A survey of user studies for digital libraries

Nick Bryan-Kinns & Ann Blandford

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Introduction

Digital libraries are on-line collections of heterogeneous information which are usually maintained by some digital librarian. They pose interesting problems for design because of the large amounts of information involved and the difficulty of determining just what users wish to do with such systems. Elsewhere (Bryan-Kinns & Blandford, 2000) we have examined the use of digital libraries in terms of interaction and its properties. Before drawing broader design implications it is important to consider what attempts to understand digital libraries and their use have been undertaken. This issue is addressed in this document. First we discuss surveys of users and potential users of digital libraries – who use, or might use, digital libraries. This then feeds into the next section which considers what kinds of activities these users might get up to. We then go on to consider studies of digital library user interfaces, and possible new designs, there are and what they can tell us about the design of digital libraries. Finally we sum up with a discussion of the varying techniques used to conduct surveys of digital library use and their suitability. Of course, studies of digital libraries cover a combination of these topics – organising the discussion in this way gives us purchase on the different aspects of digital libraries and how they are related.

Studies of Potential Users of Digital Libraries

Digital libraries are not used in isolation – there are many different factors that affect their use. Several studies have looked at digital libraries *in context*, that is, not just the library itself, but also how it sits within a larger frame of use. A fine example of such studies is Bishop's (1999) consideration of the use of digital libraries by people from different social and economic backgrounds. The interesting results of her studies indicated that people from different backgrounds (low-income, and academic) could just as easily be put off using digital libraries – small problems tended to be magnified until they deterred potential users, and lack of awareness of library coverage often prevented users from understanding what they could get out of the libraries. Covi and Kling (1997) took a similar approach as they were interesting in the patterns of use of digital libraries by different groups of users, and how they vary across academic fields and universities. However, they focussed on interviewing potential users, and moreover, were concerned primarily with university members, rather than additionally considering the population at large.

Studies of Activities in a Digital Library

In this section we consider what kinds of things people get up to, or might get up to, in a digital library.

Searching

Searching for interesting articles is often the first thing that comes to mind when someone mentions ‘digital libraries’. However, it is not just a case of entering a search term and viewing a list of results. Furnas and Rauch (1998) studied use of digital libraries and found that in searching for information a ‘one-shot query’ is very rare. More typical is an extended and iterative search which involves opportunism *i.e.* the searching evolves over a period of time and relies on users being able to follow new (interesting) paths as they appear which may not necessarily have been specified at the start of their search. Such findings impact digital libraries in terms of how searching is supported – according to Furnas and Rauch there needs to be integrated support for information gathering and organisation rather than simple searching support.

These notions of extended searching are supported by research carried out in conventional libraries. O’Day and Jeffries (1993) studied the topic of searching in conventional libraries. As with digital library studies they found that one-shot searches were rare. Rather, they found that single searches evolved into other kinds of searching which they identified as:

- **Monitoring a topic over time** – returning to a search repeatedly to keep up to date with new developments *e.g.* returning to specific journals each month to view the new issue, or repeating a search to find out what new developments have taken place over the last month.
- **Following an ‘information-gathering plan’** – having a specific set of criteria about what kind of information is needed, and which information sources would satisfy these criteria. The plan then involves deciding which sources are most appropriate, and locating the information in them.
- **Exploring a topic in an undirected way** – having some notion of a topic that is interesting, and exploring information resources to find out about it. This essentially involves a less well formed plan than the previous point.

Understandings of activities in conventional libraries need to be utilised in considering what tasks users may wish to complete in digital libraries. Clearly they will not be the same tasks carried out in the same way, but they provide a starting point from which we can consider what the differences would be, and why such differences would exist.

Similarly, studies of the use of web-based search engines by Spink *et al.* (1998) showed that users issue similar search queries over extended periods of time (similar to the monitoring discussed by O’Day and Jeffries). Again, this has implications for the design of digital libraries in terms of allowing people to save, modify, and review queries for reuse over time. Indeed, Spink *et al.* regard digital libraries as part of the web in the broadest sense – as repositories of information. Other opinion would contend that digital libraries are more focussed than the web. Nevertheless, understanding the nature of search and the need to support extended search is important to the development of successful digital libraries.

Browsing

People do not just search for items in digital libraries, but also browse for them. Jones *et al.* (1999) characterise this distinction as follows:

- **Browsing** – users traverse information structures to identify required information
- **Searching** – users specify terms of interest, and information matching those terms is returned by an indexing and retrieval system. Users may, in turn, browse these results in a possibly iterative manner as discussed in the previous section

Curiously, there appears to be a dearth of studies of browsing in digital libraries, especially given the importance of browsing with respect to extended searching outlined in the previous section. Gutwin *et al.* (forthcoming) do discuss the browsing in digital libraries, but tend to focus on how user interfaces they develop can support browsing, rather than considering what browsing is – what it means to browse. However, in their discussion of browsing support they do categorise the purpose of browsing as follows:

- **Collection evaluation**
  - What's in this collection? Is it relevant to my objectives?
- **Subject exploration**
  - How well does this collection cover area X?
- **Query exploration**
  - What kind of queries will succeed in area X? How can I access this collection?

This is probably a minimal set of browsing purposes, but it provides us with leverage on the tricky issue of determining what browsing is, and what purposes it has.

Studies of browsing in the context of the world wide web need to be drawn on to give us further ideas on the issues there may be with respect to browsing. For example, Jones and Cockburn (1996) compared different www browsers in terms of their navigational support. Findings from such studies could be used to inform design of digital library navigation support. In particular, efficient methods for supporting access to large amounts of unstructured data (*i.e.* web pages) can give us insights into how we could support access to large amounts of structured, or semi-structured data (*i.e.* the content of digital libraries). We need to take on board notions of how data is presented, how users are supported in navigating around these large collections, and how users notion of context (their position within the collections) can be supported.

Working

Once a document has been located a user typically does some work with it (not necessarily immediately afterwards) – otherwise, there would be no point in finding it in the first place. Amongst the activities associated with working with documents are: reading and annotating documents. These are discussed in the following section. It is important for designers of digital

libraries to understand what people do with documents once they have found them in order to understand what working support is needed.

Reading

An important use of documents is to read them. This initially sounds an obvious and simple activity. However, some work such as Adler *et al.*'s diary based studies (1998) unpack the notion of reading into sub-activities, all of which place their own requirements on the development of digital libraries. They describe ten categories of reading which are summarised below:

- **Reading to identify** – to work out which document it is (usually simply by glancing at it)
- **Skimming** – getting a quick idea of the content of a document
- **Reading *own* text as a reminder** – *e.g.* reading post-its to remind of actions to be done
- **Reading to answer questions** – reading to search for the answer to specific questions
- **Reading to self inform** – furthering one's general knowledge without any specific question in mind
- **Reading to learn** – where the intention is to relate or apply information at a later date
- **Reading for cross-referencing** – integrating information from various sources
- **Reading to edit or critically review** – monitoring content, style, grammar, syntax, and overall presentation
- **Reading to support listening** - .*e.g.* following a presentation from the printed slides
- **Reading to support discussion** – referring to text during a discussion to back up a position

Such a categorisation is supported by other studies such as Marshall *et al.*'s (1999) in which they looked at the use of reading materials – in particular the use of digital reading devices. Their categorisation also included categories such as skimming and, as discussed below, annotating. The variety of research which have identified such a wide range of reading purposes and styles highlights the need for flexible reading environments in digital libraries.

Orthogonal to this categorisation, Bishop (1998) studied how people read documents, in particular, journal articles. She found six basic processes of reading articles:

- **Read the abstract and introduction** – to get an idea of the key points of the article
- **Skim article headings** – to get an overview of the work
- **Look at bulleted lists, summaries, and pictures** – to capture key points of the article
- **Zero in on particular sections that seem relevant** – *e.g.* methods, findings
- **Read conclusions** – to check understanding of content
- **Skim references**

Note that she did not find that people simply read articles from beginning to end. Moreover, these reading processes impose interesting requirements on digital library reading support. For example, the ability to skim article headings – we may ask whether, in order to support users skimming articles, simply providing a list of headings is sufficient, or whether there needs to be a way of skimming the headings in the context of the article *e.g.* showing some or all of the first page of the article so that the abstract and some of the introduction are also shown. Providing a list of headings would involve less bandwidth on the part of the digital library, but the lack of context may render them uninformative. Another important feature of her study was that the basic processes illustrate how people move between levels of information – from authors and titles to reading the conclusion. Again, digital libraries should consider how to support these transitions. In particular, we need to consider how to support navigation based on different forms of information *e.g.* authors, titles, or conclusions, and how these different aspects of articles can be interrelated.

Writing

People do not only read documents; they also create, update, and annotate them (Bishop, 1998). Adler *et al.* (1998) followed on from discussing categories of reading to discuss categories of writing in relation to documents. Again, these ideas will have an impact on the design of digital libraries as working environments. Their categories of writing include:

- **Creation** – creating or modifying documents
- **Note-taking** – writing in an abbreviated and unstructured way
- **Annotation** – marking on top of an existing document

An important finding from their studies was that reading frequently co-occurs with some form of writing. This clearly has an impact on the design of digital libraries where documents are hard to read on-line and even harder to annotate usefully. O'Hara *et al.* (1998) focussed on such writing activities in their studies of PhD students' use of libraries. They too found that reading and writing were inextricably intertwined – a significant finding for the design of reading environments.

Studies of Digital Libraries' User Interfaces

Studies do not just examine how people use libraries in general, but also how they use particular interfaces and how their use differs between interfaces and between tasks.

Allen (1998) discusses the suitability of particular user interfaces for different tasks. He looked at four different interfaces which gave different amounts of spatial information with respect to relevance of keywords to queries. This was combined with two different tasks – one to write a research paper, and another to write a student newspaper article. He found that users with well developed spatial abilities were better able to use spatially organised query tools than those whose cognitive abilities were better developed. This clearly provides some input into the design of digital library interfaces – that they should take account of people's cognitive and spatial abilities.

Jones *et al.* (1999) also studied the difference between user interfaces through experimentation. They were interested in the suitability of Venn diagrams for representing complex queries and so compared such interfaces to typical English formulations of queries. Sugimoto *et al.* (1997) also followed this approach when comparing five different user interfaces to support access to digital libraries.

Similarly, France *et al.* (1999) examined the use of their digital library user interface by giving subjects several tasks to complete. Theng *et al.* (1999) also gave users tasks to complete with different interfaces, and then followed these up with questionnaires in order to gain some insight into design issues for digital libraries. In contrast to Allen, France *et al.* used *verbal* protocols to give them anecdotal evidence of problems users encountered when using their interface. These suggestions were then used to inform re-design of the system.

Techniques Used in Studies

Many different techniques have been used to study people's use of digital libraries. This section outlines the range of techniques used and their applicability. We consider the people how take part in studies to be the *participants*, and the people conducting the study the *analysts*. The table below indicates which study techniques have been employed by various authors – these are discussed in the following sections.

Author	Diary study	Questionnaire	Observation	Usability testing	Focus Group	Interview	Logs
Adler *et al.*, 1998	°					°	
Allen, 1998				°			
Bishop, 1998					°	°	°
Bishop, 1999		°	°	°	°	°	°
Bradshaw *et al.*, 2000				°			
Covi and Kling (1997)						°	
France *et al.* (1999)				°			°
Furnas and Rauch (1998)			°			°	
Jones *et al.* (1999)				°			
Jones *et al.* (1998)							°
Jones and Cockburn (1996)				°			
Jones and Paynter (1999)				°			
Marshall *et al.* (1999)						°	°
O'Day and Jeffries (1993)						°	
O'Hara *et al.* (1998)	°					°	
Park (1999)				°			
Sugimoto *et al.* (1997)				°			
Theng *et al.* (1999)		°		°			

Diary Studies

Adler *et al.* (1998) asked people to keep daily notes of their document activities, and followed up these descriptions with structured interviews to expand on their understanding. Similarly, O'Hara *et al.* (1998) asked library users to note their activities in a diary – entries in the diary were then followed up by interview.

Such techniques have the advantage of low effort on the part of the analysts – they have to view the diaries and conduct interviews. However, a large load is placed on the participants as they have to keep notes of their activities. Moreover, as individuals keep their own diaries there will be differences between their note taking styles which may be significant and cause problems in generalising results. However, such approaches do help us to understand what people do and in some way why they do it which will give useful input to design or some qualitative evaluation results.

Questionnaires

Questionnaires, on-line form filling, or registration documents can provide simple feedback. Bishop (1999) used registration documents (in this case 1346 registration documents were returned) to build up an understanding of the different backgrounds of digital library users. In contrast she used surveys (more in depth questionnaires than the registration document – 234 replies) to find out information about users' use of the system after a period of time. Advantages of using such techniques include the ability to get a large response (*e.g.* 1346), but the information returned often provides little additional information – typically just simple answers to questions asked with no explanations of answer rationale. Theng *et al.*'s work (1999) contrasts these approaches by using extensive questionnaires with a small group of users after they have completed tasks with digital libraries. These questionnaires gave extensive details of users' perceptions of the digital libraries used, but again, they provide no means of assessing the rationale for users' perceptions – why they felt as they did.

Observation

Observing what people do as they use systems is a time consuming activity. However, it can provide useful insights into the usability of systems. Bishop (1999) discussed her use of observation to gather information on engineering work and learning activities. This information can then be used to inform (re)design, and/ or followed up in other ways such as interviews as illustrated by Furnas and Rauch (1998).

Usability Testing

Allen (1998), Bishop (1999), Park (1999), and Sugimoto *et al.* (1997) used experimental design to compare the applicability of user interfaces for digital libraries – as did Jones and Cockburn (1996) in terms of www browser usability. The use of experimental design gives statistically significant results, but are costly to develop and run, and can only answer specific questions. Theng *et al.* (1999) used a less rigorous form of design to informally compare different digital library interfaces in terms of utility for searching and browsing. In contrast Bradshaw *et al.* (2000) and Jones and Paynter (1999) followed a completely different route as they were more interested in how well their retrieval system worked – *i.e.* whether it returned appropriate articles to satisfy users' queries. Therefore, rather than comparing different user interfaces, they compared their retrieval results with the set of documents that users would have selected to meet the query (making the assumption that users select the most appropriate articles to match the query) – many other such experiments have been performed in the Information Retrieval field (see standard IR literature).

France *et al.* (1999) took a slightly different approach in that they gave users different tasks to perform with their digital library interface, but asked subjects to verbalise their actions, reasons for what they did, and problems they encountered. This does not give statistically significant quantitative results, but can be used to identify troublesome parts of the interactive system.

Focus Groups

Bishop (1998) used three focus groups to elicit understandings of how faculty members used journal articles, and what requirements such use placed on design of digital libraries. Following on from that Bishop (1999) used focus groups to help understand different socio-economic backgrounds of digital library users. Although focus groups are useful to gaining an overview of the issues and problems, they tend to produce information which is often sketchy and in outline form.

Interviews

Bishop (1998; 1999) used interviews, and semi-structured interviews to follow up on topics that were raised in her focus groups. This approach allows the analysts to develop a fuller understanding of the issues raised in the focus group, but interviews are time consuming and are, again, producing qualitative results which feed into design. Other studies such as those conducted by Covi and Kling (1997) relied solely on interviews to assess people's perceptions and use of digital libraries. Similarly, O'Day and Jeffries (1993) only used open interviews in which topics could be pursued at will by the analyst. As with other techniques, a more holistic approach involving other study techniques may provide more comprehensive results. Approaches such as those employed by Furnas and Rauch (1998) show this combination as they use interviews to inform further observation of people using digital libraries. In contrast Marshall *et al.* (1999) used interviews to follow up other techniques such as examination of transaction logs – their interviews were less structured and allowed analysts to get to the bottom of why users were performing certain patterns of interaction identified from the logs. O'Hara *et al.*'s (1998) use of interviews illustrates the potential burden such studies can impose on subjects. In their study each subject kept a diary of their activity in a library. In addition, at the end of each day (if possible) they were interviewed for an hour or so about their activities for the day. The combination of these two techniques clearly places a large burden on the subjects of the study.

Transaction Logs

Several studies (Bishop, 1998; 1999; France *et al.*, 1999; Jones *et al.*, 1998; Marshall *et al.*, 1999) employed transaction logs to gain an understanding of the activities users were engaging in with digital libraries. These logs give quantitative accounts of user actions and so can be used to make statements such as '(about 5%) took advantage of the ability to search for terms in individual components of articles' (Bishop, 1998). However, such logs do not provide an understanding of why users use particular features of systems. Understanding why things have happened is typically tackled by interview and possibly diary studies.

Summary of Studies

From the view of the studies presented here it is clear that although there has been of work on studying the usability of specific user interfaces for searching, and to a lesser extent browsing, in digital libraries there has been little work on understanding the nature of these tasks. Moreover,

there has been little work which compare different approaches to these tasks and draw conclusions about interface suitability in different task situations.

Design Implications

The main design implications for digital libraries at this stage relate to their support for searching and browsing. First we need to consider what searching and browsing is. We can take as a starting point the notions mentioned previously:

- **Searching**: Complex - not just one-shot (O'Day *et al.*). Single searches evolve into: monitoring a topic over time, information-gathering, and/ or exploring a topic in an undirected way. Searching itself relies on the ability to browse results and the maintenance of queries over time.
- **Browsing**: Gutwin *et al*. (forthcoming) suggested 3 main purposes discussed previously: Collection evaluation, Subject exploration, and What kind of queries will succeed in area X?

The following points outline how these notions might relate to our interactional properties discussed previously:

- **Event potential**: in order to support exploration we need multiple ways of reaching objectives. That is, the event potential should be high.
- **Discrimination**: forming understandings of the content and possibilities in a collection relies on being able to discriminate between possibilities. Therefore we need to ensure that the potential events are easily discriminable. This relates to the problem our studied user experienced when browsing through articles – it was difficult for her to discriminate between articles from the indexes and so had to view individual articles which took extra time and effort.
- **Potential event expression**: not only should potential events be discriminable, but they should also convey suitable amounts of content. What this suitable amount actually is is a topic for further research, but it relates to Bishop's (1998) notions that people need different forms of information to support different browsing tasks.
- **Familiarity**: related to the notion that we need different levels of information, we also need different forms of structuring of collections. The basic hierarchic topic based categorisation serves some purposes, but additional forms of structuring need to be considered to better support a wider range of activities. Again, we need to consider what these different forms of activities are, and who that relates to the structure of collections.
- **Extended interaction**: search needs to be supported over extended periods of time. In terms of IF this means that trajectories and state should in some way be carried over between interaction sessions to give persistence to the queries and activities that were involved in forming them.

Conclusions

To briefly conclude, there have been several studies of the use of digital libraries. However, this is a relatively small corpus compared to the work carried out in the hypertext, WWW, and information retrieval fields. Moreover, the studies have tended to focus on comparing user interfaces and search techniques rather than considering what people require of information sources such as digital libraries, and how they might wish to use them. Future studies need to address this issue, possibly by following up work from other fields such as studies of conventional library usage, or document use.

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