Interacting with information resources:
digital libraries for education

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Abstract

This paper reviews the capabilities of libraries for supporting learning. We consider the various roles traditional libraries play and how they are being transformed into digital information repositories. Effective strategies for deploying digital libraries will retain the strengths of traditional libraries while exploiting new possibilities offered by the digital medium.

Keywords: digital libraries, usability, information seeking, information use.

Introduction

One important element of learning is the use of information, including finding, re-presenting, applying, critiquing and synthesising information from multiple sources. There is now a plethora of sources for information, including other people, television and radio, the internet and libraries. In this paper, we focus on traditional and digital libraries as repositories of and places to work with information, considering in particular how digital libraries are changing interactions with information and how they can effectively support learning.

The history of libraries in engagingly reviewed by Battles (2003). From the history, we can draw out the main developments that have influenced users' experiences and expectations of the library and the information within it:

o   from the library as an unstructured collection of documents in various forms to the library as an organised, catalogued collection, generally managed by a librarian;

o   from the library as a private collection to a public resource;

o   the physical library becoming a place to study as well as a place to access documents;

o   the library becoming recognised as an archiving service with responsibility for preserving historical collections;

o   the library also becoming a service for all, such that everyone can access, and usually borrow, materials – often in different media; and

o   the emergence of digital libraries, making access to electronic documents possible for many people 'from the desktop', without the need to go to the physical library.

The focus of this paper is on the latest of these transitions: from the library as a physical place to the digital library, accessible – at least in principle – from any networked computer. In particular, we focus on the impact of digital library resources on learning. In doing so, it is necessary to recognise the various roles that libraries (generally) serve in supporting education, so that the strengths of traditional libraries, which have evolved over thousands of years, are recognised and retained. New media also create new interaction possibilities, which can be exploited to create new ways of learning. However, the potential of new interactions can only be realised if we recognise and either work with or change established practices. These practices include the ways people currently find and work with information, their roles and interrelationships. In the following sections, we consider the nature and potential of digital libraries, the nature of information work and established roles and relationships that have developed around information work. In doing so, we identify existing challenges, constraints and unknowns that need addressing as digital libraries come to play a greater role in learning.

Digital libraries: a new kind of information resource

We start by considering the nature of digital libraries, how they compare and contrast with traditional libraries, and also the new capabilities they offer.

What is a Digital Library?

There are many definitions of a 'digital library' (DL) – and many terms that refer to similar concepts. Within the sciences, DLs are typically referred to as 'libraries', whereas librarians will often refer to the same systems as 'databases' and people in the arts and humanities typically call them 'electronic archives' (Adams & Blandford, 2002b). Within the UK and western Europe, DLs tend to be regarded as digital surrogates for traditional libraries – focusing on the role of libraries as collections of validated and structured information. More widely, DLs are perceived as serving many different roles, as summarised by Sumner and Marlino (2004).

Sumner and Marlino (2004) note that the term "digital library" is not well defined, and suggest that current work is "extending the boundaries of the digital library metaphor in creative and diverse ways" (p.171). They propose three perspectives on what DLs are: that DLs are cognitive tools, enabling students to think about and work with ideas and knowledge in new ways, supporting learning and sense-making; that DLs are component repositories; and that DLs are knowledge networks. They take their examples from projects within the National Science Digital Library (NSDL: www.nsdl.org), which are effectively extending the definition of a DL to be a place where learners can interact with information and with each other.

In this paper, we focus on the view of DLs as structured collections of validated information. From this perspective we can draw a moderately clear contrast with the World Wide Web. Information on the Web is variable in quality, but easily accessed by anyone with the necessary technology and web navigation skills. In comparison, information in DLs has some kind of quality stamp, having been explicitly selected for inclusion; however, DL access is often restricted to users who have appropriate authentication, and often requires more sophisticated information skills than general web access. From this starting point, we can compare DLs with traditional libraries.

DLs and traditional libraries

Various authors, such as Twidale and Nichols (1998) and Stelmaszewska and Blandford (2004) have explored the analogy between physical and digital libraries. Twidale and Nichols focus on the collaborative activities that take place within the library – particularly those between library users and library staff. They note the importance of user–librarian interactions in supporting information seeking (especially during the early stages where users are refining the information problem, as discussed further below). From this, they argue that there needs

to be a digital surrogate for the exploratory dialogue. This argument is echoed by Theng (2002). Stelmaszewska and Blandford (2004) focus more on how people interact with library resources; while echoing Twidale and Nichols' emphasis on the importance of interactions between people, they also highlight the importance of people being able to quickly assess the relevance of information resources against their current requirements. Within physical libraries, features of documents such as their positions relative to recognisable landmarks (e.g. shelf numbers) and readily available information such as title and keywords were found to be important discriminators, but less obvious features such as the thickness of a book or its apparent age were also used by participants – as was information found through a rapid scan of the text, such as how many diagrams it contains, or whether it contains computer code. Few of these features of information resources are currently reflected in the presentation of digital documents for assessment. Another important feature of traditional libraries was found to be the support for serendipity. The physical grouping of texts by theme, and the fact that the user walks past (and can rapidly scan the spines of) many texts on the way to a particular book provides low-effort support for serendipitous information encountering. Within journals, serendipity features more in the practice people reported of rapidly scanning journals within their area of interest, often working backwards from the most recent issue; again, the facility to rapidly scan, assessing features such as diagrams and layout as well as obvious text (such as titles and section headings) was reported as helping with assessment of the relevance and importance of material, usually followed by more detailed assessment of material that looks promising.

Duncker (2002) uses a study of Maori perceptions of libraries – both physical and digital – to argue that the analogy between physical and digital libraries is deeply flawed. The use of the library metaphor – for example, in classifications of documents and in the browsing structures implemented – and the lack of support for use were found to make DLs essentially unusable by Maoris. She points out that while physical libraries are well embedded in many cultures, there are others – such as the Maori culture – that have an oral tradition, using trusted individuals as "living repositories" (p.224) of tribal knowledge. That knowledge is sacred, and should not be made available to people outside the tribe. The Maoris who might use DLs are typically bi-cultural, having adopted many Western cultural practices while also retaining features of their traditions. Since libraries are repositories of knowledge, they are typically viewed as sacred – a view that is in tension with the fact that library-based knowledge is publicly accessible. This can create a sense of alienation from the library. In addition, Western-style subject headings and classification systems are meaningless to such cultures. Duncker reports (p. 227) that Maori "understanding of how materials are organised in a library [...] apparently depends on whether or not they find somebody – typically another Maori – who [...] supports them in overcoming their threshold fear and makes them feel welcome in the library". She also argues that "Libraries emphasise individualism in contrast to the collectivist Maori culture"; in other words, libraries have typically had a "silence please" culture, so that individuals can work with information, rather than being places where people can gather together to work collaboratively. While this situation is gradually changing in physical libraries, there is a real risk that DL deployment into individuals' offices and homes will reinforce the individualist culture rather than exploiting the new possibilities for people to work together – an issue we return to later in discussing the development of Communities of Practice.

An alternative view is that traditional and digital libraries are complementary resources. D'Elia *et al* (2002) studied the changing uses of public libraries and the internet within a community; they conclude that there continue to be roles for both libraries and the internet, but that over time users of both are starting to differentiate their uses, with the internet being used more for general information provision while the physical library remains a place to go (e.g. with children), with higher quality information and better privacy for users. Because they were studying public libraries, rather than academic ones, their survey did not cover digital libraries *per se,* but their observations about the physicality of the traditional library and its role as a place to meet and engage in activities clearly provide a contrast with digital libraries.

Stelmaszewska and Blandford (2004) found that the role of a library as a quiet place to study was frequently cited by respondents, providing further evidence that libraries serve many functions that cannot be directly replicated in digital form.

In summary, as well as the obvious differences between physical and digital libraries, such as the tangibility of media, DLs tend to exaggerate cultural values and provide less support than physical libraries for activities such as learning to use the system effectively and providing space for working and collaborating. While the 'library' metaphor can be very powerful and helpful for some users, it is simultaneously limiting and disenfranchising for others.

Beyond the library metaphor: new interaction possibilities

The motivation for developing DLs often appears to be based on cutting costs (Miller-Francisco, 2003), reducing the storage problem, preserving precious historical documents (the originals can be better cared for if people can access digital surrogates), and a fuzzy perception that digitization will improve access. As noted above, DLs also have potential in creating new interaction possibilities, such as new ways of collaborating over information and ways of personal document management. In this section, we consider these two main classes of interaction possibilities: collaboration and personalisation.

One way in which DLs might be expected to extend features available in traditional libraries is through the support for remote collaboration and interaction. Many DLs now support limited collaborative working by explicitly supporting the notification of others about documents. This is exemplified by web-accessible databases of news items such as CNN (www.cnn.com) and Reuters (ww.reuters.com), which support users sending articles to friends. Theng *et al* (2000) present the design for a digital library in which students can collaborate more fully, posting comments and criticisms of each others' work within the library so that a repository of students' work is gradually accumulated. A similar approach is reported by Bartolo *et al* (2004) for the MatML materials library. Arguably, web-based resources that support collaborative document creation and organisation such as Wikipedia (http://en.wikipedia.org/wiki/Main_Page) might also be thought of as supporting remote collaboration and interaction in a library-like format. Such systems present real challenges to our traditional assumptions about the roles of producer, gatekeeper and consumer of information, as such systems blur the roles. They are creating new ways for learners to interact with and through information. However, with collaborative systems, questions such as how information is validated and how learners assess information quality become central. There is a need for new ways to authenticate information and establish appropriate levels of trust in it.

Another way in which DLs might offer enhanced features over traditional libraries is in the provision of personalised serviced to users. Personalisation features have become widespread in digital libraries. 'Alerts' (usually email messages) informing users of new publications (e.g. a new issue of a journal) are probably the most common personalisation feature, being relatively simple to implement and use. In contrast, recommender systems, now common in e-commerce environments, have made little impact on DLs. More complex personalisation features such as 'bookshelves' (or 'binders'), in which users can store links to selected articles, have been introduced in some libraries but there does not appear to have been any formal evaluation of their use or perceived value, or of what impact they might be having on users' information behaviours. Overall, personalisation appears to have had limited take-up as yet. To understand why, it is necessary to consider access policies for DLs. Commercial DLs need revenue, which might be by institution (typical for large academic organisations), by individual or by information resource. Of these mechanisms, individual subscriptions is usually the most costly to administer. Consequently, few users have a need to personally register with each DL, since they are either registered through an institution or able to purchase individual articles without subscription. This raises a small, but nevertheless significant, barrier to many personalisation services since they demand that individuals be individually identifiable. A further factor in limiting take-up of some personalisation features

is that of trust: of trusting that features will continue to be provided and that time invested in organising documents remotely will not be wasted, and valuable work lost, if the feature is discontinued or substantially redesigned.

Overall, although new technologies offer the promise of new ways to interact with information, these new features pose new social and technical challenges, such as authentication and trust, that need to be resolved.

Interacting with information

In the previous section, we considered the nature, and potential, of digital libraries. The main role of digital libraries is to enable users to interact with the information contained therein. In this section, we shift attention to how people find and work with information.

The two most common forms of interaction are browsing through structured lists of contents and searching. The ease of browsing depends on the detailed design of a particular system; in contrast, there are some common themes that emerge from studies of users searching. It is widely recognised that creating effective search criteria to achieve a particular information goal is a demanding and difficult task, particularly for less experienced users, and particularly when the goal is as yet under-defined. Shneiderman *et al* (1998) observe the challenges of selecting a variety of search attributes, such as the words to be used in a query and the syntactic peculiarities of the system at hand. In addition, the mapping of an information need to the use of metadata fields or full text search can prove difficult (Blandford *et al*, 2001). Compared to the web, where the document text is the usual target for a search, Digital Libraries provide greater control over the search: the user has a much wider potential range of selections (classification, author, publication date, etc.) to make. Effective searching relies on the careful selection and use not only of words or syntactic commands, but also of fields and information sources. We consider the problem in terms of three levels of interaction; the first is the process of formulating a query and assessing the relevance of results; the second is the broader information seeking task; and the third is the overall information work in which the user is engaged.

Query formulation and results evaluation

The field of Information Retrieval (IR) has traditionally been concerned with how to take a well formulated query and deliver appropriate results to the user. The effectiveness of an IR algorithm is traditionally measured in terms of recall (typically measured as the percentage of all possible appropriate results that are returned to the user) and precision (the percentage of results that are returned that are relevant to the user's query). While algorithm performance is important, since a poorly performing algorithm will fail to return appropriate results to the user, greater challenges from the user perspective are those of formulating appropriate queries and assessing the results that are returned.

Considering the nature of expertise in query formulation, recent studies have compared some of the search criteria used by expert librarians against those used by less knowledgeable searchers. For experimental purposes, most researchers (e.g. Hsieh-Yee, 1993; Sutcliffe & Ennis, 2000) treat expertise as a binary state: either novice or expert. Two key variables that have been studied are information seeking expertise and subject knowledge. Hsieh-Yee (1993) found that information seeking experts tend to explore synonyms, to establish what effects these have on search results, whereas novices (even subject experts) do not. Within their subject area, the differences were relatively small, but outside their area differences were much greater: experts were able to use on-line tools such as thesauri to assist in generating alternative search terms whereas novices relied on their own intuition in selecting terms.

Stelmaszewska and Blandford (2002) found that novice users have very little persistence in query formulation, usually giving up a particular search after only two or three attempts. In contrast, Fields *et al* (2004) found that expert users – in their case, librarians acting as information intermediaries for users who had reasonably well defined information

requirements – have well honed strategies of refining search terms to achieve a results set of the desired size and quality. For example, an expert may explore synonyms and probe results to see which terms are working well, whether there are 'distractor terms' that need to be explicitly excluded from the search terms, and whether there are alternative terms that appear in documents that might usefully form part of the search query. For example, in a search on behalf of a user who requested information about "fault diagnosis and ADSL (Asynchronous Digital Subscriber Line)", one librarian explored variants of "diagnos*" (to include words such as "diagnosing" and "diagnose"), introduced the term "subscriber" and excluded the term "optical" at various stages in the interactive search process, systematically expanding and reducing the size of the results set until she considered it to be of appropriate size and quality for the user. The skills displayed by this expert are not ones that a novice is well supported in acquiring by any extant DLs.

Once the user has received results, their relevance to the task at hand needs to be assessed. As discussed above, Stelmaszewska and Blandford (2004) found that users in physical libraries have a range of strategies for assessing the relevance of documents, most of which do not currently have digital surrogates. With a limited window onto a search results list, it appears that users rarely scroll through more than the first page or two of results. An obvious consequence of this is that users rarely even see results that are not returned near the top of the list, highlighting the importance of having effective ranking algorithms that return the most user-relevant results near the top of the visible list.

Information seeking

Query formulation and results evaluation do not sit in isolation, but are steps within a broader information seeking task. Within the information seeking literature, much attention has been paid to what users do without describing the designs of the resources that influence that use. These information seeking models have been proposed to give high-level accounts of the overall searching process (e.g. Ellis, 1989; Ingwersen, 1996; Kuhlthau, 1988; Kuhlthau & Tama, 2001; Vakkari, 2001). All share important features in common, while also being informed by the particular data sets on which they are based; for example, Kuhlthau and Tama (2001) focus specifically on the information seeking processes of lawyers, while Vakkari (2001) bases his model on empirical studies of student writing research proposals. Models typically talk about phases of seeking in terms of starting with a broad, under-defined search requirement and gradually refining it. At early stages, the search requirement is often poorly articulated by the searcher, who therefore probes the available information resources finding out what is possible. This enables the searcher to refine and clarify the search problem until they reach a focus, at which point more detailed and targeted search can take place. From this point, they may work iteratively through unfocused and focused search as new issues are discovered in the information acquired. Depending on the task, this overall searching may take place over hours, weeks or even longer. Within the context of formal learning, the starting and finishing points of a search will depend on factors such as the scale and specification of an assignment. Within informal learning – for example, an enthusiast wanting information about their hobby or a patient seeking information about their symptoms, condition and treatment – the search can similarly be more or less well focused, and with varying timescales.

Vakkari (2001) presents the main concepts derived from his studies of students preparing research proposals as follows:
   o *Stages in task performance*: There are three main phases. The first is pre-focus, where the user is making sense of the information problem, selecting information resources that might support them in addressing that problem (e.g. particular libraries to search in) and exploring those resources to find out what information is available and what foci are possible. The second is formulation, in which the user formulates their problem understanding. The final phase is post-focus, in which information is gathered, synthesised and presented.

- *Types of information*: Users need three main types of information: general background information related to the problem area; faceted background information that picks up on particular aspects of the problem; and specific information needed as part of the 'solution' to the problem.
- *Sources of information*: The two main sources of information are people and information systems. Although not discussed explicitly by Vakkari (2001), information systems may include traditional libraries, digital resources and resources in other media such as television and radio.
- *Relevance judgements*: According to Vakkari (2001) the four important aspects of relevance judgement are assessing the degree of relevance; defining the relevance criteria used; assessing the type of contributory information; and assessing the precision of the results set (where precision is as defined above: how well the overall set of results matches the query).
- *Search tactics*: Vakkari (2001) asserts that he has identified twelve search tactics, based around aspects of searching and browsing. Vakkari (2000) presents these tactics under three headings: strategies to begin a session (breaking a complex problem into simpler sub-problems or starting with a comprehensive expression of the problem); search formulation tactics (six tactics that describe ways of formulating queries at a search interface); and 'other' tactics, which cover ways of narrowing (or limiting) a search and the broader idea of focusing the search more precisely.
- *Search terms and operators*: Vakkari (2001) lists the number and types of search terms as being important, as well as the types of operators (such as Boolean AND and OR) as being important.
- *Mental models*: the primary aspect of mental models discussed by Vakkari (2001) is whether it is general or vague.

In presenting this categorisation of aspects of information seeking, Vakkari conflates core information retrieval concerns (such as search tactics and search operators) that apply only to digital information sources with higher level constructs that apply more broadly to information seeking, such as stages of task performance and information types. He does not discuss in any more detail the nature of a mental model, or its role(s) in information seeking. Indeed, very little work has been done on this topic. Blandford *et al* (2004) present one preliminary model of the concepts that users need to be aware of when working with a particular digital library, highlighting which of those concepts can and cannot be ported from the user's understanding of a traditional library. However, other important aspects of a mental model of a digital library, such as a model of the information architecture, of the information management features of a particular library or of the search algorithm, also help determine the effectiveness with which the user can actually use the library; these have received little attention as yet.

Information work

As noted above, various information seeking models have been based on data from different domains; however, the relationship between the model and the nature of the information task has largely been left implicit. As discussed by Attfield, Blandford and Dowell (2003), surprisingly little work on information seeking has set that seeking within the context of the broader information work of which it is a component. While this divorce from the context may be valid when considering work in physical libraries, where the information seeking task is often a bounded activity delineated by arrival at and departure from the library building, it is less so for digital libraries that can be accessed from the user's normal place of work, removing the marked transitions between information seeking and other activities. Within formal educational contexts, the integration of information seeking within the broader learning assignment has been considered for particular kinds of learning objects (discussing how they fit within the curriculum). However, the broader question of how students refine information problems, and in particular how digital resources can be well designed to support the overall information working process, has received little attention.

Within the academic sphere, different disciplines typically have different information needs that specialise their requirements for information resources. For example, within computer science, the greatest need is for recent articles, and the visual appearance of the information is of little consequence as long as the material is comprehensible. There is little requirement for historical material. In contrast, within media studies, Adams and Blandford (2002b) found that subject specialists need to see how information was presented in its original context; for example, newspaper items need to be studied within the context of their layout, positioning and neighbouring articles. Consequently, digitisation needs to include facsimile representations of content as well as textual representations for material typically used by students and researchers in media studies, whereas only substantive content is needed in many other disciplines.

A similar contrast can be found between the needs of users in the sciences and the humanities. Considering work in the humanities, Stone (1982) and Watson-Boone (1994) established that users need a much wider range of resources than those in other disciplines. Monographs are as vital to them as journals, and they may need to refer to material which is much older than that used by researchers in the sciences and social sciences, such as manuscripts or early printed books, even if digital surrogates are available (Warwick & Carty, 2001; Duff & Johnson, 2002).

In professional disciplines such as medicine and law, an important role for information is as evidence. However, evidence is used in different ways within the disciplines. Kuhlthau and Tama (2001) quote a lawyer in their study (p.30): "The hardest part of the job is figuring out a strategy for a complex case and figuring out what path to take. […] Trying to figure out how it is going to play before a jury." This illustrates both the poorly determined nature of early information needs, as the lawyer is looking for a suitable angle on the case, and also the need to identify information as evidence – in this case, maybe to present before a jury. In medicine, within the UK, there has been a recent shift in emphasis towards clinical audit and Evidence Based Medicine (Adams and Blandford, 2002a; Adams, Blandford and Lunt, forthcoming). This perspective demands that clinicians have access to information about current best evidence (e.g. of diagnoses and treatment plans) and best practice, readily accessible to them. Compared to lawyers, clinicians have traditionally made little use of such evidence interleaved with their ongoing work, typically relying on a combination of prior training and experience, discussions with colleagues and Continuing Professional Development that is not focused on an individual case. Thus, clinicians have a relatively underdeveloped culture of accessing professional (evidential) information within the context of their day-to-day practice (with some notable, well defined, exceptions such as ward protocols and information on drugs).

This brief overview of the needs of a few disciplines illustrates the breadth of different kinds of information requirements and tasks that DLs need to support – whether for students learning formally or practitioners learning informally 'on the job'. A further consideration is not just what resources people need, and why, but how people acquire the skills necessary to find the information they need.

Development of Expertise in Information Seeking

Earlier, we discussed the "threshold" of fear experienced by Maori library users; another threshold – of competence and understanding – emerged in the studies of Blandford *et al* (2001). In a detailed qualitative study of 8 computer scientists (who had not received specific training in using DLs), Blandford *et al* found that users had to overcome substantial obstacles in learning to use DLs, including conceptual understanding of library organisation and of how to construct and refine queries. Several other studies (e.g. Stelmaszewska & Blandford, 2002; Borgman, 1996; Marchionini, 1995) have also found that many users of electronic information resources lack both the knowledge and experience to construct organised and disciplined search strategies across individual queries. In the case of many novices, failed queries are repeatedly attempted, and partially successful ones abandoned without

development. In contrast, as discussed above, expert librarians rely heavily on systematic approaches to the evolution of their searches and the selection of search criteria (Fields, Keith & Blandford, 2004). Experts demonstrate comprehensible strategies, whereas novices can seem perplexingly illogical. Inexperienced users clearly need to learn some of the decision-making tactics and the coherent strategies identified by, for example, Sutcliffe and Ennis (1998) and Bates (1979).

However, little work has considered the nature of skills in using DLs effectively; they will clearly include general computing and navigation skills as well as information skills (such as query formulation and refinement). As discussed above, researchers such as Hsieh-Yee (1993) have used two dimensions of expertise: in information seeking and the subject domain. Cothey (2002) criticises studies such as that of Hsieh-Yee (1993) as confusing expertise with experience, assuming that sophistication of searching is correlated to the amount of searching done. In a longitudinal study of changing search practices by web users over a ten-month period, Cothey found that, rather than becoming perceptibly more sophisticated, users' behaviour was more characterised as shifting from searching to browsing, and focusing on fewer selected sites – both features of information gathering that indicate streamlining of search effort. Thus, Cothey appears to be arguing that familiarisation with particular resources, appropriate to their usual needs, is an important element of user experience. However, another aspect of her argument is that most users do not appear to develop the sophisticated information working skills observed by Fields *et al* (2004) in their study of librarians; as well as users minimising effort, it would also appear that the tools available to them do not support them in developing more sophisticated strategies.

Further evidence to support the idea that familiarity is important is provided by the studies of Adams and Blandford (2002b), who found even librarians commenting that if they did not access DLs regularly they lost the skills of using them in a period of rapid change, and of Blandford *et al* (2001), who found that users invariably chose to work with familiar resources when given a choice. Familiarity with a particular DL includes many facets: its structure, features, contents, effective indexing terms, etc. This ability to probe and gain familiarity is another aspect of expertise.

In practice, within the DL domain, there has been a focus on improving search algorithms and user modelling (e.g. Sutcliffe and Ennis, 2000) to yield good search results. Less attention has been paid to improving users' information skills so that they are empowered to search more effectively. There are outstanding research questions over the appropriate balance of power and capability between user and system. However, effective searching is such a sophisticated skill that it seems unlikely that it can be completely delegated to any system – at least in the foreseeable future. Therefore, it is necessary to find ways to improve users' information skills; this may be by improving system design or by the appropriate inclusion of information intermediaries within the broader information system context.

Changing roles and relationships

The information intermediary role is often taken by librarians. However, this is not the only role for the librarian. The librarian has also been the arbiter of quality (deciding what resources to make available); the gatekeeper who determines who can access particular resources; the guide to library services; and the archivist caring for and preserving resources. The relative importance of these roles is largely determined by the organisation and functions of the library. The shift to digital resources is forcing a major review of the roles of the librarian within the web of information resources – and hence also the relationship between librarian and information user.

Information mediation: the changing role of the librarian

One well established role for librarians, or related information professionals, is as information intermediaries. Such positions can be found in domains including academia, healthcare, journalism and legal work. Traditionally, their primary role was as finders and presenters of

information, in situations where the domain specialist is not expected to have the necessary information skills.

Nicholas and Martin (1993) discuss the information seeking of journalists, looking in particular at when they do and do not employ the skills of expert information intermediaries to help with their searches. They conclude that intermediaries are of most help at the focused stage of searching. At this point, the information problem is well defined, but the journalist typically does not have the skills to formulate queries and probe information resources effectively. In the pre-focus stage, where the concern is more with finding out what might be relevant, what has been written previously on a topic and what possible focuses for an article might be, journalists need to interact directly with the information themselves, even if that interaction is comparatively inefficient in objective terms.

A similar point is made by Kuhlthau and Tama (2001) regarding the information work of lawyers. They argue that lawyers frequently choose paper-based over electronic texts because it is so often necessary to provide well-specified search terms for the latter, and it is relatively difficult to compare and synthesise information across multiple documents within current computer environments. They extend this to argue for 'just for me' services that involve intermediaries and well designed systems that can tailor information delivery to the particular needs of an individual lawyer.

Both of these examples illustrate the role of the intermediary as someone who takes a user's information need and delivers relevant documents back to that user. Adams, Attfield and Blandford (2004) relate various intermediary roles to a user's "information journey". They describe an information journey as passing through three important stages: identifying an information need, acquiring information, and then interpreting that information in context. For example, a patient may want to learn more about their condition and get information from the internet, but that information still needs to be interpreted and made personal for them (e.g. understanding what it means in terms of the severity of the condition or ways to manage it). Within the context of the information journey, Adams *et al* identify three roles for intermediaries:

- o *Information initiator*: someone who initiates the requirement for information – not necessarily an information professional. This role is often taken by educators who provoke new questions in the minds of their pupils.
- o *Information facilitator*: someone who locates information for the user, as discussed above (using the term 'intermediary').
- o *Information mediator*: someone who interprets information on behalf of the user – turning it into language more easily assimilated by the end user, or contextualising the information to the user's situation.

Adams, Attfield and Blandford derive their findings from a study of clinicians and patients, including clinical teams that include information specialists, and of NHS Direct (an organisation that is oriented towards healthcare information provision for the UK population). While these roles are not new, the need to explicitly recognise and support all of them is becoming greater as new ways of delivering information are developed.

One of the challenges articulated by librarians in an earlier study (Adams and Blandford, 2002b) was that as their users (in that case, lecturers and students) shifted towards digital information use, there was less reason to visit the physical library. Although librarians remained responsible for selecting material for inclusion in the library, they were becoming less well informed by the users of that material about their requirements; in addition, information providers would sometimes change the design of the system or the conditions of use, leaving the librarian – still responsible for subscriptions but not necessarily seeing the fruits of their expenditure immediately – as the last to know about changes. As well as selecting the material to be made available to users, librarians also administer authentication mechanisms whereby users can access materials. So librarians serve as 'gatekeepers' in two

directions: they select the resources that users can access, and they select the users that can access the resources.

They are also responsible for ensuring user awareness of what is possible. However, in both the academic and health arenas, Adams and Blandford (2002b) found that users expressed a wish that particular resources could be available, only to have library staff confirm that those resources were already available; what was missing was user awareness of the resources. Thus, an important role for librarians is that of awareness raiser – a role that is made more difficult by the lack of serendipitous meetings between librarians and users.

In summary, the shift to desktop access for digital resources means that the gatekeepers and awareness raisers are marginalised within the user–information interaction, leaving a need for new means of communication across the "information community". There is a corresponding change in the role of the librarian with respect to their users.

The impact of technology on work: the changing roles of users

Just as DLs are changing the roles of librarians, so they are also changing the roles of many information users. Some attention has been paid to the impact access to digital resources has on particular user communities. For example, Elliot and Kling (1997) report on the use of legal resources and their effects on the practices and attitudes of various stakeholders within the legal profession. They note a "strong interplay between home computer use and [legal research DLs] at work" (p. 1023), and also note that members of the legal profession prefer one-to-one assistance rather than group training. There appear to be several factors at work here; firstly, ready access to a computer is essential for accessing digital libraries in a timely way; secondly, regular use of a computer gives people better transferable skills and more confidence in using new systems; thirdly, people need a learning environment that is suited to their own needs – given their current circumstances, understanding and information problems.

Access is clearly an important issue – and remains so at the time of writing (seven years after the publication of Elliot and Kling's work). Access is not just about whether an individual can physically use a computer that is connected to the internet (although that is clearly important). In a study of DL use in hospitals, Adams and Blandford (2002a) found many reports of computers being located in places that were not equally accessible to all members of staff; access might be restricted by physical location (e.g. placed in a doctor's office rather than on a ward, or in the nurses' area rather than socially shared space); alternatively, it might be restricted by the application of security mechanisms such as passwords that effectively block use from many legitimate users. Within the hospital setting, possession of information is one important source of power, with the consequence that high status users can feel threatened if lower status users have improved information access. Similarly, within educational settings, poor accessibility was found to be caused by inappropriate system design, obstructive access mechanisms, poor usability and inadequate support for searching (Adams and Blandford, 2002b). This typically resulted in lecturers using unvalidated web resources in preference to quality-checked ones such as peer reviewed articles. While physical accessibility is essential, more subtle aspects of access such as learnability and social factors also need to be taken into account.

It might be argued that lecturers have appropriate skills in assessing the quality of information for themselves; however, it is less likely that their students have such well honed assessment skills. Stelmaszewska and Blandford (2004) found that within the academic context, peers and teachers are valued sources of recommendations. One important feature of these recommendations is that they come from a trusted source.

More broadly, the role of peers has been found to be central to effective information use. Within the clinical domain, Adams, Attfield and Blandford (2004) found that peers are a primary source of information – whether solicited or incidental. Adams, Blandford and Lunt (forthcoming) compare three different approaches to making information accessible in

clinical contexts, each involving different relationships between users, librarians and technology:

- o The traditional situation where information is made available within a physical library setting, including networked computer systems to access digital resources;
- o A situation where computer systems were made available in the workplace, to facilitate access to technology, and hence to digital resources; and
- o One employing an intermediary who spent an average of two hours a week with each team in the work setting, attending their meetings and making digital resources available to them.

Although apparently improving access, the second of these arrangements was found to be more divisive than constructive; the set-up was perceived as threatening by many of its potential users, and there was no immediate support to overcome the 'thresholds' discussed above. In contrast, the third was found to empower users. The clinicians in that situation reported a growing understanding of the possible roles for information within their day-to-day work and also a growing confidence in their own ability to find and work with information (because they were prepared to try things on their own, in the knowledge that help would be available soon, if not immediately, from the intermediary). This finding was explained in terms of Communities of Practice (Wenger, 1999): that the third of these situations enabled people to work with, and expand, their established communities of practice. This, in turn, enabled people to learn from peers, and for the culture of the teams to evolve to make information practices more central to their work in a non-threatening way. While this study took place in a professional setting, in which learning is relatively informal, there are clear implications for the use of DLs and similar resources within formal educational settings. In particular, there is a clear need for the creation of environments that support the acquisition of appropriate and effective information working skills. At present, human intermediaries are the most effective way to achieve this; one of the challenges for the future is to find new design and deployment strategies that facilitate knowledge-based Communities of Practice that support learning for their members.

Looking to the future

Several times in this paper we have noted how little is known about various aspects of information work and the design of systems to support it. We seem to be feeling our way, unsure of when and why particular designs work well. As noted above, in traditional libraries, the flexible role of the librarian enables him or her to mediate between the information resources and the user where necessary, and thereby reduce many of the hurdles to using the system. Digital libraries do not, as yet, provide such intermediaries (whether computer-based or human-at-a-distance), leaving users to overcome, circumvent or be deterred by the barriers they encounter. Meanwhile, there is a growing need for information skills as the volume of information and the number of ways of interacting with that information expand. Correspondingly, there is a need for focused studies that enable us to better understand how users work with information and how the design of DLs can enhance, rather than obstruct, the experience of information work.

New technologies will create new possibilities; for example, Stutt and Motta (2004) discuss possibilities emerging from the inclusion of more semantic information in digital resources. DLs have the potential to enhance 'anywhere, any time' learning, creating new forms of collaboration and personalisation. It will become increasingly easy to work with multiple media and to enhance the experience of interacting with information. In principle, digital technologies should facilitate information access from remote and impoverished locations that cannot afford extensive paper-based resources. However, we have shown that simply making digital resources available is not sufficient to make them used effectively. There are enormous barriers to effective working that need to be recognised and addressed in the design of future systems. This refers not only to the design of the technology, but also to the design of broader

information working systems, including physical places, information professionals and ways of working.

Important challenges remain. For example, in many domains the information that is currently accessible to the informed lay-person is markedly different from that available to the professional, creating gulfs of understanding; there are unresolved issues over how digital information is financed, which can disenfranchise some user groups; and ways to support users learning to work with information need to be improved.

It seems unlikely that it will ever be possible to dispense completely with the flexible intelligence of human intermediaries who support learners in acquiring information skills – even if this were considered desirable. Analogously, the roles of peers in helping people identify appropriate, trusted resources needs to be recognised and regarded as a strength rather than a weakness of system design; peers may sometimes interact most effectively face-to-face, but ideally there will be powerful ways for them to interact with and about information through digital channels. The future may well consist of hybrid libraries that combine the strengths of the physical library as a place to meet, a place to archive valuable physical resources and a focus for information work, with the strengths of digital libraries, as large, internationally available repositories of trusted information that are available anywhere and at any time, and that support collaboration and joint knowledge construction.

Conclusions

Witten *et al* (2001) discuss the role that information and communications technologies play in extending the "chasm between "knows" and "know-nots"" (p.82). It will be essential for the students of the future to acquire the information skills that ensure they are on the side of the "knows". As discussed above, these skills are complex and sophisticated. The view that technology should be "ready to hand" – a transparent tool that can be used effectively with minimal thought – is a compelling one. However, any tool takes practice to use effectively. Within Western culture, learning to use a library is a lifelong process, starting with 'story time' in the children's section of the public library or with 'alphabet skills' at school. More generally, within the physical library, there are staff and peers to help new library users acquire the early skills to 'bootstrap' themselves into the library culture and practices. With the shift towards electronic information use, there need to be analogous, though different, structures and mechanisms in place to provide equivalent – or even improved – support for learners, as information working skills become increasingly important. We have sketched out partial approaches to this challenge, such as information intermediaries and group sharing systems; the real challenge for the future is to devise new and powerful approaches to empowering information learners and users.

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