

Digital libraries' support for the user's 'Information Journey'

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ABSTRACT

The temporal elements of users' information requirements are a continually confounding aspect of digital library design. No sooner have users' needs been identified and supported than they change. This paper evaluates the changing information requirements of users through their 'information journey' in two different domains (health and academia). In-depth analysis of findings from interviews, focus groups and observations of 150 users have identified three stages to this journey: *information initiation*, *facilitation* (or *gathering*) and *interpretation*. The study shows that, although digital libraries are supporting aspects of users' information facilitation, there are still requirements for them to better support users' overall information work in context. Users are poorly supported in the initiation phase, as they recognize their information needs, especially with regard to resource awareness; in this context, interactive press-alerts are discussed. Some users (especially clinicians and patients) also required support in the interpretation of information, both satisfying themselves that the information is trustworthy and understanding what it means for a particular individual.

Categories and Subject Descriptors

H.1.2 [User/Machine Systems] *Human factors*; H.5.2 [User Interfaces] *Ergonomics, Evaluation/methodology, User-centered design*.

General Terms

Design, Human Factors and Theory.

Keywords

Digital library intermediaries, Clinical, Health, Academia, User communities, Context of Use, Grounded Theory, Digital libraries, HCI.

1. INTRODUCTION

If digital library (DL) information requirements were simple and uniform, these resources could have dramatically changed our lives by now. However, digital library designers not only

deal with increasingly complex data sources but are continually confronted by the complexity of different user needs and abilities. Furthermore, no sooner are user needs and abilities supported than they change. The focus of this paper is on the way that users' information requirements change over time. We do this by reference to the user's 'information journey', which has been found to consist of three important stages: *initiation*, *facilitation* (or *gathering*) and *interpretation*. Most existing work on information seeking (e.g. [30]) has focused attention on what we are calling here *facilitation*; this work sets that within the broader context of information use and, in particular, considers how an information need arises (and how existing tools support that early phase of information work), and subsequently how people make sense of (or *interpret*) information in the light of their own needs – for example, interpreting the significance of a clinical finding in relation to the treatment of the current patient.

Over recent years there have been many papers that review the temporal elements of the data utilized within digital libraries (i.e. video, audio, geospatial, annotation and event data). Applications that support the search and retrieval of dynamic data resources create interesting and exciting user opportunities [3, 19, 26, 31]. However, it has been argued that DL designers must appreciate the social elements of information seeking to avoid digital libraries being limited to the role of 'passive warehouses' [8,12]. Ultimately, digital library designers need to identify not only the temporal aspects of the data stored within digital libraries but also the changing needs of the users interacting with those resources. Some researchers (e.g. [10]) have detailed 'cycles of activities' to make sense of the context within which digital libraries exist. Such cycles include phases in which information is accessed, 'discovered' (i.e. related to other information), stored (e.g. within another DL), disseminated to other people and preserved. Whereas that work focuses on the library as the centre of the activity, the work reported here focuses on cycles based around user needs and activities in the form of an 'information journey'. This paper seeks to detail that 'information journey' for different user groups in different domains and the impact of digital libraries on that journey.

2. BACKGROUND

Almost 10 years ago, Brewer *et al* [8] highlighted the importance of proactive digital libraries 'facilitating' appropriate knowledge to the user – i.e. making that knowledge easily available. They also argued that digital resources must support users' information requirements in the

interpretation and application of this information. Digital libraries have since developed into far more than ‘passive warehouses’ of static information. They can now be dynamically tailored to users’ varying needs – not just in terms of topic and depth of knowledge, but also to support different cognitive abilities [2]. Users are becoming more adept at traversing boundaries between different resources (e.g. digital libraries and the web) to create seamless interaction between resources [16, 21]. However, there is still great scope for understanding and designing to support the sequential processes through which users work with information.

With the growth of networked services, more and more people from different backgrounds and cultures, and with varying skills, are using digital libraries. For example, Kuhlthau and Tama [17] present findings from a study of information use by lawyers, while Attfield and Dowell [4] studied journalists’ use of electronic information resources. The work reported here focuses on two contrasting domains in which the use of electronic information is relatively mature but, nevertheless, developing rapidly – namely, academia and health services. By studying two domains, we can start to tease apart issues that are generic across domains from those that are domain specific.

2.1 Temporal digital library information

Much of the research into users’ requirements for digital libraries focuses on the facilitation of information and, in particular, to information searching, classification and filtering [8]. Allen [3] discusses temporal elements of digital library content and the user in his ‘event gazetteer’. This application provides flexible data (relating to ‘actors’ and timelines) with the additional ability to present alternative viewpoints of events according to different user perspectives. This highlights a growing interest in the different viewpoints and needs of users, although it does not articulate how they differ, or how this might impact on DL design.

Within the context of searching, patterns of users’ behavior over time have been identified. Blandford *et al* [7] summarize previous research into work patterns with library resources. One clear distinction is between the acts of *browsing* and *searching* information sources. Browsing is widely understood as a user traversing information structures to identify the required items of knowledge, and maybe recognize new information needs, while searching involves users describing (e.g. by entering search terms) what they are looking for [14, 15]. Blandford *et al* [7] also discuss issues of serendipitous interactions. This study identified that users were positively motivated by unexpectedly finding articles of interest on their ‘information journey’. Serendipity is a prime example of an information need being recognized at the time of information discovery rather than the more common situation of discovery following recognition of need.

Research has also been done into the process of interpreting documents (e.g. reading and annotating them) rather than simply locating them [6, 20]. Understanding the temporal complexities of the evolving interaction between users’ requirements and different ways users search and utilize information resources may be a starting point for thinking about novel digital library designs.

2.2 Users’ changing needs

Within the health and academic domains, time-based aspects of social and contextual issues are key elements of information usage (e.g. who’s responsible for providing or

interpreting the next bit of information, how important the information is at this stage etc). As digital libraries can change the context of people’s work-practices, and therefore restructure their relationships with each other and the task at hand, these elements need to be understood [24, 28]. Reddy and Dourish [23] review the temporal elements of information seeking behaviors in a clinical setting, and report that colleagues are the most important drivers for the information journey:

1. Colleagues are the first information reference point for clinicians (for *initiation* and *facilitation*).
2. Clinical staff provided the contextual information and interpretation that cannot usually be provided in a hardcopy format (*interpretation*).

Schneider and Wagner [25] also highlight the importance, within a clinical setting, of local knowledge, informal collaboration and technology to support the sharing of information. Similarly, Cicourel [11] notes that team members on medical ward rounds provide contextualizing information to each other. Within the academic domain, contextualization of information is also important, and that contextualise understanding is often achieved through negotiation with librarians [13]. However, the crucial difference between the domains is that the collaboration highlighted in the academic domain is that between librarian and user, while colleagues take on this role within the clinical domain. This difference in work practices may reflect the different social structures within these two domains.

Although digital library research has concentrated on the facilitation of information, there have been a growing number of studies analyzing the interpretation and use of information. Brewer [8] argues that digital libraries should be more proactive, and notes the importance of interpretation and application of information for digital libraries. He argues that value can be added during the mediation process through information translation (e.g. language services) and publication. Recent applications demonstrate how digital library information can be integrated within the authoring and publishing process and support the interpretation of information [9,10]. Integrated environments for both seeking and organizing information are utilized to support the sequential activities of the writing process.

O’Hara *et al* [20] argue that there is a need to have more comprehensive views of information within the context of related tasks and along their temporal continuums. Other work [5, 19] has explored how users can be given access to digital information while users are mobile (i.e. contextualizing the information to users’ current time and place). However, most of these research directions detail facilitation and interpretation of digital library sources yet do not tie these into a higher level user’s temporal process which starts before searching commences with the initiation of information requirements. Bishop’s [6] study into digital library users reviews information initiation, noting that users can easily be deterred from using libraries and that poor awareness of library coverage prevents a full understanding of their potential.

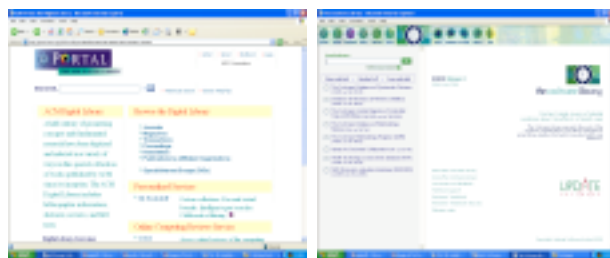
3. RESEARCH METHOD

This paper covers five different contexts of use, based in two domains: academia and healthcare. The two domains were studied over a 4-year period, and results from 150 users – end-users, librarians, designers, management – were gathered,

compared and contrasted, to identify relevant issues, both specific to each domain and generic. For this paper, the analysis has concentrated on the data relevant to the temporal elements of online and offline resource usage.

3.1 Digital library applications used

A pre-defined concept of a 'Digital Library' was not employed, so that users could explore what they perceived as comprising a digital library. However, the resources referred to most frequently by the users as digital libraries were similar kinds of systems (such as the ACM Digital Library and the Cochrane Library) within both domains (See Figure 1). The only exception to this was NeLH (the UK National Electronic Library for Health), which is more appropriately regarded as a portal to specialist digital libraries (primarily organized according to profession), discussion forums and search engines for quality assured web pages. Within the NeLH, although there has been an attempt at standardizing all of the sub-libraries, they have been developed by diverse design groups with different agendas; this diversity poses challenges to users who need to work across different libraries, as discussed below.



(a) ACM digital library

(b) Cochrane library



(c) NeLH National Electronic Library for Health

Figure 1. Academic and clinical domain libraries

The five broad user groups studied were as follows. This information is summarized in Table 1.

3.2 Study 1: Academics and academic librarians

The findings within the academic domain are based on data gathered from a London-based university that is split over several geographically distributed campuses. Focus groups and in-depth interviews were used to gather data from 25 academics and librarians from 4 different campuses within the

university. All of the respondents had a high degree of computer literacy and had used digital libraries at some point.

3.3 Study 2: Users of computers on hospital wards

The first clinical setting studied was a London teaching hospital. In this hospital, computers have been placed on the wards, with web-accessible digital libraries. Focus groups and in-depth interviews were used to gather data from 73 hospital clinicians. 50% of the respondents were nurses while the other 50% were junior doctors, consultants, surgeons, Allied Health Professionals (AHPs; e.g. occupational therapists), managers and IT department members. In this and the other two hospital-based studies (3 and 4), there was a wide spread of computer abilities and digital library experience amongst those interviewed.

3.4 Study 3: Users of computers in hospital offices and the library

A second study within the clinical domain was conducted in a provincial teaching hospital. In this hospital, although all computers allowed access to web-accessible digital libraries, they were not placed on the wards, but within specified offices and the library. 20 in-depth interviews were used to gather data from management, library, IT, consultant and nursing employees.

3.5 Study 4: Clinical information intermediaries

An evaluation of an information intermediary's role within clinical communities of practice was undertaken. 26 in-depth interviews were conducted across 8 different clinical teams over a 6 month period, as well as an observational study of one team and information intermediary collaborating during a drop-in session.

3.6 Study 5: Information providers

The final study focused on information providers based in an NHS Direct call centre (NHS Direct is a branch of the UK Health Service which provides health information to the public 24/7). 6 in-depth interviews and several observational studies were conducted over a 6 month period at one call centre. A representative sample was taken from across the organizational structure (i.e. call handler, nurse advisor, nursing manager, clinical lead, information manager, health information officer). The observational studies focused on activities and procedures within the call centre and the adjacent library. The call takers (all trained nurses and information professionals) had a high level of computer skills; callers had a spread of IT literacy although few used digital libraries.

3.7 Data Collection and Analysis

Four issues guided the focus of questions within all the studies:

- Perceptions of individuals' roles within the organization and their information requirements (both changing and constant).
- Perceptions of information practices, social structures and organizational norms (again, both changing and constant).

- The evolution of practices, structures and norms, and their impact on information resource awareness, acceptance and use.
- Technology perceptions (specifically of DLs) and how these affect other issues already identified

An in-depth analysis of respondents' perceptions was conducted using the Grounded Theory method. Grounded Theory [27] is a social-science approach to data collection and analysis that combines systematic levels of abstraction into a framework about a phenomenon which is verified and expanded throughout the study. Once the data is collected, it is analyzed in a standard Grounded Theory format (i.e. open, axial and selective coding and identification of process effects). Compared to other social science methodologies, Grounded Theory provides a more focused, structured

approach to qualitative research. The methodology's flexibility can cope with complex data, and its continual cross-referencing allows for grounding of theory in the data, thus uncovering previously unknown issues.

In the results discussed below, many points are illustrated with verbatim extracts from the interviews and focus groups. Quotations have reference numbers to relate them back to the descriptive data in Table 1. In these quotations, the speaker is identified by role, but not as an individual (so, for instance, multiple excerpts from a 'Pre-registration nurse' are not necessarily from the same individual).

Table 1: Participant descriptive data

(Study reference numbers are included for reference in quotes used in the paper)

Group	Ref.	Job	Status & Role	No.	Major DLs used
Academic	St1a	Lecturers (CS, Business, Humanities)	Research & teaching roles (from Lecturer to top ranking Professor)	12	ACM DL & LEXIS
	St1b	Librarians (CS, Business, Humanities)	Subject librarian to management	13	ACM DL, PROQUEST & LEXIS
Inner City Hospital	St2a	Nurses	Pre-Registration to Registered	36	Medline, the Cochrane library and the UK National electronic Library of Health (NeLH).
	St2b	Clinicians etc.	Doctors, Consultants, Surgeons, Allied Health Professional, managers & IT	37	(as above)
Provincial Hospital	St3	Clinicians, Nurses etc.	Nurses, Consultants, Managers, Library & IT	20	(as above)
Outer City Hospital	St4	Clinicians & Nursing	Nurses, Doctors / Consultants, Psychologists, Social Workers.	26	(as above)
Patient Call Centre	St5	Call Centre operatives	Health information & Nursing call handlers & managers	6	(as above) + NHS Direct Online & Leaflet digital library (DORIS)

4. RESULTS

The data analysis from all 5 settings showed that users interact with information temporally, traveling through a personal or a team-based information journey. The journey has three stages:

- Information Initiation: someone, something or some event initiates information requirements.
- Information facilitation: someone or some system facilitates required information retrieval

- **Information Interpretation:** someone or some system supports contextual information interpretation and / or modification.

We illustrate this journey with a simple example. In the UK, there have been various health scares (e.g. linking the MMR vaccine to autism, or HRT to incidence of breast cancer). When one of these scares hits the media, it typically initiates and information need in people who perceive the issue as being relevant to them. Those people typically try to find out more about the topic – maybe by reading more in the newspapers, talking to their friends about it, discussing it with a health professional, or some combination of these; this is the stage of information facilitation. They then need to interpret that information to relate it to their circumstances; for example, the information might inform their decision about whether or not to elect for treatment, how to advise a relative or what position to take at a public meeting on the topic. Of course, it is possible that facilitation or interpretation leads to the recognition of a further information need, spawning a further information journey on a different topic.

The results are reviewed in two sections: an overview of the resources used within the information journey, then a detailed analysis of the sub-issues relating to each stage of the

information journey (i.e. initiation, facilitation, interpretation), specifically in relation to digital libraries.

4.1 Users' Information Journey Resource Use

People are supported on their information journeys by both online and offline resources, and also by their social interactions. The findings from our studies reveal the role of different resources in the users' transitions through the stages of their information journeys (see Table 2). Digital libraries were identified as mainly supporting the facilitation of information (rather than initiation or interpretation) in the users' information journey. Academic librarians were found, however, to utilize this role more than any other users. It was also only this user group that referred to information needs being initiated by email alerts or bulletin boards linked to digital libraries. Typically, clinical users initially skim-read journals off-line to initiate information requirements and use digital libraries to facilitate information retrieval. The offline resources also support their need for serendipitous interactions with articles indirectly related to their area of expertise.

Table 2. Participants' descriptive data. Examples are placed in order of user noted priority (darker shading represents the increased role of digital libraries for different user groups in the 'information journey')

	Initiation		Facilitation	Interpretation
	Passive	Active		
Academic Librarians	Colleague, DL email alert & bulletin	Student coursework / personal query,	Digital library, Book, Web.	Colleague
Lecturers	Colleague	Course development, Research	Book, Colleague, Web, Some Digital Libraries	(as above)
Inner City & Provincial Hospital	Colleague, Press, conference	Patient / Colleague query,	Colleague, Book, Web Some Digital Libraries.	(as above)
Outer City Hospital	Colleague, Librarian, Press, conference	(as above)	Librarian, Colleague, Book, Some Digital Libraries, Web.	Librarian, Colleague
Patient Call Centre¹	Press, family friend	Personal / Relative health query	Press, Family, Friends, Support groups, Leaflets, health professionals, web, digital libraries	Family, Friends, Support groups, health professionals.

Since digital resources are used largely for facilitation, we focus on that phase of the information journey to highlight the contrasting perceptions of different user groups regarding which resources facilitate information. The results are shown in Figure 2.

Clinicians and Lecturers (from both humanities and CS departments) primarily referred to books and paper as facilitating resources (71% and 56% of resources noted respectively) while librarians referred mainly (56%) to digital libraries for this role. The role of the web was increasingly important for many users, especially lecturers, who regarded its ease of use a advantage over digital library search engines.

¹ The patient call centre reviews intermediary digital library usage, but the data obtained relates to patient enquires and their information journey

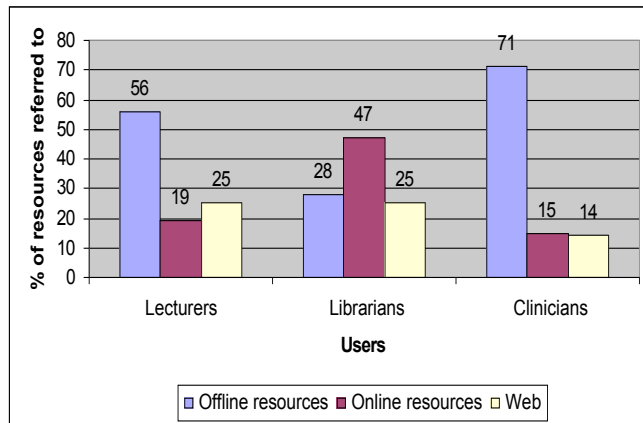


Figure 2: Percentage of resource usage for facilitation of information by different user groups

4.2 Information Journey Sub-Issues

For each of the temporal stages in the users' information journey (i.e. initiation, facilitation and interpretation) specific sub-issues were highlighted, some of which pertained only to a particular domain and some of which were generic. Figure 3 shows which user groups in our studies focused attention on each phase of the information journey.

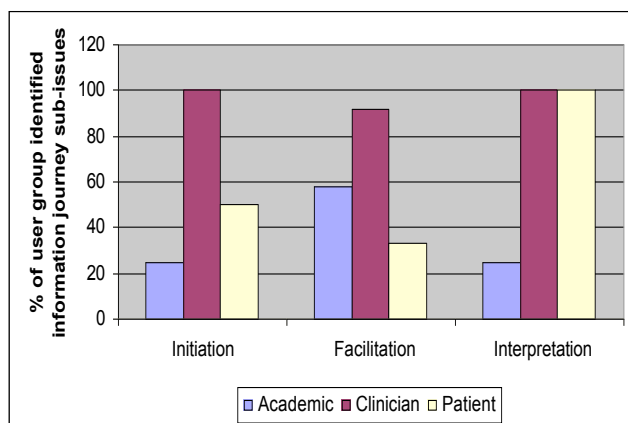


Figure 3: Percentage of user group identified information journey sub-issues

For example, only 25% of the academic participants identified initiation issues, whereas 58% identified facilitation as being important in the 'information journey'. Within the hospital domain almost all of the issues within the information journey were noted as important for the majority of user groups. For patients, however, concerns around facilitation of information were noted by only 33% of users, while issues relating to initiating information requirements and interpreting that information were noted by more user groups (50% and 100% respectively). We now consider each of the stages of the information journey separately.

4.2.1 Initiating Information Requirements

In the first stage of the information journey, there are many sub-issues, but the most prominent was the distinction between information requirements initiated by a specific active task or condition or requirements identified passively

(i.e. by friends and family, information intermediaries or the press).

Lecturers identifying initial information requirements did not often utilize digital libraries. It was argued that they lacked support in recognizing what digital libraries and resources were available that would fit their needs.

"It's an area of enormous ignorance for me. If I knew more, I would know better how to advise people."
(Humanities senior lecturer – St1a).

This, in turn, affected their abilities to support the students which may be why they tended to direct students to web resources or librarians, who were able to initiate relevant digital libraries usage for information retrieval.

*"Information searching techniques and ... *** (subject librarian) would help them to work out their research proposals and give them some different ideas about things to look at."* (Humanities senior lecturer – St1a)

Librarians' increased awareness of digital library resources was often initiated by technology intermediaries (DL alert systems, notice boards) but librarians noted the time taken to support these activities. Communication barriers between librarians and lecturers meant that librarians' DL expertise was not transferred across to lecturers. For example, humanities lecturers were found to be unaware that DL resources that they discussed as being ideal in a perfect world had been available to them for the past year.

Within the hospital domain, awareness of digital libraries was similarly poor. Of those who were interviewed within studies 2 and 3, approximately 80% had not heard of the largest national clinical digital library (NeLH), or were unaware of how it could support their specific needs. However, a project placing information intermediaries within clinical teams (study 4) was found to support increased awareness of digital resources and their relevance to clinicians needs. Intermediaries attended team meetings and ward rounds, recording queries and searches in situ or actively proposing searches.

"(The information intermediary) would sort of raise the flag and she became very good also at predicting and anticipating ... a clinical question" (Consultant St4).

All the clinicians noted how the clinical intermediary supported their use of digital information sources to raise awareness and initiate future DL information requirements.

"She was showing me a web-site which is now put onto my favourites ... and there's one site and you can go onto that and it'll email you the contents of every journal." (Physiotherapist St4).

Patients' information requirements, when not initiated by directed searches for specific conditions, were often initiated by press, family or friend induced fears.

"Because there is a lot of information out there in the media and in the press. People hear about it and they call us because I think they're worried about it, or they think it's going to affect them. I mean we certainly have a lot more health alerts than we ever had"
(Health information officer St5)

It was also noted by clinicians in settings 2 and 3 that they were being forced to become more aware of current press issues, both to allay patients' fears and to find out what

position was being taken by their professional body or their hospital. Nursing staff (St 2a) reported that it would be useful to have a resource that captured these changing issues and related them to current evidence, organizational and national health perspectives.

4.2.2 Facilitating Information

After initial information requirements have been established, most users move on to issues surrounding facilitating information retrieval. Users identified a variety of sub-issues concerned with this stage of their 'information journey'. However, the most prominent concerned the resource content and their interaction with it. Important features of resource content included its quality, format and classification; how familiar it is; and how well the information is set into an appropriate context. Important aspects of users' interaction with information included concerns over how resources change over time (e.g. as interfaces get redesigned) and over search times; and positive comments regarding serendipitous interactions.

Many specific issues were highlighted by users with regard to the quality and format of the information content. However, it was the theoretical rather than practical content of many digital library resources that restricted their value for users. Within the clinical domain, the immediate benefits of up-to-date content were recognized. Participants reported a need for day-to-day clinical information (e.g. policies, procedures, induction data, guidelines, and protocols) that was updated, locally relevant, electronically stored and quickly retrievable.

"... how to care for a wound point 6 ohhh yes I have to use this type of dressing and where are they kept ohhhh right they're kept under there" (Nursing manager St2a).

Many lecturers also noted that digital libraries were not designed around supporting practical teaching activities, regarding them purely as research tools, with content that was beyond most undergraduate programme levels and thus pointless to refer to.

Many clinical users noted that the way DL information was often classified according to professions hampered their DL search activities. Clinical tasks often require interdisciplinary information, so that retrieval from DLs involves time-consuming identification of discipline-specific information structuring and terminology. It was suggested that topic based portals with access to relevant journals, guidelines and standards would greatly increase the usability of these systems. In particular, clinicians noted the importance of familiarity with the language used.

Both the academic and clinical user groups noted the changing nature of digital library resources, in both its content and the interface.

"You have to keep training every year, every 6 months. It's not static" (CS librarian St1b).

This was highlighted as a barrier to DL usage, particularly where DLs are used relatively infrequently. For clinical digital libraries, in particular, users were worried about their ability to quickly identify applicable information from the resource.

"... but they haven't got time to sit down and actually play per se." (nursing management St2a).

The information intermediary support in study 4 ensured that they received a high level of appropriate information within a reasonable time-frame.

"... you knew that she, through her training and knowledge, was accessing everything that there was available." (Social Worker St4).

Current clinical digital libraries also did not support users flicking through pages to skim-read sections. Clinicians, therefore, often interleaved online and offline resources because they perceive digital libraries as providing poor support for serendipitous information finding. However, despite the limitations of current medical DLs, many clinicians considered these resources to be a major advance in information facilitation over traditional libraries (which suffer from limited source materials, and poor support form managing information).

4.2.3 Interpreting Information

Having retrieved their information, users require different levels of support in its interpretation. Within the clinical domain, this is a vital stage in the information journey (see Figure. 3) that is largely unsupported by digital resources. In both the academic and clinical domains, there are references to digital library barriers to information interpretation; in the clinical domain (i.e. clinicians and patients), support for information analysis and decision making is also a key interpretation issue.

A major barrier to interpreting digital library information, in both academic and clinical domains, is the limitations of online reading.

"Most people if they're going to do it, serious reading, download it and print it off." (CS senior lecturer – St1a).

Once articles have been identified, the full documents (and abridged versions) are always printed and read off-line. All the user groups, therefore, repeatedly noted the importance of adequate printing facilities and usability problems with downloading and printing documents. For many user groups this simply removed the effectiveness of digital libraries:

"The sort of texts they need to have access to are widely available and the quantity we expect them to look at would be a problem as far as reading them on a computer or expensive to print up." (Humanities Reader – St1a).

The format of documents within some digital libraries was more of a barrier to interpretation for some disciplines than others. Within the humanities discipline the flow of the material (e.g. literature, journalism) is as important as the content itself. Hyperlinks and annotations were felt to change the flow of interaction (e.g. speed reading key words, jumping around an article) and document interpretation. Although support for information interpretation was not perceived necessary within this discipline, this kind of support was seen as advantageous within the clinical domain. The hierarchical structure of the clinical domain has always relied on senior clinicians supporting junior clinicians in their interpretation and appropriate application of information.

"she'll say (referring to a consultant) – this is what I found and this is what I feel." (Specialist nurse St3).

However, this relies on consultants' time which is limited and many junior clinicians were eager to have online digital support with these issues. Patients are similarly eager to obtain trusted analysis of digital library information according to their own needs or at the least support in interpreting the information themselves.

"They call up and say which is the best one, like operation, or do you think I should have this operation and we can't tell them that we say no you have to discuss it with your consultant what is the best one for you." (Information handler St5).

5. DISCUSSION

Brewer [8] argued that digital libraries must be pro-active and dynamic in their support of users' changing information needs so as not to become 'passive warehouses' of navigable information. However, for digital libraries to effectively support users, there is a need to understand them within their context and along the continuum of their changing needs. In this paper, we have presented a users' generic (across the academic and health domain) 'information journey'; from the initiation of information requirements, through the facilitation of information to the user and finally to the interpretation and application of that information. Within each of those stages there are several sub-issues which are either generic or specific to each domain. Within the health domain, patients and clinicians require a great deal of support for the interpretation of information. Clinicians require more than simple electronic representations of documents. In their view, DLs would be much more usable and useful if they also supported communication activities (e.g. reviews, debates) and task specific variations (e.g. providing local knowledge and prompts to update information). It was felt that it would be useful if web-crawlers [16, 21] could be applied within this domain. A key issue that needs to be addressed is that of supporting information analysis, with trusted and contextualized reviews of papers relating to specific circumstances (e.g. Does this therapy work with the elderly with several other conditions or do other findings suggest that it wouldn't?). In contrast, academics have more interest in support within the facilitation of information; this substantiates the continued need for academic digital library research on how to make information readily accessible. These results appear to confirm those of Theng et al [29], who found that less than a third of the participants in their academic study recommended that DLs should include an environment to exchange ideas and learn. However, it could simply be that the current poor support within DLs for these activities means that users prefer to conduct them offline. For clinicians, there is an even greater need for support in DL information facilitation; this is probably due to the tight time and quality restrictions within this domain increasing these resources to the level of safety critical systems.

Clinicians also need support in initiating information requirements, and have poor awareness of what digital resources are available. Mechanisms such as DL alerts are utilized well by librarians, but most users are unaware of these facilities and their potential value. Further research is required to identify how the profile of digital resources can be raised, to improve utilization of these valuable resources. One application that could support users' DL usage is the concept of press alerts. A mechanism that links recent press articles on a particular subject with related current research and

professional articles, and collates them for the clinician, would be invaluable. A consultant or patient may want alerts not only when new papers on, for example, diabetes are available in the DL, but also when press alerts arise on the subject, with links to any corresponding DL literature. Within the academic domain, initiation of information requirements is not perceived as a high priority issue. However, where reviewed with regard to disciplines we find that librarians are very aware of what digital resources are available, motivated to use them and need little support in any of the information journey stages. Lecturers, in contrast, had a poor awareness of what digital resources were available and were not motivated to utilize them; this confirms previous research findings: that awareness is a key issue in digital library implementation [1, 6].

Digital libraries and their content are constantly changing. One library may not have anything of use for a specific subject today, but may have just the right paper tomorrow. A constant review of these libraries and their structure and content is required. However, potential digital library users have their own offline 'information journeys' to follow that rarely entail regular use of one particular resource. This is because few jobs entail only information retrieval; they also require some sort of analysis and dissemination, and the parameters of what information they require are continually changing. Most occupations, as in the academic and health domain, also have a practical element. Clinicians and patients need to have conditions seen, diagnosed and treated as well as sometimes retrieving specific information for various reasons. Lecturers and students also need specific information, but their needs and usage patterns vary according to subjects, assignments and schedules (e.g. breaks, exam times). It is this issue of the divide between practical and theoretical information content that was highlighted in the findings as a barrier to clinicians', patients' and lecturers' usage of the information. However, with the recent development of more temporally contextual and interactive digital library applications the practical content of these resources has also increased [9, 10, 19, 16]. These resources provide dynamic information that feeds into users' interaction with the world and related tasks along user defined continuums. These applications may provide users with flexible access to practical information within their own time-frames, which is part of what made the web so appealing to them.

For lecturers and some clinicians, searching the Internet as one big digital library was identified as quicker for learning technology skills (e.g. browser usage) and accessing information than using specific DLs that employ varied, and often complex, searching mechanisms. The Internet was also believed to be an important aid, for skilled clinicians, in accessing reputable up-to-date information sources (e.g. academic sites, professional colleges). However, senior clinicians expressed a concern with the web that less experienced junior staff would not be able to discriminate between reputable and non-reputable information sources – hence another argument for reputable information analysis to support users in the interpretation of information.

Finally it must be noted from this research that books and paperwork are still regarded as essential for users, especially in the health domain. Some of the important features of books and paperwork that users noted were their portability, particularly for reading and annotating, and the focus they could represent as interaction points with colleagues [18].

Another advantage of the hard-copy format over the digital was noted as its ability to support serendipitous interactions through skim-reading. Serendipity is a prime example of an interactive information facilitation activity. Blandford et al [7] found that users are positively motivated by unexpectedly finding articles of interest. Our results have also found that users quickly jump between serendipitous and directed searching. Any electronic provision of information must, therefore, enable users to easily interleave these tasks. This research also identified the importance of the activity of quickly flicking through pages to skim-read sections to support serendipitous and directed searches. However, information sources with pages that are easily turned and annotated without the clutter of extra functions are not available within existing digital libraries. Press [22] also notes the importance of technology being transparent, so that page turning becomes an unconscious act. Poor support for this activity will always allow the paper copy to overshadow electronic versions for usability.

6. CONCLUSION

This paper identifies users' changing information needs over time via an 'information journey' that involves the use of both online and offline resources. In the first stage of the information journey, information requirements are initiated by either an active specific task or condition, or passively (e.g. by friends and family, information intermediaries or the press). After initial information requirements have been established, most users require support in facilitating its retrieval and then its interpretation and application. DL designers will learn from these findings that there are many additional ways that users within the academic and health domain require information resources to support their journeys. Recent digital library advances have facilitated access to different types of temporal data [3, 19, 26, 31]. However, digital libraries have further to go in supporting users' changing needs for all types of information (both theoretical and practical) according to varying contextual requirements. One major problem identified was that of resource awareness. Unlike lecturers, clinicians and patients, librarians were aware of a wide variety of digital library resources and utilized them to their full potential. They also utilized alerts to keep them abreast of frequent changes and to initiate further searches. Few other users were aware of these tools and when some clinicians (see results from Study 4) were introduced to these mechanisms they greatly appreciated their usefulness. The finding presented here also highlights the need for press-alerts that would link recent press articles on a particular subject with related current research and professional articles, then collate them for the user. Ultimately, digital library applications should seek to support users' changing needs in the type of information required and what they wish to do with that information.

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