasks, and contexts must be examined because contexts differ too much and design is too complex an activity for general ergonomic principles and best practices, though important, to be sufficient.

One of the more common methods for studying users is lab-based user testing, examining representative or surrogate users as they work through set tasks in a controlled environment. For example, a survey of Digital Library Federation members reports:

Half of the DLF respondents reported conducting or planning to conduct user protocols. With rare exception, libraries appear to view

think-aloud protocols as the premier research method for assessing the usability of OPACs, Web pages, local digital collections, and vendor products. (Covey, 2002, p. 24)

Although we have used and continue to use lab-based testing in our work (Fuhrman, et al., 2001; Swan, et al., 2002; Swan, 2002b; Swan, 2003), this paper describes studies of DL usage in natural settings. We used three methods:

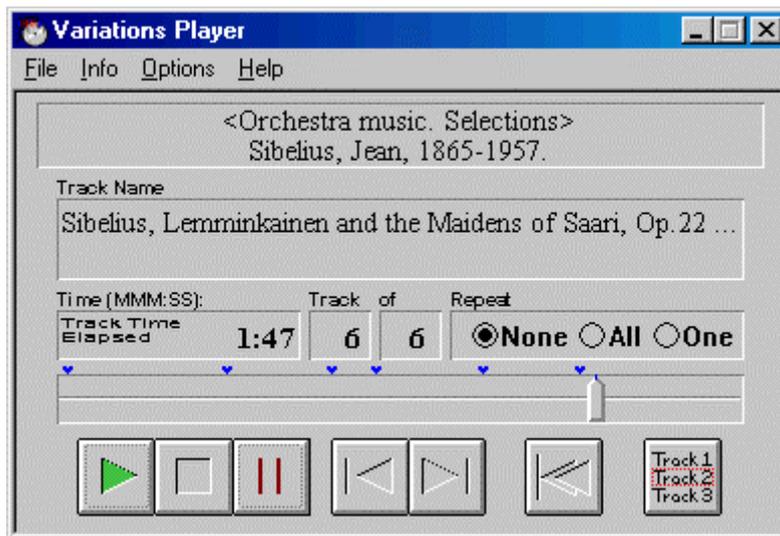
- User satisfaction questionnaire (2 studies)
- Session activity logging
- Contextual inquiry

These studies were motivated by a recognition that lab-based testing differs from actual use, a difference we are exploring in greater detail (Notess & Swan, 2003). Unlike many studies of DL use, our studies primarily examined information use rather than information seeking. After a brief description of our digital music library systems, the method and findings of each study are summarized. Then, comparisons are drawn among the methods, looking at cost, skill requirements, and the nature and usefulness of the findings.

## **Variations and Variations<sup>2</sup>**

Variations is a heavily used digital music library, providing online access to music recordings and scores in the Indiana University (IU) Cook Music Library since 1996 (Dunn & Mayer, 1999). Variations contains over 200 scores (printed music) and 8000 near-CD quality digitized recordings, most of which are classical, although jazz and popular music are also represented. The online collection has grown in direct response to requests for online reserve material or for access to special collection items. Items are available from the online catalog as well as from course reserve web pages. Students can use Variations recordings from any of 90 PCs in the music library. Faculty can use Variations from several music classrooms to support instruction.

Items in Variations are accessed by URL. Recording URLs in the MARC-based online library catalog (IUCAT) lead to a web page summarizing the item and its contents. Links on course reserve pages also lead to item web pages. The Variations player window (Figure 1) is invoked by clicking on a link on the item web page. Because Variations audio files are stored on tape and copied to disk-based cache on demand, users may have to wait several minutes for the player to appear if no one has requested that item during the previous day or two. Variations score items do not have summary web pages: their URLs display the scanned musical score in a standard browser window.



**Figure 1. Variations audio player window**

Variations2 is a completely new digital music library system under development as part of a research project (Variations2, 2003). Even though the Variations2 collection is quite limited at this point (approximately 60 recordings and 6 scores), it is already deployed in the music library and has experienced pilot usage by several faculty and their students. Variations2 also offers an audio player, but a score viewer and search window, along with additional functionality such as bookmarking, make Variations2 a far more capable system than the original Variations (see Figure 2).



Figure 2. Variations2 score viewer, audio player, and bookmark editor windows

## The questionnaire studies

We have completed two questionnaire-based studies of actual use. The first study looked at usage of Variations; the second study looked at usage of Variations2 during a pilot deployment. Both studies used a user satisfaction questionnaire adapted from QUIS (Chin, et al., 1988). The questionnaire contained a section for collecting demographic information, presented 11 subjective satisfaction ratings on 7-point Likert scales, and invited respondents to offer additional comments.

The purpose of the first study was to establish a baseline for user satisfaction with the existing DL implementation. Students in the Cook Music Library were recruited as they entered the computer lab. 30 students who used Variations during their visit filled out paper-based questionnaires after completing their planned work and received a gift certificate as compensation for their participation. While we could have surveyed music students at large (nearly all of whom use Variations regularly), we wanted to get questionnaire responses immediately after a specific experience with Variations rather than simply asking for their general feelings about the software.

The purpose of the second study was to get an early comparative reading of user satisfaction with the new DL, again taking that reading after a specific experience. Variations2 is not yet in broad use because of its limited catalogue size, so we selected a particular class assignment for the pilot. Approximately 30 students in a graduate song literature class were asked to complete a listening assignment (students listen to several songs and write an analysis of each), but for this pilot, they were required to use Variations2 instead of Variations. Prior to the pilot, students were given a brief introduction to Variations2 along with a demonstration. The assignment was presented as a web page with hyperlinks to each of the songs (M531 Schubert listening assignment, 2002). For each song, students could access a recording, the score, and the song text in German and English. The song texts were provided in the score viewer as scanned images even though they were not scores. The web page also invited them to click on a link and fill out a web-based satisfaction questionnaire after completing the assignment, but no compensation was offered for doing so. Twelve students submitted questionnaires.

### Questionnaire results

Detailed findings from the first study (Variations) are available in a technical report (Swan, 2002a). A summary of findings is given in Table 1. A number in parentheses following a comment indicates how many respondents made a similar comment.

Topic	Findings (n=30)
Frequency of Variations use	26 use Variations at least once a week. 7 of these use it more than 5 times per week. 14 had first used Variations more than 2 years ago.
Purpose for using Variations	17 were studying for an exam or completing an assignment for class. 5 were doing personal listening.
Satisfaction ratings	Overall mean: 5.56 (1-7 scale). All items averaged above 5 except for "slow...fast", for which the average was 4.77.
Positive comments	"Very useful" (2); "simply tremendous to use...a veritable heaven for all musicians here".
Negative comments	Waiting to retrieve recordings and the inability to launch multiple retrievals simultaneously (7); difficulty in moving to a specific point in a recording and the delay in hearing the music (2); sound skipping or cutting off (2).
Recommendations	Provide more detailed information (liner notes, track times, etc.) (3); more music or types of music (2); improved search (2).

**Table 1. Variations satisfaction survey findings summary**

The satisfaction ratings from the second study (Variations2 pilot assignment) are compared with the ratings from the first study in Notess & Swan (2003). A summary

of findings is given in Table 2. Note that even though we were studying Variations2 use, we also asked the questions about Variations use.

Topic	Findings (n=12)
Frequency of Variations use	All use Variations twice per week or more; 3 use it five times a week or more.
Typical purposes for using Variations	Class assignments, listening to course reserves, or exam preparation (11); performance or voice lesson preparation (11); personal listening or pleasure (4); research (1).
Satisfaction ratings	Overall mean: 5.38 (1-7 scale). All items averaged 5 or above except for "number of screens/windows: confusing...very clear", for which the average was 4.86.
Positive comments	Five students specifically praised the easy availability of the scores and song texts, saying that it saves time and improves the overall experience: "my listening was accelerated greatly because I could reference the translations at any time", "great to have the translations and text handy, saves time as well---great program", "I love that I can look at a score and the text while listening to a song! That saves me so much time & my experience is 10x better because of it. Thanks.". Other positive comments mentioned the speed improvement over Variations (2).
Negative comments	Students offered disparate complaints. The only issue mentioned by more than one student was the difficulty of handling the many windows (2). Most respondents offered just one critique although one respondent offered 5 thoughtful, well-described user interface issues.
Recommendations	Two students mentioned that they would like to have a "repeat" option--Variations does this but Variations2 does not.

**Table 2. Variations2 satisfaction survey findings summary**

### **The session activity logging study**

The Variations2 software logs user activity. For this study we examined log files generated during the song literature pilot assignment mentioned above. Unlike many action log studies of digital libraries (e.g., Jones, et al., 2000), users in our study were not searching for items in a digital library. Because items in the pilot assignment were pre-identified, students did not need to search. They merely opened the item and used it.

### Log file analysis method

Each log file entry contains a timestamp, an identifier for the window, and information about the user action. Hence logging captures information about window opening, closing and resizing; button pressing, etc.

Text-based log files are easily processed by scripts. We developed some basic tools for extracting each session from the log file into a separate text file and creating a summary file showing the length of each session and the materials accessed. Beyond that we did not use any specialized tools. Analysis has been performed using Unix text processing command line tools.

A second form of analysis is the manual examination of a log file to try to reconstruct what the user did. The researcher walks through an individual session file performing a step-by-step analysis to interpret the user's experience.

### Log file analysis results

Table 3 shows a selection of metrics that were generated from the log files. Although there were 175 total sessions, we only analyzed sessions which included accessing media. The other sessions were either failed or neglected login attempts (13) or sessions where Variations2 was launched from the Start menu (34). In these latter cases, 0 or more searches were performed but no items were opened.

Measure	Results
Number of sessions	128
Average session length	30 minutes
Average number of items accessed	3.5
Maximum number of windows open at one time	7
Maximum number of sessions in one day	11
Sessions using bookmarking functionality	11% (14/128)
Sessions where any menu item was selected	17% (22/128)
Sessions where record details were viewed	23% (30/128)
Total "stop" button presses	200
Total "pause" button presses	385
Total "play" button presses	588
Total number of manual slider adjustments	295

**Table 3. Selection of log analysis results**

Manual analysis yields a picture of an individual session. We have not completed manual analysis for the sessions, but we offer a narrative representation for one complete 15-minute session below as an example, using a pseudonym for the anonymous user.

Karita began her session by clicking on the first song (3:02 in length) on the pilot assignment web page. It took 28 seconds for her to log in, see the audio player, and hear the song. 16 seconds later, she paused the audio. 81 seconds later Karita clicked on the hyperlink in the audio player to view the detailed bibliographic information of the recording. After 6 seconds, she clicked on the score link on the assignment web page. The score viewer took 11 seconds to appear. 45 seconds later, she closed the "view details" window and maximized the score viewer. After 9 seconds, she clicked the "Zoom in" button (zoomed to 70%). 7 seconds later, in the audio player, she clicked the "rewind" button and then pressed "play". 20 seconds later, Karita clicked the "next page" arrow in the score viewer (the score for the song is two pages long). 28 seconds later, she clicked the "previous page" arrow (the song has a repeat of all but the two-measure introduction). After 27 seconds, she again went to the second page, and after 30 more seconds, again back to the first page. 18 seconds later, Karita brought up the song text and translation by clicking on the web page link. The text viewer took only 3 seconds to appear. Karita immediately maximized the text viewer window. After 14 seconds, she went to the next page in the text (the text is split across 2 pages). 27 seconds later she pressed the "stop" button on the audio player (this is 10 seconds before the song's end, but the singing had stopped and it was evident from the decrescendo that the song was over). After 67 seconds, Karita restarted the audio by clicking on the track in the track list and pressing "play". She immediately paged back to the first page in the text viewer. 41 seconds later she clicked to go to the next page, and then quickly went back and forward again. 94 seconds later she stopped the player 30 seconds shy of the song's end. Then there was no activity for 3 minutes, after which she restarted the audio as before and moved the slider twice to listen to specific parts of the song (for 11 and 21 seconds, respectively). Following a 69-second break, she proceeded to the second song in the listening list. The second audio player took only 3 seconds to appear. Karita then closed the first player, stopped the second one with the "stop" button and then closed each of the remaining windows, ending the session.

This session does not reveal any major issues. The slow initial startup is a known problem. The incident at the end of the session (starting a new audio player and then ending the session) is enigmatic but uninterpretable from this session's data. Looking at an immediately subsequent session from the same network address, we can guess that Karita started a new session 42 minutes long and completed the entire assignment in these two sessions. But the reason for closing all the windows and then starting a new session 16 seconds later remains unknown.

A minor issue raised by this session is that Karita uses the "stop" button and a click on the track list to go back to the beginning of the song. The Variations2 "stop" button rewinds the recording all the way to the beginning, unlike the Variations "stop" button, which maintains playback position (analogous to "pause").

Knowing the nature of this specific assignment, we can make guesses about the reason for the gaps in listening: the student was writing up the song analysis, which is the deliverable for this assignment. But this is merely a guess.

## The contextual inquiry study

Contextual inquiry is a field study technique combining observation and interview methods to gain an interpretation of work practice (Beyer & Holtzblatt, 1998). The researcher watches someone doing normal work activity, takes notes, and asks questions to ensure a shared interpretation of the activity. Beyer & Holtzblatt's Contextual Design process adds onto contextual inquiry a method for building work models (diagrams) with the inquiry data. The present study used both contextual inquiry and the work modelling process.

Four graduate voice students (3 male, 1 female) were observed during 14 contextual inquiry sessions that focused on information usage patterns in academic study. Participants were selected from among volunteers recruited in a graduate song literature class. Participants received a gift certificate for participating in up to 5 hours of sessions. We observed a range of academic activities. Although we mainly observed library work, we wanted to get a holistic picture of the students' information-related activities, so we also included observations of voice lessons, a class session and a rehearsal. The library work often included use of Variations, but not Variations2, which at that time had an extremely limited amount of content.

For each contextual inquiry session, the participants were asked to do whatever work they needed to do next and were observed in their usual contexts, typically a library computer carrel or work table. While a participant worked, the researcher took handwritten notes. Discussion of the work sometimes happened during the observations, and the sessions nearly always ended with a discussion of the observed activity. The focus of both the observations and discussions was to understand what the user was doing and why. Especially of interest were any problems participants encountered in their work (breakdowns).

## Contextual inquiry findings

Most of the observations (10/14) occurred in the music library. Kinds of activities observed include the following:

- Listening assignment: students listen to an assigned set of songs, or select from among assigned songs, and write brief analyses of what they hear and think. (The pilot assignment described in the log file analysis section, above, is this kind of assignment.)
- Recital assignment: students plan an imaginary voice recital following one or more specific themes, e.g., British art songs related by some thread such as having the same poet or same subject matter.
- Audition "package" preparation: students auditioning for, e.g., a summer singing job select vocal material to polish that will meet usual audition criteria for quantity and variety while also showing off the strengths of their individual voices.
- Lesson piece, recital or performance part preparation: students study a particular piece or part for performance in their lesson, recital or a production. Study includes not only listening to and/or watching various performances but also uncovering background information about the composer, the poet, the performers, etc. Study may also include making a literal translation of the text.
- Song analysis project: students perform an in-depth analysis of a particular song, tracing its history through various performers and performances.
- Exam preparation: students study a body of work so that they can identify and discuss a given song upon hearing it in an exam.

Contextual inquiry generates a large amount of data, and the work models themselves are also detailed and extensive. This paper presents a fraction of the findings to give a flavour for the kind of results achievable with this research method. Of the various work models constructed from the data, the sequence model was the most interesting. A sequence model captures the step-by-step actions users take to accomplish an intent. Multiple sequence models can be consolidated to derive typical task sequences for a category of work. Table 4 shows a high-level view of a consolidated sequence model. The contextual inquiry data from the library observations consolidated into two typical sequences, "study in detail" and "collect and select". The two consolidated sequences share their overall activity structure (shown in the first column) and also share some steps (shown by the table cells that span both of the right-hand columns). Although there were indications (and it is rather obvious) that the "collect and select" consolidated sequence is sometimes followed by "study in detail", none of the sessions included both.

Activity	"Study in Detail"	"Collect and Select"
Prepare to do library work	<ul style="list-style-type: none"> <li>- get headphones</li> <li>- find available carrel</li> <li>- locate assignment</li> <li>- log in and locate on-line tools</li> </ul>	
	<ul style="list-style-type: none"> <li>- select piece to study</li> <li>- retrieve known recording</li> <li>- retrieve known auxiliary materials (scores, texts, reference works)</li> </ul>	
Work with library materials	<ul style="list-style-type: none"> <li>- study material (listen, and follow along in score and/or text; repeat whole piece or key parts)</li> <li>- make personal notes to capture key points gleaned from studying</li> </ul>	<ul style="list-style-type: none"> <li>- find candidate materials</li> <li>- examine many details quickly to decide which to select (listen, check length, performer, key, etc.)</li> <li>- make personal notes to guide selection</li> </ul>
	<ul style="list-style-type: none"> <li>- write assignment deliverable</li> </ul>	
Wrap-up the work	<ul style="list-style-type: none"> <li>- preserve notes and/or assignment deliverable (email to self, save on Zip disk or network drive, print)</li> <li>- log out</li> <li>- pack up</li> <li>- return reserve materials</li> <li>- return headphones</li> </ul>	

**Table 4. Two common consolidated sequences of library work**

For each of the sequence steps, there is a further level of detail showing some of the variation in how the work is performed and the breakdowns (problems) that can occur. For example, Table 5 shows the three ways to "retrieve known recording" from the "study in detail" task sequence. "BD" indicates a breakdown.

<p><b>Option 1:</b></p> <ul style="list-style-type: none"> <li>- Find course reserve list</li> <li>- Scroll to desired recording (BD: reserve list may be very long)</li> <li>- Select item (BD: easy to pick wrong item due to title similarities)</li> </ul>	<p><b>Option 2:</b></p> <ul style="list-style-type: none"> <li>- Looking at assignment sheet, type Variations URL for item in browser field</li> </ul>	<p><b>Option 3:</b></p> <ul style="list-style-type: none"> <li>- Enter search terms in online catalogue</li> <li>- Scroll through search results to find desired item (BD: easy to pick wrong item due to title similarities and lack of distinct visited-link colour)</li> <li>- Select item</li> </ul>
<p><b>Common final step:</b></p> <ul style="list-style-type: none"> <li>- Select CD/Side within Variations web page to retrieve item</li> </ul>		

**Table 5. Detailed steps for "retrieve known recording"**

Each of the breakdowns in Table 5 provides an opportunity for improving usability in the existing product or points out a difficulty to consider in the design of a new product. The different approaches to accomplishing the work indicate differences between users (e.g., willingness to type in a long URL), as well as between faculty (e.g., willingness to put the item URL on an assignment sheet and hand it out to students).

## Comparison of methods

User study methods can be compared in several dimensions. In this section, we will describe our experience with each of the methods we used in terms of the expertise and time required, other costs, and the kind of benefit derived. In examining benefits, we consider whether the results are helpful formatively (for design) and/or summatively (for overall system assessment). For broad descriptions of and comparisons amongst user study methods, see Kuniavsky (2003). The paper by Covey (2002) provides a survey of how such methods are currently used in research libraries.

### Questionnaire studies

The chief expertise required for our questionnaire studies was survey design. The need for this expertise was moderately reduced because we borrowed ideas and items from an established user satisfaction instrument (Chin, et al., 1988). However, survey design was still important because we wanted to modify the survey to fit our study, which included adding items. Some web form processing technical expertise was required to set up the online survey.

For the first questionnaire, conducted at point of use in the library, we spent three separate three-hour sessions recruiting participants. After we collected the paper surveys, it took a half-day to transcribe the results. The second questionnaire, conducted online, took a half-day to create, aided by a survey generator tool (Perlman, n.d.). This survey took no time to administer and several minutes to copy/paste the emailed responses into a text file, which was then imported into a spreadsheet. For both questionnaires, analysis time was limited to a half-day spent categorizing the free response data and summarizing the demographic and Likert-scale items. An additional cost of the first questionnaire study was providing gift certificates worth \$3 for each of the 30 participants.

The benefit derived from the survey data was mainly summative: the ability to compare between Variations and Variations2, identifying major differences. The formative benefit was not large. Although we learn key satisfiers, dissatisfiers, and opportunities for improvement, the findings tended to confirm things we already knew or suspected. Most helpful were the five recommendations for user interface improvement from one respondent.

### Session logging study

Our session logging study required significant technical expertise. To log user activity, we had to instrument Variations2 with logging statements. This required expertise in Java programming as well as access to the source code. Processing of the data was accomplished by writing some Perl scripts and running Unix commands. The detailed session analysis was accomplished by hand on paper but also required running Variations2 and examining logging output experimentally to try to reproduce the sequence of entries in the log file.

Once the logging mechanism was in place, the study took no time to execute. Analyzing the results has taken several days and is still incomplete. For example, analyzing the 15-minute session included in this paper took approximately 2 hours and is the only session we have yet analyzed in detail. To analyze and summarize all 64 hours of data would be a full-time job for several months. There were no additional costs for this study beyond disk space, which only amounted to a trivial 1.4MB for all the log files.

The main benefit of the session logging data was obtaining accurate, quantitative measures of overall utilization and feature usage. These data may identify usability problems or issues addressable either by training or software modification, but the benefit is more summative. Detailed log file analysis offers more promise in providing formative insights, but such analysis can raise as many questions as it answers. Why did the user close all the windows after opening the second audio player and then immediately restart? Log file analysis raises such questions; other methods must answer them.

### Contextual inquiry study

The contextual inquiries and subsequent analysis required expertise in the Contextual Design methodology, a skill best developed by guided practice under expert supervision.

The inquiry sessions took 8-10 hours to plan and arrange, including visiting a class to explain the study and recruit participants, and email exchanges with participants to schedule the sessions. Because contextual inquiry is a real-time method, the 14 inquiries of 1-2 hours in length took approximately 24 hours to conduct. Creating the work models and then putting them into a presentable format took approximately ten days. An additional cost of this study was \$25 gift certificates for each of the 4 participants.

Contextual inquiry illuminated how our tools fit into users' tasks and contexts. A strength of the method is the comprehensive user stories it generates. The stories are also detailed (because of the observations and note taking) and memorable (because they were seen). We have used contextual inquiry data to make design decisions and prioritize requirements, a significant formative benefit. The researcher who conducted the inquiries internalized much of the data simply by observing, but the modelling process helped identify patterns and made the results sharable with the other members

of the development team. The small number of subjects in this study limited the summative benefit.

### Comparison summary

Method choice depends on available resources and objectives. Table 6 summarizes our experience with these three methods. The values in this table are approximate and represent what happened in our particular studies.

	Satisfaction Questionnaire	Session Activity Logging	Contextual Inquiry
Expertise	survey design	technical (programming, scripting)	observation, interviewing, work modelling
Time to set up	moderate	low	moderate
Time to conduct	none (online) to moderate (recruit & use paper survey)	none	high
Time to analyze	low	moderate (metrics generation) to very high (manual analysis of all files)	high
Benefit	primarily summative	summative (metrics generation) and formative (manual analysis)	primarily formative

**Table 6. Method comparison summary**

### Conclusion

This paper has described using three methods to study digital library use in its natural setting and has also compared the costs and benefits of the methods. Each of these methods has its place, and we plan to continue using all three. The time required for contextual inquiry can be reduced simply by doing fewer sessions. Watching even one user is likely better than watching none. We can build better tools for analyzing log files, perhaps automating much of the metrics generation. Questionnaires offer an inexpensive albeit gross measure of user satisfaction and occasionally yield helpful suggestions.

A limitation of this paper is that we did not apply all three methods to the same digital library: the studies were split between Variations and Variations2. A future opportunity is to use all three methods during a pilot project and compare the value of the results. In addition, findings from these studies of usage should be compared to findings from lab-based testing to help us better understand the difference between the two contexts. Finally, we plan to compare findings from different user populations to see how DL use by, e.g., a small sample of graduate voice students compares to other user communities.

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## References

- Arms, W.Y. (2000) *Digital libraries*. Cambridge, MA: MIT Press.
- Bishop, A. (ed). (1995). *How we do user-centered design and analysis for digital libraries: a methodological forum* [Collected papers from the 37th Allerton Institute, Oct. 29-31, 1995.] <http://edfu.lis.uiuc.edu/allerton/95> (13 Jun. 2003).
- Beyer, H. & Holtzblatt, K. (1998) *Contextual design: defining customer-centered systems*. San Francisco, CA: Morgan Kaufmann.
- Blandford, A. & Buchanan, G. (2002) *JCDL'02 Workshop on Usability of Digital Libraries*. <http://www.ucl.ac.uk/annb/DLUsability/JCDL02.html> (13 Jun. 2003).
- Borgman, C. [Principal Investigator] (2002) *Fourth DELOS Workshop [Final Report]*. [http://www.sztaki.hu/conferences/deval/presentations/final\\_report.html](http://www.sztaki.hu/conferences/deval/presentations/final_report.html) (13 Jun. 2003).
- Chin, J.P., Diehl, V.A., & Norman, K. (1988) "Development of an instrument measuring user satisfaction of the human-computer interface." In: *Proceedings of CHI '88, Washington DC, May 1988*. pp. 213-218. New York: ACM Press.
- Covey, D.T. (2002) *Usage and usability assessment: library practices and concerns*. Washington, DC: Digital Library Federation and Council on Library and Information Resources. <http://www.clir.org/pubs/reports/pub105/pub105.pdf> (13 Jun. 2003)
- Dunn, J.W., & Mayer, C.A. (1999) "VARIATIONS: A digital music library system at Indiana University." In: Rowe, N. & Fox, E.A. (eds.) *DL '99: Proceedings of the Fourth ACM Conference on Digital Libraries, Berkeley, CA, August 1999*, pp. 12-19. New York: ACM Press.
- Fuhrman, M., Gauthier, D., & Dillon, A. (2001) *Usability test of VARIATIONS and DML prototypes*. <http://variations2.indiana.edu/pdf/VariationsTest.pdf> (13 Jun. 2003)
- Jones, S., Cunningham, S.J., McNab, R. & Boddie, S. (2000) "A transaction log analysis of a digital library." *International Journal of Digital Libraries*, **3** (2), 152-169.
- Kuniavsky, M. (2003) *Observing the user experience: a practitioner's guide to user research*. San Francisco, CA: Morgan Kaufmann.
- Lesk, M. (1997) *Practical digital libraries*. San Francisco, CA: Morgan Kaufmann.
- M531 Schubert listening assignment (2002). *M531 Schubert listening assignment*. <http://variations2.indiana.edu/pilot/example-schubert.html> (13 Jun. 2003).
- Notess, M. & Swan, M.B. (2003) "Predicting user satisfaction from subject satisfaction." In: *CHI '03 extended abstracts on human factors in computer systems, Fort Lauderdale, Florida, USA, April 2002*, pp. 738-739. New York: ACM Press.

- Perlman, G. (n.d.) *Web-based user interface evaluation with questionnaires*.  
<http://www.acm.org/~perlman/question.html> (13 Jun. 2003).
- Swan, M. (2002a) *Variations satisfaction survey results*.  
<http://variations2.indiana.edu/pdf/var-sat-survey.pdf> (13 Jun. 2003).
- Swan, M. (2002b) *Variations2: IU digital music library first-round usability test report*. <http://variations2.indiana.edu/pdf/v2v1-early-test.pdf> (13 Jun. 2003).
- Swan, M. (2003) *Variations2: IU digital music library version 1.0 usability test report*. <http://variations2.indiana.edu/pdf/v2v1-test.pdf> (13 Jun. 2003).
- Swan, M., Notess, M. & Isaacson, E. (2002) *MMTT prototypes usability testing first round report*. <http://variations2.indiana.edu/pdf/mmtt-usab-test-1.pdf> (13 Jun. 2003).
- Variations2 (2003) *Variations2: the Indiana University digital music library project*.  
<http://variations2.indiana.edu> (13 Jun. 2003).