

Investigating users' mental models of traditional and digital libraries

Stephann Makri

Project report submitted in part fulfilment of the requirements for the degree of Master of Science (Human-Computer Interaction with Ergonomics) in the Faculty of Life Sciences, University College London, 2004.

NOTE BY THE UNIVERSITY

This project report is submitted as an examination paper. No responsibility can be held by London University for the accuracy or completeness of the material therein.

Acknowledgements

I would like to thank my supervisor, Dr. Ann Blandford, for her wise words of guidance, and the participants of my research for their valued assistance.

Abstract

There is much HCI-related literature on mental models and on the usability of digital libraries, however there is no previously published literature on users' mental models of either traditional or digital libraries. This is surprising, since many digital libraries are difficult to use and it is not immediately clear why. Our study begins to fill this void by examining users' mental models of traditional and digital libraries through a series of Contextual Inquiry interviews that mix traditional think-aloud observations, which usually demand minimal researcher intervention, and semi-structured interviews, which usually demand significant intervention.

The study finds that participants' mental models of traditional and digital libraries extend beyond surface similarities and differences, such as the hierarchical organisation of items in both types of library and the availability of documents in paper and electronic mediums. These models contain deeper similarities and differences based on the information-seeking goals that can be fulfilled by each type of library, issues concerning the contents and relevance of individual documents and entire libraries, and 'how searching works' and how to 'troubleshoot' in both types of library. Although the use of concrete analogies to influence users' understanding or usage of digital libraries was not widespread, participants used their knowledge of Internet search engines to infer how searching might work in digital libraries. Additionally, most participants assumed that even if different at the interface level or at the level of the underlying technology employed, the search components of digital libraries, Internet search engines and other digital entities work in a similar way to bring back search results. The study also finds that a large component of users' mental models of digital libraries is the notion of access restrictions.

The insights gained from the observations relating to the above recurring themes in users' mental models are discussed with a view of helping to improve digital library usability by reducing access restrictions and notifying users of any such restrictions upfront, by providing dynamic and context-dependent help to users, by carefully introducing analogies into the digital library interface (if and where appropriate) and by making multiple digital libraries searchable under a single front-end to enable them to be accessed, browsed and searched in the same way.

Table of contents

1.	Introduction	
1.1	The relevance and interest of this study to HCI	6
1.2	The concept of mental models in relation to this study	6
1.3	The concept of digital libraries in relation to this study	8
1.4	Overview of study	10
2.	Literature review	
2.11	Overview of mental models literature	12
2.12	Introduction to the nature of mental models research	12
2.13	Mental models research in HCI.....	14
2.14	Mental model components	18
2.15	Mental models of electronic information seeking	22
2.16	Metaphor, analogy and similarity in mental models	24
2.17	Mental model elicitation.....	30
2.18	Summary of mental models literature	37
2.2	Digital libraries.....	37
2.21	Overview of digital library literature	37
2.22	The need for mental models research to improve digital library usability	38
2.23	The relationships between digital libraries, traditional libraries and the Internet	41
2.24	Summary of digital library literature.....	48
3.	Methodology	
3.1	Think-aloud observation approach and critique	49
3.2	Summary of the mental model concepts identified from the literature	52
3.3	Data analysis approach and critique	55
3.4	Summary of methodology	56
4.	Findings	
4.1	Overview of findings	57
4.2	Discussion of themes that emerge from our findings	58
4.21	Similarities and differences between traditional and digital libraries	58
4.22	Access issues in traditional and digital libraries	61
4.23	The use and construction of ad-hoc ‘how-it-works-knowledge’ as a result of system feedback.	65
4.24	How items are organised	66
4.25	How users assess the contents and relevance of particular documents and entire libraries.....	73
4.26	The use of analogies	77
4.27	Troubleshooting in the traditional and digital library	84
4.3	Summary of findings	86
5.	Recommendations and findings	
5.1	Overview of recommendations.....	88
5.2	Discussion of recommendations.....	88
5.2	Potential for future work arising from this study.....	98
5.3	Conclusion	100
	Bibliography.....	102
	Appendix 1: Participant instructions and consent form	108
	Appendix 2: Final protocol used in study.....	109
	Appendix 3: Transcripts	111

List of tables and figures

Tables

<i>Table (a) - Harter's (1997) Potential properties of a Digital Library</i>	9
<i>Table (b) - Jonassen's (1995) characteristics of mental models and associated measures</i>	32
<i>Table (c) - Winograd's (1995) list of differences between the '[traditional] library culture' and the 'Internet culture'</i>	41
<i>Table (d) - Nürnberg et al.'s (1995) translation of traditional library entities into the digital realm</i>	43

Figures

<i>Fig. (a) - Norman's Action Cycle, Re-printed from Norman (1986)</i>	16
<i>Fig. (b) - Example use of Bates' (2002)'Cascade of Interactions' in the digital library interface</i>	39

1. Introduction

1.1 The relevance and interest of this study to HCI

There is a wealth of literature on mental models, including the use of mental models in HCI, and much literature on the usability of digital libraries. However, there is currently no published literature on users' mental models of either traditional or digital libraries. This is surprising, since many digital libraries are difficult to use and it is not immediately clear why.

Digital libraries are not only intriguing because they have remained difficult to use. They are also intriguing because interesting similarities and differences exist between traditional and digital libraries and also between digital libraries and other electronic domains such as Internet search engines and e-commerce sites. These similarities and differences remain largely unexplored in the literature, possibly because they are not straightforward to identify and their potential impact on digital libraries is not easy to ascertain.

Despite these potential difficulties, we argue that attempting to study users' mental models of libraries is a potentially fruitful area of research. We argue that attempting to unlock some of the internal processes held by users' can simultaneously unlock some proposals for working towards the long-term goal of increasing digital library usability. This study examines users' mental models of traditional and digital libraries and discusses how insights gained from the recurring themes that are identified can help to improve digital library usability by reducing access restrictions or notifying users of such restrictions upfront, by providing dynamic and context-dependent help to users and by making multiple digital libraries searchable under a single front-end to enable them to be accessed, browsed and searched in the same way.

The remainder of this introduction examines the concepts of mental models and digital libraries in relation to this study and concludes with a brief overview of the study itself.

1.2 The concept of mental models in relation to this study

In their comprehensive review of the literature, Staggers and Norcio (1993) highlight the disagreement on the definition of 'mental model' and suggest that it cannot be assumed with absolute certainty that users form mental models in the first place. They highlight the variety of terms used by authors for the overall concept, including 'mental model,' 'cognitive model' and 'conceptual model.'

Staggers and Norcio (1993) argue that not only is there inconsistent terminology, but also a lack of a precise definition of a mental model. They cite Carroll and Olson's (1988) definition as "knowledge of how the system works, what its components are, how they are related, what the internal processes are, and how they affect the components." Staggers and Norcio (1993) themselves define a mental model as "an internal mental representation created by system users." Schumacher and Czerwinski (1992) argue that definitions of mental models fall into at least three classes: descriptions of mental models as collections of knowledge structures, descriptions of mental models as metaphors and analogies, and process descriptions of how users interact with complex systems. The above definitions follow the tradition as started by the papers in Gentner and Stevens (1983) which focuses on physical systems. Staggers and Norcio (1993) also cite de Kleer and Brown (1983) to assert that these types of models can be used for explaining and predicting system behaviour. Staggers and Norcio (1993) summarises other mental models concepts, such as that they can be 'run,' implying that the models are qualitative and may be simulated in the user's

'mind's eye.' Norman (1983) highlights the fact that users' mental models are neither complete nor accurate, however they still function to guide much of their behaviour.

O'Malley and Draper (1992) note that some of the differences in the literature may also derive from the various contexts in which mental models are studied, such as text comprehension (Johnson-Laird, 1983), the understanding of physics (Gentner and Stevens, 1983) and Human-computer Interaction (Young, 1983, Kieras and Bovair, 1984). For example, regarding the definition of the term, Gentner and Stevens (1983) propose a more abstract definition to HCI scholars such as Norman and Carroll. As noted by Staggers and Norcio (1993), Gentner and Stevens (1983) propose that mental models focus on the way people understand a specific knowledge domain, whilst more concretely Norman (1983) suggests that mental models provide predictive and explanatory powers for understanding the interaction and Carroll (1984) views mental models as information that is input into cognitive structures and processes.

In order to help control use of the term 'mental models,' Norman (1983) distinguished between four kinds of model of a target system (t) as follows:

1. The user's mental representation of the system, $M(t)$
2. The designer's conceptual framework for the description of the system, $C(t)$
3. The image the system presents to its users, $S(t)$
4. The psychologist's conceptual model of the user's mental model, $C(M(t))$

Norman's (1983) model suggests many important points, as discussed by Tauber (1988). Since a user's mental model should be in accordance with the conceptual model, the designer must take into consideration the mental model he ideally requires of the future user. The system's image should also be consistent with the conceptual model, which means it should properly communicate the conceptual aspects of the system to the users so that they can acquire a mental model which is in accordance with the conceptual model. This extends beyond the use of computer-based systems, such as digital libraries, into the realm of the traditional library. The traditional library can also be regarded as a 'system' of sorts. However, users rarely interact with a library system only once and there is little exploration in the literature of the ways in which people might develop and alter their mental models. Norman (1983) does suggest, though, that through continuing interaction with the external system he or she is trying to model, a person will continue to modify their mental model in order to find a workable result.

Norman's (1983) model also provides a useful basis for clarifying the purpose of this study from the outset; to examine users' mental representations of the traditional and digital library systems ($M(t)$). This notion is referred to throughout this report simply as the user's 'mental model.' However, since mental models cannot be observed directly (Sasse, 1997), the result of a study such as this is for the researcher to form a conceptual model of the users' mental models ($C(M(t))$). This model may also be incomplete and inaccurate to some degree. This is because, as Norman (1983) argues, mental models are owned by individuals and hence are usually incomplete, partially wrong and differ from person to person. Hence it was important for this study to adopt as transparent a research approach as possible, where important assumptions and limitations are highlighted, methodological tradeoffs examined, and full transcripts provided (see appendix 3).

This study follows the tradition established by the papers in Gentner and Stevens (1983) which focus on physical systems, by examining users' mental models of both traditional and digital libraries. The study is based on the assumption that users *do* form mental models when interacting with both traditional and digital library systems, but that exact nature of these models is not completely discoverable. However this should not discourage researchers from attempting to gain as rich a conceptual model of the user's mental model, $C(M(t))$, as possible. This is especially the case when examining users' mental models of digital libraries, which are widely used in academia.

Digital libraries are often poorly usable, yet for inter-connecting reasons that are not immediately obvious and hence not immediately rectifiable. This study finds that examining users' mental models of digital libraries can provide insights for improving the usability of digital libraries, or at least to provide a stepping stone for improvement. Further utility is also provided by examining users' mental models of traditional libraries and relating these findings to digital library usability.

Furthermore, by focusing on following the broad mental model tradition rather than attempting to adopt a specific or precise definition of a mental model, this study aims to show sensitivity to a field of research which focuses on eliciting internal user processes. Since these processes cannot be studied directly, it is no surprise that there is disagreement in the literature. However, it is important not to dismiss such disagreement as simple 'confusion,' since this might falsely justify a haphazard or overly-intuitive approach to the study of mental models. Hence to aid those wishing to assess the validity of this study or to follow on from it, a transparent research approach (as highlighted earlier) is necessary.

1.3 The concept of digital libraries in relation to this study

In her review of the literature, Borgman (2003) argues that despite its popularity, 'digital library' remains a problematic term. She cites Lynch (1993), who notes that the term obscures the complex relationship between electronic information collections and libraries as institutions, which is a relationship examined by this study. Borgman also cites Greenberg (1998) and Battin (1998); Greenberg proposes that "the term 'digital library' may even be an oxymoron: that is, if a library is a library, it is not digital; if a library is digital, it is not a library," whilst Battin (1998) goes further and completely rejects the use of the term 'digital library' on the grounds that it is 'dangerously misleading.' For the purpose of this study, however, it is more important to note the potential ambiguity and problematic nature of the term rather than to reject the term entirely. This is because the ambiguity and problematic nature itself yields useful insights into users' mental models (and will be discussed later).

Borgman's (2003) review of definitions reveals that the digital library describes a variety of entities and concepts. She argues that the most succinct one arising from within the computer and information science research community is that of Lynch and Garcia-Molina (1995): "A digital library is a system that provides a community of users with coherent access to a large, organised repository of information and knowledge."

Borgman's (1996) own comprehensive but broad definition encompasses two important notions:

Firstly, digital libraries are a set of electronic resources and associated technical capabilities for creating, searching and using information. In this sense, they are an extension and enhancement of information storage and retrieval systems that manipulate digital data in any medium and exist in distributed networks. The content of digital libraries includes data, metadata that describe representation, creator, owner, reproduction rights, and metadata that consist of links or relationships to other data or meta data, whether internal or external to the digital library.

Secondly, digital libraries are constructed collected and organised by (and for) a community of users, and their functional capabilities support the information needs and uses of that community. They are a component of communities in which individuals and groups interact with each other, using data, information and knowledge resources and systems. In this sense they are an extension, enhancement and integration of a variety of information institutions as physical places where resources are selected, collected, organised, preserved and accessed in support of a user community. These information institutions include, among others, libraries, archives and schools, but digitallibraries also extend and serve other community settings, including classrooms, offices,

laboratories, homes and public spaces. This broad definition moves beyond information retrieval to include the full life cycle of creating, searching and using information. Rather than simply collecting content on behalf of user communities, it embeds digital libraries in the activities of those communities, and it encompasses information-related activities of multiple information institutions.

In a similar vein to following a mental model tradition rather than adopting a concrete definition of a 'mental model,' a useful way to view the disagreement about what constitutes a digital library is to be aware of a broad continuum of possibilities, as highlighted by Harter (1997). According to Harter, the most inclusive view takes a digital library to be, as its starting point, essentially what the Internet is today. But from this extreme perspective it can be seen that the metaphor of the traditional library fails in several respects. Table (a) describes what Harter considers to be essential properties of a digital library ranging from quite traditional to extremely broad views and will be discussed in detail in section 2.23.

Potential Properties of a Digital Library		
Narrow View (based on traditional library)	Broader View (a position between the extremes)	Broadest View (loosely based on current Internet)
objects are located in a physical place	objects are located in a logical place (may be distributed)	objects are not located in a physical or logical place
objects are information resources	most of the objects are information resources	objects can be anything at all
objects are selected on the basis of quality	some of the objects are selected on the basis of quality	no quality control; no entry barriers
objects are organised		no organisation
objects are subjected to authority control	some aspects of authority control are present	no authority control
surrogates of objects are created	surrogates are created for some objects	no surrogates of objects are created
surrogates are 'finely searchable'	surrogates and objects are finely searchable	only objects are searchable
authorship is an important concept	concept of author is weakened	no concept of author
objects are fixed (do not change)	objects change in a standardized way	objects are fluid (can change and mutate at any time)
objects are permanent (do not disappear)	disappearance of objects is controlled	objects are transient (can disappear at any time)
access to objects is limited to specific classes of users	access to some objects is limited to specific classes of users	access to everything by everyone
services such as reference assistance are offered		the only services are those performed by computer software (AI)
human specialists (called librarians, etc.) can be found		there are no librarians
there exist well-defined user groups	some classes of objects have associated user groups	there are no defined user groups (or, alternatively, infinitely many of them)
use of library is free for specified user groups	use of library requires payment for some services and/or user groups	use of library requires payment

Table (a): Harter's (1997) Potential properties of a Digital Library

By appreciating that users often forge their own definition and mental model of a particular digital library or libraries somewhere within the above continuum, this study embraces the disagreement in the definition of both the term ‘digital library’ and ‘mental model.’ Hence this report does not examine these disagreements in detail, but instead aims to provide some insight into the role that differing views of a digital library might play in enabling users to form mental models of digital library systems. By highlighting similarities and differences in users’ mental models of digital libraries and relating some of these differences to traditional libraries, this serves as a stepping stone for achieving the long-term goal of increasing digital library usability. Whilst this study does not provide any ‘magic solutions’ to ensure that this goal is achieved in the near future, it highlights that users’ minds already hold useful information that can provide insight for improving the usability of digital libraries and that attempting to obtain this information is a valid and potentially fruitful area for future study.

1.4 Overview of study

There is no previously published research on users’ mental models of either traditional or digital libraries. This study takes the first step in providing insight into users’ mental models of traditional and digital libraries with a view of helping to achieve the long-term goal of improving digital library usability.

The study reports on a series of think-aloud observations of eight Masters students performing a similar broad information seeking task in both the traditional and digital library or libraries of their choice. The observations conducted were a cross between traditional think-aloud observations, which usually demand minimal researcher intervention, and semi-structured interviews, which usually demand significant intervention. This cross resulted in a product highly similar to Contextual Inquiry interviews, with probing ‘what,’ ‘how,’ ‘why’ and ‘what if?’ questions asked by the researcher in order to gain an insight into users’ mental models (see Beyer & Hotlzlblatt, 1998).

The observations were transcribed and a natural coding scheme developed to highlight important themes, similarities and differences in the models. These were discussed in relation to the broad mental models concepts in the literature and in relation to the wider literature surrounding mental models, including the literature on previous HCI-related studies on mental models, mental models of electronic information seeking and metaphors and analogies. Furthermore, the findings were also discussed in relation to the wider literature surrounding digital library usability, including electronic information seeking in digital libraries. The findings are also discussed in relation to the literature highlighting the relationships between digital libraries, traditional libraries and the Internet.

The study finds that participants’ mental models of traditional and digital libraries extend beyond the surface similarities and differences identified, such as the hierarchical organisation of items in both types of library and the availability of documents in paper and electronic mediums. These models contain deeper similarities and differences based on the information-seeking goals that can be fulfilled by each type of library, quality control issues concerning the contents and relevance of individual documents and entire libraries, and ‘how searching works’ in both types of library. Although the use of concrete analogies to influence users’ understanding or usage of digital libraries was not widespread, users did not only use their knowledge of Internet search engines to infer how searching might work in digital libraries, but most participants assumed that even if they differed at the interface level or at the level of the underlying technology employed, the search components of digital libraries, Internet search engines and other digital entities such as electronic library catalogues and e-commerce sites work in a similar way to bring back search results. The study also finds that a large component of users’ mental models of digital libraries is the notion of access restrictions.

This report begins by examining the varied and often disagreeing literature on mental models in the HCI field, along with the reported components of users' mental models as suggested in the literature. We then examine the limited previous mental models research into electronic information seeking, followed by examining some of the key literature on metaphor, analogy and similarity in mental models. We also examine the literature on mental model elicitation and discuss how it informs our methodology.

The report continues by examining the need for mental models research to improve digital library usability and the literature which explores the relationship between traditional libraries, digital libraries and the Internet. Next our methodology is presented and justified and our findings discussed both as a valuable source of information in their own right and in relation to the literature. This allows us to make practical recommendations for improving digital library usability, such as the need to reduce access restrictions or notify users of such restrictions upfront, the need to provide dynamic and context-dependent help to users and the potential of making multiple digital libraries searchable under a single front-end to enable them to be accessed, browsed and searched in the same way.

Finally, the potential for future work arising from this study is discussed, particularly the scope for further investigation into the use of analogies, and comparisons between digital libraries and other traditional and digital entities.

2. Literature review

2.1 Mental models

2.11 Overview of mental models literature

This review of the mental models literature begins by examining the nature of mental models research, highlighting the fuzziness surrounding the subject. Next we examine some of the key mental models studies in the HCI literature and then highlight some important components of mental models that can be identified from the literature. This is followed by an examination of previous studies related to users' mental models of electronic information seeking and an examination of the relevance of metaphor, analogy and similarity to digital libraries. Finally we highlight the difficulties associated with eliciting mental models from users, as discussed in the wider mental models literature and examine methodological considerations associated with mental model elicitation, along with potential frameworks for eliciting mental models.

2.12 Introduction to the nature of mental models research

Schumacher and Czerwinski (1992) tell the well-known fable about the six learned blind men and an elephant. Each blind man encounters the elephant from a different perspective and develops his own narrow opinion as to the nature of the beast: One grabs his ears and thinks it is a fan, another feels his tail and believes it to be a rope, and so on. This inevitably creates confusion about what constitutes an elephant. Similarly, confusion can arise about what constitutes a digital library. Users may identify some features of a traditional library that transfer into the digital realm and conclude that a digital library is very similar to a traditional library (Harter's (1997) 'narrow view'). Some users identify features of a traditional Internet search engine and conclude that a digital library will function in similar manner. Other users notice different parallels either for the digital library as a whole or its component parts. Just as disagreement in terms may make it difficult for the learned blind men to ride the elephant, it can be argued that they might help explain why digital libraries are notoriously difficult to use.

It is useful to state at the outset that like Schmacher and Czerwinski (1992), we do not pretend to be any less blind than other researchers who have tackled problems surrounding mental models, nor do we propose to provide a 'silver bullet' solution to improve digital library usability. The remainder of this section examines some of the 'fuzziness' of the mental models literature in order to explain the nature of the 'blindness' experienced by researchers of mental models. Later sections examine the concept of mental models in more detail, examining some of the components of mental models from the literature, mental models contributions in the HCI literature, the concept of mental models as metaphor or analogy and finally how to elicit users' mental models.

Researchers are well aware that the fuzziness surrounding the subject is a concern. As Staggers and Norcio (1993) conclude, "without precise definitions, the terms are meaningful on intuitive appeal, because they mean whatever readers want them to mean." Rutherford and Wilson (1992) agree: "Given all the different perspectives of those wishing to apply the notion, mental models are in danger of being shrouded with sufficient ambiguity to become all things to all people." We recognise that taking an intuitive approach to the study of mental models contradicts our earlier ethos of transparency. We do not regard the state of mental models research as a 'concern' per se, but instead argue that greater responsibility should lie with individual researchers to create as much clarity as possible amongst the potential ambiguity.

Craik (1943) originally made the assertion that humans represent the world they are interacting with through mental models. Craik viewed all mental representation as mimicking the physical world and that people operate on mental representations to simulate real-world behaviour and produce predictions. In the context of HCI, Norman (1983) goes further to argue that not only can mental models provide predictive power for understanding the interaction, but also explanatory power. This view is also supported by Young (1983). Craik (1943) also argues that the model does not need resemble the external process it imitates, so long as it works in the same way. Nor does it need to be as complex, so long as it represents the most important processes, since models are not improved by the addition of information beyond a certain point.

Johnson-Laird (1983) adopts many of Craik's (1943) assertions and further argues that mental models are either analogical representations or a combination of analogical and propositional representations, distinct from, but related to images. As noted by Preece et al. (1994), a mental model represents the relative position of a set of objects in an analogical manner that parallels the structure of a state of objects in the world. An image also does this, but more specifically in terms of a view of the world. Johnson-Laird (1983) argues that different people have more or less elaborate mental models, depending on what they need to know. This may be explained by Preece, et al. (1994), who note that mental models are usually constructed when we are required to make an inference or prediction about a particular state of affairs. In constructing the mental model a conscious mental simulation may be 'run' from which conclusions about the predicted state of affairs can be deduced. This helps to distinguish a mental model from an image, since an image is considered to be a one-off representation (Preece et al., 1994) and hence cannot be re-constructed or refined.

More recently, Payne (2003) suggests that the disagreement over the term 'mental model' emerged in 1983 when both Johnson-Laird and Gentner and Stevens published their volumes on the subject. Gentner and Stevens (1983) regard mental models as a topic for cognitive science, suggesting that it was worthwhile to investigate the theories people construct about specialised, delimited aspects of the environment and to study how these theories affect their thinking and behaviour in a particular domain. Johnson-Laird (1989) regards mental models as a particular kind of mental representation: an analogue representation of a state of affairs that might be derived directly from perception, or indirectly from discourse. Johnson-Laird (1989) further argues that some authors draw distinctions among various concepts of mental models when they likely represent "the same underlying reality." Payne (2003) disagrees with Johnson-Laird on both points. He does not agree that these differences are superficial, nor that at a deep level the different work on mental models is addressing the same cognitive phenomenon.

Payne (1991) argues that independent theoretical claims have been made under the banner 'mental models' and are nested in a strict inheritance hierarchy, like a set of Russian dolls, which stronger theories inheriting the commitments of weaker theories. Payne (2003) argues that his earlier assertion is actually too much of an idealisation to be sustained and that relatively stronger theories support a constellation of these claims and relatively weaker ones only one or two. His first and weaker idea views mental models as theory and suggests that people's behaviour will be best explained by appealing to the content of their memories, what they know and believe, independently of any mental mechanism. This is the claim that is shared by the papers in Gentner and Stevens (1983). The second idea involves mental models as problem spaces. Payne (2003) argues that knowledge-based behaviour is essentially problem solving and therefore relies on knowledge in the form of a problem space to search.

The contributions above highlight the fact that disagreements in the mental models literature are often subtle, yet cannot be dismissed as superficial. Whilst examining the exact nature of such disagreements may be a research thread in its own right, we argue it to be somewhat of a red herring for the purposes of this study. It is more important for our purposes to recognise simply that

differences do exist in the literature, often wide-ranging and often subtle, and hence justify the need for a careful and transparent study.

2.13 Mental models research in HCI

HCI scholars have long realised the relevance and potential for mental models research to aid the design and evaluation of interactive systems. For example Norman (1983) argues that a user's mental model evolves through their interaction with a system, guiding their usage of the system. The concept of an internal mental representation created by users is also adopted by Borgman (1985, 1996).

Leiser (1992) argues that a mental model of a user interface consists of a set of representations of the relationship between user actions and system responses. This view is based on Johnson-Laird's (1989) view of mental models as a form of knowledge representation and their manipulation as a form of reasoning, where a mental model is regarded as the set of possible representations of the available information. Leiser (1992) argues that because the model consists of a set of representations, there is scope for inconsistency between them and highlights that an opposing and more common view of mental models in the study of human-computer interaction is the view of a mental model as a kind of internalised flowchart of a system's functionality. It can be argued that whether actually flowchart-based or based on reasoning, mental models are likely to provide scope for representing users' knowledge of digital libraries. Although difficult to break down into concrete and repeatable stages, the information seeking process underlying a digital library can be viewed as a complex flowchart. Similarly, information seeking can also be regarded as a problem-solving task where reasoning is required to choose, administer and refine a suitable search pattern.

Other authors discriminate between types of users' mental models. Preece et al. (1994) distinguish between Structural Models, which describe the internal mechanics of a device, ('how-it-works knowledge') and Functional Models, which help people understand how to use a device ('how-to-use-it knowledge'). They also assert that a runnable mental model also contains 'how-to-use-the-how-it-works-knowledge.' It is important to note, however, that although a model may be 'runnable,' this does not mean that users will always run it. Card and Moran (1986) found that thinking through a mental model is intellectually demanding and hence will be avoided by users if an alternative is available. This suggests the potential of creating a spiral of usability problems; should a digital library provide incorrect, ambiguous or inconsistent information cues, the user may be forced to run their model which may have been altered by those cues and hence become less accurate, spurring even further confusion.

Newman and Lamming (1995) suggest four model types: State Transition, in which users' models are based on changes in the system's overall state, mapping, which allow users to 'map' their intentions into sequences of actions, analogical, which are based on experience with a similar, previously experienced system and object-action, in which users learn what parts of a system can be manipulated. The role of an object-action model in the development of expertise is noted by Young (1983). He asserts that a user model of an electronic calculator may represent merely a simple causal link from pushing certain keys to the execution of certain mathematical functions. To exploit the calculator fully, the user requires a richer model that maps specifications of particular sequences of actions. Similarly it might be argued that a richer model of a digital library might map (albeit indirectly) different information seeking actions to expected type, relevance, quality or number of results. Young himself (1983) suggests there may be as many as eight different model types: Strong Analogy, Mapping, Coherence, Vocabulary, Problem Space, Psychological Grammar, Commonality and Surrogate. He does, however concede that there may be some overlapping features.

Young (1983) suggests that a surrogate model completely matches the target system's behaviour and does not assume that the way in which output is produced in the surrogate is the same as it is produced in the target system. According to Schumacher and Czerwinski (1992), Young's (1983) concept of a Surrogate Model, as well the concept of analogical models (forged by Young, 1983, Gentner and Stevens, 1983 and Newman and Lamming, 1995) add additional support to the idea that users may rely on past experience with other systems or other domains to build models (be they accurate or not) of novel or unfamiliar systems. This might suggest that user mental models of digital libraries may be influenced by existing models of traditional libraries even before a digital library is used. Indeed, Duncker (2002) makes a similar assertion with regard to traditional and digital libraries, which is discussed later. Schumacher and Czerwinski (1992) note that model development is the first general intersection of opinion regarding mental models in HCI. They highlight that a number of authors, including Borgman (1985), Johnson-Laird (1989), Norman (1988), Sasse (1992), Staggers and Norcio (1993) and Wilson and Rutherford (1989) propose definitions of users' mental models that base their models of a system on their experience with it.

This characterisation supports the above notion that users do not need direct experience with a particular system in order to have a mental model of it. Hence there is potential for users who have not previously used a digital library, yet notice that it has similar constituent components to e-commerce or Internet search engines (e.g. a search box or certain hierarchical structure) to form a mental model based on their knowledge of the constituent components that they are familiar with in other contexts. This study finds that such behaviour can yield some interesting insights into digital library usability.

It can also be argued that lack of direct access to a particular system may inhibit users from enriching their mental models of that system. Card and Moran (1986) concluded that having a rich mental model assists problem solving and Norman (1988) argued in a similar vein that "the operation of any device - whether it be a can opener, a power generating plant, or a computer system - is learned more readily, and the problems are tracked down more accurately and easily, if the user has a good conceptual model."

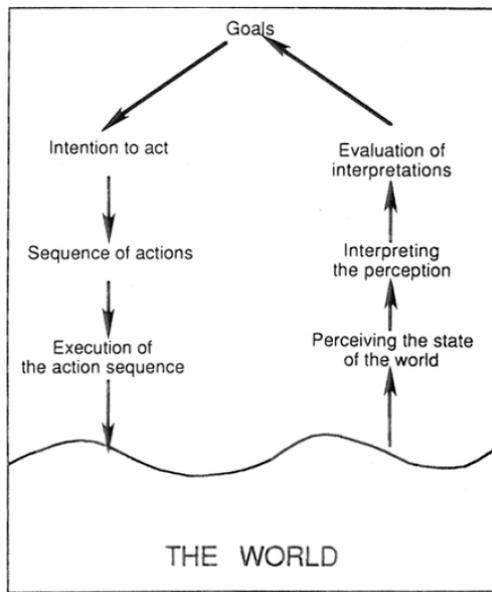
It can be argued that that part of this 'richness' (which may be an important characteristic of a good mental model) can be obtained through detailed 'how-to-use-it knowledge.' However, exposure to the system does not guarantee model enrichment. Surprisingly Card and Moran (1986) found that expert users of a system sometimes had very shallow models of how the system worked. Therefore although the information seeking tasks supported by digital libraries include an element of problem solving and hence might be enriched through more advanced or more frequent exposure to the system, this cannot be taken for granted.

There is also no guarantee that users, through interaction or instruction will form a working model of the system that is in-line with the designer's (Sasse 1997). Sasse (1997) argues that the fact that the models may be different is not necessarily a problem. The problem arises when a user's model is inappropriate. Sasse notes that the observable effects of users building a model which fails to support their interaction with the system range from selection of inefficient procedures for completing tasks to severe disruption or breakdown of the interaction (errors and problems with error recovery, inability to identify requested functionality).

Norman and Draper (1986) propose that designers could facilitate the construction of appropriate users' models of a system through the design of its user interface. The designer can decide on an appropriate model and structuring the presentation of information and user-system interaction accordingly. However, this raises the question of what is an appropriate model for a digital library. Should it be based loosely on the principles of a traditional library? On an Internet search engine? An e-commerce site? Or perhaps on a mixture or completely different model? Whilst our study was initially motivated by this question, it can be argued that it is too simplistic to assume that there

may be a single ‘appropriate model’ for a digital library, especially since (as we will discuss later) there is no agreement in the literature surrounding the definition of ‘digital libraries.’ It can be argued that a more useful, yet broader, research question to pose is: what are the common themes, similarities and differences in users’ mental models of traditional and digital libraries and how can insights into these models be used to inform digital library usability? This is the question that this study will address.

Newman and Lamming (1995) use Norman’s (1986) action cycle (see fig. a) to help explain the notion of conceptual breakdowns. Each of the seven stages depends on the user’s level of understanding and draw on knowledge of different kinds. The ‘execution stages’ on the left are particularly dependent on the user’s understanding of what system functions are available and how to put together a sequence of actions that will have the desired effect. In contrast, the ‘evaluation stages’ on the right rely on the user’s understanding of the system’s state in order to tell whether the desired effect has been achieved. To avoid misconceptions, Newman and Lamming highlight the need to attend to these stages in the cycle and help the user build adequate models of the system’s function and state.



Figure(a): Norman’s Action Cycle. Re-printed from Norman (1986).

Sasse (1997) argues that an appropriate model does not have to be complete and correct in every detail. All it has to do is explain the functions and behaviour of the system which are relevant to the user. Furthermore, she argues that the cueing and construction of such a model can be supported by the way in which information is presented to a user. Form and content of information can help determine which existing models are cued, and how new information is mapped onto existing or new models through the mechanism of procedural semantics. Applied to HCI, this means that designers would have to identify suitable existing knowledge to be cued, and present relevant information about the system in the context and form which directs the model-building process towards the intended mental model (Sasse, 1997). This goes hand-in hand with preventing the spiral of user confusion and usability errors that may arise from incorrect, ambiguous or inconsistent information cues.

Katzeff (1990) points out that mental models do not develop from scratch. On the contrary, in attempting to construct adequate mental models of a computer system, users necessarily refer to

their prior knowledge in order to construct new models. Consequently, the ease with which users are able to construct adequate mental models depends to a large extent on how well the system relates to their prior knowledge (Katzeff, 1990). Katzeff (1990) also highlights that although users might possess the necessary knowledge to develop adequate mental models of the system, the system as it is presented to its users might not provide the necessary links to this knowledge. Thus, to allow users to develop adequate mental models, system designers must make sure that the intended user group possesses appropriate knowledge, and also that the system is clear in suggesting which type of knowledge should be used. This suggests that the answer to the initial research question posed earlier about choosing an appropriate model for a digital library is less important than making the user aware of where the designer's model arose from in the first place.

Various specific studies on mental models of interactive devices and computer systems have been conducted which have relevance to HCI. Kieras and Bovair (1984) discuss the role of mental models in understanding electronics and found that subjects who learned a mental model showed improvements in learning, recall and transfer over those who did not. Halasz and Moran (1982) reported similar results in their study of problem solving using a calculator. They noted that performance was "significantly improved" when users were taught an explicit model of the calculator's internal mechanism and that the group who learned the model performed better on novel tasks. Norman's (1983) observations led him to believe that users' behaviour with hand-held calculators was heavily influenced by their "understanding of the details of calculator mechanics."

However Kieras and Bovair (1984) found that the important content of a device model is the specific configuration of components and controls, and not the motivational aspects, component descriptions, or general principles. This specific information is what is logically required to infer the procedures. Thus, according to Kieras and Bovair, the benefits of having a device model depend on whether it supports direct and simple inference of the exact steps to operate the device. Kieras and Bovair (1984) argue that this has several implications for teaching device models to users; the model must support inferences about the exact and specific control actions; The relevant 'how-it-works knowledge' can be very superficial and incomplete, because the user does not need to have a full understanding of the system in order to be able to infer the procedures for operating it; Teaching a device model will not always be of value – it depends on whether the user in the actual task situation both needs to infer the procedures, and also needs the supplied information in order to be able to infer the procedures and if the user is taught a device model but fails to learn it correctly, incorrect inferences will be made, and performance may not be facilitated at all, or may be impaired. However, these studies suggest that even though mental models may not be directly observable, surface evidence is observable through user interaction with a device or system.

Regarding digital libraries, the study by Kieras and Bovair (1984) suggests that if models of interactive systems behave in a similar way to those of a device then care should be taken at the interface level to allow users to infer the exact steps to operate the library. This goes beyond making buttons 'obvious' or providing online help and may suggest the need for ad-hoc procedural knowledge to be dispensed by digital libraries during use. This argument is supported by Carroll and Olson (1984). They note that Kieras and Polson (1985) observed, on closer inspection of the Kieras and Bovair (1984) study, that neither of the models gave the user any action-oriented help; the models merely gave a story about what the connections of the control panel were, not how they worked.

Although he did not deal with procedural inference per se, Payne (1991) did focus on examining the predictive aspects of mental models. He found when examining the behaviour of word processor users that users often do not know the precise effects of frequently-used actions, such as the final position of the cursor, even though these effects are vital for future planning. Payne (1991) found that even experienced users must acquire the information they need from a device's display during interactions, and that they do not necessarily remember regular details that are available in this way.

He asserts that his findings conflict with those models of user psychology that assume routine skill relies on complete mental specifications of methods for performing tasks. This may help to explain why Card and Moran (1986) found that expert system users sometimes had shallow models of how the system worked.

Payne (2003) highlights that users tend not to create the same mental model of a system. He found, in his study of automatic teller machines (ATMs), that people report very different understandings about how the ATM works. Whilst Payne suggests that this is a weakness of mental models, it can be argued that should these different understandings be understood and embraced by digital library designers, and systems designers in general, usability can be increased. Hence different understandings can be viewed as an important reason to encourage further research into users' mental models of interactive systems and devices.

Payne (2003) also argues that the term 'mental models' is used in so many different ways as to be almost void of any force beyond the general idea of the users' knowledge about the system they use and that "the rapid uptake of the idea of a mental models may have contributed, ironically, to the downturn in interest in theoretical approaches to HCI." This study challenges this viewpoint and suggests that it is possible to create a broad, empirically supportable taxonomy of mental model concepts even though these concepts may not all be absolutely complementary. There may also be some overlap. However, we argue that such an approach of identifying mental models concepts in the literature embraces this disagreement rather than criticises the consequences of such disagreements. This study also attempts to demonstrate that through the employment of an ethos of transparency, it is possible to move away from intuitive approaches to mental model elicitation and towards approaches based on theory, even though a direct mapping between theoretical mental models concepts and explicit methodological protocol may not exist.

2.14 Mental model components

In order to facilitate an approach to studying mental models which is more than intuitively informed by the mental models literature, it is necessary to highlight some important components of mental models that can be identified from the literature. Whilst this seems fairly obvious, few studies explicitly mention that they employed an approach which utilises specific components of mental models from the literature to inform their methodology, even if this may have been the case. Although this is probably due to the fact that the mapping between such components and explicit methodological protocol may be indirect, we argue that it is beneficial to highlight the theoretical basis from which our understanding of mental models theory has been formed in order to provide research transparency and allow our findings to be judged in the context of the literature review undertaken (and possibly in an alternative light by future researchers). Therefore this section summarises the key theoretical contributions to the mental models literature which propose that mental models consist of specific components.

Kieras (1982) examined types of knowledge that appeared when expert and novice subjects were asked to describe actual pieces of equipment, ranging from devices as simple and familiar as alarm clocks to those as complicated as unfamiliar as pieces of electronic laboratory equipment. He found that device knowledge consists of the major categories of what the device is for, how it is used, its structure in terms of sub-devices, its physical layout, how it works and its behaviour. Kieras found evidence that this knowledge consists of a hierarchy of schemas, corresponding to a hierarchical decomposition of the device into sub-devices, with each level containing the major categories of information. Kieras (1982) argues that the manifestations of apparent schema use can be classified in terms of whether the subject is using conventions (e.g. the standard culturally-dependent position for an on-off switch), general properties (e.g. the perceived datedness of the device due to its components), expectations of features (e.g. a non-present second-hand dial on an alarm clock) or

patterns of features (e.g. assuming a device modifies inputs to produce outputs if it contains calibrated dials, input and output connections, but no visible source or controls for power). Kieras (1988) summarises the findings of his 1982 technical report and suggests that the following are features of mental models of devices:

- Label or name of the device
- Function or purpose (what goals can be accomplished, at both the level of the whole device and also at the level of individual controls, connectors and other features).
- Controls and indicators
- Inputs, outputs and connections
- Power sources and requirements
- External layout and appearance
- Internal layout and appearance
- External behaviour (input-output function)
- How to operate the device to accomplish goals
- Procedures for troubleshooting and maintenance
- Internal structure and mechanisms (how it works)

Kieras (1988) asserts that the above findings suggest that most knowledge about devices seems to be related to using the device, as opposed to how-it-works knowledge about the internal structure and operation of the device. He supports this assertion by referring to his earlier (1982) observation that when asked to freely describe a device, experts would provide considerable detail on the procedures for using a piece of equipment, but often they did not consider it necessary to provide any details about how the device worked, although it was clear that they could do so.

Norman (1983) finds users' understanding of devices "meagre, imprecisely specified, and full of inconsistencies, gaps, and idiosyncratic quirks." However he also finds that users are often aware of their limited knowledge and they can offer assessments of certainty regarding components and results of manipulation. Therefore guided by their certainties, people develop behaviour patterns that make them more secure in their actions (Norman, 1983).

Although Kieras' (1982) and Norman's (1983) findings are specific to device knowledge, we propose that there may be parallels between users' mental models of physical devices, systems in a physical sense (such traditional libraries) and interactive systems (such as digital libraries). For example, consider some parallels between Kieras' (1982) observations and traditional/digital libraries; Traditional library users are often aware of the layout of the library, but are less concerned with the 'external layout and appearance' than with the internal layout. They are also often aware how inputs turn to outputs, such as placing a request on an item in the library and receiving an e-mail when the item arrives and finally the item itself. Similar parallels can be made for a digital library, such as requesting a document (and possibly providing login details for access) and receiving it in electronic form. However, validating such parallels is another study entirely and it would be unwise to discuss our findings purely in light of one or two authors' contributions (especially due to the high level of disagreement surrounding the term 'mental models'). Hence the remainder of this section examines other, similar theoretical contributions concerning mental models concepts.

Relating to non-device specific mental models, Norman (1983) highlights three functional factors that apply to both the user mental model and the designer's (or researcher's) conceptualisation of the model:

- 1) **Belief system.** A person's mental model reflects his or her beliefs about the physical system, acquired through observation, instruction or inference.

- 2) Observability. There should be a correspondence between the parameters and states of the mental model that are accessible to the person and the aspects and states of the physical system that the person can observe.
- 3) Predictive power. The purpose of a mental model is to allow the person to understand and anticipate the behaviour of a physical system. This means that they model must have predictive power, either by applying rules of inference or by procedural derivation. In other words, it should be possible for people to ‘run’ their models mentally.

Payne (1991) discusses Rumelhart and Norman’s (1983) claims and presents them in what he considers to be in order of increasing subtlety and increasing theoretical commitment:

- Beliefs predict behaviour. Payne (1991) suggests that this involves examining what people know and believe and how this affects their behaviour, without regard to the design of their mental machinery. He suggests that it emphasises that these beliefs represented in mental models can only provide important constraints on behaviour if they are constructed spontaneously (in the absence of prompting). However, Payne (1991) also notes that there is little evidence for spontaneous construction of models.
- Inferences can be made by ‘mental simulation.’ Rumelhart and Norman (1983) illustrate this by inviting the reader to consider a snooker player lining up a shot. The role of imaged trajectories is compelling. Payne (1991) also highlights that the mental simulation of ‘device models’ may also support the inference of a different knowledge, the procedural knowledge needed to work the device (as shown by Kieras and Bovair 1984).
- Mental representations can be analogical. This is examined in detail later in this report, but as highlighted by Payne (1991), also embodies three additional assumptions from Johnson-Laird (1983):
 - 1) A mental model is a representative sample from the set of possible models satisfying the known propositions.
 - 2) New information that is inconsistent with the current mental model provokes search for new models, utilising the remembered propositional base.
 - 3) The content of mental models is partially determined by their function.
- Mental models are based on physical experience. Payne (1991) points out that although there are as yet no well articulated theories of the development of mental models in the cognitive literature, there is a bias about the kind of learning that is important. For many investigators, it is a defining property of mental models that they are induced from empirical experience, from ‘hands-on’ interactions with the content domain (Payne 1991).

Aside from the claims discussed above, Norman (1983) also makes the following specific observations on mental models:

- They are incomplete and naturally evolving, being modified through interaction with the system in order to achieve a workable result. Although they need not be technically accurate, they must be functional.
- Peoples’ abilities to ‘run’ their models are severely limited.
- Mental models are unstable: People forget the details of the system they are using, especially when those details (or the whole system) have not been used for some period.
- Mental models do not have firm boundaries: similar devices and operations get confused with one another.
- Mental models are ‘unscientific’: People maintain ‘superstitious’ behaviour patterns even when they know they are unneeded because they cost little in physical effort and save mental effort – they ‘seem to work’ even though they make no sense. Norman argues that these superstitious attributes of mental models can be regarded as direct user statements of the limitations in their own mental models. The statement implies uncertainty as to

mechanism, but experience with the actions and outcomes. This superstitious behaviour indicates difficulties in the mental model and the user belief that a particular sequence of actions will reduce or eliminate the difficulty.

- Mental models are parsimonious: Often people do extra physical operations rather than the mental planning that would allow them to avoid those actions; they are willing to trade-off extra physical action for reduced mental complexity. This is especially true where the extra actions allow one simplified rule to apply to a variety of devices, thus minimising the chances for confusion.

Norman (1983) does, however, conclude (as has been highlighted throughout) that mental models are inherently difficult to define. This explains why not all cognitive scientists agree with the above defining characteristics of mental models, or to any particular set of mental model components for that matter. However we argue that this does not authorise the abandonment of a mental model elicitation approach informed by literature in favour of an approach based purely upon intuition, but instead suggests that there is no single ‘right’ way to elicit users’ mental models, nor a single ‘correct’ set of mental models components to draw upon. Once again, this suggests the need for research transparency in mental models studies.

Holland et al. (1986) view mental models to be the basis for all reasoning processes and suggest that they are best understood as assemblages of synchronic and diachronic rules organised into default hierarchies and clustered into categories. They argue that “the rules comprising the model act in accord with the principle of limited parallelism, both competing and supporting one another.” From this standpoint based on reasoning, Holland et al. (1986) suggest that some of the characteristics of mental models are:

- They are incomplete and constantly evolving and may even be internally inconsistent.
- They are usually not accurate representations of a phenomenon; they typically contain errors and contradictions.
- They are parsimonious and provide simplified explanations of complex phenomena.
- They often contain measures of uncertainty about their validity that allow them to be used even if incorrect.
- They can be represented by sets of condition-action rules.
- They can contain a controlled vocabulary and assumptions to aid prediction.

Relating specifically to interactive systems, Carroll and Olson (1988) list three aspects of the system to be known from the mental model:

- 1) The Task- Knowing what the goal is and in general what sub-tasks need to be accomplished to achieve the goal.
- 2) The System Interface - Knowing how to accomplish the sequence of sub-tasks in the system, given the data presentation and interaction languages of the system.
- 3) The System Architecture - Knowing the way the data are stored, the internal processes the interactions invoke, and in general how the system works.

Finally, relating both to interactive systems and users of those systems, we turn to a contribution by Johnson and Henderson (2002). Although they examined designers’ conceptual models and not models belonging to users, Johnson and Henderson argue that a conceptual model is a high-level description of how a system is organised and operates and should specify and describe:

- The major design metaphors and analogies employed in the design, if any.
- The concepts the system exposes to users, including the task-domain data-objects users create and manipulate, their attributes, and the operations that can be performed on them.

- The relationships between these concepts.
- The mappings between the concepts and the *task-domain* the system is designed to support.

Since a designer's conceptual model should aim to closely match users' mental models (Norman 1983, 1988, Newman and Lamming 1995), these are still useful mental models concepts for use in eliciting users' mental models. In addition, this work is especially relevant to the current study, since Johnson and Henderson (2002) relate their above description to the design of an online library catalogue and suggest that the designer's conceptual model might include:

- Metaphors and analogies: e.g., the information is organised as in a physical card-catalogue.
- Concepts: e.g., item (with attributes: title, ISBN, status; with actions: check-out, check-in, reserve), subtypes of item (e.g., book, periodical issue, LP, video), periodical volume, user account (with attributes: name, items checked out), librarian.
- Relationships: e.g., a book is one *type* of item, periodical volumes *contain* issues.
- Mappings: e.g., each item in the system corresponds to a physical item in the library.

Although this framework is relatively broad and does not arise from a formal study, it is likely to provide a useful basis for analysing the data arising from studying users' mental models of traditional and digital libraries. The framework will be discussed later with regard to its long-term potential for increasing digital library usability.

2.15 Mental models of electronic information seeking

Whilst there are no published studies of users' mental models of libraries, the issue of mental models of electronic information seeking has been tackled by a few researchers. Most studies of mental models have, however, tended to focus on the effects of models on device or system-related learning and performance. Halasz and Moran (1983) measured problem solving ability in users of calculators; Kieras and Bovair (1984) studied users' operation of a control panel; and Sasse (1992) studied users interacting with a variety of computing systems, including several software applications. Even Borgman (1985), who studied the use of an online catalogue and users' ability to query an information retrieval system did not focus directly on users' mental models.

Carroll and Olson (1984) report that Borgman (1984) found a lack of correlation between ability to describe the approach to search tasks and ability to describe the system. Subjects were frequently able to describe their approach to performing searching tasks in terms of the system's operation, but were unable to describe the same operations when asked how the system worked. Borgman argues that this may be a result of the questions soliciting two types of model; a problem solving model (which results in performance effects) and the model used in describing the system. Carroll and Olson (1984) suggest that the fact that no relationship was found between model articulation and performance further suggests that the measures captured articulation ability only. However, this cannot be ascertained fully since Borgman does not elaborate on the level or type of training provided to the subjects, nor how the conceptual model or procedural instructions were taught.

Borgman (1985) found on-line card catalogue users had trouble articulating a model of the system they used, although some could articulate a problem-solving framework. She attributed this in part to the manner in which her question about mental models was asked. Staggers and Norcio (1993) suggest that "perhaps models, especially in novices, are innate or so immature they cannot be identified by their owners . . . Perhaps users' actions speak differently from their words, or perhaps mental models defy words." Whilst this paints a rather bleak future for mental models research, especially when studying complex information retrieval systems, this has not stopped some researchers from persevering with such studies; Over a decade later, and re-visiting the same

question of why online catalogues are (still) hard to use, Borgman (1996) found that model-based training on an information retrieval system led to better performance when users were required to complete complex tasks that “required extrapolation from the basic operations of the system.” This suggests that despite slow progress, mental models research can still yield fruitful findings that can be used to improve the long-term usability of information retrieval systems, whether on-line catalogues, digital libraries or other systems.

Doomen and Leuven (1995) argue that users starting with a firm basic knowledge of the Internet exhibit completely different electronic searching behaviour from those lacking such background knowledge. They use different strategies, find the information they are looking for quicker and develop broader and richer higher-order strategies, because survey knowledge is achieved faster.

More pertinent to this study are the findings by Slone (2002), who discovered that the expectations users had of on-line catalogue interaction were sometimes based on their understanding of the Internet. Specifically, they assumed that if something works well on the Internet then it might work well on the on-line catalogue. An exemplification of this is in the failure of some users to select necessary indexes when using the on-line catalogue because they thought searching it was like searching the Internet. This finding was mirrored in our study when users used the online library catalogue and also extended to the use of digital libraries, where users assumed that if something works well in an Internet search engine, it might work well when searching a digital library. These findings are discussed in detail later in this report.

Katzeff (1990) investigated the relationship between mental models required by a full-text database, cues provided by the system to these models, and users’ behaviour in operating the system. Katzeff attempted to identify the required mental models of the system by analysing knowledge needed to carry out these tasks. Then, through analysing the specific system cues to the mental models, difficulties subjects would run into were predicted. Katzeff (1990) provided a set of seventeen user tasks, requiring users to issue commands to the database system. This approach involved an analysis of representative user tasks and identification of the type of knowledge needed in order to correctly carry them out.

However it can be argued that many of the difficulties encountered by users in Katzeff’s (1990) study, such as ‘difficulty with record numbers,’ ‘orientation-difficulty within and between articles’ and ‘difficulty with help information’ cannot be generalised across database systems or digital libraries. In addition, it can be argued that a highly-directed task based experiment such as that conducted by Katzeff (1990) might not provide sufficient scope to explore differences in users’ mental models and although the tasks provided may be representative of real user tasks, Katzeff is unlikely to have been able to ensure that these were natural tasks for all users. Hence whilst some users may have been highly practiced at some of the directed tasks, they may still have held a potentially weak overall mental model of the system which may have remained undetected by the procedure employed by Katzeff (1990). Similarly some users may not have possessed the knowledge needed to carry out those particular specific tasks, yet hold an overall rich model of the system. This justifies the need for a non-directive approach to mental model elicitation as reported in this study, based on a suitably broad and naturalistic information seeking task for users to perform.

Despite the above criticisms, the study by Katzeff (1990) makes some interesting arguments that are pertinent to our study, particularly with regard to users creating an appropriate mental model for a digital library. Katzeff (1990) argues that when user first encounter a computer system they select schemata to interpret what is happening. If they have experience from similar systems, their schemata will probably partly consist of knowledge based upon this experience. If they do not have any experience of computer use at all, users will still attempt to find schemata to comprehend the situation. Computer systems differ in the schemata they implicitly suggest to their users.

According to Katzeff (1990), for readers or users with similar background knowledge (e.g. traditional library use, search engine use), a particular system will probably suggest similar schemata.

Katzeff (1990) argues that cues from the interaction with a system suggest possible mental models of the working of the system and that these models are then evaluated against the feedback from the system until finally consistent models are developed. This makes the assumption, however, that consistent models are actually developed, which our study finds is not always the case. Even so, Katzeff gives three reasons as to why a user might fail to construct a mental model of the system that they face:

1. Users may not have the appropriate schemata. Consequently, they simply cannot understand the ideas being communicated.
2. Users may have the appropriate schemata but the clues provided by the system designer may be insufficient to suggest them. Similarly, users may have the appropriate schemata but the clues provided by the system designer may be insufficient to suggest adequate mental models of system behaviour. Katzeff (1990) argues that in these cases the system will not be comprehended, but with appropriate additional clues it might be.
3. Users may find a consistent interpretation/mental model of the text/system, but they may not find the interpretation intended by the author/system designer. According to Katzeff (1990), a computer system failing to suggest appropriate schemata will probably make it difficult for its users to develop adequate mental models. Likewise, a system failing to provide unambiguous clues to adequate mental models will make the development of this new knowledge difficult.

Katzeff (1990) argues that attempting to anticipate conflicts between users' potential schemata and adequate mental models of the system makes it possible to predict certain difficulties users will have in operating the system. Whilst we agree that gaining a better understanding of users' mental models might aid the prediction of user difficulties and hence help to enhance usability, it can be argued that an 'adequate' mental model is difficult to define in the context of complex systems such as digital libraries. This may be because, unlike simple devices, there are few explicit 'right' and 'wrong' ways to operate a digital library. Furthermore it is difficult to separate users' searching behaviour (including deficiencies in their behaviour) from their knowledge (or lack of knowledge) used in operating the system.

2.16 Metaphor, analogy and similarity in mental models

The relevance of metaphor, analogy and similarity to digital libraries

Metaphor, analogy and similarity are an important part of the mental models literature in relation to this study. There is certainly scope for similarity comparison between digital libraries and traditional libraries. According to Gentner (1983) a physical and digital library might have literal similarities, sharing similar features and similar relations. Although not reported in the published literature, there is also scope for comparison between digital libraries and Internet search engines or e-commerce sites. This is because all of the above have a 'search' component and a mechanism for organising their 'collection' of documents or records.

This section examines the key literature in this area and highlights its relevance to our study. Before we do so, however, it is useful to highlight a subtle distinction at the outset: Comparison

between different search components across domains is, in effect, an analogy between components, rather than an analogy between domains. Hence it is too simplistic to assume that ‘a digital library is like a search engine’ (possible inter-domain analogy) or ‘a digital library can be regarded as a search engine’ (possible metaphor). Instead, it is the search components that may be *similar* to one another in some ways, although the ways that they are similar or different may not be clear.

Craik (1943) argues that perhaps the most culpable use of physical models in scientific research is where the analogy of one among many possible mechanisms is taken to prove that the actual mechanism at work in some phenomenon is exactly, or closely similar. He argues that the most satisfactory function of models and analogies is to indicate the *kind* of mechanism necessary to produce the results found (e.g. that earthquakes and geological faults are due to certain types of stress). This suggests the potential of using candidate analogies to help explain some of the causal and structural relationships present in users’ mental models of traditional and digital libraries.

Leary (1990) suggests that “all knowledge is ultimately rooted in metaphorical (or analogical) modes of perception and thought.” Leary explains his assertion through the analogy of searching for the meaning of an unknown word until it can be defined in terms of other words. He explains that this can be viewed as a paradigm for understanding ‘reality.’ When any aspect of our experience strikes us as worth understanding, either for the first time or in a new way, we begin to search for ‘similar instances.’ Only when we have found an apt ‘peg’ or ‘pigeonhole’ for this aspect of our experience do we feel the subjective satisfaction that brings our search to an end. Since digital libraries are often difficult to use, this might suggest the need for users to find a ‘peg’ in order to attempt to understand the workings of the library. A similar viewpoint is held by Vosniadou (1989). She highlights earlier findings that people borrow a ‘sand and grain’ model to reason about the behaviour of molecules in water (Collins and Gentner 1987), and (incorrectly) describe the workings of a home thermostat in terms of an analogy to a car accelerator (Kepton 1987). Vosniadou (1989) further argues that the richer and more tightly structured one’s representation of a system is, the easier it becomes to see the structural similarities between it and other systems and the greater the possibility of identifying productive analogs. Hence more and more remote analogs can be accessed to see the structural relationships between superficially unrelated systems and to map increasingly complex structures.

Sasse (1997) makes an important distinction between metaphor and analogy within HCI. She argues that the use of analogies to construct users’ models seems to be restricted to users who already have a knowledge of similar systems. For users who do not have such a knowledge, the user might cue a suitable metaphor from a different domain as a starting point. This seems logical in the context of this study. Only digital library users that have previously used the search components of an e-commerce site such as Amazon, of a traditional library catalogue or an Internet search engine such as Google are likely to compare or make assumptions about how these components work in relation to one another. Similarly a brand new user of a digital library, with no prior Internet experience, might attempt (most likely unsuccessfully) to construct an initial model based on a traditional library. Sasse (1997) notes, however, that the process of constructing a user model via a metaphor is a somewhat fragile process which may or may not succeed. Leary (1990) agrees, arguing that metaphors and analogies move mental models into the unknown and therefore the use of metaphor and analogy is a weak, or general heuristic, dependent on mental models of the source and target domains for its success.

Forming successful models

Briggs (1988) cites Carroll and Rosson (1986) to help explain why an initial model constricted by use of metaphor may be unsuccessful. Carroll and Rosson (1986) highlight the ‘cognitive paradox,’ in which people’s previous knowledge and experience is brought to bear on the learning process, so that new information can be ‘assimilated’ into an existing structure; but in the course of this assimilation process the knowledge of the new system is distorted, often in inappropriate ways, to

accord with existing held beliefs. Hence those users who believe that ‘a digital library can [always] be regarded as a traditional library’ (or anything else) are likely, according to Carroll and Rosson, to have employed inappropriate metaphors. Briggs (1988) suggests that the problem is that “new users cannot introspect fully as to the accuracy of their knowledge. There is no opportunity for self evaluation, for they have no metastructure for the representation of their newly acquired information independent of the structure implicit within the current metaphor.” This is the flipside to the Sasse’s (1997) finding that users who possess relevant background knowledge to a problem are more likely to relate relevant existing knowledge to the problem presented. An important proviso, however, is that “the structure of the information presented is compatible with the structure of existing knowledge.” (Sasse, 1997). This is especially relevant when comparing the function of search components from different domains (where their inner-workings may be unclear or confusing).

Sasse (1997) concludes that source models should be identified by empirical means, rather than just assuming that users have particular models in a particular format. She suggest that this can be achieved in practice by discussing source models which designers think are suitable with users, to establish that those parts relied on in the mapping are ‘present and correct.’ Sasse (1997) also suggests that the amount of ‘conceptual baggage’ carried by a source model should be determined, since “source models which cover too much beyond the intended [user model] introduce an undesirable cognitive overhead, which is even more detrimental than models which do not cover enough of the intended [model].” A simplistic assumption such as ‘a digital library is [always] like a search engine’ is not only flawed because a digital library does, in fact, contain a search engine component and therefore ‘is’ a search engine in some respects, but also because search engines may carry ‘conceptual baggage’ such as sponsored documents attracting higher relevance or the need to verify the integrity of the documents, for example when searching for published research. Similarly a traditional library may carry baggage such as the need to request items that are not currently available or the need to browse for items in a certain physical area should an item not be where it is meant to be on the shelves. This baggage might lead users astray when using a digital library.

Burstein (1988) argues that once an analogy has been used successfully to explain one example in the new domain, it is apparently assumed that other, related examples may be explained using the same analogy, even if this requires extending the analogy by establishing correspondences between additional objects and relations of the two domains, so that examples involving those things can be mapped from the base domain. When successful, this kind of incremental extension of analogies enables students to interpret more complex situations in the target domain using knowledge from the base domain that was never explicitly presented as analogically transferable. Burstein (1988) argues that “it is one of the hallmarks of a useful analogy that it can be extended in this way,” but that typically some of these subsequent uses of analogy are wrong. This suggests the need to employ ‘good’ or consistent analogies.

Holyoak and Thagard (1995) identify three constraints that must be satisfied by a good analogy:

1. Similarity. “The source of the analogy and the target must share some common properties. Both birds and humans have heads and legs and are living creatures. These commonalities justify making the analogy in the first place.” (Holyoak and Thagard, 1995). Both traditional and digital libraries organise and store information; both facilitate information-seeking. This constraint also highlights the inter-relationship between similarity and analogy since according to this definition, an analogy must include similarities, but a collection of similarities may not necessarily form an analogy. (Holyoak and Thagard, 1995).

Gentner and Brem (1999) propose a notion when dealing with similarities that they call the ‘confusability account.’ Under the confusability account, thematic influences (e.g. chicken

and egg) intrude upon assessments of similarity (chicken and turkey) but are not an essential part of the similarity process. Hence they argue that similarity is more vulnerable to error and intrusion than is generally thought.

2. Structure. “Each element of the source domain should correspond to one element of the target domain, and there should be an overall correspondence in structure. If the tree plays the role of the bird’s garden then the nest (which is located in the tree) ought to play the role of the bird’s house.” (Holyoak and Thagard, 1995). Here traditional and digital library analogy becomes slippery as there are similarities between the differences and differences between the similarities. However, there are still broad parallels; documents are organised into sections, often hierarchically. Both require authority to obtain documents (whether through the use of a library card or in a traditional library or authorisation service such as Athens in a digital library).

Gentner (1998) suggests that comparing structural representations yields commonalities, differences related to the commonalities (alignable differences) and differences not related to the commonalities (nonalignable differences). Structure-mapping theory (Gentner, 1983) predicts that in certain cases, listing differences between two things can actually lead to a heightened focus on the structure common to both. Furthermore, Gentner and Markman (1994) found that it was easier to find the differences between pairs of similar items than to find the differences between pairs of dissimilar items. This may suggest that it should be easier for users to find differences between search engine components from digital libraries and from other domains than to find differences between traditional and digital libraries as a whole. This argument is superficially supported by our findings, although more research is required in this area to make any firm conclusions.

3. Purpose. The creation of analogies is guided by the person’s goals which provide the purpose for considering the analogy at all, in the case of libraries perhaps the need for effective and efficient information-seeking. Holyoak and Thagard (1995) highlight that these three kinds of constraints do not operate like rigid rules dictating the interpretation of analogies. Instead “they function more like the diverse pressures that guide an architect engaged in architectural design, with some forces converging and others in opposition, and their constant interplay pressing toward some satisfying compromise.”

Some authors question the need for a ‘good’ analogy altogether. Whilst there is evidence of analogies and metaphors being successfully applied to facilitate the construction of new models in many other domains (e.g. Gentner and Stevens, 1983), Carroll and Olson (1988) deem it to be an open question as to whether an *incorrect* analogous model can actually facilitate learning and be used more effectively than more explicitly provided and more correct models. However, Kurtz et al. (2001) found that although analogies are typically drawn from a well-understood situation to a situation that is poorly understood, comparison between two partially understood situations can act to promote comprehension and abstractions. They concluded that mutual alignment could be an effective means of promoting insight. This is relevant to digital libraries, since comparisons are often made between other information-seeking systems (such as Internet search engines) which employ methods of organising search results that vary in ‘opacity.’ Indeed, this suggests that not only can search engine functions (for example) inform digital library design and evaluation, but also vice-versa.

In a similar vein to mutual alignment, Gentner et al. (2003) describe a technique called analogical encoding – in which learners compare two examples and by doing so come to understand the underlying structure common to both. They argue that although in typical analogical learning, knowledge is being mapped from the well-understood example to the new example, in analogical encoding, the mapping can occur in both directions – whatever is understood about one example

can serve to shed light on the other. Hence they argue that analogical encoding both captures the value of using concrete cases and focuses learners on precisely those aspects that generalise across cases, therefore learners who compare cases will develop a more general problem-solving schema that primarily captures the common structure of the cases rather than the surface elements. Consequently, in contrast to cases studied individually, cases that are compared should be more easily retrieved when the learner encounters a new case with the same structure. This suggests that an appropriate model of a digital library can be formed through direct comparison between the digital library itself, electronic library catalogues, Internet search engines, e-commerce sites and/or other similar examples. This could be facilitated by hands-on exercises or tasks to aid comparison between these systems. It can be argued, however, that this approach treats the symptoms and not the cause of the problem. Gentner et al. (2001) list two metaphoric passages utilising novel metaphors. The final line of the second passage shifts base metaphor from 'a debate is a war' to 'a debate is a race' and disrupts the previous consistency of the metaphor. Just as a consistent metaphor is likely to tell a more coherent story, a common set of principles could be developed to promote consistency amongst digital libraries and hence enable more effective comparisons. However, users' information-seeking goals are not the same across digital libraries, nor are the purposes of every digital library identical. Therefore forging a 'common set of principles' may be easier said than done.

In light of the practical difficulties surrounding the forging of 'common principles,' an alternative approach to enriching a user's mental model of a digital library is to use analogies for the purpose of exploration. Holyoak and Thagard (1995) argue that analogies can be used in an exploratory manner in which a source is used to explain or develop a new hypothesis about a target or for problem solving and planning, where achieving a practical goal is sought. They can then be modified as new information comes in. In explanatory uses of analogy, Holyoak and Thagard (1995) argue that what matters are the causal relationships in the source analog that can suggest causes for what is to be explained in the target, but that it is not enough to be able to represent specific causal relations (such as a fact that a library card can be used to borrow items); it is also important to represent more general and abstract regularities, such as the fact that a library user can use a physical or digital instrument to gain access to documents. Holyoak and Thagard (1995) also argue that mapping will be much easier if users can weed out as many irrelevancies as possible before trying to map the analogs. Although Holyoak and Thagard are referring to problem solving and not usability, it can be argued that when confronted with an unfamiliar digital library, users are unlikely to be entirely certain at the outset exactly what information is actually relevant to its effective use, just as Holyoak and Thagard (1995) would argue that people are unlikely to be certain of what information is required in order to solve a problem. Holyoak and Thagard (1995) argue that it is necessary to find a way to identify useful mappings based on a mixture of information that will vary in its importance. They argue that it will therefore also be helpful if information used in the mapping is weighted in proportion to how important it appears to be in achieving goals. For example, since an important goal of information seeking is accessing documents, it may be extremely important to understand the issues of access restriction in digital libraries if the user is attempting to access the digital library from a location where access is restricted (e.g. from off-campus in the case of this study). However, a distinction between access restrictions to documents in a traditional and digital library is unnecessary if users always access the digital library on campus (and if the library provides automatic authentication in these cases).

Interestingly, even if an analogy is made, there is no guarantee that the analogy will be drawn upon. Gentner (1998) cites Gick and Holyoak (1983) who gave subjects a classic thought-problem: How can a surgeon cure an inoperable tumour without using so much radiation that the surrounding flesh will be killed? Only 10% of participants came up with the ideal solution, to converge on the tumour with several weak beams of radiation. If given a prior analogous story in which soldiers converged on a fort, still only 30% provided convergence solutions. It was concluded that people often fail to retrieve potentially useful analogs, even when it is clear that they have retained the material in

memory. Furthermore, Gentner (1998) also cites one of her previous studies which concluded that memory often produces superficially similar items instead. Subjects were given a set of stories to remember and were later shown probe stories that were either surface-similar to the memory item (e.g. similar objects and characters) or structurally similar (i.e. analogous, with similarly high-order causal structure). Subjects were told to write out any of the prior stories that they were reminded of. Recall rates were two to five times higher when the probes had surface commonalities than when the probed had structural commonalities. However in a separate rating task, structurally similar pairs were rated much higher in inferential soundness and even in rated similarities than surface-similar pairs. Participants rated their own surface-similar reminders as low in inferential values and in similarity. Therefore although it is argued that people are more sensitive to similarity in descriptive properties than to similarity in structural aspects (Vosniadou, 1989) and surface similarity has a large say in initial memory retrieval (Gentner, 1998), people often reject purely superficial matches quickly, retaining matches with structural commonalities for further processing (Gentner, 1998). This finding is useful for our study, since it suggests that superficial similarities (which often act as a red herring for aiding digital library use) will be discarded and users will focus on assessing structural similarities that are potentially more fruitful in explaining how the digital library is organised and how it operates. We found this was the case and the surface and deeper similarities identified by participants of our study are discussed later.

Borrowing from different analogies

There are parallels between candidate analogies for digital libraries and the ‘flowing waters’ and ‘teeming crowds’ analogies for electricity proposed by Gentner and Stevens (1983). Just like with electricity, a digital library’s mechanisms are essentially invisible. Moreover, just as with the ‘flowing waters’ and ‘teeming crowds’ analogies with electricity, no single analogy has all the correct properties to map directly from or to a digital library. This explains why it may be necessary to choose and compare different analogies for the same target domain. In addition, Collins and Gentner (1987) argue that in cases where no one base domain seems to provide an adequate analogy for all the phenomena in the target domain, people partition the target system into a set of component models, each mapped analogically from a different base system. This suggests that not only might users compare different analogies for the same target domain when forming a mental model of a digital library, they might also choose from components of analogies should they run into difficulties.

Collins and Gentner (1987) find that people vary greatly in the degree to which they connect these component models into a consistent whole. They highlight that an extreme case of inconsistency is the pastiche model, in which a target domain model is given by a large number of ‘mini analogies,’ each covering only a small part of the domain and each somewhat inconsistent with the others. At the other extreme, some people connect together their component models into a consistent overall model. Thus, they can combine the results of their mappings to make predictions about how the overall target system will behave. This also suggests that people are capable of holding two or more inconsistent models within the same domain. A novice learner may give one explanation of what causes a towel to dry in the sun and a completely different explanation of what causes a puddle of water to evaporate, failing to see any connection between the two phenomena (Collins and Gentner, 1987).

The possibility of creating a ‘pastiche model’ might help explain why some authors even consider analogy as predominantly harmful to the formation of mental models. Halasz and Moran (1982) argue that the user drawing upon an already familiar analogy when learning to use a new system is potentially dangerous. They argue that although analogies may help a user to learn and understand a new system, they may hinder novices from developing a good understanding of the system. Halasz and Moran recommend that the appropriate tool for importing a mental model of a new system is to provide an abstract conceptual model, not an analogy. The conceptual model could be

shaped to contain specific information about the current system, which would help the user with his or her required interactions without the baggage that analogies can bring. Halasz and Moran (1982) illustrate their argument by showing how the 'filing cabinet' metaphor for electronic document storage seems to work well until other add-on concepts require the model to be 'fixed up,' for example in this case the concept of file-based password protection. They argue that one approach is to add the concept of password to protection to the filing cabinet model, for example by evoking the notion of a filing cabinet in which each individual folder has its own combination lock, or a whole new analogical model can be invoked, such as a guard whose duty it is to retrieve documents from the filing cabinet.

To make effective use of analogical models, the new user is faced with the confusing task of sorting out the relevant interfaces from among the many possible irrelevant or incorrect inferences suggested by the analogy (Halasz and Moran, 1982). According to Halasz and Moran (1982), analogical reasoning requires considerable work to sort out the relevant mappings and allowable inferences. They argue that when someone says that a file system is like a filing cabinet, it may be simple and natural to infer that the computer file system functions as a storage and retrieval system, but it is a complicated task to work out in detail how computers and filing cabinets are similar. Schumacher and Czerwinski (1992) disagree with Halasz and Moran's view on analogies, claiming that analogy is a powerful and ubiquitous tool and it is the responsibility of the designer and instructor to pick and use analogies carefully in order to aid in system understanding. This study recognises that whilst comparisons and analogies between domains can be useful, there is also the potential for user confusion. This will be discussed later in this report in relation to our findings.

2.17 Mental model elicitation

Difficulties associated with eliciting mental models

Sasse (1997) asserts that although one of the main concerns when designing mental models studies is to create a situation and task context which was conducive to eliciting users' models, this is a point hardly ever discussed in the literature. Cooke and Rowe (1994) conclude that, "there is no single agreed upon measure of a mental model," and Rutherford and Wilson (1992) suggest that a so-called 'best method' isn't even realistic until we know more about how to effectively elicit information from users. Rutherford and Wilson (1992) highlight that although the mental model notion has been used to generate testable hypotheses, which have been examined by experiment (e.g. Borgman 1986, Halasz and Moran 1983, Kieras and Bovair, 1984), the hypotheses studied are usually restricted to predictions of superior performance given appropriate but unspecified mental model operation. As most mental model studies do not assess predictions based on descriptions of mental model mechanisms, the form of explanation provided by most current mental model conceptions cannot be equivalent to that which characterises a full theory. More sense can be made of the mental models literature if the majority of mental model studies are regarded as explorations of the mental model notion, rather than as exemplars of the classical deductive experimental approach.

Sasse (1997) argues that in mental models studies, a lack of ecological validity can arise from the type of subjects, the devices used and the experimental scenarios. Sasse highlights that the use of 'novice' or 'naïve' users focus on a particular stage of model building and use. Sasse argues that while it is certainly desirable to establish how models are constructed and employed by novice users, theories of users' models have to cover groups of users: even novice users are novice users only for a certain period of time.

Sasse (1992) also argues that the experimental scenarios in studies on users' models are often designed to establish a high degree of internal validity. "Experimenters tend to structure user-system interaction tightly and to control or eliminate all possible other influences. This is a difficult goal to achieve. Even when user-system interaction is tightly structured, users will create different situations in the course of the interaction, and different interactions and responses will be required from the experimenter." Sasse (1992) argues that studies which place the user in a less restrictive and artificial setup might yield more reliable observations. We agree with this argument in the context of examining users' mental models of traditional and digital libraries and hence set a broad and fairly non-directive task for users to undertake in both traditional and digital libraries. More details are given in the methodology section.

Leiser (1992) highlights some other potential problems in applying mental models:

- The user's mental model is hard to get at. No standard methodology has been accepted and validated and the techniques developed by individual researchers for their own purposes tend to be limited in their applicability to others and lack validation in other domains or even in the domain to which they were originally applied.
- The process of eliciting a mental model obscures its internal inconsistencies. When a user has become a little familiar with a system, their mental model will be mostly accurate in so far as it leads to effective interaction. It is the inaccurate remainder of the model which leads to breakdowns in interaction and is of real interest, because it highlights areas where improvement is required.
- Mental models are explanatory, not predictive. Mental models are never identified in their purest form and tend to be identified by the symptoms they produce in the system user. In this role, mental models provide a fire-fighting technique rather than a design tool.
- The process of elicitation may be more informative than the model itself. The process of eliciting a user's mental model inevitably leads the psychologist to stumble upon user interface problems. Thus by the time the model is elicited (as far as this is possible) its usefulness is often complete.
- Mental models do not account for all aspects of user-system interaction. For example, attributes which are not attributable to belief.

We argue that part of the reason why mental model elicitation techniques are seldom discussed in the literature is because there is often an indirect mapping between observable mental models concepts and questions to pose or tasks to set in a study. This is partially supported by Rutherford and Wilson's (1992) assertion that "researchers do not know what questions to ask." However despite this difficulty, we believe that mental models studies can only be fully assessed (and an eventual 'theory' based on mental models proposed) if the research approach is as transparent as possible. Furthermore, it can be argued that a transparent methodology will aid mental models research as a whole, by spurring discussion and possibly further disagreement about how best to carry out such studies. Hence in this section we review the limited existing research on how to elicit user's mental models, beginning with the frameworks by Young (1983), Jonassen (1995) and Miyake (1986).

Potential frameworks for eliciting mental models

With a focus on mental model elicitation, Young (1983) suggests a broad framework to facilitate observing evidence of users' models. He suggests that researchers should observe:

1. Users *using* the system;

2. Users *explaining* the system (including explanations about the causes of an event and diagnoses of the reasons for malfunctions).
3. Users *predicting* the behaviour of the system (predicting what will happen next in a sequential process and how changes in one part of the system will be reflected in other parts of the system). Allen (1997) adds that the most informative aspects of their predictions are often the errors from the model.
4. Users *learning* the system.

We argue that Young’s (1983) framework can be used as a ‘skeleton framework’ for hinging and hence categorising many mental models concepts identified by other authors that have so far been highlighted in this report. This brings together concepts that may have otherwise remained isolated in a sea of disagreement. This use of Young’s framework is presented at the end of this section.

Jonassen (1995) studied the mental models of novice and expert refrigeration technicians when learning a new refrigeration system and presented them with the description of a complex refrigeration problem. In the context of the problem, he used think-aloud protocols to collect:

- Structural knowledge – the knowledge of the structure of concepts in a knowledge domain, using Pathfinder nets using a constrained set of refrigeration systems concepts.
- Performance/procedural knowledge – through performing problem solving tasks. Jonassen intervened to prompt at various stage with questions requiring the user to explain or infer why certain results occurred and to make predictions about what will happen next.
- Reflective procedural knowledge through the ‘teach-back’ procedure, in which users are asked to teach another learner (typically a novice) how to perform certain tasks or how to use a system.
- Image of the system by providing opportunity to allow users to articulate and visualise their ‘runnable’ physical models or the physical devices of processes using interviews.
- Metaphors – the relation of new systems to existing knowledge by associating them with other physical systems, asking users to explain the similarities between the refrigeration system and the metaphor.
- Executive knowledge – knowing when to activate certain mental models and which ones to activate. Jonassen deemed this was only possible by presenting a variety of problems to solve and hence was not possible in his initial study.

Jonassen (1995) argues that since mental models are process-oriented and relatively intangible, and since they need to be assessed using multiple data sources, it is important to identify potentially useful criteria for assessing the quality and utility of individual mental models. The criteria he identified, along with their reported measure are shown in table (b):

Characteristic	Measure
Coherence	Structural knowledge, think-aloud
Purpose/Personal relevance	Self report, cognitive interview
Integration	Cognitive simulation
Fidelity with real world	Comparison to expert
Imagery	Generating metaphors, analogies
Complexity	Structural knowledge
Applicability/transferability	Teach back, think-aloud
Inferential/Implicational ability	Running the model

Table (b): Jonassen’s (1995) characteristics of mental models and associated measures

However, whilst Jonassen claims that “a rational analysis of the construct suggests the following criteria,” there does not appear to be any empirical evidence to relate each characteristic of a mental model to the associated measure or measures. Nor does Jonassen provide any reasoning or justification for the measures chosen. Hence although relevant to this study and intuitively logical, Jonassen’s (1995) framework was not directly adopted in this study (although many of the measures overlap with the mental models concepts we identify from the other wider literature). Further research may be warranted to relate Jonassen’s (1995) characteristics of mental models to their associated measures.

With a focus on capturing device knowledge, Miyake (1986) presents a framework to capture the iterative nature of understanding a physical device. He argues that each point of trying to understand a complex physical device is incomplete and requires a new level of understanding. Miyake’s (1984) framework is a hierarchy with levels corresponding to psychological ‘levels’ of understanding. At the top level, level 0, the function of the sewing machine is to make stitches. At level 1, there is an understanding of the physical objects involved in a stitch, rather than what is involved in creating such a stitch. In level 2, the concern shifts to the exact topology of the sewed stitch. Do the threads cross over, or is there some other type of interaction between two loops? Level 3 looks deeper into the topology, introducing the role of the bobbing. In level 3, the bobbin and its all surrounding mechanisms are regarded as serving just one function – providing a free end. In level 4, the role of the bobbin relative to the surrounding mechanisms are noted and lastly, in level 5, the physical configuration of the bobbin parts come into focus. Miyake (1986) notes that the distinction of the levels is relative, not absolute and there can be more intermediate levels or sublevels on each of the levels.

We argue that Miyake’s (1984) framework can be usefully adapted to capture the iterative nature of understanding digital libraries. At level 0, the function of a digital library is to facilitate information seeking. At level 1, there may be an understanding of the ‘objects’ at the interface level that will be involved in facilitating the information-seeking, rather than what is involved in the information-seeking itself. In level 2, the concern might shift to the organisation of the library. Are documents arranged in a particular hierarchy, or is there some other way to conceptualise how they might be retrieved (e.g. though searching)? Level 3 might take a deeper view and introduce the role of the search engine component. In level 3, the search engine component and the surrounding library would be regarded as serving just one function – bringing back relevant results and documents. In level 4, the role of the search engine component relative to the digital library’s function as a whole would be noted (e.g. the effects of particular search terms or operands on document or result relevance) and lastly, in level 5, the rules and algorithms involved in searching the digital library might come into focus. This adaptation will be discussed later in relation to our findings.

Finally, Stelmaszewska and Blandford (2004) highlight that both physical and digital libraries contain artefacts which can be viewed, evaluated and used by people. They suggest that these artefacts (or entities) have various attributes that help people to assess their relevance. Whilst this does not directly relate to mental model elicitation per se, it can be argued that such entities and their associated attributes are important components of users’ mental models and hence care should be taken to ensure that they are elicited in our study. The pertinent themes and issues surrounding the entities and attributes can then either be discussed directly or referred to in relation to broader themes identified from the findings. We argue that the approach chosen depends greatly on how directed the questions that participants are asked and how targeted the tasks are that they are set. Our study was based around a broad information-seeking task designed to promote naturalistic behaviour amongst participants. Therefore it was more suited to the latter approach, as there would not be much overlap in the concepts, attributes and relationships identified between participants. We do not, however, suggest that this is the only approach to designing mental model elicitation studies. The choice of approach is more of a personal choice than a scientific one.

Methodological considerations when attempting to elicit mental models

Cohen et al. (1995) argue that elicitation techniques vary from those that are both close to the natural task and nondirective (e.g., observation of actual performance) to those that are both highly artificial and highly directive (e.g., structured interviews that attempt to directly elicit general rules). They point out that between these extremes lie techniques that are somewhat unnatural and somewhat directive (e.g., think-aloud solving of simulated problems, critical incident interviews). Other methods are more natural in some respects (e.g., requiring less verbalisation) but at the cost of failing to resemble the original task at all (e.g., concept mapping, problem sorting, multi-dimensional scaling). Cohen et al. (1995) assert that according to Ericsson and Simon (1993), the more efficient a technique is at extracting specifically targeted knowledge, the more artificial and/or directive it is, and thus the more likely it is either to misrepresent or to influence the processes it purports to capture.

Rutherford and Wilson (1992) argue that classical experimentation is inappropriate for much current mental models research not only because of the practical difficulties of application, but also because induction rather than deduction seems to be the main aim of current data analysis. However, they also argue that quasi-experimental and naturalistic approaches can suffer from retrospective distortions.

Studies by Sasse (1992) suggest that constructive interaction scenarios are most suitable for exploratory studies, i.e. eliciting users' models. They require careful planning and execution, and the effort involved in preparing and analysing the data collected is substantial. Sasse (1997) argues that structured scenarios which may include heavily directed tasks which aim to test users' knowledge, require less time to prepare, conduct and analyse, but have to be carefully targeted otherwise they may yield less information about the content or form of the model. These trade-offs highlighted by Cohen et al. (1995), Rutherford and Wilson (1992) and Sasse (1992) highlight the presence of a series of significant methodological dilemmas for the mental models researcher.

The above dilemmas are made all the more difficult to deal with due to the fact that there is often an indirect mapping between mental models concepts identified from the literature and questions to be asked or tasks to be set in a mental models study. Rutherford and Wilson (1992) highlight that in those studies where mental models are induced from subjects' responses, "the route from the mental model information elicited by the various methods to the hypothesised mental model remains opaque." Hence, we argue for as much research transparency as possible. Rutherford and Wilson (1992) explain that experimenters employ intuitive rather than formal procedures to suggest possible mental models and hence such opacity is not surprising, as so little is known about the creative and inductive processes underlying model or hypothesis generation. Intuitive approaches to mental model elicitation might also lead to preconceptions of likely mental models being confirmed only and never rejected (Rutherford and Wilson, 1992).

Rutherford and Wilson (1992) also note that a number of studies have used interviews as their primary source of mental model information. In most cases, they argue, the style of interview carried out is described as 'in depth,' but no further information regarding the interview is provided. Slone (2002) began her study of information-seeking behaviour with a pre-search interview to determine user goals, asking 'what is your purpose for using the computer today?' and 'what do you want the information to look like when you're done?' Three categories of goals were explored – broad/situational goals that drove users to search, specific goals that guided on-line interaction as users sought information they thought they needed to meet the situational goals and format goals which were what the participants wanted the information to look like, or sound like, in the end. Gentner is likely to approve of the pre-search interview aspect of Slone's (2002) approach; Gentner (2002) highlights that "directly asking people about their mental models is not enough, for people are often unable to fully articulate their knowledge." Therefore she suggests that the direct

interview is followed by other methods of validating the proposed mental models. In our study, we integrate an element of direct interview into our think-aloud observation approach. The product of this mix is a Contextual Inquiry interview, where probing questions are used to gain insight into users' mental models.

Although we argue that pre-observation interviews can yield interesting mental models data which places the users' task in context with similar tasks that they have performed in the past, we do not advocate asking library users to explicitly state their goals at the outset. Yielding useful results from such questions may be problematic, supported by Blandford and Stelmazewska (2001) who argue that digital library users often behave reactively, responding to external stimuli in a fluid way likened to 'shooting the information rapids.' The same might also be said for traditional library users, although this has not been explored in this study.

Regarding think-aloud observations, Rutherford and Wilson (1992) note that these are the most popular method of eliciting mental model information (see Clement, 1983 and Katzeff, 1990). However they argue that, as with interviews and questionnaires, the information that can be captured using this method is restricted to that which may be verbalised. Rutherford and Wilson (1992) also argue that the theoretical understanding of verbal protocol generation is not adequate to assure the absence of reactivity (where the verbal protocol alters primary task performance) without an empirical check. It can be argued, however, that it may not be easy to create a valid and reliable empirical check for all tasks and task contexts, including the context of information-seeking in either a traditional or digital library. Hence an empirical check was not conducted in this study.

Rutherford and Wilson (1992) also acknowledge that verbal accounts can be incomplete and/or erroneous because people may not have conscious access to the cognitive structures that determine their behaviour and because genuinely, they have a particular belief, but do not act in a concordant manner. They support this argument by citing Norman (1983), who suggests that the demand structure of the situation may 'force' people to provide reasons for their behaviour when they did not base their actions on any particular conscious reason. With regard to think-aloud protocols, Sasse (1992) argues in a similar vein that the cueing or construction of a user's model is a subconscious process, and we cannot expect verbal accounts of subconscious process. She argues that if we ask a user to verbalise these processes, the very shift from subconscious to conscious processing can change the nature and content of the processes we are trying to tap. Sasse (1992) agrees with Norman (1983) that users may try to rationalise their behaviour if they have to explain it or tell the experimenter what they think she/he wants to hear, or might be guided by subtle verbal and non-verbal cues given by the experimenter. Although these drawbacks may be regarded as undesired but endurable side-effects, we argue that asking careful, open-ended and sometimes seemingly ambiguous questions can minimise these side effects. In addition, actual behaviour can be compared with described or predicted behaviour in order to identify individual cases that demonstrate signs of or users that exhibit 'over-rational' behaviour.

Sasse (1992) also suggests a method for sanitising think-aloud studies of mental models. She argues that it is possible to remove some of the 'artificiality' surrounding think-aloud behaviour by making the explanation of models a necessary part of a higher-level task. To facilitate such explanation in this study, the think-aloud tasks were interweaved with probing 'what,' 'how,' 'why' and 'what if?' questions in order to obtain explanations surrounding users' models and avoid the pitfall of having a record of what the user did, but not knowing why they did it. These probing questions come from the mental models elicitation method employed by Collins and Gentner (1987), who studied mental models of evaporation and asked subjects several open-ended questions regarding explanations, such as 'why can you see your breath on a cold day?' They then content-analysed their answers.

Payne (1991) also adapted the methods of Collins and Gentner (1987) and others to ask ‘what if’ style questions to uncover student’s theories about ATMs. Payne’s questions ranged from direct requests for explanation of processes – ‘what’ or ‘how’ questions (e.g. ‘what do you think happens when your cash-card disappears?’), through ‘why’ questions (‘why does the card stay inside the machine throughout the transaction’) to ‘what if’ questions (‘what would happen to your transaction if...’). With these questions, Payne found a variety of beliefs of the workings of an ATM and found partially incorrect, but widespread and important beliefs such as that keying ahead during performance would not work, when in fact in many ATMs it would. Using these simple types of probing questions, Payne also found that spontaneous, explicit analogies were constructed, including a library card or recorded tape for a bank card and a combination lock or key for a personal identification number. Similar probing questions were asked to traditional and digital library users in this study.

Overcoming the methodological dilemmas

Although Sasse (1997) remains aware that the choice of mental model elicitation method depends on the goals of the study, Sasse concludes that think-aloud protocols can offer a rich source of data from which users’ models could be reconstructed. She concedes that although they may not provide a record of users’ reasoning processes, the outcome of the reasoning processes will reveal some indication of the elements and mechanisms involved in them. Therefore Sasse argues that the outcomes of reasoning processes are the closest researchers are likely to get to the processes themselves. She suggests that a battery of predictions and descriptions of aspects of various systems (according to Young’s (1983) framework) is employed to enable empirical data to be collected on users’ explanations, predictions and descriptions of aspects of various systems as well as users’ overt performance. This approach can work hand-in-hand with verbal protocols, as illustrated by our study.

Rutherford and Wilson (1992) argue that when deciding which information elicitation methods to employ, the particular limitations, biases and potential errors associated with any information elicitation method must be considered seriously, along with the specific goals of the study. Cooke and Rowe (1994) conclude, in a similar vein, that the answer to the question of mental model measurement validity depends on the exact nature of the application and specifically, the criterion thought to be related to the mental model construct. This approach implies that there is no single best measure of a mental model, but that there are measures that may identify different aspects of mental model knowledge. Cooke and Rowe envision an eventual taxonomy of applications and predictions, with each criterion associated with a mental model measure or family of measures that best predicts it. However, none of these authors suggest an explicit or formal method of determining whether one form of data is more valid than another. Nor do they, or any other authors (with the exception of Bostrom et al., 1994) suggest how verbal protocol-based data aimed at eliciting mental models should be coded or analysed.

Bostrom et al. (1994) evaluated the impact of risk communication using multiple evaluation methods, including think-aloud protocol analysis. They coded subjects’ comments from the think-aloud protocol as content (referring to what was said) or presentation (referring to how something was said) and as negative, positive or non-evaluative. Negative content comments included confusion about what was being said, or questions about missing information, such as ‘I think that’s kind of, I don’t know, fuzzy.’ Positive content comments included associations with prior knowledge and spontaneous (correct) inferences, for example ‘I think that they make that really clear.’ However, Bostrom et al. did not give any justification for their choice of coding structure. Hence although their structure may have been appropriate for coding opinions regarding risks, the benefits of emulating this structure in other studies (including our own) are unclear, if not questionable. Hence with regard to data recording and analysis, we argue that it is necessary to form and justify our own naturalistic coding structure which can later be mapped (albeit indirectly)

to the mental models concepts identified in the literature. Our approach is described in the methodology section.

2.18 Summary of mental models literature

An interesting aspect of the literature surrounding mental models of electronic information seeking is that users' expectations of on-line catalogues may be based on their understanding of the internet. This relates closely to the literature on analogies that has been discussed in this section. This theme of overlapping mental models of digital entities is examined in detail later in this report. The literature also highlights the relevance of analogies to explain the role of digital libraries, where the mere presence of the word 'library' in the phrase 'digital library' suggests the potential of analogy or comparison between components of traditional and digital libraries. We highlight the need for careful use of analogies when designing interactive systems.

With regard to mental model elicitation, the literature in this section highlights that although there is much 'fuzziness' surrounding the subject of mental models, there is a need to create as much clarity as possible through careful and transparent mental models studies. We argue that although it is necessary for the research to remain aware of this 'fuzziness' in the literature, the disagreement in the mental models literature should not be used as an excuse for researchers to perform mental models studies which do not give a clear and transparent account of the methodology used.

We also highlight that although the wider mental models literature may not influence the researcher's mental model elicitation methodology in a direct fashion, it is possible nevertheless to identify several components of mental models from the literature that can inform the findings of mental models studies. These components, already discussed in this section of the report, are also summarised in section 3.2. However the literature that has been discussed suggests that mental model elicitation is by no means easy, particularly due to the indirect mapping between the observable mental models concepts discussed in this section and the questions to pose or tasks to set in a mental models study. We have highlighted several potential frameworks to make mental model elicitation easier and have demonstrated that a particularly relevant framework that can be adapted to explain the iterative nature of understanding digital libraries is that of Miyake (1984).

The section which follows examines the literature on digital library usability, particularly where the literature can provide further insight into users' mental models of traditional and digital libraries.

2.2 Digital libraries

2.21 Overview of digital library literature

The second part of this literature review focuses on digital library usability. We begin by highlighting the need for mental models research to improve digital library usability and go on to discuss literature that explores the relationships between digital libraries, traditional libraries and the Internet, whilst also focusing on the 'blurred boundaries' of digital libraries and literature on traditional and digital library organisation.

2.22 The need for mental models research to improve digital library usability

Borgman (2003) notes that usability issues in digital libraries and other forms of information systems persist, despite the technological advances of the last two decades. Borgman (1984) asserts that many of the challenges identified early in the 1980s have yet to be resolved. Furthermore Borgman (2003) highlights that “determining factors that make computers difficult to learn and use, defining a set of characteristics for ‘user friendly’ systems and applying the research to design is all easier said than done.” However, this does not mean that the long-term goal for improving the usability of digital libraries should be abandoned. Instead, we argue for a slight change in approach and advocate the study of users’ mental models of digital libraries in an attempt to go ‘back to basics’ and get as close to users’ underlying mental processes as possible in order to develop a better understanding of the issues facing users as they interact with digital libraries.

Theng et al. (2000) developed a usability evaluation tool for digital libraries which relies on a combination of heuristic evaluation and an online questionnaire designed to identify problems encountered by users as they search for information and to compare usability factors among digital libraries. They found that users preferred the tradition of traditional libraries; they preferred human librarian help and a traditional library environment where the library users can learn and exchange ideas with other users. Theng et al. (2000) argue that unless digital libraries provide cues, users will rely on their prior experiences with digital libraries and traditional libraries when forming mental models. They argue that “this itself is not bad, however if users have preconceived notions of what the structure of a system is supposed to be, and if that structure does not match the actual structure of the system they are using, they experience the ‘lost in hyperspace’ problem regardless of whether they are novice or experienced users.” We argue that mental models of digital libraries may not only be formed based on prior experience with digital libraries or traditional libraries, but also based on prior experience with Internet search engines. Furthermore we argue that users rarely form mental models of digital libraries based solely on the use of one particular system (including the traditional library ‘system.’) We discuss these arguments in relation to our findings and examine their impact later in this report.

Blandford and Buchanan (2003) note the range of things that ‘usable’ can mean: How efficiently and effectively users can achieve their goals with a system (for which it may be possible to apply performance measures); how easily users can learn to use the system; how well the system helps the user avoid making errors, or recover from errors; how much users enjoy working with the system (the quality of the user experience or whether they find it frustrating and how well the system fits within the context in which it is used. They argue that although errors may be less of a problem for digital libraries than for systems in which the user is changing data, many user difficulties can be attributed to their making mistakes that they do not even recognise as such and thus fail to make progress in their interactions. This may be attributed to incorrect assumptions in their mental models. Whilst users with incorrect assumptions can be ‘set straight’ by experience, trial and error, tutoring from more experienced (or even less experienced) users or by reading instructional materials, it can be argued that this is too much of a reactive approach. The real challenge is to identify why such incorrect assumptions occur and use this understanding to inform the design of digital libraries. This is the proactive approach that we hope this study will begin to promote. We discuss possible reasons for incorrect assumptions in users’ mental models later.

Buttenfield (1999) cites Lancaster (1995), who argues that while the digital library implies some fundamental conceptual differences [from the physical one], most obviously document access instead of document delivery, “user objectives and evaluation criteria will not change in substance even where contents of the digital library may differ most profoundly from those of a traditional library (e.g. non-static items versus static items, items with fuzzy boundaries versus items with precise boundaries).” Buttenfield argues that in 1995, when Lancaster made his statement, it was reasonable to expect that the complexities of a traditional library were understood well enough to

anticipate their recurrence in a digital environment. This argument, it seems, is based on an incorrect assumption that specific user difficulties with traditional libraries will actually manifest themselves in the digital realm. Whilst it is likely that some information-seeking errors may be pervasive and hence extend from a traditional to a digital context, the examination of information seeking models is beyond the scope of this study.

However, in order to explain how user difficulties in digital libraries relate to mental model formation, it is useful to review the interaction model presented Bates (2002). This model shows the cascade of interactions in the digital library interface (and hence is not an information-seeking model per se). The diagram in fig. (b) presents example layers, including use patterns and use environment that, according to Bates (2002) determine the overall functional effectiveness of a digital library. Bates (2002) highlights that design decisions at each layer have a cascading impact on subsequent layers; poor design at later layers can block products of earlier layers. The cascading nature of the model also suggests that incorrect mental models of certain aspects of a digital library might also block the formation of richer mental models of earlier layers. For example, incorrect assumptions surrounding the function of the interface with regard to searching, including of ‘how searching works’ may impair the creation of an accurate model about how information within the library is organised or indexed (see fig. b).

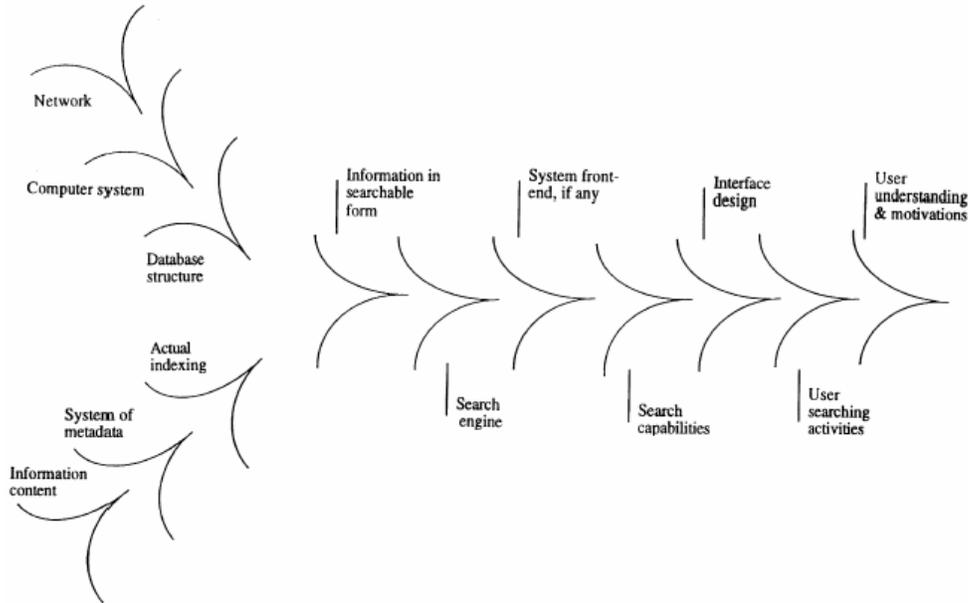


Figure (b): Example use of Bates’ (2002) ‘Cascade of Interactions’ in the digital library interface.

Furthermore, Bates (2002) notes that the layers in the model can be broken out in a different manner, or even put in different orders relative to each other depending on the specific digital library system being analysed. In the context of mental model formation, this suggests that forming a rich mental model of digital libraries may be challenging. This is because with every reshuffling of layers in the cascade model for different digital library systems lies the potential of further incorrect assumptions being formed in a user’s mental model. A digital library user may gain a deeper and deeper understanding of a particular digital library system through experience, and hence develop a richer model of that system. However, this model may not hold when the user attempts to apply the same knowledge to a similar system. Furthermore, false confidence in the transferability of the model might leave the user confused as to why the library does not work as expected or is not returning the expected types of results. Add in the potential confusion surrounding attempting to apply knowledge from other electronic domains to the system and we begin to see why digital libraries are so difficult to use, yet the reasons for this are not immediately

obvious. However, this study argues that studying users' mental models can help identify reasons for the confusion described above. The first step to change an undesirable situation is to understand it more clearly. Hence Bates' (2002) model is discussed in relation to our findings later in this report.

2.23 The relationships between digital libraries, traditional libraries and the Internet

Exploring the blurred boundaries of digital libraries

As introduced earlier in this report, Harter (1997) suggests that a digital library can be defined across a continuum of possibilities, ranging from a narrow view based on existing properties of traditional libraries, to a broader view based on existing properties of the Internet (see table a). This raises pertinent issues for users creating mental models of digital libraries, since their assumptions surrounding different properties of digital libraries in general (or even of a particular digital library) may not form a consistent alignment within the above continuum. Users may hold different and possibly contrasting views for different properties of a digital library. For example, users might believe that objects are subject to authority control, for example through access restriction to non-registered users (narrow view based on a traditional library). They might also believe, however, that a document being part of a restricted document collection does not provide any indication of document quality (broadest view loosely based on the current Internet). These potential differences in viewpoint might manifest themselves as inconsistencies in the users' mental models, possibly creating another dimension of confusion based on the blurred views of what constitutes a digital library.

Taking a view close to Harter's (1997) broadest view of digital libraries, Winograd (1995) argues that upon close examination, e-mail is the harbinger of many of the characteristics of the items that will form the digital library and that the contents of digital libraries of the future. He argues that "whether they be web-pages, local documents in progress, or software modules, will be more like today's e-mail than like published books and journals." According to Winograd, they will be continually appearing and changing, often targeted to a limited audience, and not under the control of authoritative institutions. Winograd (1995) does not, however, give any justification for this viewpoint. He does, however, argue that "the price of excluding such materials from the digital library would be its gradual slide into irrelevance for the ordinary information patron." We highlight that the counter-cost of including such materials, in reference to Harter's (1997) continuum, is compromising on authorship control and hence potentially on quality control.

More pertinent to this study, however, is that the assertion by Winograd (1995) suggests that even if users form a mental model that holds consistent across the range of digital library properties described by Harter (1997), there may still be scope for the user's mental models of digital libraries in general to become blurred. This is because different libraries may 'evolve' (perhaps in the way that Winograd suggests, or perhaps in other ways) according to different timescales and to different degrees. Hence the future digital library user is likely to be faced with an even greater challenge; of forming as consistent a mental model as possible for every digital library system that they interact with, noting the similarities and differences between systems and recognising the impact of the assumptions associated with each model and their relation to each other model. This may not be easy to accomplish.

Winograd (1995) highlights the differences between the 'library culture' and the 'Internet culture' with pairs of associated terms (see table c). Whilst Winograd recognises that this is an oversimplification, he argues that it characterises two distinctly contrasting orientations to providing people with information. He argues that the differences are not just in methods and techniques but in the underlying value priorities – who is to be served by the digital library and what is important to them. The library culture emphasises structure, correctness and authority whilst the digital culture emphasises change, flexibility and diversity. Interestingly, Winograd does not distinguish between the 'digital library culture' and the 'Internet culture,' and the headings in table (c) below are Winograd's own terms. This can be regarded as a practical illustration of the 'blurred

boundaries’ highlighted elsewhere in this report, possibly due to Winograd’s personal standpoint within Harter’s (1997) continuum.

Digital Library	Traditional Library
Open	Managed
Diversity	Quality
Available	Authentic
Access to everything	Careful selection
Operational	Descriptive
Effectiveness	Correctness
Dynamic	Permanent
Support evolution	Get it right initially
Hypertext	Bound volumes

Table (c): Winograd’s (1995) list of differences between the ‘[traditional] library culture’ and the ‘Internet culture’ [which Winograd (1995) includes digital libraries as part of].

Duncker (2002) asserts that the term ‘library’ in the phrase ‘digital library’ is only a metaphor and a traditional library is characterised by many features that do not transfer well to the digital context. Elements of the traditional library can be considered as a space in which particular studies (reading, studying, being quiet) are expected, as well as being a repository of information. Conversely, digital libraries offer capabilities that are not well matched by traditional libraries, such as ease of accessing information without an explicit change in focus that is often inherent when using a traditional library (Duncker, 2002). This argument supports the idea of a continuum of possibilities to define the term ‘digital library’ as proposed by Harter (1997). There is also scope for further mental model inconsistency to be developed if the user incorporates inappropriate elements of the traditional library into their model of a digital library. Conversely it is possible for users to incorporate incorrect assumptions about a digital library into their mental model, based on the preconception that digital libraries *do* aim to incorporate most features of traditional libraries.

Duncker’s (2002) study of Maori students highlights the fact that background knowledge of library material organisation is important for the understanding of the library metaphor and the use of digital libraries. All Maori students understood the terms ‘title’ and ‘full-text,’ but the terms ‘reviews’ and ‘index terms’ were not known. Those who tried to use the advanced search options hesitated, tried different things, got stuck, and either returned to the basic features or turned to the researcher for assistance. This suggests that despite the possible detrimental consequences for the formation of mental models, it is necessary for users to incorporate some assumptions based on features of traditional libraries. As Duncker puts it, “beneath the seemingly universal and simple library metaphor lurks a network of assumptions related to objects and relationships in traditional libraries.” To help ensure the appropriate creation of such assumptions, Stelmaszewska and Blandford (2004) emphasise the importance of implementing the metaphor from traditional libraries relating to the cataloguing, classification and retrieval of information in an appropriate way. We argue that this can be achieved, in the context of mental models research, by trying to reduce the possible blurring of boundaries and scope for error that might arise from users’ incorporating assumptions from traditional libraries into their mental models. This challenge extends beyond merely educating users about how to use both types of library. We must focus on highlighting the ways in which the mental models of traditional and digital libraries overlap and they ways in which they significantly differ. This long-term goal of examining the interplay between mental models also includes other models from which features may be drawn that (correctly or incorrectly) guide users in their interactions with digital libraries.

The ‘blurring of boundaries’ is also discussed by Van House et al. (2003). They argue that as collections go digital, blurring the boundaries between published and unpublished, public and

private, questions arise about the inclusion of information from a variety of sources and the issues of expertise, authority and quality. (Van House et al. 2003). This notion of blurred boundaries can be explained by Harter's (1997) continuum, which illustrates that firm boundaries do not exist between the properties mentioned by Van House et al. (e.g. authorship, access control, quality control, authority control).

Another argument which alludes to the blurring of boundaries is made by Levy (2003), who cites Weinberger (1996). Weinberger (1996) argues that "the word 'document' doesn't mean much these days; it covers everything from a text-only word processing file to a spreadsheet to a Java-soaked interactive Web page." Although neither Levy nor Weinberger relate this idea specifically to blurred boundaries surrounding the properties of digital libraries, Levy (2003) argues that since there are no firm answers about how libraries will evolve, it is necessary to inquire into the nature of the materials that make up their collections. He argues that "we will fail to see the current transformation [of libraries] correctly unless we also see the ways in which current developments are deeply continuous with the past." This might suggest that continuity can be sought not through examining the properties of digital libraries, but through examining the evolution of libraries in general. In a similar vein, Levy and Marshall (1994) warn that by centring digital library efforts around an unintended allegiance to an idealised view of what libraries have been, rather than what they actually are or could be, we risk creating digital libraries that are unnecessarily limited, and, in the worst case, entirely fanciful and unusable. This suggests, albeit implicitly, that an understanding of the blurred boundaries surrounding digital libraries might hold some of the answer to creating digital libraries that *are* usable.

Van House et al. (2003) suggest that "the point is not that boundaries are desirable or undesirable but that they have desired and undesired effects." We agree that the effects of blurred boundaries in digital libraries are important, and suggest that further research is warranted in this area. We also suggest that the blurring of boundaries might help to explain why digital libraries have remained difficult to use and provides an interesting theoretical basis to shed light on some of our findings, as discussed later.

Exploring the relationship between traditional libraries and the Internet

D'Elia et al. (2002) examined the evolving relationship between the public's use of traditional libraries and its use of the Internet. They aimed to identify why people currently use or do not use the public library and the Internet, the decision criteria people use in their choices of which provider to use and the areas in which the library and the Internet appear to be competing and complementary. D'Elia et al. did not find that the use of the Internet is changing the reasons why people use the library. Nor did they find that recency, length or frequency of use of the Internet affect why or how often people used the library. D'Elia et al. (2002) did, however, find that users of both the library and the Internet are heavy consumers of information resources and services and are currently using both providers for this purpose. A noteworthy finding, according to D'Elia et al. is that the average percentage of respondents who used only the Internet (20.3%) is twice as large as the average percentage who used only the library (9.7%). This might suggest that the Internet, and associated digital resources fulfil more of the information needs of users than traditional libraries do and perhaps suggest that digital library designers should not rely so much on incorporating the traditional library metaphor into the digital realm. However, this is a very risky conclusion to draw from this data and further research is needed before a tentative claim such as this can be substantiated. It is also unclear whether improving digital library usability in general is likely to increase the percentage of people who use solely the Internet, since the overall data obtained by D'Elia et al. (2002) suggests that the use of the Internet and use of the library are complementary; 75% of Internet users are library users and 60% of library users are Internet users.

The finding that Internet and library use are complementary adds some additional weight to our earlier assertion that many users find parallels between the information-seeking process in a traditional library and the process when using Internet search engines, or when using a digital library. Those who use both the library and the Internet suggest that the library is maintaining its edge in terms of such aspects as accuracy of information, privacy, and a place to go with children. Unsurprisingly, these properties of traditional libraries are broadly in line with Harter's (1997) 'narrow view' of digital libraries.

Finally, D'Elia et al.'s data do also show that users are beginning to differentiate between library and Internet as information providers in terms of their reasons for use of each provider and their opinions about the service characteristics of each provider. The Internet was overwhelmingly preferred to the library for the majority of uses, many of which fall under the library's traditional mission of information provision. According to D'Elia et al. (2002), this suggests the need, along with avoiding eventual obsolescence, for libraries to start thinking in terms of change. This would see the public library continuing to exist, but with a revised mission and a mix of services. We argue that the Internet and traditional libraries also share information provision resources with digital libraries. This, we argue, is one reason why the digital library boundaries (as discussed earlier in this section) are blurred and hence why there is often confusion in users' mental model surrounding how digital libraries work in relation to Internet search engines. There is far less confusion concerning how digital libraries work in relation to traditional libraries. This is discussed later in this report.

Exploring the relationship between digital libraries and traditional libraries

Nürnberg et al. (1995) translate several traditional library entities into the digital realm and argue that this can provide a starting point for discussing the elements and domains of digital libraries (see table d). They argue that the accuracy of translation into the digital realm is likely to affect the overall library experience. Even those elements of the traditional library that have no direct physical translation are often inextricably tied to the physicality of data and the library itself. According to Nürnberg et al., these abstractions also need to be translated into the digital realm.

	Data	Metadata	Processes
Translations of traditional library entities	Book Journal Movie	Static index Classifications Spatial arrangement	Acquiring data Suggesting sources Helping locate sources
New digital library entities	Hypernovel Scientific visualisation Computer program	Dynamic index Personalised structure Annotations	Full-text searching Personalising presentation Retrieving by agents

Table (d): Nürnberg et al.'s (1995) translation of traditional library entities into the digital realm.

We argue that a more pertinent issue surrounding the translation of library entities from the traditional to the digital realm is the appropriateness of such translations. Do we necessarily want to abandon the notion of 'books' in return for 'hypernovels,' which arguable carry with them different entities entirely? Do we want to abandon the familiar notion of 'classifications' in favour of personalised structures which may vary from digital library to digital library? Can we make the assumption that 'full-text searching' is the appropriate means for 'acquiring data' in a digital library? And do we actually want an agent, or even a 'digital librarian' to help us locate sources in a digital library even if we would normally approach a librarian for help in a traditional library? Nürnberg et al. (1995) do, however, appreciate that digital libraries will deal with not only translated physical elements, but also conceptual elements of the traditional library adapted to the digital realm and completely new digital library elements with no apparent traditional library

analog. Even so, we argue that the need for Nürnberg et al.'s 'new digital library entities' in table (d) cannot be justified without further research and arguably present a rather radical view of the future of digital libraries (close to the 'broadest view' of Harter's (1997) continuum) which many authors would not agree with.

However some similarities between traditional and digital libraries do certainly exist (and are arguably less radical than the translation of entities proposed by Nürnberg et al., 1995). According to Buttenfield (1999), "user needs for information will modify as they gather information. Patrons expect to focus on topical interests, not in struggling to learn the library organisation (Kemeny, 1965). The intention is to shorten the learning curve." Buttenfield (1999) argues that this drives the logic underlying traditional library organisation (books in the main stacks, current periodicals in a special reading room, maps and large or heavy artefacts in the basement etc.) (Buttenfield, 1999). This may allow for the transfer of mental models from one specific library system to another and hence can be deemed as valuable in aiding users to form richer mental models of groups of libraries.

It is important to note that there is no guarantee that users will make parallels between similar library systems, especially if their primary and most urgent goal is to attempt to 'shorten the learning curve' for a particular traditional or digital library. Therefore, attempting to rapidly gain competence using a particular traditional or digital library system may be useful for forming a rich mental model of the library (or at least a model of the library in relation to the types of information-seeking tasks undertaken, such as browsing for an item on a particular subject or searching for a specific item in the library).

However, creating a rich mental model of a particular library system does not go far in highlighting the differences between how that system works and how a similar (yet not identical) system works. We argue that competence across several digital library systems can only be gained by spending time highlighting the similarities and differences between the libraries and more pertinently by highlighting the subtle similarities within the differences presented by the systems, and the subtle differences within the similarities. Making assumptions based purely on the organisation or one or two example systems may, in the long run, provide more mental model inconsistency than consistency.

An interesting relationship between traditional and digital libraries is the presence (or lack) of what Harter (1997) refers to in his continuum as the inclusion of 'human specialists.' Buttenfield (1999) argues that in a traditional library, a reference librarian is a very intelligent, advanced 'interface.' This is a similar view to that of Adams and Blandford (forthcoming) who argue that intermediaries (often librarians) can play the role of information initiator, facilitator, mediator and/or trainer when supporting clients to use libraries. Borgman (1996) as cited by Buttenfield (1999) views librarians as "the missing safety net of human assistance" She argues that "the librarian can sense, respond and interact with a user's elation, confusion or frustration. The software interface cannot accomplish this, in spite of best intentions." (Buttenfield, 1999). In addition "the interface cannot... differentiate between a search returning wanted items from a search returning unwanted items." (Buttenfield, 1999). She argues that "Although patrons can work in a traditional library without consulting a reference librarian, in the case of the digital library, the interface is a gatekeeper to the collection. If the interface is not understandable or does not work, the digital library holdings remain essentially inaccessible." Marchionini (1995) goes further to argue that ideally, one would prefer a self-evaluating and self-modifying system, as for example described by Stephenson (1992).

Stelmaszewska and Blandford (2004) also highlight the role of the librarian in supporting physical browsing and searching activities and highlight the potential of hybrid libraries supporting users who have difficulties formulating queries on-line. They highlight that there is also a need for 'digital librarian assistance' with regards to authentication issues and other administrative matters.

These issues raise interesting questions of how users ‘troubleshoot’ problems in both traditional and digital libraries, what support should be incorporated in digital libraries to facilitate troubleshooting, and how such support should be incorporated. We begin to address these questions later in this report.

Examining the role of libraries in a more abstract sense, Miksa et al. (1994) reflected on certain internal intellectual realities of the term ‘library’ in order to explore the question of whether a digital library should be called a library at all. The notion of the library as a ‘collection’ is deemed partially inappropriate because a traditional physical collection represents only a very small segment of a gigantic whole of publications, where access to the materials is provided by creating multiple libraries or collections, where the expense and labour in assembling, describing, storing and making them available is shared among countless people and organisations. Miksa et al suggest that this raises the question of whether a digital library is a series of such collections or one such collection and whether the use of a digital library precludes boundaries. This may have direct impact on users’ mental models, since it suggests a further blurring of boundaries than the one highlighted earlier between digital libraries and traditional libraries and other electronic search domains. It suggests that even the boundaries between individual digital libraries may be blurred and perhaps further confused by issues of access restriction or document ownership. This is discussed in relation to our findings later.

When examining the notion of a library as a collection of information sources ‘in a place,’ Miksa et al. (1994) argue that a digital library is not a place as a physical location but rather a place as an intellectual construct whilst the physicality of a traditional library ties its divergent elements together as an integrated entity and makes it more than a loose assemblage of items. Hence Miksa et al. argue that traditional library classification systems have severe implications with respect to modern information needs since knowledge may not be best organised linearly, in chiefly a two-dimensional hierarchical structure, with monothetic classes nor may there be only one true way to organise it or that there was only one purpose for organising. We argue that while this may be true, an important feature present in some digital libraries is the ability to allow users to browse sets of hierarchical structures. Browsing is a type of search behaviour featured in many of the users’ mental models of traditional libraries in our study, yet interestingly none of the users articulated that a similar behaviour would be possible in the digital realm. This is surprising, since browsing may lead to serendipity and Blandford et al. (2001) found that serendipitous discoveries were the main source of really positive user experiences when working with digital libraries. This is discussed in more detail later in this report.

With regard to document quality, Stelmaszewska and Blandford (2004) highlight quality assurance differences between physical and digital libraries, where users often find difficulties in making the distinction between general web quality and that of documents in a digital library, whilst a more manageable collection makes quality assurance in a traditional library easier. Stelmaszewska and Blandford (2004) note that the process of document evaluation is also supported in a traditional library through rich cues about where each kind of information can be found, provided by typography, page layout and position within the document. They highlight the fact that although some digital libraries give users access to keywords, indexes and abstracts to help users evaluate the relevance of information, other components such as conclusions, introduction and references are not available without a complete download.

Stelmaszewska and Blandford (2004) also found that in academic libraries, people often follow reference recommendations from their colleagues, supervisors or from other information sources. They highlight that neither physical nor digital libraries support such recommendations explicitly as there is no formal structure to support them. Nichols et al. (1997) argue that the key feature that links recommendations together is that of usage. They argue that in a traditional library examples of usage are a well thumbed volume, a book that falls open at an often referred to page and the often

checked out book with a large number of recent return stamps. They suggest that usage in a digital library could be recorded in great detail.

Regarding the preliminary evaluation of document relevance, Stelmaszewska and Blandford (2004) highlight that electronic catalogues in the traditional library support preliminary results evaluation based on information gathered from a title and, in more detail, from a 'title page.' They note that although some digital libraries provide keywords and index terms associated with a particular document, this information is not available to users from the preliminary results list, but at the later stage of information seeking when working with an individual document. Issues of result and document quality assurance are discussed later, in relation to our findings.

Exploring traditional and digital library organisation

With regard to finding a broad location within an information space, Doomen and Leuven (1995) cite Neisser (1976) in that even in unfamiliar physical environments, people usually find their way because they have at least a model of the environment which bears certain information about it (e.g. that elevators in a building usually give out on a corridor). A mental model like this is often called a 'schema' or 'cognitive map.' In a new environment, the suitable schema is activated followed by a search for features and eventually the routes between features are learnt to create a map of the environment. However, should the user lack the schema which suits the new environment (e.g. it is the first time they have entered a traditional library) then there is no model which can be used for determining features, so the development of survey knowledge will be difficult. We argue that this notion partially extends to the digital realm, where users are aided (or hindered) by virtual 'signposts' should they find themselves in a digital environment that they are not previously familiar with.

Stelmaszewska and Blandford (2004) also found that familiarity of the physical environment could be aided by knowledge of the layout of the furniture, stacks, etc. and of the physical appearance of different areas of the library. They argue that there is further scope to reduce the feeling of 'lostness' in the digital realm through providing general but detailed search instructions with examples or context dependent tips as part of the system response to a user's query, indicating an explanation about what happened during the search, and suggesting ways to improve the search results.

Regarding more detailed classification of items in the library, Greenberg et al. (1992) highlight that traditional libraries classify objects via broad categories (subject, genre, and format) and formal classification schemas (e.g. Dewey Decimal Classification). A top classificatory level is provided by signage or labels, which give an immediate orientation and create a sensory connection to a physical collection. For example, signs may identify collection subjects (e.g. history, science), genres (e.g. fiction, non-fiction), and formats (e.g. books, videos, audio recordings). Greenberg et al. (1992) argue that digital libraries often emulate the classificatory systems used in traditional libraries. Topical labelling is found in site maps, navigation bars, and hot-lists (lists of hyperlinks), making digital libraries more concrete at the top level, and formalised schemas are often applied at the secondary level. (Greenberg et al, 2002). Greenberg et al. interviewed eight sixth grade students about how objects were grouped in selected physical environments compared to in a Science Education Digital Library based on topical labelling and taxonomies. She concluded that vague answers given by students concerning the digital library suggest flaws in the design and illustrate an instance of difficulty in transferring classification knowledge to the digital environment. These findings on the organisation of libraries are also discussed in relation to our findings later in this report.

2.24 Summary of digital library literature

The literature on digital library usability also illustrates that the term ‘digital libraries’ can mean many things to many researchers and users and hence can create ‘blurred boundaries’ in users’ mental models of digital libraries. These ‘blurred boundaries’ manifest themselves, albeit indirectly, in much of the digital library usability literature. This is particularly true when examining users’ mental models of digital libraries as part of a group of models of digital entities. These digital entities all have a search engine component and facilitate electronic information-seeking. This includes on-line library catalogues, Internet search engines and ecommerce sites amongst others. Harter’s (1997) continuum of the potential properties of digital libraries provides a good basis to discuss the notion of ‘blurred boundaries.’ Further discussion surrounding these issues can be found later in this report.

With regard to the relationship between digital and traditional libraries, the literature highlights the difficulties associated with directly translating physical entities into the digital realm. This is closely related to the need to ensure careful use of analogies and comparisons between traditional libraries and digital libraries or digital libraries and other digital entities, as discussed in the previous section of the literature review. The literature does suggest, however, that there is scope to learn lessons from traditional library organisation, based on making the organisation of the library obvious to the users and carefully using ‘sign posts’ to avoid ‘lostness.’ These lessons, and their potential to inform the design of digital libraries, are also discussed later.

The section which follows describes our methodology and tries to remain sensitive to the potential difficulties surrounding the ‘blurred boundaries’ of digital libraries, the ‘fuzziness’ surrounding the subject of mental models and the challenges surrounding mental model elicitation.

3. Methodology

3.1 Think-aloud observation approach and critique

Overview of approach

A study was conducted with the assistance of nine Masters students who were both traditional and digital library users (one of which was used solely for piloting purposes). Participants were asked to perform a similar broad information seeking task in both the traditional and digital library (or libraries) of their choice. The observations conducted were a cross between traditional think-aloud observations, which usually demand minimal researcher intervention, and semi-structured interviews, which usually demand significant intervention. Probing ‘what,’ ‘how,’ ‘why’ and ‘what if?’ questions (Collins and Gentner 1987, Payne 1991, Shadbolt and Burton 1995) were asked at appropriate times before, during and after the observation in order to gain an insight into users’ mental models.

A cross-over study was conducted, where participants were divided into four groups. Two MA Library and Information Studies students were asked first to use the traditional, then the digital library or libraries of their choice. Another two LIS students were asked first to use the digital, then the traditional library or libraries of their choice. Similarly, two MSc Human-computer Interaction with Ergonomics students were asked first to use the traditional, then the digital library or libraries of their choice. The remaining two HCI-E students were asked first to use the digital, then the traditional library or libraries of their choice.

Although there was no set time limit for the tasks or observations, each participant provided an average of 65 minutes of verbal data. Transcripts of this data are included in appendix 3. This yielded enough data, and rich enough data specifically pertaining to users’ mental models of traditional and digital libraries from which to base the discussion which follows later in this report.

This approach takes into consideration the pertinent issues identified in the section of the literature review on mental model elicitation (section 2.17).

Choice of participants

Participants were self-selected by replying to an e-mail sent to their respective student mailing lists. We have no reason to believe that this has any significant impact on the quality or nature of the results obtained.

Although this study was not concerned with mental model differences between varying degrees of experts and novices or academic disciplines, MA Library and Information Studies students were chosen alongside MSc Human-computer Interaction with Ergonomics students in order to provide the potential for interesting differences in mental models to be highlighted should they exist. LIS students were likely to be specialists in traditional libraries and perhaps hold more detailed, or different ‘how-it-works’ ‘how-to-use-it’ or ‘how-to-use-the-how-it-works’ knowledge on traditional libraries (Kieras and Bovair 1984, Preece et al. 1994). Similarly HCI-E students, having been exposed to digital libraries in their course might possess similar knowledge about digital libraries.

Choice of task and setting

Participants were asked which traditional and digital library or libraries they used most before they attended the observation. This enabled the researcher to gain a degree of familiarity with the traditional and digital libraries that might be used during the observation by participants and hence

allowed the researcher to concentrate on asking pertinent and appropriate questions during the observation, rather than trying to keep up with the actions of the participants. It was, however, emphasised on the day of the observation that participants were free to use any library or libraries of their choice, irrespective of the libraries they had indicated that they used most frequently in their prior e-mail. This was to ensure that participants used the libraries in as natural a manner as possible (as suggested by Sasse, 1992). In practice, participants (with the exception of the pilot study student who was studying at the University of Hertfordshire) only used the main UCL Science Library, DMS Watson for information seeking within a traditional library. Most HCI-E students chose to use the ACM (Association of Computing Machinery) Digital Library, possibly because this was the library that they were directed to by teaching staff early in the course. One participant also used the 'HCI Bibliography.' LIS students used a greater variety of digital libraries. Most popular were the Library and Information Studies Abstracts database (LISA) and Ariadne. Other digital libraries used included DoIS (Documents in Information Science), Emerald and SwetsWise.

The task chosen for users was for them to find a document on the same topic of interest in both the traditional and digital libraries. The topic should be narrow and related to their studies but one that they had not used either type of library to find information about before. Hence, it was permissible for users to choose a topic related to their Masters thesis, provided they had not already used a library to find information on that topic before. This would help ensure that their behaviour was as natural as possible (Sasse, 1992).

Participants were invited to take their time when thinking about a topic and instructed what to do if they felt that their choice of topic was too broad or too narrow (see the final protocol of the study, in appendix 2). Participants were told that they could navigate both the traditional and digital libraries freely and that this was to encourage them to look for information as they would normally do when using a library.

In practice, participants often took their time to think of a topic to choose during part 3 of the protocol (see appendix 2). Many commented that they wanted to find something related to their Masters thesis, but had already done considerable research on related topics. The researcher then suggested that they might wish to choose a topic based on an angle of their research that they have not already looked into, or on a different topic altogether – perhaps a subject touched upon in lectures during the year but not examined in depth. This guidance enabled those participants who were struggling to choose a suitable topic. No other questions were asked relating to the instructions given.

Although as would be expected, some participants were better at verbalising their thought processes than others, we did not deem it necessary to halt the observations in order to suggest a practice 'think-aloud' task. Only the pilot participant and one other (LISTD1) exceeded the upper bound of the expected task time and hence, after forty minutes using digital libraries was told "I think I've got a good idea now about how you go about finding things using both types of library" by the researcher, who then moved on to ask a final set of questions (see appendix 3). One participant (HCITD2) finished using the traditional library within around 15 minutes. It was therefore necessary to ask the participant how they would go about finding similar articles, as stated in part 6 of the protocol (see appendix 2). This provided a natural way of allowing verbalisation to continue.

No participant became frustrated or drifted off-topic, nor did anyone request to withdraw from the study or end the observation/interview early due to other commitments. One participant (HCIDT1) halted after conducting an electronic catalogue search in the traditional library and not deeming any of the items in the current library to be relevant. The participant was asked whether they had finished their task by the researcher, who then moved onto some final questions. In accordance with the rest of the protocol, any non-rhetorical questions by the participants were responded to

with another question and in the event of problems or confusion being verbalised, the researcher attempted to delve deeper by asking probing questions where appropriate (see appendix 2 for the full protocol).

Ethical considerations

In accordance with university regulations and the recommendations by Kvale (2004), informed consent was sought from participants. Participants were asked to sign a consent form indicating that they agree to participate and that they are aware that the study would be audio recorded and that they could withdraw from the study at any time. This is especially important in the unlikely case that the participant becomes over-flustered or frustrated during the study.

Participant confidentiality was secured by making all names and references to gender in the transcripts anonymous. It would be impractical to ask each participant to listen to the audio recording of their observation and verify that what was transcribed is a 'loyal written transcription' of the interviewee's verbal statement (Kvale, 2004). However, the verbal data and accompanying transcripts were presented to another researcher with experience in qualitative analysis and checked for reliability.

Questioning approach

Rutherford and Wilson (1992) argue that there is a tendency to record more behaviour that will be employed in the analyses that provide the basis for the psychological inferences. This may lead to an overwhelming amount of data and to the researcher losing sight of his or her overall goals. To avoid such a situation, care was taken to focus on obtaining data pertaining to the users' mental models first and foremost. Hence it was necessary to build a corpus of mental model components from the existing literature in order to provide an indication of the sorts of ideas or comments that, when elicited from users, were likely to yield data that was pertinent to the study. The components identified from the literature are listed in section 3.2. Attention should only be paid to collecting information related specifically to the task, including performance measures, should this be deemed to provide relevant insight into the user's mental model itself or if the data satisfies the goals of the study in some other way. However, it may not be possible to deem certain types of data as relevant or irrelevant before the study commences, hence the need for careful piloting in order to develop the craft skill required to make such ad-hoc judgements and ask questions (or refrain from doing so) to alter the course of the observation accordingly.

The notion of semi-structured yet ad-hoc questioning is highlighted by Seale (1998), although in the context of interviews and not think-aloud studies. Seale suggests the use of a topic guide informed by the notion that each interviewee should be encouraged to talk about similar topics. A topic guide cannot be constructed for the current study as it is difficult to identify explicit topics to be asked in order to uncover ideas surrounding the mental models concepts identified from the literature. In effect, the summary of mental models concepts from the literature acts as an underlying, often passive topic guide of sorts. The only exception to this rule are the pre and post observation questions which were asked separately from the 'what,' 'how,' 'why' and 'what if?' questions which were asked in a much more ad-hoc fashion in response to participants' comments or actions. Only three types of such question were asked and are listed below with justification.

1. When you last used the [traditional] or [digital] library, what did you use it for and how did you go about finding what you were looking for? This sort of question is loosely based around the 'Critical Incident Technique' described by Cooke and Rowe (1994) and was used to identify mental models knowledge or concepts that may not have otherwise featured in the participant's verbal account. This also acted as a good ice-breaking question to put participants at their ease.

2. Did you notice any [similarities] or [differences] between finding information in the traditional library and in the digital library? This type of question yielded some interesting data surrounding the blurred boundaries of digital libraries, especially in relation to other digital entities such as Internet search engines.
3. Did you find using the [traditional or digital] library similar to anything else that you have used in the past? Although questions of this type provided a mixed quality of response due their perceived ambiguity, the questions overall were also useful in obtaining some analogies and further data on 'blurred boundaries' as described above.

Regarding questioning during the observations, it is important to highlight the responsibility of the researcher not to ask too many questions, or questions at an inappropriate time, since this might cause participants to shift their focus away from the task completely and possibly lose their thread. It is also important to note that researcher intervention with 'what,' 'how,' 'why' and 'what if?' questions is necessary in order to elicit mental models even though this approach is in direct contrast to Ericsson and Simon's (1993) classic approach to think-aloud observations (as cited by Bainbridge and Sanderson, 1995). Ericsson and Simon (1993) argue that any comment or prompt from the researcher turns subsequent verbalisations into data which requires additional cognitive processing beyond that required for task performance or verbalisation and hence "could be considered suspect or irrelevant." We argue, however, that this sort of data is highly relevant to studies of mental models.

To help maximise user speakership, Boren and Ramey (2000) suggest a useful approach of using acknowledgement tokens such as 'ok, yeah, or mm hm' can be used to provide the response expected of engaged listeners, while still 'lying low' and promoting the participant's speakership. They argue that this is far less abrasive than Ericsson and Simon's (1993) recommendation of silence interspaced with commands to 'keep talking.' Acknowledgement tokens were used in all observations and in all cases, speakership remained with the participant. With regard to the specific instruction for participants to continue to speak, Boren and Ramey (2000) found that in practice that requests for the participant to 'keep talking' resulted in apologies, interrupting the task flow and flustering the user and casting the researcher into a more controlling, authoritative role. They recommend phases such as 'and now...?' as a content-free alternative which would not imply criticism to the participant. This approach also proved to be useful in the context of this study.

A pilot study was conducted which followed essentially the same process as described above. The pilot was regarded as a trial run to improve the researcher's interviewing technique which, as we have pointed out earlier is craft skill that can be developed through such practice. Our subsequent observations (and the resultant transcripts) are less question-centred and researcher led, with a more natural flow to the asking of questions. The final protocol used in the study is presented in appendix 2 and the transcripts in appendix 3.

3.2 Summary of the mental model concepts identified from the literature

As stated earlier, we realise that there is often an indirect mapping between mental models concepts identified from the literature and questions to be asked or tasks to be set in a mental models study. Whilst this often leads to an 'intuitive approach' towards eliciting users' mental models, we choose to follow an approach of research transparency. This follows the view that if readers are aware of the course we have taken when reviewing the literature and how we have conducted our user tasks, they are likely to be in a feasible position to critique the study and eventually push mental models research forward. We are aware, however, that defining a rigid methodology for the elicitation of

mental models is not possible given the fact that researchers' understanding of mental models is still relatively limited. Furthermore, we agree with Posner (1989) who suggests that a particular mental model elicitation technique should be based around the goals of the study. Additionally, since no previous researchers have examined users' mental models of libraries, we are unable to compare elicitation techniques like-for-like.

The concepts below have been identified from the literature covered earlier in this report and are grouped according to Young's (1983) framework to clarify the types of situations where the associated mental models concepts might arise, when the user is either explaining, predicting or learning the system (or a combination of the three). Note that we are not suggesting that these are definitely aspects of users' mental models, nor are we suggesting that the list below is comprehensive or completely consistent. We provide the list in order to advocate a transparent research approach that illustrates our understanding of the term 'mental models' and its associated concepts/components in order to allow future researchers to critique our approach and hopefully drive mental models research further forward.

Mental models concepts that might be observed when the user is using, explaining, predicting or learning the system (Young, 1983)

- Knowledge of the internal and external layout of the system and how inputs become outputs; (*Kieras 1982*)
- Underlying assumptions in their mental model(s); (*Duncker 2002*)
- Inconsistencies in the model(s); (*Collins and Gentner 1987, Norman 1983, Allen 1997*)
- A set of controlled vocabulary; (*Young 1983*)
- Spontaneous construction of mental models; (*Norman 1983*)
- Inferences made by 'mental simulation' (*Collins and Gentner 1987, Kieras and Bovair 1984, Payne 1991, Rutherford and Wilson 1992*)
- Boundaries of the model (possible confusion from non-firm boundaries or confidence from firm boundaries); (*Norman 1983, Miksa et al. 1994*)
- Parsimony and mental planning (e.g. thinking ahead in information seeking strategies); (*Norman 1983*)
- Behaviour, analogies, inferences or models based on physical experience; (*Norman 1983*)
- Heuristics or rules that may be derived from the model and their appropriateness; (*Collins and Gentner 1987, Holland et al. 1986, Norman 1983*)
- How well complex phenomena are described and levels of understanding of these phenomena (*Norman 1983, Miyake 1984, Schumacher and Czerwinski 1992*)
- Attempts to minimise or foresee error and familiarity with procedures for troubleshooting and maintenance (*Allen 1997, Kieras 1982, Norman and Draper 1986, Payne 1992, Staggers and Norcio 1993*)
- Level of completeness of the model and any impact on understanding of the functionality of the system (*Allen 1997, Johnson-Laird 1989, Miyake 1984, Norman 1983, Norman and Draper 1986, Payne 1991, Sasse 1997, Staggers and Norcio 1993*)
- Level of coherence between the model articulated by the user and the user's methods or actions (*Newman and Lamming 1995, Payne 1991*)
- Analogies and their appropriateness, including the use and appropriateness of analogical reasoning; (*Carroll and Olson 1988, Collins and Gentner 1987, Craik 1943, Gentner 1983, Halasz and Moran 1982, Johnson-Laird 1983, Kieras and Bovair 1984, Newman and Lamming 1995, Norman 1983, Nürnberg et al. 1995, Payne 1991, Young, 1983*)
- Relationship between candidate analogies for the digital library (e.g. complimentary, conflicting) and the consequences; (*Craik 1943, Holyoak and Thagard 1995*)

- Level of connection and consistency between component models (which may be based on different analogies); (*Kieras 1982, Kieras and Polson 1985, Collins and Gentner 1987*)
- Level of ‘conceptual baggage’ provided by any analogies used (*Sasse 1997*)

Mental models concepts that might be observed when the user is only using and explaining the system (Young, 1983)

- Purpose of using the system and expected outputs; (*Kieras 1982*)
- Whether attention is focused on relevant stimuli and tasks to complete the user’s goal (and whether the goal is relevant in the first place); (*Kieras 1982, Norman 1988*)
- Knowledge of the states of the system (or world); (*Norman 1983, 1988, Sasse 1997*)
- Appropriateness of methods or actions employed when using the system, including when undertaking more complex tasks; (*Borgman 1986, Halasz and Moran 1983, Miyake 1984, Norman 1983, 1988*)
- Information seeking (e.g. searching and browsing) strategies; (*Schumacher and Czerwinski 1992, Staggars and Norcio 1993*)
- How user goals and tasks are accomplished in the context of the structure of the system; (*Norman 1988*)
- Superstitious or well-reasoned behaviour patterns and the consequences; (*Norman 1983*)
- Feedback from the system and its role in aiding or hindering predictions of system behaviour; (*Kieras 1982*)

Mental models concepts that might be observed when the user is only predicting the system (Young, 1983)

- User’s ability to predict searching strategies; (*Schumacher and Czerwinski 1992, Staggars and Norcio 1993*)
- Other predicted behaviour about the goals that can be accomplished and how they can be achieved; (*Norman 1988*)
- Predictions of how user actions will change the state of the system (or world); (*Norman 1983, 1988, Sasse 1997*)
- Feedback from the system and its role in altering the mental model; (*Kieras 1982*)

It is important to state that many of these concepts could not be identified from observation alone, nor would it be possible to prompt users with direct questions related to these concepts, since this is likely to alter their mental models. This highlights a challenge for the researcher, who must strike a careful balance between asking questions and allowing the participant to verbalise aspects of their mental models without necessarily becoming aware that they are doing so. This is achieved by asking seemingly innocuous ‘why,’ ‘what,’ ‘how,’ and ‘what if?’ questions before, during and after the task. However, challenges associated with the asking of such questions involve conveying a sense of interest rather than implying criticism and knowing when it is appropriate to ask questions and when it is likely that the participant will continue to articulate valuable data related to their mental models and hence the researcher should save the question for later. We argue that the process of conducting contextual-inquiry-type interviews is a craft skill which can only be developed through practice (i.e. piloting).

3.3 Data analysis approach and critique

Data analysis approach

Posner (1989) highlights that in studies of users' mental models, "it is necessary to infer the processes from the verbal reports that form part of the user's mental model, rather than attempt to encode processes directly." Posner (1989) suggests that "the coding formalisms can be constructed from the actual vocabulary used by subjects, economising by defining equivalences between words used nearly synonymously." This 'natural' approach to the coding of transcripts, using categories that are similar to the actual verbalisations both avoids loss of information and promotes reliability in coding (Posner, 1989). According to Posner, reliability is secured by using a simple and precise coding scheme. Note that the mental model concepts identified from the literature are also observable from the verbalisations in each category however, as explained earlier, the mapping between concepts and observable behaviour is indirect.

The natural coding scheme developed from the data includes observations, statements and/or assumptions based on the categories/themes listed below:

1. Similarities and differences between traditional and digital libraries.
2. Access issues in traditional and digital libraries.
3. The use or construction of ad-hoc 'how-it-works-knowledge' as a result of system feedback.
4. How items are organised in a traditional library and search results are ordered in a digital library.
5. How users assess the contents and relevance of particular documents and entire libraries.
6. The use of analogies.
7. The role of Internet search engines during the library search.
8. Troubleshooting in traditional and digital libraries.

Critique of data analysis approach

Bainbridge and Sanderson (1995) highlight that there is no one accepted way of coding data resulting from protocol analysis. They do, however, suggest a broad technique for preparing the data for analysis and analysing the explicit and implicit content of the protocol:

1. Identify the general protocol structure, which can be done at several levels – from finding the most general stages of activity over the period recorded, to finding units within each stage of activity, to dividing the material in each unit of activity into a sequence of elemental phrases, each of which represents a separate thought or activity.
2. Segment the material into phrases by identifying meaningful units within the protocol that may suggest discrete mental processes.
3. Infer structure of mental activities and cross-reference phrases by combining them into groups, making use of the semantic content.
4. Apply a formal descriptive language to summarise and systematise, in the context of the chosen research question or framework.
5. Infer what is not spoken

A similar process is suggested by Posner (1989), who also highlights the iterative nature of coding data and refining the codes used. Posner (1989) cites Weber (1985) to highlight some issues to consider when coding data. Firstly, the context-versus-reliability tradeoff, where "large portions of text such as paragraphs and whole texts are usually more difficult to code as a unit than smaller portions such as words and phrases, because large units typically contain more units and a greater

diversity of topics.” On the other hand single words or phrases often do not include enough content to disambiguate meanings. As Weber emphasised, the resolution of such issues in each case must depend primarily on the goals of the research. In the large units of text in this study (see appendix 2), there was not a large diversity of topics and hence this did not pose to be a significant problem.

Another issue highlighted by Posner (1989) involves the scope of the categories. “If the categories are too wide, one loses resolution, but if they are too narrow, the power of abstraction is lost in the proliferation of categories.” In our opinion, the categories defined earlier proved to be neither too narrow nor too wide. Lastly, Posner (1989) highlights the issue of category exclusivity; “whether a unit of information should be encoded into a single category or, if it seems to fit more than one category, should be encoded in all of them.” Although assigning weighting or hierarchically coding the categories was possible, we did not find enough overlap in data to warrant this approach. Hence it was decided to encode data that fit more than one category into all categories in which it fit.

3.4 Summary of methodology

Eight Masters students (not including our pilot student) were asked to perform their choice of narrow information-seeking tasks in both the traditional and digital library or libraries of their choice. A cross between traditional think-aloud observations and semi-structured interviews resulted in a product highly similar to Contextual Inquiry interviews, where probing ‘what,’ ‘how,’ ‘why’ and ‘what if?’ questions were asked by the researcher in order to gain an insight into users’ mental models. The observations were transcribed and a natural coding scheme developed to highlight important themes, similarities and differences in the models. These themes, similarities and differences will be discussed in relation to the literature later in this report.

4. Findings

4.1 Overview of findings

All eight participants chose to use the DMS Watson Science library and the UCL electronic catalogue system, which contains details about items held in all UCL libraries. Some participants also used Internet search engines to aid either their traditional or digital library searches. As highlighted in the previous section, all MSc HCI-E students chose to use the ACM (Association of Computing Machinery) Digital Library and one participant also chose to use the HCI Bibliography (HCIBib). The digital libraries used by MA LIS students varied from full-text libraries such as SwetsWise and Ariadne, to abstracting services such as LISA (Librarianship and Information Science Abstracts). All participants chose to use at least one digital library that they were already familiar with and all libraries chosen had either a strong HCI or Librarianship content.

The participants all chose to conduct information-seeking tasks based on narrow topics related to their Masters theses that they had not previously conducted any research into. These topics ranged from the design of children's libraries, to voice user interfaces in HCI. All users conducted primarily search-based information-seeking, although many users chose to browse items on the shelves in the traditional library. Whilst some users were better at thinking aloud than others, appropriate use of probing by the researcher ensured that an insight was gained into all users' mental models.

Our findings show that participants' mental models of traditional and digital libraries go beyond the surface similarities identified, such as the hierarchical organisation of items in both types of library and the availability of documents in paper and electronic mediums. These models contain deeper similarities and differences based on the information-seeking goals that can be fulfilled by each type of library, quality control issues concerning the contents and relevance of individual documents and entire libraries, and 'how searching works' in both types of library. This included observations, comments and assumptions on how items are organised in the traditional and how search results are organised in the digital library.

Additionally, a large component of users' mental models of digital libraries was the notion of access restrictions. These access restrictions were a source of confused or incorrect assumptions in users' mental models, as well as mental model inconsistency. System feedback was found to play a role in helping users to clarify assumptions in their mental models of digital libraries, although sometimes this did not yield greater richness or clarity as intended, but instead unknowingly directed the user away from their goal.

Although the use of concrete analogies to influence users' understanding or usage of digital libraries was not widespread, participants used their knowledge of Internet search engines to infer how searching might work in digital libraries. Additionally, most participants assumed that even if they are different at the interface level or at the level of the underlying technology employed, the search components of digital libraries, Internet search engines and even e-commerce sites work in a similar way to bring back search results. This has implications for understanding users' mental models of all digital entities with a search engine component.

Overall, all of the above issues that were identified in this study have an impact on digital library usability and hence can be used to inform the design of digital libraries. This section discusses these issues using quotations from the data. An explanation for the naming convention used to denote each participant, along with the full transcripts, can be found in appendix 3.

4.2 Discussion of themes that emerge from our findings

The discussion below contains excerpts from the full transcripts that can be found in appendix 3. Researcher questions and statements are in bold. Actions performed by the participant and comments implied by the researcher are in square brackets. Each participant is named using the following convention; the name begins with either HCI or LIS to indicate whether the participant was an MSc Human-computer Interaction or MA Library and Information Studies student. This is followed by either ‘DT’ (to signify that the participant first used the digital then the traditional libraries of their choice) or ‘TD’ (to signify traditional followed by digital). The recurring themes identified from the transcripts are discussed below and key mental models findings, based on the mental models components identified in section 3.2, are also discussed for each of the themes.

Note that this report focuses on identifying mental model themes, similarities and differences with the goal of improving *digital* library usability. Therefore whilst our findings on users’ mental models of traditional libraries may be interesting in their own right, the ‘key mental models findings’ at the end of each section only focus on insights concerning traditional libraries where we believe that these insights have the potential for improving digital library usability.

4.21 Similarities and differences between traditional and digital libraries

Similarities between traditional and digital libraries

Participants highlighted that both traditional and digital libraries have an element of hierarchical organisation:

“I presume that a digital library is organised in a similar way in that it splits things up into articles and books and things like that and I suppose a physical library splits things up into sections such as journals and books, so they’re kinda organised in a similar way.”
– HCITD2

Furthermore, the broad information-seeking goals of users can be satisfied in both traditional and digital libraries:

“You might have been searching for similar things in both types of library . . . books and articles and in terms of cross-referencing and stuff like that.” – HCITD2

However, participants suggested that only the premise of the traditional libraries, based around fulfilling users’ information-seeking needs, is the same. This suggests that users’ mental models were rich enough to see beyond the surface similarities between traditional and digital libraries:

“The premise is the same, which is that you’re looking using terms that make sense to you and allow a certain amount of flexibility . . . either I go for ‘exact match’ ‘full title’ shebang . . . or I’ll go for just part of a subject search . . . and both allow you to do that. Also if you don’t know what you’re looking for, I find them both as equally difficult to use as each other . . . the traditional libraries in effect, because they’ve got really poor search software . . . I mean for me it’s badly done [the software] and I just haven’t bothered to figure out how to use it” – HCITD1

“[You use] similar search terms, using ‘design,’ ‘layout,’ . . . umm . . . you’re both typing search terms into a box and clicking ‘go’ . . . so they both start off similar. But using the traditional library then moves over and you’re browsing through books and looking at

indexes, contents pages . . . looking through chapters, whereas this one just sort of stays online . . . and you're just looking through lists of abstracts and things.” – LISTD1

“Umm . . . you don't really look through contents and index with this [digital libraries] . . . With this you move from the UCL and try different catalogues and then go to Google, whereas with books you're following up references. It's all finding information, but it's a slightly different process.” - LISTD1

Differences between traditional and digital libraries

Some surface differences were also identified between traditional and digital libraries:

*“There's a lot more of them [available documents] because they're all electronic.”
– HCIDT1*

These surface similarities can impact how each type of library is used with regard to the ownership of documents and how users go about using them to fulfil their wider information-seeking goals:

“Going and looking for the book itself is a different experience as you're physically going to a floor and taking books off the shelf and I have to take it out for a set period of time and return it, whereas with a digital library I can just save an article to my hard disk.” – HCITD1

“Most of the articles[in a digital library] didn't have the option to allow me to scan read them straight away, whereas something I do in a physical library is that I pick up a book when I think it might be useful and scan read it. You haven't got the option on a digital library and that makes me a lot more choosy about what I think might be relevant in a digital library. For example, in that article I just found [on DoIS – Documents in Information Science digital library], I might take down some of those citations, but I would take down a lot less in a digital library than I would from a book that I thought was relevant.” – LISTD2

Although the premise of information-seeking was deemed to be the same, users of traditional and digital libraries were often aware that different (but overlapping) information-seeking goals could be fulfilled by each type of library. Interestingly, the participant below assumes that the meta-data stored about library items in each type of library plays a role in dictating which goals can be fulfilled:

“One of the important differences would be the subject matter of what I'm looking for. In a traditional library, I'm looking for books so probably looking for searches under the title and the author because there's not a lot else that they would have entered into the library system. Whereas when I'm looking on Google, it can search through the text . . . and ACM . . . the abstract as well as the title . . . the full text of the papers.” – HCIDT2

Participants also highlighted that traditional and digital libraries had contrasting benefits. Digital libraries can bring back seemingly irrelevant results, yet it is quicker and easier for users to assess the relevance of electronic documents. Items located in the traditional library catalogue are more difficult to assess for relevance, since only limited meta-data about the items are displayed to users. However, this is counter-balanced by the perceived quality of physical resources, which may be available exclusively offline:

“I think sometimes a digital library gives you more scope because then you can immediately click through and scan something quickly and see if it's relevant and if it is,

then you feel happy pretty soon that you've made a good start . . . in a traditional library, you're not knowing if what you're finding on the catalogue is going to be relevant, but then there are still some really good quality resources that you are going to find in a physical library and not in a digital library.” – LISDT1

“I think the main difference I find is that you get an awful lot of rubbish back when you're searching on a digital library. They're good when you've got something specific to look for though . . . a very specific example for example. Ploughing through lots of search results can be a pain. Whereas with a traditional library, you can generally find the area of the books you are interested in pretty quickly and then it's usually quick to flick through books and see what content might be interesting. So in some cases it can be a lot quicker using a digital library and in some cases quicker in a physical library. [A digital library would be quicker to use] when you're after a specific article or when you can be very specific in what you want to look for, for example how focus groups might be used to evaluate mobile phones . . . [a traditional library would be quicker to use] when you're not really sure where to find stuff or want something that's not so specific, such as finding out about focus groups in general. You might even want to look through books and learn more about the subjects to base future searches on . . . get a feel for the subject area.” – HCIDT2

Participants also highlighted that there are often fewer resources on the traditional library catalogue, which can lead to greater search accuracy when compared with searching in a digital library. Interestingly, two MA LIS students attributed this to human involvement in the cataloguing of electronic library catalogues:

“I always find on the library catalogue that there's fewer resources compared to all the individual documents held on a digital library, so your results are generally more accurate to what you're looking for . . . in a digital library, I think it's often hard to distinguish between words meaning something different [synonymous search terms] . . . I know you can say 'NOT' . . . but it's very hard to do that, so I often find you get a lot of double meaning in your results and perhaps they're not so relevant. But sometimes you get something really, really good . . . but I dunno, in a physical library I tend to get more specific results . . . probably also because you get into the way of thinking of how people catalogue things . . . and we study cataloguing and I know . . . I know the general terms that cataloguing systems use, because you have to use the set standards, which are generally the Library of Congress headings, so yeah . . . perhaps I'm more in tune with how they're cataloguing.” – LISDT1

“The standard of cataloguing and classification of books is much higher than in digital libraries . . . digital libraries are still new. People have been arguing about how to go about classifying books for a hundred years . . . and you can be a lot more approximate with a physical library . . . you can physically place things together that are useful, whereas with a digital library you can't. It just doesn't work in the same way. I think you have to be a lot more specific when you're looking on digital libraries because you can't see 'oh, it's roughly over there . . . I'll go and have a look.' Umm . . . and because of that, you have to spend a lot more time [searching digital libraries].” – LISDT2

Conversely, one MA LIS student identified the need for greater search accuracy using the traditional library catalogue as attributable to out-of-date software and limited meta-data that could be used for retrieving results:

“I did realise that the library catalogue doesn't cope with 3 word terms very well. You have to be more specific in the catalogue. In the digital library, you can probably use many

more search terms. . . the [electronic catalogue] software is not as good and is probably not as up-to-date.” – LISTD2

“Whereas on the Internet you can use the full-text of the whole article as a basis for the search . . . the electronic catalogue is probably only searching on key terms.” – LISTD2

Key mental models findings based on the similarities and differences between traditional and digital libraries

These findings suggest that users have a good idea of the layout and procedures (i.e. ‘how inputs become outputs’ (Kieras, 1982) in the traditional library. However, with digital libraries users tended to focus more on describing the common inputs (search terms) and outputs (search results) with varied levels of understanding with regard to how search terms are turned into search results. This is an insight that will be discussed in more detail later.

By asserting that only the premise of information-seeking in traditional and digital libraries was the same, users seemed aware of how their information-seeking goals could be accomplished in the context of both types of system (Norman, 1988). This is supported by users highlighting that different (but overlapping) information-seeking goals could be achieved in both types of libraries and by the fact that users took a more search-centred approach to information-seeking in digital libraries than in traditional libraries, where both searching the electronic catalogue and physically browsing the shelves was common. Users also demonstrated that they were aware of how their goals could be accomplished in the context of both types of library through their predicted behaviour on the goals that could be accomplished in each type of library (Norman, 1988). For example, assessing relevance of documents with a digital library was highlighted to be quicker and easier than if using a traditional library, whilst many users regarded traditional libraries as better at bringing back relevant results.

Two of the MA LIS students (LISDT1 and LISDT2) held the interesting underlying assumption (Duncker 2002, Stagg et al. 1993) that the electronic catalogue of the traditional library could bring back more relevant results than the digital library due to human involvement in the cataloguing of traditional libraries. Another LIS student (LISTD2) assumed that this was due to dated traditional library catalogue software. Other students held different and wide-ranging assumptions. For example, one HCI-E student (HCIDT2) assumed that the digital library would not bring back more relevant results than the traditional library because it was searching through more records. A possible interpretation of this assumption is that the digital library would return too many results that the system would judge as relevant but the user would not, whilst the traditional library would not. Another student (HCIDT1) assumed that the traditional library brought back fewer results because less thought had been spent on designing the search component than with digital libraries or Internet search engines. Although there is no evidence that these assumptions led to anything approaching ‘superstitious behaviour’ (Norman, 1983) lack of detailed knowledge of ‘how inputs become outputs’ in a digital library might help explain why digital library users are often prepared to conduct searches which they know from the outset are unlikely to yield valuable results. This will be discussed further later in this section.

4.22 Access issues in traditional and digital libraries

Access issues in traditional libraries

The notion of a library card as a key to access documents in the traditional library was held by all participants, although since the task did not require them to actually take items out of the library

building, there were not as many comments surrounding traditional library access as might be expected.

Aside from providing physical access to the library building, the library card was identified as a physical entity which holds information about the patron based on the barcode printed on the card. It was recognised that this barcode would simultaneously allow the electronic library catalogue to recognise the patron:

“So I go to my own information . . . my sign in, and put my barcode in [Clicks on ‘log in’ button and enters barcode on the back of library card].” – LISTD2

Interestingly in the case above, providing authentication was unnecessary, since the participant went on to search the library catalogue and did not perform any actions which would have required the user to have logged in, such as viewing current loans or requesting an item that is currently unavailable. There is far more evidence of confusion surrounding digital library access, however, which will be discussed later.

The library card was also regarded as an entity which would restrict the amount of items that could be loaned from the library at any one time:

“We’ve got a staff library [where the participant works] and I tend to use that more than here, because I can just take books rather than checking them out.” – LISDT2

“[Whether I take an item out] depends how much space I have on my library card. If I had space I might just get a few out . . . you can look through the references and things like that and find other relevant articles and books and stuff. But if I only have space for three books, then I’d just sit and look at them and make sure that they had stuff that I was sure was relevant to what I’m looking at.” – LISTD1

The above case illustrates that the document ‘take away’ restrictions, perceived as imposed by the library card, also impact on the participant’s choice of whether to assess the relevance of the documents that they have found on site or at home. Digital libraries may also influence this choice, since many are difficult to access or completely inaccessible from off campus. However, since this study was conducted within the university library (with fewer digital library access restrictions), no participants made that specific assertion.

Also in the traditional library, interdisciplinary MSc HCI-E students highlighted the physical access issues surrounding items related to their course being “spaced around a little bit” (HCIDT2) either in different sections of a particular library, or in different university libraries altogether:

“Bizarrely, one of the books, ‘Usability Engineering’ is actually in the architecture library!” – HCIDT2

This participant suggests that the possible reason for this is that “*although all the libraries are controlled by UCL, maybe they’re autonomous to some degree and the Science library will often hold the same books as other libraries. It’s probably a space issue as well.*” (HCIDT2)

An interesting observation regarding physical access issues in traditional libraries is that they can yield incorrect assumptions. Whilst some participants were aware that items could be requested from other university sites, in the case below the participant remains unaware of this fact and not being able to obtain the required documents immediately discourages the user:

“It puts me off when a book is elsewhere because it’s not like I want to get the book straight away or make so much effort, I would have preferred it if there was a way to order them so that I could view them [requested items] at my own leisure.” – HCIDT1

In addition, physical access issues can combine with other document access restrictions in a traditional library, such as the length of loan associated with a particular copy of an item:

“Oh, it says in Psychology there’s also one . . . but this one isn’t a one week loan like the one in Psychology, so you could take it out and wouldn’t have to renew it every week. But if it was going to be a real pain finding the Anthropology library, I might just get the one from Psychology. I can’t imagine Anthropology’s a huge library, so I should be able to find it fairly easy.” – HCIDT2

Access issues in digital libraries

Access issues in digital libraries pose far more of a problem than with traditional libraries and have the potential of creating far more inconsistencies and errors in users’ mental models. Digital library users find it unclear as to why certain sections of digital libraries are restricted, whether registration/subscription is required to view certain content and whether payment is required in order to do so:

“It says ‘request document’ . . . I’m not sure if that means I would have to pay for it.” – LISTD2

Interestingly, this lack of clarity in users’ mental models arising from access restriction issues also discourages users from using certain sections of the digital library. In both cases below, users made the choice not to invest time in verifying their assumptions or answering their questions surrounding the need to register and/or pay for access to the library:

“I think the reason I was put off [the ACM binder feature] was because you have to have your own personal ACM account and we’ve got our account as a group account through the university, so there’s complications in doing that . . . I think you have to be a member of CHI [special interest group] to have access and I don’t have a membership number and can’t be bothered to go through the whole process of trying to get one . . . or pay for it.” – HCIDT1

“Oh no! You’ve got to log in! That’s probably why I haven’t used [the ACM binder feature] before, because I couldn’t be bothered to set up a personal ACM account. And I think you now have to register or subscribe or something and I never know whether you have to pay or whether you don’t have to pay.” – HCITD2

Access issues surrounding digital libraries can influence the behaviour of users depending on how the user perceives the access restrictions to work. For example a user without a clear idea of how access restrictions apply to a particular digital library may become discouraged from using the library. Conversely a library without noticeable access issues is likely to be used more frequently:

“Most of the time I’m not that concerned in registering unless I really really need to get a certain paper. I know with the ACM . . . you can download it all and view it all [have unrestricted access] . . . certainly on the university network anyway.” – HCIDT2

Another possible behaviour involves seeking only information from sources which the user knows they will have unrestricted access to:

“If I wanted to look at a journal . . . the ‘Bookseller’ or something [name of a journal] . . . but I know you need to subscribe to that unless you use it from UCL . . . so in that case I could use the UCL electronic journal database to see if I find something there.” – LISTD2

Alternatively the user might sidestep the issue of electronic access by reverting to traditional forms of information seeking in order to retrieve the full-text of documents that might be difficult to obtain due to access restrictions in a digital library:

“The access can be really slow and confusing when using different journal providers, so I’d rather use indexing services like LISA and the physical journals themselves.” – LISDT1

Such confusion surrounding access restrictions is also illustrated by other participants who encounter difficulty using digital libraries. The participant below, for example, expects that since the DoIS (Documents in Information Science) digital library claims to have several thousand documents ‘available for download’ that it is possible to access the full-text of all documents which, in fact, is not the case:

“I expected it to take me to the document but it’s taken me to another index. . . [begins to scan list of articles for the article deemed potentially relevant in the search]. I can’t even find the one I wanted now, I don’t think! I don’t even think the one I was there . . . it was 41 volume 8 . . . [continues to scan down list for a few seconds]. Ok, well that’s a right load of rubbish! That’s completely put me off!” – LISDT2

Other participants highlight the confusion arising from having to access different information through different providers, which is worsened by one electronic provider re-directing the user to other digital libraries in order to continue their information seeking task:

“It’s provided through another server and I find that a bit confusing really, because sometimes I just click on that [the documentation for the ERL server that provides the abstract service] by accident.” – LISTD1

“Ok, that leads me to a different digital library . . . Emerald . . . or maybe it’s just a publisher of the book . . .” “Why do you think it did that?” “Ummm . . . they probably own the rights to this article or whatever it is.” – LISDT2

In addition, it is possible for the user to be re-directed to a site which is assumed to be another digital library but is not and hence hamper the search for information:

“It leads me to a different database [actually the publisher’s own homepage] . . . to Kluwer . . . at this point I would not look at this further. It doesn’t seem to give me what I want. It doesn’t actually link to any proper articles as far as I can see.” – LISTD2

Key mental models findings based on digital library access issues

Although one participant did note a positive benefit of access restrictions, in terms of helping to assure document quality (LISDT1), these findings highlight the fact that a significant amount of confusion and inconsistency (Collins and Gentner 1987, Norman 1983, Allen 1997) in users’ mental models of digital libraries arises from access issues and that such issues can have a negative impact on user behaviour. By being unwilling to invest time in verifying assumptions based on access issues and instead seeking only information from sources which the user knows they will have unrestricted access to, or reverting to traditional forms of information-seeking, users are likely to be demonstrating parsimony in mental planning (Norman 1983, Stagg et al. 1993). Users may be

making such inferences by ‘mental simulation’ (Collins and Gentner 1984, Kieras and Bovair 1984, Payne 1991, Rutherford and Wilson 1992) of how to overcome such access restrictions or subscribe to access the required information. Hence these users may be making attempts to minimise and foresee error (Allen 1997, Kieras 1982, Norman and Draper 1986, Payne 1992, Staggers and Norcio 1993), for example in relation to the many things that could go wrong with registering or subscribing for access to the digital library. Alternatively, this might suggest confusion rather than foresight arising from non-firm boundaries of users’ mental models with regard to access restrictions (Norman 1983, Miksa et al. 1994). Either way, these findings suggest that steps should be taken to address the issue of access restrictions in digital libraries. Recommendations based on these findings are made later in this report.

4.23 The use and construction of ad-hoc ‘how-it-works-knowledge’ as a result of system feedback.

Participants often tried to clarify assumptions in their mental models by performing certain actions with the digital library and observing the resulting feedback. This had a positive result in many cases by identifying errors in their models that would allow them to use digital libraries more effectively, for example the following user re-enforced his ideas about how the ‘citations’ feature of the ACM digital library worked by using the feature:

“You can press ‘citations’ and I think that when this paper is referenced in other, more recent papers, it brings up those papers. So this should give me papers written after August 2000 that cite the paper I’m looking at . . . [Presses ‘citations’]. Yeah, that’s what happens. So now I can read through these and see if any of these are useful as well.” – HCIDT1

A similar example was noted when the following user tested their (incorrect) assumption that requesting a document in PDF format from a digital library would always provide a more formatted document than one in HTML format. In fact, the user found that requesting an HTML document from a digital library as opposed to a PDF document could make re-using the document in an assignment easier:

“Generally PDF you can navigate easier than HTML. I’m never so sure what it actually shows you when you choose HTML.” “What do you expect it to show you?” Text, just not formatted . . . [Clicks on HTML and submit]. Oh, it is actually formatted! Ok, I was wrong! The HTML version is even better than the PDF version because you can also copy and paste from this . . . into a Word document perhaps.” – LISTD2

It is also possible for the user’s mental model of the inputs and outputs of a digital library to provide positive expectations when using an unfamiliar digital library system and either guide the user towards their goal, or in this case steer the user away from an area of the library that would not have led them further toward their goal:

“Looking at an electronic journal database, I would expect there to be an article about the book . . . maybe a short write-up or something . What I can see is a table of Contents . . . which I don’t understand what it gives me . . . nothing related to children’s books apparently! So I go back.” [Presses back button on browser]. – LISTD2

Testing assumptions present in the mental model can also have an unknowingly negative result. In the case below, the participant assumes that the CrossRef search front-end to the ACM digital library finds documents written by the same author. Since this is one, but not the only, function possible using this front-end, the user’s assumptions have led to the construction of a highly limited mental model of how it works:

“I’d be tempted to put in an author’s name that I knew of to see if it brought up similar articles. Actually, let’s try it . . . I’ll type in ‘Drew’ because she does lots of things on usability [conducts search]. This is showing me all the articles that the author’s written I think . . . because this person is always included in the author’s list [in the CrossRef search description]. So maybe it does do what I thought it would!” – HCITD2

System feedback was also found to influence users’ future searching behaviour by suggesting potentially useful search terms for use in subsequent searches. These either described a slightly different (but relevant) aspect of the search topic or were synonyms of search terms used previously:

“I’m going to go back to my original search list and put in ‘dialogue’ and ‘coding’ because I hadn’t thought about looking for that term, but even some of the article I found a minute ago [on data coding] had stuff in it about dialogue structure . . . and I hadn’t thought about using that term before!” – HCITD2

“I’ll just have a quick look down to see if there’s anything specific to my topic. [Scrolls down the list of librarianship journal titles]. There’s nothing specific. [Notices a journal with the word ‘young’ in the title]. I suppose ‘young’ is another word for children. Maybe I could have searched using that.” – LISTD1

Key mental models findings based on system feedback

These findings highlight that system feedback can play a key role in ensuring as complete a mental model as possible is formed by the user in order to maximise users’ understanding of the system (Allen 1997, Johnson-Laird 1989, Miyake 1984, Norman 1983, Norman and Draper 1986, Payne 1991, Sasse 1997, Staggers and Norcio 1993). The findings suggest that a challenge for digital library developers is to design systems that promote the creation of mental model assumptions that are likely to take users towards their goals rather than further away from them. The findings highlight the role that feedback can play in allowing users to spontaneously construct new models of unfamiliar systems or aspects of systems (Norman, 1983) and in altering users’ existing mental models (Kieras, 1982). Recommendations to help rise to these challenges are made later.

4.24 Item organisation

How items are organised in a traditional library

All participants articulated that items in a traditional library are arranged hierarchically. However, two MA LIS students highlighted that although different libraries may have different classifications systems for organising items, the way of finding items in traditional libraries is broadly similar:

“I’ve been through 5 or 6 years of universities and have used different libraries, but I usually approach it in the same broad way . . . I find the classmark and browse the area.” – LISDT2

“I’m just gonna go and find the area, which is arranged alphabetically within the area . . . it’s quite a small room, so it’s obvious where to find things and easy to find your way around . . . and within the room, it’s a classification that I don’t really know much about called the Garcide system and there’s an explanation of it on the wall . . . I think it’s a system made up here at UCL.” - LISDT1

Whilst these students noted the broad approach, the case above illustrates that sometimes explanation is needed for the particular classification system within a traditional library, to build the user's 'how-to-use-the-how-it-works knowledge' for the specific classification system. Explanation can also be provided from a librarian:

“How would you know how to find the books you’ve said you’re interested in?” Umm . . . I’m not entirely sure I do! I’m assuming that’s Institute of Architecture [Referring to the first part of the book’s classmark]. I’d go and ask at the desk. I’d ask what they’re for.” [how to interpret the classmarks] – LISDT2

With regard to finding the location of a particular item, participants often learned where relevant sections of the library were located through a library induction or, in the case below by using the signage on every floor and section of the library as guidance:

“The computer record will usually say which floor [the book is on], so usually it’s just a case of going there and following the signs. You’re just walking up and down looking at the signs for the relevant book cases and probably doing that a few times and realising that you’ve actually walked past it. Once you’ve found it, you can find your way back. It’s just the initial time that’s a problem.” – HCIDT2

Within a particular section, participants highlighted that items are arranged in numerical order and alphabetically according to the classmark of the book:

“When you’re searching for a book in a library it’s normally got a certain code because it’s in a certain section. This one’s in the ‘Architecture’ section. Then it’s arranged alphabetically and in numerical order by code. The code here is BA 4LE. So it’d be organised first in As then Bs and the Bs might be divided down into BA, BB, BC. It’s normally the author’s initials . . . but you don’t usually use those because once you’ve gone down that far, they’ll probably only books and you can just spot the one you want. It’s kinda like a hierarchy going all the way down.” – HCIDT1

“It says at location ‘LIBRARIANSHIP,’ which I know is at the 1st floor, that’s basically the room it’s stored in . . . and D281 is the shelf location. REY is short for the author.” – LISTD2

The location of the item also provided users with some preliminary information about the relevance of items:

“Oh that’s interesting, it’s in ‘ENGINEERING’ . . . so maybe although the title of the book looks highly related to what I want, the title might be completely misleading.” – LISDT2

Browsing for information

A common misconception amongst users was that the act of browsing was only possible in traditional and not digital libraries when, in fact, several of the digital libraries that were used by participants in the study facilitated the browsing of journal titles and individual journals in some way:

“With a digital library it’s harder to find things that are similar because you have to actively search for similar things and try different search terms, but in a traditional library, you can browse . . . and you know that all those things have been put together because they are similar, so it’s easy to find a few and quickly decide whether they are relevant or not.” – HCIDT2

“The way I use a traditional library is I tend to find a general physical area and then browse, and you can’t do that with a digital library. That’s why I prefer using material in book form.” – LISDT2

An interesting angle on this misconception is provided by one participant, who alludes to the fact that the dynamic organisation of documents in a digital library prevents digital library designers from incorporating browsing facilities:

“People have been arguing about how to go about classifying books for a hundred years . . . and you can be a lot more approximate with a traditional library . . . you can traditionally place things together that are useful, whereas with a digital library you can’t.” – LISTD2

Another participant highlighted that misconceptions about the lack of browsing facilities can lead to frustration with the digital library:

“The digital library is frustrating because when you’re doing a subject search and you don’t know what you’re looking for, you know . . . you tend to look by subject and it’s a hit or miss thing . . . you don’t know if you’ll find what you’re looking for.” – HCITD1

Browsing in both types of library, more positively, can lead to serendipitous discoveries that can aid the information-seeking search:

“I quite like browsing to be honest . . . you tend to find things by accident a lot more when you’re browsing than when you’re searching for something specific.” – HCITD2

“I was actually browsing for another book in the HCI section of this Science Library and I was reading along the titles and came across it by accident in a book by Heath and Luff.” – HCITD1

“The ‘Bookseller’ is B . . . [Clicks on ‘B’ link and reads relevant part of list]. Book history . . . [Scans for required journal]. [Laughs] It doesn’t seem to be here. But ‘book history’ [discovered because it was close to where ‘Bookseller’ would be in the alphabetical list] . . . let’s have a look at that.” – LISTD2

In addition, browsing items located in a similar physical area of a traditional library can help the user find information on a similar subject or in some cases be combined with a search on an electronic library catalogue, where a catalogue search is used to pinpoint a relevant subject area classmark and subsequent browsing ensures that relevant items belonging to that section are not overlooked:

“You really don’t have enough information on the catalogue to determine whether they’ll be useful or not, so you just take a few approximate classmarks and go and traditionally look on the shelves . . . I find browsing is much more useful than searching for specific things on a title . . . I tend to use the classmarks as a guide for material that I would expect to be together.” – LISDT2

“A lot of the records are getting the same class marks coming up, so that’s good because I can just browse the relevant area when we go to the shelves.” – LISDT1

“These look quite good . . . I mean, this is the one I found, isn’t it? [earlier on the library catalogue] and noted down the location. [Note the participant did not look for the book specifically]. SK5 BLA [checks that it was the book she had written down].” – LISTD1

One participant alludes to the benefit of this hybrid approach, where searching is used to ensure precision and browsing used to ensure thoroughness:

“You can be ‘a bit more free’ with it all, you can just look around and browse . . . but I always feel when I’m looking around browsing through books that I’m not searching in the best way and that it’s quite imprecise.” – LISDT1

How searching works and results are organised in a digital library and a traditional library catalogue

Participants had varying levels of understanding how searching works in a digital library and traditional library catalogue, observable from how they perceive the system decides on an order to bring back their search results. One extreme was a deliberately limited understanding:

“I don’t know how it was actually managing it. I typed some search terms in and it brought me some search results back. I don’t think about it any further than that.” – LISDT2

The other extreme was a deeper understanding based on occurrences of the search term somewhere in the document or meta-data and presenting records in order based on number of search terms matched or frequency of search terms matched:

“I think it’s all down to the way that it does the searching, it’s all down to probabilities. The top things on the list [of search results] mean that, for example, they are 90% likely that they’ve got it right [the content will be relevant to the key words typed in] and that percentage would reduce as you go down the list. I don’t know why they do that though, because I’ve got no incentive to look at something where I’m only 10% sure that they’ve got it right.” – HCITD1

“How do you think it might be retrieving [the results] from the search terms you provide?” “Umm . . . looking at key words of articles, searching those articles and seeing how many times those phrases come up and returning those ones where the phrases come up most higher up in the relevance list.” – HCITD2

Users’ assumptions about exactly *where* the digital library was searching for their search terms also varied, especially amongst MSc HCI-E students who all chose to use the ACM Digital Library at some stage:

“I’d first think that the two words would have to be . . . first of all in the title, perhaps . . . and then in the . . . article? So the words I’ve typed in are not the author’s name or anything like that. So I’d then assume that it’s an ‘intelligent’ type of system and that the order of the words matters to decide on a priority. Perhaps the ones very low down [the list] would only have one of the words in the title.” – HCITD1

“How do you think that the ACM decides what is relevant?” “Erm . . . my guess is it must have inclusion of those terms that I entered . . . I don’t know, maybe in the abstract or in the citations or the references . . . and maybe how many times it’s [the search terms are] mentioned decides how far up the list to put them.” – HCITD2

Understandably, explaining where an abstracting service searches for occurrences of the search terms proved to be less problematic:

“Where do you think it might look for occurrences of words?” *“I think only in the abstract because I think reproducing the abstracts is a lot less work, especially for an abstracting service like LISA . . . I’m not sure whether external publishers would even allow them [abstracting services] to have access to the full-text of all the articles anyway, so I think probably just from the abstract . . . which I suppose, people who write good abstracts will include the relevant terms in it.”* – LISDT1

Those participants who used the ACM digital library had the most difficulty in ascertaining how the search retrieval process worked because of the apparent lack of transparency between the search terms that were input and the results which were output; they did not seem to reflect each other:

“I’m never quite sure how the search . . . I wouldn’t say random, but you seem to get funny stuff back from the ACM in terms of results. I’m not sure how exactly . . . whether it checks the keywords of papers or the titles or exactly how it brings back stuff that it thinks is relevant. Usually it’s the case of putting in a few things and seeing what it comes back with.” – HCIDT1

The symptoms of the lack of transparency between search terms and results were observable when users explained how the relevance bar in the ACM digital library works. Users distrusted the relevance bar, often ignoring it and making their own heuristics of how far to trawl through their list of results before they ceased the search. Surprisingly, two separate MSc HCI-E students made the unlikely analogy of the relevance bar in the library representing a ‘pint of Guinness:’

“I think from using this system before it goes by ‘relevance’ and it’s got this thing on the right-hand side. It looks like a pint of Guinness [laughs]. The more full it is, then the more relevant it should be to your search. I largely ignore that and just cycle through the first, sort of, couple of pages. I sort of take [the relevance scale] as a sort of implied rather than a hard thing to go by. When I’ve used this system before, not unless I’m searching for something very specific are they at the top. I mean they could be anywhere in the first 2 pages.” – HCIDT1

“You mentioned earlier that it was presenting articles in order of relevance . . . how do you think that works?” *“Gawd knows! I have no idea! I don’t find it particularly reliable to be honest, especially with the ACM library, which usually gives me stuff I don’t want [irrelevant articles]. I don’t rate its search engine that much! Things that it thinks are relevant aren’t relevant, for me. Maybe it’s just the way I’m searching, or maybe it’s the search tool. But usually I’m more successful searching on the web.”* – HCITD1

“You have what looks like a pint of Guinness here [points to relevance bar next to each search result] which is meant to show the relevance scale, but I don’t use that at all because it’s not useful. Again, I can’t see why . . . [reads title] “. . . automatic usability evaluation of user interfaces” . . . why I got that back using focus groups and evaluation as my search terms. I find it all a bit arbitrary . . . usually, from when I’ve done it before, if [the ACM relevance bar] drops below half way, you’re not very likely to find what you’re looking for.” – HCIDT2

Interestingly, the above participant attributes the ACM’s perceived poor relevance to the quantity of documents held in the library database and not to the fact that the database might be working in a different way to other digital libraries. In fact, the participant assumes that the other digital library he used during the observation, the HCI Bibliography, works in a similar way:

“How do you think the HCI Bibliography searches for articles?” *“Umm . . . I think it’s pretty similar to the ACM. So again, keywords and words in the abstract and title and*

things like that. It seems to be more the way you get stuff back . . . the way it's ordered as well seems to be slightly better . . . you don't have to go through so much to find articles to find what is actually relevant . . . I dunno if it's just that it's searching slightly less stuff, so you don't get that much back anyway. Maybe that's part of the problem with the ACM, it's just got lots and lots of stuff [the ACM digital libraries].” – HCIDT2

An MA LIS student has an alternative assumption surrounding library relevance, suggesting that digital libraries that bring back more relevant results have their documents classified, at least in part, by humans:

“They do [the indexes in the LISA database] seem to be very reliable, so perhaps humans might play some part in allocating things to them . . . but actually, LISA is so massive that I'm not sure that that's possible.” – LISDT1

Non-ACM users also displayed different levels of understanding about how search results were returned. Interestingly in these cases, confusion about the relevance of search items led to useful assumptions or discoveries about how searching actually worked:

“I'm not sure why this has come up [in the search results] . . . obviously there's something to do with 'building' in it . . . maybe not actual building [in terms of library building] but that's just useless!” “Why do you think it might have come up?” “I've only used two really basic terms, and 'library' is gonna come up all the time in these sort of articles and 'building' is the sort of word that can be used in lots of different ways.” – LISDT1

“It's brought back only three terms. It actually ignores 'recent' and gives me a result for 'developments' and 'children's' and 'publishing.’ “Why do you think it did that?” “There might not have been anything in key term or in the actual article that says 'recent.’” – LISTD2

“To be honest with you, I can't see why it brought up 'indexing and museum' [why it brought up the record based on the search terms given, since the search terms were nowhere in the title]. [Clicks on hyperlink before the title of the book in question, which displays the full library record]. Oh, here it is in the subject field . . . [notices 'indexing' as one of the listed subjects of the books and begins to read other subject categories].” “Why do you think that 'indexing' and 'museum' came up in the subject fields and not the title?” “Because I asked it to do an 'all-fields' search, so it's not just searching the title fields . . . it's searching the subject fields as well.” – LISTD2

Similar confusion surrounded how participants envisaged that searching works on an electronic library catalogue within the traditional library. Similarly to the digital library, users were generally unsure how inputs turned into outputs. In the following example, the user did not perceive this to be associated with finding relevant records:

*“Right, now I'll look through all of those 82 results from the previous search . . . **How do you think it's deciding on an order to show you these?** Hmmm . . . I'm not sure. I don't know if it might be to do with how near together the words that I've searched for are in the title . . . and other information . . . I know that it searches the whole record, because one of the first records that came up on my other search wasn't relevant at all and the word 'library' was really separated from the word 'architecture' . . . so perhaps it's not that [how near together words are]. I mean I'm only searching for two words, so I suppose . . . I don't know actually! But generally I do find records a long way down in the list that are relevant.” – LISDT1*

However in this second example, the way in which they perceived the library catalogue to be performing its basic search served to confuse the user and suggest a lack of logic surrounding how the system works:

“How do you think that it has ordered the list of 33 results? I don’t know really. It’s looking for results containing ‘Christopher’ and ‘Alexander’ but I don’t think it’s recognised the author . . . I mean it’s come out with articles with ‘Christopher’ and ‘Alexander’ in them, but I would have expected articles by Christopher Alexander at the top of the screen . . . but in the things [records] that it’s found, both those terms are separated. I think it might be showing me variations of those two types of words rather than the actual phrase that I typed in [which was not technically a phrase]. . . I would have thought it would have put those to words the same, in that order, together towards the top of the results . . . but it wasn’t. That doesn’t seem that sensible to me. Perhaps they’re [records] are not ordered down there [on the electronic catalogue], or ordered in a way that is not useful, whereas Google and probably the ACM as well are good at those things [traditional search engine functions].” – HCIDT1

This confusion might explain why digital library users are often prepared to conduct searches which they know from the outset are unlikely to yield valuable results:

“So I’m typing in ‘pattern languages,’ but I know this is a real long shot.” – HCIDT1

“Actually, like before I’m going to do an ‘architecture’ search . . . but I’m not sure that word’s very useful, but I’m going to do it anyway.” – LISDT1

*“I’ll just do a very basic ‘library and buildings’ search and see what happens. [Types in URL for Ariadne Digital Library and conducts search]. **What do you think will happen? I think I’m gonna get a lot . . . well, not a lot of rubbish, because this site is quite specific to do with libraries, but I’m not sure it’ll be ideal . . .**” - LISDT1*

Key mental models findings based on how items are organised

As highlighted earlier, these findings show that traditional library users have built a strong knowledge of the layout of the library and how inputs become outputs (Kieras, 1982). This is sometimes achieved by physical cues such as signage and other times through inductions run by librarians. This knowledge sometimes even allows users to form assumptions about the potential relevance or utility of an item in the traditional library based on where the item is located. The lack of such depth of knowledge with regard to digital libraries suggests the need for digital cues as well as suggesting the potential role of the librarian (whether a conventional or digital librarian) to aid troubleshooting. Recommendations for improving digital library troubleshooting are discussed later.

The misconception that browsing is only possible in a traditional and not a digital library may be explained as an incorrect underlying assumption held by users (Ducker 2002, Stagg et al. 1993) or as a partially complete model (Allen 1997, Johnson-Laird 1989, Miyake 1984, Norman 1983, Norman and Draper 1986, Payne 1991, Sasse 1997, Stagers and Norcio 1993) that has so far only concentrated on achieving search-based information-seeking goals. The use of browsing techniques by users to aid search-based information-seeking tasks can be viewed as a way of focussing attention to the relevant tasks that would complete the user’s goal (Kieras 1982, Norman 1988) and an example of a well-reasoned behaviour pattern (Norman, 1983) designed to improve the chance of finding relevant information in a traditional library. This may be regarded, depending on the exact information-seeking task, as an appropriate method Borgman 1986, Halasz and Moran 1983, Miyake 1984, Norman 1983, 1988, Stagg et al. 1993) to employ when seeking information in either

type of library. Therefore these findings suggest the need to address this misconception about browsing. Practical recommendations in order to achieve this are also discussed later.

With regard to how searching works and results are organised, users' varying levels of understanding might be explained by errors in the users' perceived internal structure of the system (how it works) (Kieras 1982), which in turn might be caused by lack of relevant feedback from the system (Kieras, 1982) as discussed earlier. It may also be due to users forming their own boundaries (Norman 1983, Miksa et al. 1994) about what their mental model of searching a digital library or traditional library catalogue should include. This view is supported by the MA LIS student (LISDT2) who held a deliberately limited understanding of how searching works.

An interesting symptom of this varying level of understanding is the distrust that MSc HCIE-E students felt for the ACM relevance bar, resulting in the formation of heuristics (Collins and Gentner 1987, Holland et al. 1986, Norman 1983, Stagg et al. 1993) based on personal opinions of relevance that may or may not be appropriate for finding the most relevant information in the digital library, especially in all information-seeking contexts. Another potential symptom is the fact that users are often prepared to conduct searches which they know from the outset are unlikely to yield valuable results, almost bordering 'superstitious behaviour' (Norman, 1983). Of course, this might suggest that digital library users are generally untrusting of their personal searching strategies rather than untrusting of the search components of digital libraries. However, since all users employed relatively sophisticated searching strategies and indicated a sound level of competence with searching digital domains, it is likely that lack of appropriate feedback when searching is the underlying cause of 'how-it-works' confusion with regard to searching and obtaining relevant and consistent results.

4.25 How users assess the contents and relevance of particular documents and entire libraries

Participants noted that in a traditional library, some of the potential relevance of an item can be derived from physical attributes, such as how worn the item is to indicate age or popularity, whether there were multiple copies of the item on the shelves (to indicate demand or popularity) or even by 'judging the book by its cover' to decide on potential content and hence relevance:

"This is another book [picks up book] and without opening it, it already looks horrific . . . looks a bit dated!" – LISDT1

"You can sort of tell [the age and relevance of the book] from the last time it was borrowed." – LISDT1

"They've got multiple copies of these, so obviously they're good books on children's libraries and they look like general . . . and they're quite thick. [Picks up a far thinner book to contrast with]. I mean thin things like this are gonna be far more specific, aren't they? [Puts thin book back on the shelf]. So I'd probably start off with the bigger ones and then just sort of look around. So what does it tell you if there's multiple copies of a book? It's probably on the reading list or is a core . . . and it's in high demand, if they've got so many copies of it . . . so it's probably a good place to start. It covers quite a few bases and stuff. The ones that don't have loads of copies are more specific so they might not cover the design." – LISTD1

"Oh dear! This book looks very American because of all the glossy photos on the front. . . but it's a bit newer, so hopefully it's references will be far more up to date and lead to things relevant to the British library scene." – LISDT1

Document relevance in a traditional library was also ascertained by flicking or skimming through the entire book, or reading particular sections of the book such as the contents or index pages:

*“I’d give it a flick. In this case I might look for authors or I might look for subject matter.”
– HCIDT1*

“I’m just scanning through the book to see if there is anything useful in it . . . I usually start at the contents and then if something looks good, I’ll just jump in and look it up.” – LISDT2

“I’ll look for focus groups in the index. Focus on users? No . . . nothing on focus groups. Maybe if I look in the contents.” – HCIDT2

To ascertain document relevance in a digital library, more emphasis is placed on reading the titles and abstracts of documents rather than through flicking or skimming through the contents. This might be due to the time it takes to download and scroll through a document:

“How did you decide that those two might be interesting?” “Reading the titles, just to get a quick overview. For example this title that I read just seemed too technical. The second one, ‘a debate on language and tool support for design patterns’ . . . that didn’t seem that relevant either because I don’t think it’s about pattern languages, whereas this one talks about pattern languages specifically in the title. To delve a bit deeper though, I read the abstracts the print off the whole document.” – HCIDT1

“You’ll often get a lot of stuff [search results] back and you’ll have to go through, quite laboriously, looking at the titles and sometimes the abstracts to see which ones are relevant. Sometimes you don’t get an abstract [in the search results] or sometimes it’s a bit ambiguous, so then I’d just click on it and open the file.” – HCIDT2

As highlighted earlier, ACM digital libraries generally distrusted the relevance bar and did not use it as an indication of whether an individual document might be relevant to their search. Instead, they made up their own heuristics based on experience, such as ‘usually the relevant items are displayed in the first two pages of search results.’ However, this distrust of digital library relevance also extends to other digital libraries. In the example below, the user trawls through all 277 results presented by LISA in order to make sure that a potentially relevant record has not been overlooked:

“Generally with this [LISA], you have to be quite general and just trawl through them all [search results] to find what’s relevant . . . or I do anyway. . . I would look through all 277 results and I’d just select the records that I thought were relevant rather than having to write them down.” – LISDT1

In the traditional library, the electronic catalogue allowed users to see whether each item in the search results is available from the current site (in this case the DMS Watson Science Library) or another UCL site. However, assessing the contents and relevance of individual documents is complicated by the distance between sites and the fact that some users were unaware that items could be requested from other sites:

“I must say though, it puts me off when a book is elsewhere because it’s not like I want to get the book straight away or make so much effort” – HCIDT1

Assessing individual document contents in a digital library is complicated by a different issue altogether; the fact that it is difficult to know which digital libraries contain information on certain subjects:

“In the Athens there’s lots of individual electronic libraries and some of them have got certain stuff in and some of them have got other stuff in. I find it fairly hit and miss. You normally have to go in [to each digital library] and type in the name of the author over and over again until it might crop up.” – HCIDT1

“I just want to see a list of all journals so that I can decide on ones that might be relevant. But I think I’ll have to look for ‘Web of Science’ [digital library], but I’ve no idea how to get to it from this area of the website.” – HCITD1

“Usually I use my background knowledge to try and think of which electronic journals I am familiar with and which digital library it’s likely to be in. So if I was looking for an article that applies to HCI like this one, I’d go straight to the ACM.” – HCIDT1

To find out which digital libraries might contain information related to their particular field of study, recommendation from peers and university staff is relied upon:

“‘Web of Knowledge’ . . . here we go . . . [Clicks on Link]. I’ve used this before and it seems to be pretty popular. It’s quite often recommended by people for our subject area . . . my supervisor recommends it..” – HCIDT1

Interestingly, one user highlights the parallel between physical recommendations from peers and the way in which multiple digital library providers appear to provide different information, often on the same subject, but with some inevitable overlap and confusion:

“If you have a large group of friends and you’re speaking about a similar topic and you get different feeds from that, so that I would think is a similarity to digital libraries or generally searching on the Internet. You get suggestions from several sources, rather than from the library catalogue, just from the one source. You’re not just restricted to your own knowledge.” – LISTD2

Even once the user has a rough idea that a particular digital library may be relevant to their search, access issues discussed elsewhere in this section combine with the potential blurred boundaries surrounding which providers provide which journals. To add to the confusion, one participant notes that older journals are often not carried by digital libraries, which would prompt users to revert to searching printed collections or, in the case of the participant below, avoid using full-text digital libraries altogether and use indexing and abstracting services in combination with the physical journals themselves:

“I think journal literature searching is one of the hardest things to do, the traditional journals more so for librarianship because there’s very few of them which are online . . . there’s a lot, but they [digital libraries] mainly only show the last two years anyway, and often you’ll want to go back further than that and the access can be really slow and confusing when using different journal providers, so I’d rather use indexing services like LISA and the traditional journals themselves . . . I just find that a lot better.” – LISDT1

Other users used the search results to judge the potential relevance of items:

“I’d just select the records that I thought were relevant rather than having to write them down . . . anything vaguely relevant, I’d just select them all and view the ones I’d selected at the end . . . then either print them off or write the locations down . . . and then start with other search terms and repeat the process.” – LISDT1

Looking up references and citations was highlighted as an important way of ascertaining document relevance in both traditional and digital libraries:

“If there’s a good book on this area, these two papers are likely to quote from it . . . If I find a paper in a book that is useful or a good reference, I’ll make a note of it and take it from there. I find bibliographies to be the most reliable way of finding material.” – HCIDT1

Using the ‘citing’ example quoted earlier, the participant conducts a similar operation in the digital library to find other relevant documents:

“[In the ACM digital library] You can press ‘citing’ and I think that when this paper is referenced in other, more recent papers, it brings up those papers. So this should give me papers written after August 2000 that cite the paper I’m looking at . . . [Presses ‘citing’]. Yeah, that’s what happens.” – HCIDT1

In the traditional library, potential document relevance was also judged by the classmark of the item, which indicated both the broad location of the item and the subject category which the item belongs to. Often items not categorised in the expected section of the library were dismissed as unlikely to be relevant:

“This one’s no good either. Because it’s in Archaeology [section of the library] and not Librarianship, it suggests it might not be very useful.” – LISDT2

“I’d be tempted to have a look at that one, although the classmark suggests that maybe it’s not exactly what I’m looking for. Why does it suggest that? Because I would expect it to be the same classmark as the others [that were deemed potentially useful], around K50 . . . it’s L85. It may be that it’s more along the lines of basic classification rather than indexing. But I would have a look.” – LISDT2

However, one participant used their wider knowledge of the library categories in the Librarianship room to identify a case where a particular book could have been placed in different categories (and hence was still likely to be relevant to the search):

“Oh, my first book isn’t actually in this section, it’s in N10, which is over here [points]. And N10 is more to do with National Library . . . that’s because the book is about building the British Library, and that’s a national library, so someone’s decided to put it in the ‘national libraries’ section, which is fine.” – LISDT1

Participants also highlighted the additional difficulty of judging the relevance of a document in the traditional library by using the traditional library catalogue alone, since very limited details are provided to aid users in making the judgement:

“You really don’t have enough information on the catalogue to determine whether they’ll be useful or not, so you just take a few approximate classmarks and go and traditionally look on the shelves.” – LISDT2

“I can’t really get much more information.” “What more information would you want?” “Ummm . . . I dunno . . . a bit more of a description of it. But I don’t think they do that sort of thing [provide an abstract or description] here [on the electronic catalogue].” – LISTD1

“I’d like to find out more about what each one [record] is about, so I’m gonna click on a number [beside each record] and see what that does . . . that gives me lots of information about when it was published and all that, which isn’t really what I’m interested in . . . I

thought it might give me a brief like of what the book was about, the main topics in the book.” – HCIDT2

This can lead users to dismiss a particular item as irrelevant purely due to the lack of meta-data provided about the item in the traditional library catalogue:

“Ones like this without a year showing I don’t tend to bother with because they’re either not catalogued properly or so ephemeral that they don’t even have a year.” – LISDT2

These findings suggest that access issues can create errors and potential inconsistencies in user’s mental models of traditional libraries. However, these errors and inconsistencies are likely only to lead to a delay in the information-seeking process by suggesting to users the necessity of visiting other sections of the library or other library sites in order to find items of interest. They do not hinder the process completely. However, space restrictions on a library card might persuade patrons to attempt to assess the relevance of documents onsite and perhaps more hastily than they would have done off site, therefore this suggests that restrictions such as these might have an impact on the quality as well as the duration of the information search.

Key mental models findings based on assessing the contents and relevance of documents and libraries

Deriving some of the potential relevance of an item in a traditional library from physical attributes such as ‘wornness’ can be regarded as an inference based on physical experience (Norman, 1983). Because users tend to ascertain relevance of traditional and digital items in different ways, this suggests that users are aware of the appropriateness of the methods and actions that they employ (Borgman 1986, Halasz and Moran 1983, Miyake 1984, Norman 1983, 1988, Stagg et al. 1993) when assessing document relevance in both types of library. For example, ‘flicking’ and ‘scanning’ paper documents is currently far easier than with electronic documents and is hence better suited to assessments of document relevance in a traditional library, whilst the abundance of abstracts in digital libraries make scanning an abstract a feasible alternative to attempting to scan the document by scrolling through it.

Difficulties based around which digital libraries contain information about certain subjects might be explained by confusion arising from non-firm boundaries (Norman 1983, Miksa et al. 1994) between users’ mental models of individual digital libraries. Or more precisely, they can potentially be explained by difficulties surrounding predicting which goals can be accomplished at individual libraries and how these goals can be achieved (Norman, 1988). This explanation of our findings extends beyond knowing what sort of information is available in each digital library, to the access issues surrounding which providers provide which journals. Our findings highlight the need to assist users to form ‘bridges’ between their mental models of separate digital libraries. Recommendations for doing so, based on creating a central repository of such meta-data about the digital libraries themselves and working towards integrating several publishers’ libraries under a single searchable front-end are discussed later.

4.26 The use of analogies

Interestingly, none of the participants made specific analogies between components of the traditional and digital libraries and only compared the similarities and differences between the two types of library when asked to. However, participants made interesting comparisons between digital libraries and other digital entities, such as Internet search engines, e-commerce sites and electronic library catalogues. These comparisons will be discussed below. In addition, we will

discuss insights gained from comments made by ACM digital library users about the ‘binder’ feature of the library.

Comparisons between search engine components and digital library search components

Some participants assumed that the search engine components of Internet search engines, e-commerce sites and digital libraries work (in terms of the processes that they perform) in a similar manner, even if surface differences exist at the interface level or based on what format search terms should be entered:

“I think the fundamental technology [behind search engines, digital libraries and e-commerce sites] is similar but there are specific differences at the interface level in terms of options you can select . . . different radio buttons . . . and the different ways in which they classify the things in the database . . . I mean Google’s just a free-for-all . . . it’s very non-specific. Whereas if you go to the ACM or to Amazon you’d have to tell it that it’s a book or a bit of music that you’re looking for. So at the surface level they’re different but behind the scenes I’d imagine they run on similar logic although the technology may be different . . . I mean whether it does a Boolean search automatically or whether you have to type in things for it [Boolean operators].” - HCITD1

This led the participant above to ‘adopt similar searching strategies,’ or at the very least begin their search by entering the same search terms, in both an Internet search engine and a digital library:

“Why do you use the same strategy in both Google and the ACM Digital Library?”
“Umm . . . because I think they both perform a similar operation in that you type in different words and it’s trying to bring you relevant results. I think the process of bringing you relevant results is a similar thought of process in looking for words in the higher categories and then working down . . . if it just brought you back random stuff, then it wouldn’t be any good!” – HCITD1

Although some users intended to mirror their search terms exactly amongst the different digital libraries they used, or between the Google search engine and the digital library, this was rarely achieved in practice:

“Why did you type in ‘pattern languages’?” *“Umm . . . Well I probably should have typed in ‘language patterns’ so it’s exactly like before [with Google], but I forgot.” - HCITD1*

“When you searched on the HCI Bibliography you searched for ‘focus groups’ and didn’t use inverted commas like you did on the ACM . . .” *“Oh, I didn’t do that consciously. I guess sometimes I use inverted commas, sometimes not. I probably used inverted commas originally because I was searching for focus groups and evaluation . . . I wanted to separate those two out . . . but searching just for ‘focus groups’ doesn’t really need them.” – HCITD2*

“I would do the same 6 or 7 searches that I’ve done here. I experimented a bit when choosing my topic using LISA and that’s probably how I came to my keywords of ‘indexing’ and ‘museum’ that I’ve used with this library [DoIS].” – LISDT2

When mirroring was achieved, the results were not always as useful as expected. The following participant, held the assumption that the previous use of digital libraries could provide ‘how-it-works’ knowledge when searching an unfamiliar digital library:

Interestingly, one participant highlights that the previous use of digital libraries provides some 'how-it-works' knowledge when using DoIS, an unfamiliar digital library:

"I've used similar [digital libraries] and that's helped because otherwise I would've not been able to work out what it was doing and why it [the computer system] was doing it." – LISDT2

Unexpectedly, the above participant found that using knowledge gained from using other digital libraries did not yield any results. Instead of attributing this to differences in the document content held by the two libraries, or differences in the way in which the libraries bring back relevant search results, the participant assumed that the search terms had been entered incorrectly:

"I've found them [the search terms] to be useful when searching LISA [Library and Information Science Abstracts database] in the past for my dissertation. Oh, nothing's found! Why do you think that was? I don't know, I'm looking to see if I've typed my terms properly . . ." – LISDT2

Some participants also used the same search terms that they used to search the digital library or libraries of their choice to search the traditional library catalogue:

"So I'm gonna type in the same as I did before [in the electronic library catalogue] and see what I get. So I'll start off with 'dialogue' and 'analysis' and press search." – HCITD2

Others used the search components in different ways, although confusion was rife surrounding just how similar the searching processes of digital libraries and Internet search engines are. Some of the confusion surrounding how the search components of digital libraries and Internet search engines work in relation to each other might arise from the blurred distinction between them (akin to the broadest view on Harter's (1997) continuum) which is itself symptomatic of the disagreement in the definition of the term 'digital library' as identified in the literature:

"I wouldn't know what constitutes a digital library in this case." – LISTD2

In the case below, the participant suggests that using digital libraries is similar to using a database of document abstracts and indexes. A contradiction arises when the participant suggests that such abstracting services are, in fact, digital libraries too. Interestingly, the participant also recognises that the definition of a digital library can be somewhat broad and implicitly attributes the inconsistency to this factor:

"Did you find using the digital library similar to anything else that you've used in the past?" "It's similar to LISA . . ." "Do you consider LISA to be a digital library?" "Yeah, I guess so, although it's hard to decide where a database ends and a digital library begins. It's like trying to distinguish between a librarian and an information professional, there's a very blurred distinction." – LISDT2

Other participants also highlights the blurred distinction by suggesting that Internet search engines themselves might be regarded as large, less organised digital libraries and vice versa, digital libraries could be regarded as search engines because they contain a search engine component and facilitate electronic information seeking:

"It comes back to the issue of 'what is a digital library?' because some people argue that Google isn't a digital library, it's just a search engine. But if you look at a digital library like the ACM, well that's just a search engine! So if you don't include Google as a digital library then I would say search engines are similar to a digital library, but I would class

them as the same category because all you're doing is typing in words, trying to narrow down a topic which you're interested in, whether it be a paper, book or website, and finding it.” – HCIDT1

“In a sense, I see most digital libraries as a search engine. And Google could almost be viewed as a digital library . . . putting in a title of an article brings you back results that might help you to find it. I tend to use a digital library as a search engine . . . not as I would a traditional library so much . . . and not as a digital library [in its own right]. That's perhaps why I won't use binders and other stuff so much, because I don't really look at that sort of stuff. What does using a digital library as if it were a search engine entail? Umm . . . really I guess in terms of what I expect to get back and the look and feel [of the interface]. And in constructing queries. The way I used the quotation marks to separate 'focus groups' and 'evaluation' . . . that was because of experience in using search engines like Google, where I usually use quotation marks to do that. Also in terms of the way things are presented in order of relevance and being able to go back and bookmark stuff. Are there any instances in which you wouldn't treat a digital library as if it were a search engine? Umm . . . sometimes you'll get stuff back and you can't actually look at it just like you get broken links in a search engine. I guess with a digital library, it's not so much that the link is broken, but you don't have permission to view this . . . I guess in that case it's a little bit odd using it as if it were a search engine.” – HCIDT2

“ACM results come up in Google as well, so it's kinda like searching a digital library anyway. I don't really think about the digital library side of finding articles, I just think of it as searching. If I'm searching of the web, chances are it has a field and a go button and it will allow me to select a few parameters and that's the end of it . . . I don't really differentiate between a library search versus a search engine search or a search in Amazon or anywhere else . . . or looking for electronics or software or anything.” – HCITD1

The similarities between search components of digital libraries and e-commerce sites such as Amazon seemed to create less confusion amongst those participants who identified similarity between them. This is because fewer surface similarities exist between the search engine component of the Amazon site and the search engine components of digital libraries:

“You can look through things on Amazon using search terms, but it's a lot more simple though. If you did search on Amazon, would you search in a similar way? You'd search for titles really, wouldn't you. With Amazon, you sort of know . . . 'I'm looking for a video of Harry Potter' or whatever . . . you have an idea in your mind. I suppose you could do a general search on 'Michael Jackson's music' or whatever, but on here [the digital library] I don't know the names of any of the books . . . or any of the articles. With Amazon, you could do a subject search, but usually you know the title of what you're looking for. So there are vague similarities, but not really.” – LISTD1

However, because there are more surface similarities between digital library and electronic catalogue search engine components, the confusion surrounding digital libraries and Internet search engines also extends in a similar fashion and to a similar degree to the traditional library catalogue:

“I dunno if you can do this [wildcard searching] on this [electronic catalogue] actually. Usually if you put a star [asterix character on the keyboard, referring to 'child'] it just covers everything like childs, children on the end there. I'll put that star on it just to see . . . [Types in 'child* library*' and presses search button]. No . . . 'no exact match.' I know you can do that [wildcard searching] on the Internet search engines, but whether you can do that on here, I'm not sure.” – LISTD1*

“I noticed that when you were searching the library catalogue and when you were searching the digital libraries, at one point you typed in ‘library and building’ . . . and in the library catalogue you typed ‘library building’ without the word ‘and’ in between. Was there any particular reason for that?” “I don’t know if . . . I generally think that the library catalogue doesn’t always . . . I suppose it does do Boolean searching, but I wasn’t thinking that it did . . . I don’t know, I think with the library catalogue, I’ve found in the past that you’re searching doesn’t need to be really specific and also you’re not going to return a lot of results, so I suppose I’m a bit more careless . . . and also I only ever do basic searching . . . I only ever use AND and OR or NOT [Boolean operators] and sort of like inverted commas, speech marks for a phrase . . . and I never use brackets and other things. But I always find on a library catalogue that I don’t think about my search so much.” – LISDT1

One participant, when using the digital library, found a review of a book that had been found earlier in the traditional library search. This serendipitous discovery across multiple mediums suggested the book’s relevance to the search. Interestingly, the participant attributes finding the book in both the traditional library catalogue and the review of the same book in the digital library to using similar search terms in both types of library:

“Yeah. It had a record of the same book that is here in the library, which I initially found using the same search terms . . . Well not exactly, because I had to restrict my search terms for the library catalogue. But there was a record of it on the digital library as well. That would indicate to me that it’s a fairly relevant book then!” – LISTD2

Another participant asserted that the traditional library catalogue could be regarded as a ‘bad search engine,’ suggesting that the underlying search technology of the library catalogue does not work in an identical way to that of an Internet search engine:

*“Because I’ve only searched on the digital library system [electronic library catalogue], in a crude way you might want to identify the traditional library system as a very bad search engine! But at the end of the day, you’re performing the same actions and trying to achieve the same goal. **“In what crude way would you say that a traditional library is like a bad search engine?”** Well the Google system is a lot more flexible and powerful when it recognises mistakes. It’s more intelligent. It suggests what you might have meant. It’s searching a huge huge database so has to be more powerful to sort out the wheat from the chaff. It has to be better because it’s got so much more to sort through. But the traditional library is not as good.” – HCIDT1*

The same participant also displayed an understanding that it could be the underlying search technology, and not just the superficial differences in required search syntax, which might have an impact on the results obtained from an Internet search engine, digital library and traditional library catalogue:

“A lot of better search engines will generate much more reliable results, so my expectations are that if I use one [a search engine] that uses a particular [searching] technique, I’d assume that others, even in a digital library might work using the same technique . . . and this one doesn’t. Which techniques would work in a search engine that wouldn’t work in the UCL catalogue? Just typing it in and the most likely result coming up! I don’t actually know the technology behind it, but if I type in ‘voice human factors’ in Google, I can be pretty sure that it will bring back things that are relevant . . . I don’t understand how it gets it, but it does actually return useful results.” – HCITD1

This distinction based on underlying technology is best observed when the participant was asked to explain how CrossRef, a pilot initiative between Google and the ACM might work. This service provided a Google-style front-end to several full-text digital libraries. The participant suggested that an identical search using the CrossRef service, which indexes the entire ACM digital library, and using the ACM would be likely to yield different results due to the different underlying search technology employed. Other participants did not possess such a sophisticated level of understanding:

“It’s possible that the [CrossRef] results will be slightly different if it’s based on different search technology than the current ACM digital library. I don’t know if it is, but if it isn’t, I would imagine that if I typed in ‘voice user interface’ or whatever search terms I used before in the ACM, I would get exactly the same results, plus a few others. If they’re any different, then I’d assume that they’re using different search technologies underneath . . . I don’t see the point in doing it if it’s not!” – HCITD1

The ACM binder analogy

When asked about how the ‘save results to binder’ feature of the ACM digital library might work, ACM users were able to ‘run through’ their mental models, based on the analogy of a paper binder, to varying degrees of success. All users saw the binder as a repository of searches that had been conducted. For example, one participant explains the potential time and effort-saving benefit of such a feature:

“Because if you’re doing lots of searches. . . and you don’t wanna be typing in lots of combinations and variations of searches you’ve done before, then it’ll save your actual search, or the search results to your personal binder and I suppose you could log in and see your binder and go straight to the searches rather than having to type in the searches again.” – HCITD1

However, ACM users were often unclear about how exactly the binder would work, particularly with regard to how it would store several hundred search results:

“I imagine that . . . I don’t know . . . either you select particular results to stick in it, or it saves the whole search. I presume that it’s customisable and offers you to either save all the results that you’ve found or save some of them. And I presume that you have to be registered in order for it to remember that they’re you’re searches. So perhaps . . . I mean I’ve just got 7893 results from a search . . . I would imagine if I clicked ‘save results to binder,’ it’ll save all these results to the binder. And I would imagine that maybe it would give me the option of filtering it slightly. Maybe it would ask whether I just want to save 500 [results] instead of over seven thousand. But I don’t know for sure.” – HCITD1

The mental model of another participant appeared to become clearer as they ran it through, realising that storing vast numbers of search results might be achieved by storing the results dynamically rather than storing a static list:

“I presume what it does is it makes a little folder of your searches, but I’m not really confident in using it, so I’ve never really tried it . . . Maybe, since there’s quite a lot of results here . . . this is 200 . . . I presume it would save all those . . . but that’s quite a lot to save in a folder, especially if you do more searches . . . so maybe it saves the ones you’ve selected and asks you to choose which ones you want to save to a folder. I’m not actually sure. I guess it would have to be categorised in some way with what I put as the search terms, so I’d imagine underneath that as a heading, it would have a list . . . actually, maybe it wouldn’t . . . maybe you could click on that [the search terms] and it would bring back

the results it's found already for you . . . so maybe the folder would just be a list of these search terms.” – HCITD2

Another participant introduced a second analogy, the concept of a ‘bookmark’ from an Internet web browser to help reason about how the binder feature might work:

“I’m guessing it means you can save some sort of link . . . you can maintain a link of interested articles and stuff like that . . . I usually find I just download any articles I find interesting, so in that sense I maintain my own binder really. How do you think a ‘binder’ option like that might work? Umm . . . probably a bit like bookmarks. You can go back to stuff you’ve highlighted before. So instead of downloading an article, you could add it to the binder and then go back to it.” – HCITD2

Key mental models findings based on analogies

Some participants held the assumption that the search engine components of Internet search engines, e-commerce sites and digital libraries work in a similar manner, even if surface differences exist at the interface level or search syntax. The resulting adoption of similar search strategies between digital entities is likely to be due to an underlying assumption (Duncker 2002, Stagg et al. 1993) in users’ mental models of search engine components. This assumption might be that all search components work in broadly similar ways as they are all used for similar search-based information-seeking tasks. Such an assumption would suggest an incomplete model of search engine components and hence a negative impact on understanding the functionality of the overall digital library system (Allen 1997, Johnson-Laird 1989, Miyake 1984, Norman 1983, Norman and Draper 1986, Payne 1991, Sasse 1997, Staggers and Norcio 1993). A similar explanation, although coming from a slightly different angle, is that digital library users may not have formed a deep enough level of understanding (Norman 1983, Miyake 1984, Schumacher and Czerwinski 1992) of the function of a search component in relation to overall digital library usage, i.e. maintained a lower level of understanding in relation to Miyake’s (1984) framework adapted to explain the complex levels of understanding surrounding digital libraries.

Another assumption might be that although there may be subtle differences in how search engine components work across digital media, this does not affect how these components should be operated in terms of search syntax. Once again, such an assumption can be attributed to lack of deep understanding. Alternatively, it can be regarded, as with the previous possible assumption, as false confidence from the creation of firm boundaries (Norman 1983, Miksa et al. 1994) that do not necessarily hold firm under pressure or as a type of inconsistency between component models of users’ mental models of a digital library (Kieras 1982, Kieras and Polson 1985, Collins and Gentner 1987). Whilst such assumptions could also be attributed to a degree of ‘conceptual baggage’ (Sasse, 1997) provided by making analogies between search components across digital entities, such a claim is difficult to substantiate because the ‘baggage’ with regard to search components may be ‘invisible’ and hence difficult to identify and educate users about. This suggests that although there is scope for providing clarity to users with regard to how search engine components belonging to different search entities should be used, this may not be as simple as informing users that search components across digital entities do not necessarily work in, nor should be used in, the same ways. Recommendations on how this can be achieved are discussed later in this report.

Further interesting mental model-related findings arose from questioning ACM digital library users about what they thought the ‘save results to binder’ feature of the library might do. Aside from uncovering interesting findings about perceived access restrictions, it provided evidence that suitable use of analogies in the design of digital libraries could be beneficial to users. Users were able to make inferences based on a paper binder analogy through ‘mental simulation’ (Collins and Gentner 1984, Kieras and Bovair 1984, Payne 1991, Rutherford and Wilson 1992) and one user was

able to use this as a means of questioning their own assumptions. Hence although further research is required into the successful use of analogies in digital libraries, this suggests that carefully introducing analogies into digital library interfaces can create benefits by allowing users to reason through inconsistencies in their mental models in order to ascertain how the feature might work, even where the function of the digital entity (in this case the digital binder) may differ from that of the source of the analogy (in this case the physical binder).

In addition, these findings suggest that should appropriate (Carroll and Olson 1988, Collins and Gentner 1987, Craik 1943, Gentner 1983, Halasz and Moran 1982, Johnson-Laird 1983, Kieras and Bovair 1984, Newman and Lamming 1995, Norman 1983, Nürnberg et al. 1995, Payne 1991, Young, 1983) and/or complementary (Craik 1943, Holyoak and Thagard 1995) analogies be introduced into digital libraries, this may lead to more effective learning of the system and creation of a rich, and less error-prone mental model for users. This is also likely to lead to greater connection and consistency between component parts of the digital library based on different analogies. (Kieras 1982, Kieras and Polson 1985, Collins and Gentner 1987).

Of course, as asserted by Halasz and Moran (1992, analogies should be introduced with caution, since they have the potential of creating added confusion as well as helping to reduce it. As highlighted earlier in the literature, care must be taken to minimise the level of ‘conceptual baggage’ (Sasse, 1997) carried by the analogy and to ensure appropriateness, complementariness, connection and consistency between analogies used.

4.27 Troubleshooting in the traditional and digital library

Participants often had troubleshooting strategies in a traditional library should they not be able to find the information that they were looking for. This often involves checking the surrounding area of the shelves where the item was supposed to be, checking the returns trolley and/or checking whether the item is out on loan before either asking a librarian for help or requesting the book is held if and when it is returned:

*“I’d ask a librarian to help me find it. Although these libraries are quite big and there’s not many librarians around. . . so if I went to the desk and said it’s not on the shelf, they’d expect me to find it. I shouldn’t have any problem locating where it should be on the shelf. And if it wasn’t there, it should be out [on loan], otherwise it’s lost and I’d probably report that if that’s the case . . . but I’d also look on the desks around that area because it might be that someone’s pulled it off the shelf and not put it back . . . and then look at this [the electronic catalogue] because it’ll tell you if they think it’s out [on loan] or not. If it [the catalogue] says it’s in [the book is in stock] then it should be either on the shelf, travelling back to the shelves, or lost. Here it’s happened where I’ve returned to get a book a number of times and it [the electronic catalogue] says that it [the book] is here, but it’s not. So I reported it as lost by filling out a form.” **“How would you know if a book is ‘travelling back to the shelves?’”** “You never actually know that for sure. You need to guess. You could ask the librarians and perhaps they would know on their system, but you’d probably assume it’s on its way back to the shelves because it’s more likely than being lost. Then return a few days later and if it’s not there, assume it’s lost and report it.” – HCIDT1*

“Usually it means the book’s gone walkabout somewhere. In that case I’d just give it a few days and see if it’s back, or possibly request the book so that I’m notified if it is returned . . . But I suppose it’s just lost in the system. It’s probably . . . well I get the impression, certainly at UCL, that library space and things like that are a problem so sometimes books don’t get returned in the right place or the system gets out of sync . . . considering that

you've got hundreds of thousands of books, there's probably a few where what it says on the system is not actually where the book should be.” – HCIDT2

“What would you do if you couldn't find one of the things in your list, if you were looking for it specifically?” *“That happened to me yesterday, and I found that they had moved the journals I was looking at last week to the stores, which was very annoying . . . but I didn't know that at first, so I looked to find it on the catalogue first, because you need to be sure first that it's not out or whatever . . . then I looked in the re-shelving areas and that's about it. I generally don't seem to bother telling anybody, because nothing seems to happen. But I would always check quite thoroughly first and if something was out on loan, or in stores, I'd put a request in using my lending card.” – LISDT1*

“Sometimes I look specifically for stuff, but half the time here things are not on the shelf when they're meant to be. And adding to that [problem] there isn't enough books for students on the course. I can't be bothered to look on the trolleys to see if it's being re-shelved or not. If that book wasn't at the classmark that it was supposed to be, I would have a look at the other books in that classmark to see if there are other useful things there.” – LISTD2

When more detailed searching assistance is required, the role of the librarian in aiding the search was also highlighted. This participant identified that the librarian, apart from providing 'how-to-use-it' knowledge about the traditional library can also provide users with searching knowledge (almost meta 'how-to-use-it-knowledge):

“I'd probably ask the librarian I suppose . . . if I really couldn't find what I wanted and I'd tried on the catalogue and the databases and stuff . . . yeah, I'd say 'I'm looking for information on this topic and I can't seem to find anything.' Maybe actually I'd go home first . . . take some books out and have a look properly, then I'd probably ask the librarian on the second attempt, 'cause when you don't know anything about the topic, it's a bit vague for you to say 'oh, I can't seem to find anything on the design of children's libraries.' I'd want to tell them, 'I've got these books out, I've found these references too . . . can you help me to follow them up? Or what do you think would be the best way of taking this further?’” – LISTD1

One participant also highlighted that librarians could prove to be a useful resource if the electronic catalogue was broken, since they might keep a paper record of how items are organised in the traditional library:

“I would imagine [librarians] have paper records, so they could tell me where to find relevant books if the system goes down without me having to go from shelf to shelf.” – LISTD2

Participants regarded troubleshooting information-seeking problems in a digital library to be nowhere near as straightforward as with a traditional library:

“Perhaps that's where a traditional library has a slight edge, because they can at least tell you where to go if you can't find where you are.” **“What would you do if you couldn't find what you were looking for in a digital library?”** *“. . . If it was a subject area and I was doing subject searches, then I guess I would give up . . . unless it was really important. But I can't envisage not finding anything useful at all. But I think I would give up if I had lots of trouble, just out of sheer exhaustion.” – HCITD1*

“There wouldn’t really be much I could do, I would imagine. I have never sent an e-mail to anybody to say . . . I dunno! But there is not much you could do! You might know people that search better . . . and they you would maybe speak to them . . . but in this setting, I wouldn’t go to a librarian or whatever to see if they could help.” – LISDT2

“Usually I just give up, it’s very frustrating! That happened to me yesterday as well! I was looking for some publication that the British library did and it was on their website, and admittedly it was in 1998, but I thought it might still be there or perhaps in the British Library . . . but I’ve been to the British Library and looked on the catalogue and it’s not there and it’s very frustrating. So I’ve e-mailed them about it and they haven’t got back to me! It is frustrating, it’s awful, because you’ve got nowhere to go [for help]. At least in the [traditional] library, there might be something next to it that might still be relevant. You can get round it more I think with traditional things . . . but when it’s a digital library, I just feel hopeless!”

Participants do, however, suggest potential avenues for exploration if an item cannot be found in a particular digital library, either by turning to another digital library altogether or to a general Internet search engine:

“Something might be published in a newsletter and then the author’s made the content available to another journal and they’ve gone and published it, so that’s one way of trying to find something, by looking at alternative places that it’s been published. But some things you know you’re just never going to find!” – LISDT1

“I’d probably try the Internet and that is a huge . . . it’s not catalogued or classified, so it’s not technically a library but . . . you might find something on the Internet.” – LISTD1

Key mental models findings based on troubleshooting

Traditional library users held detailed knowledge of library procedures, in effect ‘how inputs become outputs’ (Kieras 1982) in the library. This allowed them to form well-reasoned behaviour patterns (Norman, 1983) when they could not find a particular item where it was supposed to be on the shelves, or encountered another problem in the library where troubleshooting was required. In effect, this provided users with procedures for troubleshooting and maintenance (Allen 1997, Kieras 1982, Norman and Draper 1986, Payne 1992, Staggers and Norcio 1993).

Users recognise that some of this troubleshooting knowledge can be provided by librarians, along with other ‘how-to-use-it’ and ‘how-it-works’ knowledge about the library and about information-seeking strategies in general. The lack of such knowledge in order to aid troubleshooting in a digital library does not arise from errors or inconsistencies in user’ mental models of digital library troubleshooting (or at least no such evidence was articulated in our study). Hence we can conclude that users’ mental models lack troubleshooting knowledge because many digital libraries simply do not facilitate troubleshooting, particularly with regard to searching behaviour. This highlights the need for digital libraries to facilitate troubleshooting in order to avoid users from taking other forms of potentially unnecessary or inappropriate remedial action when things go wrong, such as turning to another digital library altogether or to a general Internet search engine. Recommendations on how best to facilitate troubleshooting are discussed later.

4.3 Summary of findings

Users believed that traditional and digital libraries could fulfil different but overlapping information-seeking goals, for example, assessing relevance of documents with a digital library was

highlighted to be quicker and easier than if using a traditional library, whilst many users regarded traditional libraries as better at bringing back relevant results. Because users tend to ascertain relevance of traditional and digital items in different ways, this suggests that users are aware of the appropriateness of the methods and actions that they employ when assessing document relevance in both types of library.

Users had a good idea of the layout and procedures in the traditional library and therefore were far more able to articulate procedures for troubleshooting in the traditional library than the digital library. The lack of such depth of knowledge with regard to digital libraries suggests the need for digital cues as well as suggesting the potential role of the librarian, whether conventional or in the form of digital assistance, to aid troubleshooting. Our findings also highlight the need for digital libraries to facilitate troubleshooting in order to avoid users from taking other forms of potentially unnecessary or inappropriate remedial action when things go wrong, such as turning to another digital library altogether or to a general Internet search engine. Troubleshooting assistance might also help address the misconception highlighted in our findings that browsing is only possible in a traditional and not a digital library.

The lack of detailed knowledge of 'how inputs become outputs' in a digital library might help explain why digital library users are often prepared to conduct searches which they know from the outset are unlikely to yield valuable results. Our findings suggest that this lack of knowledge might be caused by lack of relevant feedback from the system and highlights the important role that system feedback can play in ensuring as complete a mental model as possible is formed by the user in order to maximise users' understanding of the system and a challenge for digital library developers is to design systems that promote the creation of mental model assumptions that are likely to take users towards their goals rather than further away from them. This is particularly pertinent with regard to access restrictions, which were also highlighted to be an important part of users' mental models of digital libraries and were shown to have a potentially negative impact on user behaviour.

Users' varied knowledge of how search terms are turned into search results (how inputs become outputs) also might also be related to the fact that many users believed that the search components of digital entities such as digital libraries, Internet search engines, electronic library catalogues and e-commerce sites work in a similar manner, even if surface differences exist at the interface level or search syntax. An interesting symptom of this varying level of understanding is the distrust that MSc HCIE-E students felt for the ACM relevance bar, resulting in the formation of heuristics based on personal opinions of relevance that may or may not be appropriate for finding the most relevant information in the digital library, especially in all information-seeking contexts.

Our findings suggest that one potential way of reducing some of the confusion surrounding how inputs become outputs (and surrounding how digital libraries work in general) is by carefully introducing analogies into the digital library interface if and where appropriate. This can create benefits by allowing users to reason through inconsistencies in their mental models in order to ascertain how the feature might work, even where the function of the digital entity may differ from that of the source of the analogy.

The section which follows discusses the themes, similarities and differences from our findings in relation to the literature.

5. Recommendations and discussion

5.1 Overview of recommendations

This section discusses potential improvements to digital library usability by relating our findings to the literature in the early sections of the report. In doing so, and as highlighted in the previous section, we suggest the need to:

- Improve the scope for troubleshooting in digital libraries.
- Educate users about and improve the scope for browsing digital libraries.
- Improve support for the assessment of document relevance in digital libraries.
- Improve system feedback to encourage the development of rich mental models and to avoid errors and inconsistencies in such models.
- Ensure that users make correct and appropriate comparisons or analogies, especially between the search engine components present in digital libraries and other places where such components can be found, such as Internet search engines, e-commerce sites and electronic library catalogues.

The above list will be discussed in detail in this section of the report. We also discuss our findings in relation to Bates' (2002) cascade model of digital library interactions and Miyake's (1984) framework for understanding complex device knowledge.

5.2 Discussion of recommendations

Improve the scope for troubleshooting in digital libraries

In a similar vein to Stelmaszewska and Blandford (2004), we argue for the potential of 'digital librarian assistance' not only to provide context-dependent and dynamic help, but also to provide help with authentication issues. At one extreme, such assistance can be fairly limited and passive. For example, a simple expert system could be developed to provide users with searching and browsing tips and strategies or information about how best to proceed when they cannot find what they are looking for in the digital library. At the other extreme, according to Marchionini (1995), a self-evaluating and self-modifying digital librarian could be developed along the like of Stephenson's (1992) work of science fiction – 'Snowcrash.' Further research is required into user-oriented approaches to provide troubleshooting in digital libraries, particularly with regard to how passive or active such support should be. A very passive system which is seldom noticed or used is likely to be just as unhelpful as a librarian equivalent of the Microsoft Office Paperclip which might be regarded by users as constraining and possibly intrusive. However, we suggest that providing dynamic feedback based on how users appear to be using the system can be used to create, enforce or re-enforce the formation of correct and richer mental models and to make users aware of any incorrect or inconsistent assumptions that they hold.

There is also potential to extend the notion of providing dynamic feedback in other ways; users who appear to be trawling through several hundred search results, such as LISDT1, might benefit from being told other suggested (and narrower) search terms that might have brought back many of the same records. Conversely, users who obtained no results because of heavily restricted (i.e. narrow) search terms might benefit from suggestions such as 'try searching without using inverted commas' or 'try searching the full-text of the articles and not just the titles.' Such a system could offer

'intelligent' correction when words are spelt incorrectly or the digital library software finds that a similarly spelt search term yields more results and hence a mis-spelling might have been made

A similar approach to improving digital library usability was taken by Stelmaszewska et al. (forthcoming), who found that users supported by adaptive 'tips' were more likely to reformulate queries and hence develop more effective search strategies. The system developed checked each search query against a set of criteria, such as how many results were returned, how many documents contain each search term and whether the search includes the 'and' or 'or' Boolean operators etc. Stelmaszewska et al. (forthcoming) explain that "combining these criteria results in about thirty conditions, of which about ten emerge as distinct situations for which tailored tips were devised." These 'tips' do not "engage users in a protracted dialogue at the beginning of the information seeking process, but [offer] them advice when results are returned and users need to make a decision about what to do next."

Stelmaszewska and Blandford (2004) suggest that the above approach of providing context-dependent help is likely to reduce the feeling of 'lostness' in the digital realm. We have found that much of this 'lostness' arises not from errors or inconsistencies in user mental models of digital library troubleshooting, but because many digital libraries simply do not facilitate troubleshooting, particularly with regard to searching behaviour. Hence our findings based on the troubleshooting elements of users' mental models of digital libraries also suggest the need for search assistance as highlighted by Stelmaszewska and Blandford (2004) and implemented by Stelmaszewska et al. (forthcoming). Interestingly, whilst Stelmaszewska et al. (forthcoming) arrived at these recommendations from conducting a study on information-seeking behaviour, we arrive at similar recommendations through taking a mental model approach. This is probably due to the fact that users' mental models can drive their information-seeking behaviour, yet the closest we can get to internal processes such as mental models is to observe and question users' knowledge and behaviour. Hence researchers such as us, who aim to improve users' mental models, are automatically and simultaneously working towards improving digital library usability.

To extend the notion of context-dependent help, we also suggest that it may be possible to monitor the patterns of search terms entered by a particular user and make suggestions based on peer searching performance, for example 'people who searched for 'digital library evaluation' also found it useful to search for 'digital library usability' or 'people who read this article also read the following related articles.' Of course, sophisticated artificial intelligence would be required to ascertain whether search terms were, in fact, related to one another. This is likely to aid parsimony and mental planning by prompting users to think ahead regarding their information seeking strategy. However, this might introduce unnecessary side-effects associated with users over-rationalising behaviour when being observed by a researcher.

We also suggest that troubleshooting assistance could be provided to users by giving an indication of how the system judges the relevance of records based on the search terms provided. This should not involve a detailed explanation of how searching works with regard to the particular digital library or make any reference to the algorithms employed in searching or the underlying technology used. Instead, basic information such as 'x amount of results obtained by searching for all/any of the separate words/the entire phrase in the title and/or abstract and/or full-text of documents.' This syntax could be extended to encompass other Boolean conventions, such as 'excluding the following separate words/the entire phrase.' This suggestion can work hand-in-hand with the non-adaptive 'tips for beginners' functionality implemented by Stelmaszewska et al. (forthcoming), which offered users a set of detailed instructions and examples on how to search the digital library. Overall, these recommendations are likely to reduce the chance of incorrect assumptions being made by users about how the system searches and might aid users in constructing an appropriate searching strategy suited the particular digital library being used.

A potentially useful alternative to automated troubleshooting is to recognise the role of real librarians as intermediaries, as discussed by Adams and Blandford (forthcoming). One option is to provide semi-structured 'help' forms for users to submit by e-mail to an expert in using the digital library. It is also possible to allow digital library users to converse in real-time with experts using an Internet chat medium in order to solve problems and improve their understanding of how the digital library works and how to use it. An even more radical measure, although potentially more expensive, is to provide direct support to users through their browser, showing them by example how to get the most out of the library in relation to their particular goals. The technology to achieve this is already available and supplied automatically with many desktop computers. This could be offered as an option should all other troubleshooting options fail.

Educate users about and improve the scope for browsing digital libraries

Browsing is a type of search behaviour featured in many of the users' mental models of traditional libraries in our study, yet interestingly none of the users articulated that a similar behaviour would be possible in the digital realm. This is surprising, since browsing may lead to serendipity and Blandford et al. (2001) found that serendipitous discoveries were the main source of really positive user experiences when working with digital libraries.

The popularity of browsing in a traditional library might be partly attributed to the fact that users were aware of a strong hierarchical organisation of items in the traditional library. This suggests that the misconception that browsing is not possible in traditional libraries might be addressed by making digital library users aware of the hierarchies present in the digital library that facilitate browsing, as a substitute for the familiarity of the traditional library environment provided by physical cues (Stelmaszewska and Blandford, 2004). This might solve the problem of transferring classification knowledge from the traditional to the digital environment, as highlighted by Greenberg et al. (1992). This might be accomplished by providing hyperlinks to allow users to browse journals on similar subject areas, browse articles belonging to a particular issue of an electronic journal or browse issues of a particular journal title. Whilst this functionality is present in many digital libraries, a challenge for digital library developers is to make this functionality prominent and more obvious to users. It may also be possible to provide browsing functionality according to subject area (in a similar fashion to Internet search directories) as well as according to the journal or conference proceedings etc. in which the article is featured. This might be achieved through the provision of digital troubleshooting as discussed earlier.

Improve support for the assessment of document and digital library relevance

Stelmaszewska and Blandford (2004) highlight quality assurance differences between physical and digital libraries, where users often find difficulties in making the distinction between general web quality and that of documents in a digital library. This supports the argument for an inter-publisher initiative that brings digital library content from several publishers together in one place. By bringing content from several well-known publishers together, this is likely to reduce the need for using Internet search engines as a medium for aiding digital library searches and hence reduce the ambiguity surrounding the potential quality of the documents retrieved.

Increased support for the assessment of document relevance in digital libraries can also be provided by implementing a formal system for reference recommendations, as highlighted by Stelmaszewska and Blandford (2004). A potential implementation of reference recommendations, aimed at increasing the perceived 'quality' of electronic documents in digital libraries in line with those in traditional libraries, might include a peer ratings system similar to Amazon.com. Digital library users could make quantitative assessments of various aspects of an article in order to aid future users' to judge its potential quality or relevance.

With regard to the potential of translating some of the more physical aspects of relevance from the traditional to the digital realm, we note that it is not possible to emulate physical properties of traditional library items in a digital library, such as 'wornness.' Also with digital libraries, there are always multiple copies of all documents available due to the very fact that an electronic medium does not propose physical restrictions of space. Similarly, electronic documents do not have 'covers' from which users can judge the relevance of the item. However, for those digital libraries which do not provide a short abstract along with the title of articles on the search results page, an abstract could play a similar role to the cover of a paper book or journal. The abstract could be automatically presented when the user hovers over a particular title in the list of search results for a set period of time. Some other indications of relevance might also transfer well into the digital domain. For example, digital libraries could include a 'popularity rating' for each document based on how many times it has been downloaded relative to other documents in the library. Hence we agree with the assertion made by Nichols et al. (1997) that usage in a digital library can be recorded in great detail.

Similarly, 'flicking' or 'skimming' could be facilitated by enhancing document reader software or browser plug-ins, for example by allowing the user to cycle between the main headings within the document by turning the mouse wheel or by clicking the right mouse button. 'Reference hopping' could also be enhanced by introducing hyperlinks in the reference section of PDF documents, where appropriate. This would allow the user to click-through hyperlinked references in documents and be taken to the relevant electronic information resource which carries the potential article, if applicable, even if the article is held by another publisher. This is an extension of the 'citations' feature of the ACM digital library, which was used by one participant. Whilst this is already possible in some digital libraries such as the ACM, ideally such a system should also provide links between documents held by different publishers.

To assess the relevance of entire library collections to the information-seeking task at hand, our findings suggest that another challenge for digital library developers is to make it more obvious which information-seeking goals can be fulfilled by a particular library or collection of libraries. This information might include whether the full-text of a document is downloadable from this particular digital library and whether any access authentication, such as entering Athens login details, is required in order to do so. It might also include a list of which journals are held or which topic areas are covered by the digital library. Whilst such a list is already provided by most digital libraries, it is often not immediately accessible to users who may be disoriented or unsure of the relevance of the library to their information search at the outset.

Overall, these findings suggest that improvements can be made to digital libraries in order to facilitate easier judgement on how relevant the library content might be. The use of recommendations from peers adds weight to the earlier argument for a peer-rating system of digital library documents. Similarly the difficulty of determining which digital libraries contain what information suggests the need for a concerted effort of co-operation between digital library providers similar to the potential initiative discussed earlier.

Improve system feedback to encourage the development of rich mental models and to avoid errors and inconsistencies in such models

System feedback was found to play a role in helping users to clarify assumptions in their mental models of digital libraries, although sometimes this did not yield greater richness or clarity as intended, but instead unknowingly directed the user away from their goal. Norman's (1986) action cycle provides a useful basis for proposing usability improvements for digital libraries which are focused on bringing users toward rather than away from their information-seeking goals; we can begin to bridge the gulf of execution when using digital libraries through the provision of dynamic or context-dependent help, especially with regard to searching. Emphasis could also be placed on

educating users on how to devise a personal method of efficient and effective searching that is dependent on the context and requirements of their search. For example, users could be informed of synonymous search terms. These terms could be used to either broaden searches that only bring back few results or narrow searches that return too many results, by providing more specific (and hopefully more relevant) key words. Other proposals discussed in the previous section, such as informing users of the level of access restrictions in force in a particular digital library and providing information on the broad subjects, journal titles and years/issues of journals held in the digital library may also help to bridge the gulf. In a similar fashion, we can begin to bridge the gulf of evaluation by informing users exactly what search terms have been searched for and where in the article occurrences of words had been sought (as discussed earlier). This provides greater transparency to allow the user to ascertain with some certainty whether the desired effect had been achieved, by allowing an assessment to be made about whether the search terms or strategy needs to be modified in order to return more or more reliable search results, or whether the required content simply is not available in the current library.

The above recommendations are in line with Katzeff's (1999) assertion that if sufficient clues are provided by the system designer to suggest adequate mental models of system behaviour, the system will be comprehended. We argue that there is an overall need for greater 'how-it-works' transparency in digital libraries; a simple, yet currently unsatisfied need to inform users of 'what the digital library system is doing' and 'how it is doing it.' We are not suggesting the need for detailed technical descriptions of how the underlying search technology retrieves its results or the mathematical algorithms involved in doing so. Instead, we suggest that users are provided with enough 'how-it-works' knowledge to allow them to use the library efficiently and effectively. Designers should not provide too little of such knowledge, as is currently the case with most digital libraries, nor should they provide too much and risk 'blinding the users with science.'

Ensure that users make correct and appropriate comparisons and analogies

Whilst the use of analogies was not widespread amongst participants, interesting comparisons were noted between the search engine components present in digital libraries and other places where such components can be found, such as Internet search engines, e-commerce sites and electronic library catalogues. This suggests that users' mental models of traditional library catalogues may be partly based on expectations or assumptions from their models of other similar domains, such as digital libraries. Much of the literature on analogies also applies to such comparisons. For example, Halasz and Moran (1982) argue that the user drawing upon an already familiar analogy when learning to use a new system is potentially dangerous. They argue that although analogies may help a user to learn and understand a new system, they may hinder novices from developing a good understanding of the system. The same can be said when making comparisons between domains, whether based on analogies or not.

Our findings suggest that although users might be aware that the search engine components of Internet search engines, digital libraries, e-commerce sites and electronic library catalogues might not bring back search results in exactly the same way as each other, lack of knowledge about how the search engine components bring back search results hinders users from ascertaining exactly what effect entering or not entering particular search terms or operands might have on the quantity and relevance of the search results returned. This cements the need for more transparency in how results are organised and obtained.

Returning to the broader issue of analogies, our study supports the view that improving digital library usability might not be as straightforward as designing or teaching digital libraries by analogy or by comparison with traditional libraries or other digital entities such as Internet search engines. This is because, as noted in our study, such comparisons rarely yield direct parallels between concepts, whether between traditional and digital libraries or between digital libraries and other

digital entities. Put another way, similarities lie within the differences that users' found and differences within the similarities. This in effect acts as a type of 'meta-conceptual baggage,' making teaching and learning by such comparisons difficult and potentially problematic. Hence improving digital library usability will never be as easy as teaching 'how-it-works' and 'how-to-use-it' knowledge by referring solely to the similarities and differences between digital libraries and other entities.

A potential solution to ensure correct comparisons are made is to follow Halasz and Moran's (1982) recommendation of aiming to provide an abstract conceptual model that steers clear of making comparisons between entities and hence avoid conceptual baggage, whether meta or actual. However we argue that this approach simply sweeps any potential confusion arising from users making comparisons between domains under the carpet. A more useful approach is to tackle such confusion head-on. Although difficult, this can be achieved by the skilful use of inter-domain comparisons to teach users when concepts hold, do not hold or only partially hold when transferred between domains. One way of achieving this is to teach users to observe the similarities within the differences and vice versa when using domains that may be similar, or have a similar search engine component. This is similar to the 'analogical encoding' technique proposed by Gentner et al. (2003), where learners compare two examples and by doing so come to understand the underlying structure common to both. We agree that a bi-directional approach to map knowledge between domains can be useful. However our approach does not assume that "focusing on precisely those aspects that generalise across cases," (Gentner et al., 2003) or using concrete cases such as 'x is similar to y' is enough to ensure richer, more consistent and less error-prone mental models. Instead, differences within the similarities and similarities within the differences should be explored in order to gain a deeper understanding that goes beyond merely generalising about how digital libraries, or other systems work.

Consider an example of learning using our approach; users might be taught to observe how entering words in inverted commas treats the words as a phrase in Google and hence can be used to narrow search results when too many are returned. However, using inverted commas when searching the ACM Digital library seems to have little effect in narrowing down search results and other digital libraries, such as the HCI Bibliography, use a different search syntax entirely to search for phrases. Similarly, users might be taught to observe that browsing a certain classmark area in a traditional library will find other related items, since classmarks refer to subjects or categories and that at the lowest level, books by the same author in the same category are often placed together. Browsing a digital library is very similar, since browsing a particular journal title is likely to show a list of issues of that particular journal. However, at the lowest level journal articles are arranged by issue number. Therefore finding articles on a particular subject, written in the same journal by the same author may require a different approach. Some digital libraries may facilitate browsing by author, where all articles that are held in the library written by a particular author can be listed. Other digital libraries may offer the same functionality, but only by changing the nature of the information-seeking task from browsing to searching for a particular author name. These 'differences within a similarity' are subtle, but need to be appreciated by users nonetheless in order to ensure that their mental models are as accurate and consistent as possible.

Interestingly, however, participants did not make many direct comparisons or analogies between specific entities of traditional and digital libraries, even when asked whether they noticed any similarities or differences when using both types of library. This is surprising, since Duncker (2002) found that although many features of traditional libraries do not transfer well to the digital context, background knowledge of library material organisation is required for the use of digital libraries. Hence we argue that comparing some less-known features of a digital library with a similar feature or idea in the traditional realm might prove to be a useful tool in helping users to create richer, more consistent and less error-prone mental models. Care must, however, be taken to emphasise that traditional and digital library concepts often do not have direct parallels and hence

users should not regard them as simple surface similarities, but instead question the similarities and differences within the parallels in order to gain a deeper understanding of the digital library.

In practice it may be impractical to teach every user the required level of detail provided by such comparisons. These comparisons may be difficult to articulate or encapsulate in instructional materials for digital libraries, and users may simply not wish to invest the time and effort to learn the intricate rules and exceptions for using a particular digital library. One solution is devising practical inter-domain tasks to illustrate differences within similarities and similarities within differences between several domains at a time, with a view that mental models of each domain will be enriched. However, particular systems in different domains provide their own exceptions to rules that make doing so a minefield. Therefore we argue that there are only two practical options, one suitable for the short-term and one for the long-term:

1. Use practical inter-domain tasks to educate users on the ethos of creating a richer mental model for themselves and for uncovering errors, limitations and inconsistencies in their own models.
2. Follow a long-term goal of attempting to make digital library 'how-it-works' and 'how-to-use-it' knowledge more uniform across digital libraries in order to ease confusion and warrant the investment of time to learn this type of knowledge in detail. This is a similar approach to that of the CrossRef inter-publisher search front-end, which uses Google organisation and searching conventions, yet restricts results to the full-text of several digital libraries.

The pertinent issues surrounding these two approaches will now be discussed in detail, starting with the short-term option of educating users on the ethos of improving their own mental models. This approach is short-term because it actually treats the symptoms and not the cause of the problem and still requires users to invest significant time and effort in learning how digital libraries (or any other types of system) work and how to use them. Even though the participants in our study were all regular users of at least one digital library, this was time that they do not appear to have seen fit to invest already. Therefore we must question whether by following the first option, we may be attempting to educate those who do not wish to be educated, or at least do not wish to invest significant time being educated.

A potential workaround is to suggest that users invest time as and when it is felt that the payoff of such an investment will yield more benefits (i.e. improved usability, more or better quality search results) than the effort required to produce the benefits. Although this is difficult to predict and is likely to vary on a case-by-case basis, usually a rough time or difficulty estimate can be made by users. That estimate can be refined on the basis of actual time expended on a previous occasion when the user is considering investing further time in learning how to use a particular digital library.

Working with the above 'ad-hoc' method of learning, users can actively seek to enrich their understanding of the system and hence develop their mental models. The mental models concepts identified from the literature might provide a basis for questioning one's own mental model of digital libraries, although an indirect mapping still exists between the mental models concepts and questions to ask oneself or tasks to undertake in order to learn more about how the system works or how to use it. A simpler approach is to ask oneself for each significant aspect of the system; 'how does it work?' (to uncover how-it-works knowledge), 'what actions do I need to perform to make it work that way?' (to uncover how-to-use-it knowledge), and 'how do I use my knowledge of the system appropriately and effectively?' (to uncover how-to-use-the-how-it-works knowledge). The answers to these questions, just like mental models themselves, will be constantly edited and refined. This can be achieved by asking similar probing 'what,' 'how,' 'why' and 'what if?' questions as used in this study, for example 'why did the system just do x when I was expecting it

to do y?’ ‘What if I changed approach x to approach y, or I used setting y instead of setting x?’ These probing questions can extend to inter-domain comparisons once the user feels comfortable in doing so; ‘How does searching this particular digital library differ from the Internet search engine that I use the most?’ ‘What about the electronic catalogue in the traditional library that I use the most?’ In effect we are advocating system curiosity, but with the benefit of enriching and informing users’ mental models. These recommendations address not only the above findings, but also begin to address the ‘lost in hyperspace’ problem raised by Theng et al. (2000) and go further to reduce the feeling of ‘lostness’ in the digital realm as asserted by Stelmaszewska and Blandford (2004). They also present a practical approach to addressing the wider implications of the study by Slone (2002), who found that users’ expectations of electronic catalogue interaction were sometimes based on their understanding of the Internet.

Finally, it is interesting to examine the above suggestion in light of the ‘blurred boundaries’ of digital libraries as suggested by Van House et al. (2003). Part of the reason for the blur might be that the definition of a digital library can vary in scope and can be defined across a continuum of possibilities, (Harter, 1997) as discussed earlier. It can be argued that if digital library designers’ standpoints on what constitutes a digital library vary across a continuum, so too are the digital libraries which are designed. Hence one contemporary digital library might work differently to another (and hence require different how-it-works and how-to-use-it knowledge from its users) purely due to the standpoint of the designer. This short-term solution does not propose to make these boundaries less blurred, however if users are made aware that digital libraries can mean different things to different people, they are more likely to be more cautious when making assumptions about libraries or generalisations, or even when making inter and intra-domain comparisons.

Now we turn to the second and longer-term goal of attempting to make digital library ‘how-it-works’ and ‘how-to-use-it’ knowledge more uniform across digital libraries. This option clearly has commercial implications that are beyond the scope of this study and includes what might prove to be an incorrect underlying assumption that uniformity will suit and benefit all types of digital libraries, in effect shifting all digital library implementations to towards a particular point in Harter’s (1997) continuum.

Such an initiative would allow users to search a variety of digital library sources for relevant documents. The ‘CrossRef’ pilot shown to those participants in the study who used the ACM digital library begins to serve this purpose by allowing users to search for articles across several digital libraries. However, our findings suggest that traditional Internet search engines still have a role to play in both traditional and digital library searches. Perhaps a service such as CrossRef could be merged with an Internet search engine to search the entire Internet should the required article not be available in the digital libraries participating in the initiative. This is based on the notion of providing the user with information on where they are likely to find a particular electronic journal or article if it is unavailable in the current digital library. In a similar way, such a service could support traditional library searches by linking to the Amazon or an equivalent database of all books currently in print. The notion of an ‘electronic library card’ could also be incorporated into such an initiative, by making access issues associated with obtaining a particular document transparent from the outset (i.e. from the list of search results provided). This suggestion is expanded upon later in this section.

In the case of the CrossRef inter-publisher search front-end described above, Google organisation and searching conventions for digital library searches shift participating digital libraries towards the broader side of Harter’s (1997) continuum. This may create further usability problems, by taking a potentially flawed ‘one size fits all’ approach. More detailed research is required to determine the potential impact of such an option.

However in the meantime, there are also clear benefits of this long-term approach which, we argue, are likely to outweigh the drawbacks. Uniformity will allow greater ease of learning and searching across publishers, overcoming traditional inter-publisher access restrictions and the surrounding confusion. A common and consistent approach to troubleshooting can be provided, perhaps including elements of ‘intelligent’ dynamic and context-dependent help or a ‘digital librarian’ as discussed earlier. All of which will help encourage the development and refinement of richer, more consistent and more error-free user mental models and help create a more appealing effort-reward trade-off for investing time learning the way the digital library works. Whilst this is not the forum to argue for or against commercial brands such as Google taking a role in this initiative, it can be argued that should the front-end for several digital libraries also use identical organisation and searching conventions as a popular Internet search engine, digital library usability is likely to improve (providing of course that such a system is perceived as easy to use). There is also likely to be a mutual benefit when building mental models of digital libraries based upon a search engine front-end, since the ‘blurred boundaries’ of digital libraries are likely to become more concrete.

Discussion of findings in relation to Bates' (2002) cascade model of digital library interactions and Miyake's (1984) framework for understanding complex device knowledge

Earlier we asserted that the cascading nature of Bates' (2002) model suggests that incorrect mental models of certain aspects of a digital library might also block the formation of richer mental models of earlier layers of the model. Our findings suggest that this is not as large a problem for digital library usability, since users were willing to persevere and able to obtain documents from digital libraries that they had not used for some time, or had never used previously. However, those participants who struggled with the interface layers of the library are potentially more likely to abandon using the current digital library for their information task and may have refrained from doing so purely because they were being observed. Interface-level problems can, however, be regarded as ‘low hanging fruit’ that are ready to be picked and hence can be solved relatively easily compared to problems associated with deeper layers of the model.

Our findings suggest that users are unwilling to invest time in delving into the deeper layers of Bates' model and hence gaining deeper ‘how-it-works’ and ‘how-to-use-it’ knowledge about the system. This is why we argue for greater uniformity with regard to digital library design. Uniformity is likely to yield greater user understanding of the early layers of the cascade of interactions and hence allow users’ to focus on understanding the deeper layers of digital library interaction, such as ‘how searching works’ or how items are organised in the library.

Earlier we also suggested that since the ordering of the layers in Bates' (2002) model may differ depending on the specific digital library system being analysed, forming a rich mental model of digital libraries may be challenging because with every reshuffling of layers in the cascade model for different digital library systems there is the potential of further incorrect assumptions being formed in a user's mental model. An inter-publisher initiative such as the one described earlier also addresses this issue, since the uniformity that the initiative may bring will make many of the layers static, removing the need for users to need to re-shuffle their knowledge when searching multiple publishers. Therefore we argue that such an initiative has potential for reducing the level of errors in user's mental models, increasing consistency and reducing ambiguity by reducing false confidence in the transferability of the model between digital library systems and between digital libraries and other digital entities.

A similar argument for using uniformity to aid deeper understanding of digital libraries can be made in relation to Miyake's (1984) framework of understanding complex devices, which we applied earlier to digital libraries. A consistent interface, search component and document organisation system is likely to allow users that have slowly developed a mental model of the system to progress even deeper to more detailed levels of understanding. For example, users are likely to quickly grasp

how to use the 'objects' at the interface level that will be involved in facilitating the information-seeking (level 1). They are also likely to soon ascertain how the library is organised (level 2). Similarly, if the search engine works in a similar way to an Internet search engine that users are familiar with, not only will the user soon progress to level 3 (understanding the search engine component as serving the overall goal of bringing back search results and documents), but also to level 4 where effects of particular search terms or operands can be observed on document or result relevance. In effect, this is the most complex level of model that a digital library user will need to form, since a deeper understanding to the level of rules and algorithms involved in searching (level 5) is unnecessary. This suggests, therefore, that uniformity is likely to provide usability rewards for users. It also highlights that users are likely to be able to take a gradual, cumulative approach towards learning how a digital library works and how to use it. Users may feel happier investing time in such an approach if they can sense that progress is being made. They may also feel happier investing their time if they know that they are making a series of one-off investments that will allow them to get the maximum possible personal usability benefit for using the digital library in future.

Another argument for uniformity can be made if we apply the notion of access restrictions in the context of Miyake's (1984) model. Access restrictions would not feature in a user's understanding of the system unless such restrictions were preventing access to the fundamental goal of facilitating information seeking, by hindering browsing or searching for example. In many digital libraries, access restrictions are only made apparent to the user once they have sought and requested to download a document, not at the outset. This is concerning when applied to Miyake's model, since it would be possible for users to form a rich mental model of a digital library, perhaps even up to the top levels of the model, without necessarily coming across the notion of access restrictions. Uniformity should make such restrictions clearer and more consistent across information providers, however the potential usability impact of the 'late discovery' of access restrictions suggests that this should be coupled with requesting any required authentication at the outset if possible, or at least informing users at the outset of what level of authentication will be required later.

These findings cement the earlier recommendation for providing digital library users with simple information at the outset, such as which electronic journals are available in a particular digital library and the range of years covered by the library. In a similar fashion, simple information about access restrictions associated with a particular digital library can be provided, detailing to the user what actions they are permitted or restricted from performing during the current login session and how that situation might change if the user provided additional authentication, for example by logging in using the 'Athens' authentication service. There is also potential for creating a central repository of such meta-data about the digital libraries themselves, perhaps storing information about the electronic access and access restrictions for individual journals on the traditional library catalogue. This would allow users to determine at a glance whether their required journal article is available either on-line, off-line or both, whether the user will be able to access the title, abstract, and/or the full-text of documents held in the library, and what access requirements are required (e.g. logging on from the university campus itself, providing authentication using Athens etc.). These recommendations are likely to help users avoid frustration.

The well-understood analogy of the library card from the realm of traditional libraries could be explored in respect to the above recommendations. Whilst an electronic library card would not provide restrictions on how many items are downloaded as with a traditional library card, the analog of restricting access to the library holds quite firm. The 'electronic library card' could detail the level of access permissible at each digital library and the prerequisites for each level of access. This serves to allow users to foresee potential access-related errors that might occur, along with incorrect assumptions, errors or inconsistencies in their mental models.

5.2 Potential for future work arising from this study

Although this study can be viewed as a step forward for digital library usability, there is also plenty of scope for future study in related areas. Such areas include making digital libraries searchable under a single front-end, comparing traditional and digital libraries further, and gaining a deeper understanding into the relationships between digital libraries, traditional libraries and other digital entities through both computational models of analogies and by using other techniques such as metaphor elicitation techniques. These research areas will now be discussed in more detail.

Potential for study into making multiple digital libraries searchable under a single front-end

There is potential scope for examining the impact of making multiple digital libraries searchable under a single front-end. We have seen recently, with the pilot of the CrossRef service run by the ACM and other digital libraries in conjunction with Internet search engine Google, that such an idea may be technologically feasible and commercially viable. However the usability benefit of such an approach, although hypothesised in this study, remains to be seen.

A future study could take a traditional usability-centred approach towards examining user experiences with a system such as CrossRef compared with their use of some of the separate constituent libraries such as the ACM. Do users obtain more relevant results using the unified system than with the separate libraries? Do users feel more confident using the unified system? Does the unified system actually make the notion of access restrictions easier to deal with? Are there any situations where using the separate libraries have advantages over using the unified library and, if so, how can these be used to improve the design of such unified libraries?

It is also possible to take a more mental-model-oriented approach to such a study to investigate the hypotheses made in our study. Does a unified system actually reduce the level of errors in user's mental models, increase consistency and/or reduce ambiguity? Are there any ways in which it creates additional issues or problems surrounding the formation and development of mental models? Does basing the search component of such a unified system on an Internet search engine familiar to many users actually help the users form clearer mental models, with fewer errors? Or are there ways in which such an approach adds confusion rather than taking it away? These are all pertinent questions that a future study might choose to tackle.

Potential for further research comparing traditional and digital libraries

Although our study has compared some aspects of traditional and digital libraries, there is scope for more targeted comparison. Our study was based around a broad information-seeking task designed to promote naturalistic behaviour amongst participants. However, by providing a great deal of task freedom, it was inevitable that participants would highlight different parts of their mental models. Therefore there would not be as much of an overlap in the concepts, attributes and relationships identified between participants. This makes inter-subject comparisons in this study less than useful and potentially misleading, which is why we have not attempted to compare users' mental models, but instead to report on recurring themes that were observed.

A future study might take a different approach by being predominantly interview-based, utilising specific and targeted questions. Or such a study might be based on heavily directed tasks focused at observing specific mental models concepts or examining some of the themes, identified and discussed earlier in this report, in further detail. These types of approaches will allow direct comparisons between users' concepts (i.e. entities and attributes) and relationships (both causal and structural) (Johnson and Henderson, 2002). There is also scope for direct comparison of other mental model components of online library catalogues as suggested by Johnson and Henderson

(2002), such as metaphors and analogies and mappings. The distinct lack of the use of metaphors, analogies and mappings in our study does suggest, however, that Johnson and Henderson's framework should be validated as far as possible before the existence of all his proposed components of online library catalogues are assumed.

There is also the potential of examining the usefulness of computer software aimed at analysing users' mental models, such as the software developed by Kuipers and Kassirer (1984) which aims to develop a qualitative causal (mental) model based, although not exclusively, on the objects and relations identified from subjects' protocols. (Rutherford and Wilson, 1992). This approach is in-line with the direct comparison approach described above, as is preliminary work by Blandford et al. in applying the usability evaluation method CASSM (Concept-based analysis of Surface and Structural misfits), aimed at uncovering surface and structural misfits between the user and the system, to digital libraries (Blandford et al. 2004).

Potential for examining the evolution of digital libraries

An alternative to examining and comparing the concepts and relationships of digital libraries is to follow the approach suggested by Levy (2003), who argues that "we will fail to see the current transformation [of libraries] correctly unless we also see the ways in which current developments are deeply continuous with the past." A study examining the evolution of libraries in general might also encompass the work of Nürnberg et al. (1995), who translate several traditional library entities into the digital realm. Their translation of traditional data, metadata and process-related entities into the digital realm provide a starting point and potential broad framework for examining the development of digital libraries over time, with the view of learning from the mistakes of the past, but also understanding the many possible paths towards the future of digital libraries. Insights gained from such an understanding might yield interesting potential usability benefits and perhaps ways to help users improve their mental models of digital libraries further.

Potential to gain a deeper understanding into the relationships between digital libraries, traditional libraries and other digital entities:

By using computational models of analogies

Although we did not find widespread use of analogies in our studies, similarities and differences were identified between digital libraries, traditional libraries and other digital entities such as e-commerce sites, Internet search engines and electronic library catalogues. There is potential for the inter-related relationships between these systems to be explored using computational models of analogies. Two such models will be discussed here, although it is important to note that both models are not solely aimed at retrieving purely analogous matches. In fact, as Law et al. (1994) highlights, "the process should typically retrieve literally similar matches, often receive surface-similar matches and occasionally retrieve purely analogous matches."

The first model called ARCS (Analog Retrieval by Constraint Satisfaction) was devised by Holyoak and Thagard (1995) to explore excitatory and inhibitory links among objects and predicate pairs. As described by Law et al. (1994), ARCS uses a localist connectionist network to apply semantic, structural and pragmatic constraints to selecting items from memory. The initial stage uses semantic similarity to select a subset of memory over which to build a matching network. Next an ordering is placed on nodes representing retrieval hypotheses based on their activation.

The second model MAC/FAC (many are called but few are chosen), described by Gentner (1990), attempts to capture three psychological phenomena; People are extremely good at judging similarity and analogy when given items to compare; Superficial reminders are much more frequent than structural reminders; and people sometimes experience and use purely structural analogical

reminders. MAC/FAC begins by pairing down the vast set of memory items into a smaller set of candidates. The second stage applies structural constraints to select one (or a few) best matches (Law et al., 1994).

Both models have the potential for highlighting the surface similarities between digital libraries, traditional libraries and other traditional and/or digital entities. These similarities can then be used to decide on ways to use (or refrain from using) analogies or comparisons between domains in the future. There is, however, no cast-iron guarantee that this research will actually lead to a deeper understanding into the relationships between digital libraries, traditional libraries and other digital entities. In addition, both software models may require a significant investment of effort to learn and as far as we can tell only ARCS has been made publicly available. Even so, this area of research has the potential of yielding some interesting insights into digital library research and despite the challenges discussed should be considered as a possible area for future research.

By using a metaphor elicitation technique

A novel approach to gaining a deeper understanding into the relationships between digital libraries, traditional libraries and other digital entities and to gaining a new insight into users' mental models of digital libraries in general involves metaphor elicitation. One such technique which might have scope for application in the HCI domain is called ZMET (Zaltman Metaphor Elicitation Technique). This process does not solely aim to uncover the existence of, for example, the library metaphor in digital libraries. ZMET can also be used to uncover "the meaning of the concepts and ideas in the mental model . . . by fleshing out the concepts and structure identified through laddering probes" (Christiansen and Olson, 2002). Christiansen and Olson (2002) suggest that by using metaphors, more unconscious tacit content of mental models can be elicited than using traditional mental model elicitation techniques.

ZMET asks respondents to select several pictures that express their thoughts and feelings. These visual images become a projective medium to help informants identify and communicate the content and connections within their mental models. (Christiansen and Olson, 2002). Once the informant's meaning is well understood, the interviewer uses laddering probes to see how the ideas expressed are linked to other self-relevant consequences and concepts. Then these superordinate ideas are explored to assure understanding. This process continues until the most superordinate value or goal states are identified and detailed for that picture. This probing and questioning process is repeated until all the respondents' pictures are explored. . (Christiansen and Olson, 2002). In this way, according to Christiansen and Olson, the ZMET interview 'fleshes out' and details the meaning of important components in the mental model in the voice of the respondent.

The imaged-based focus of ZMET has potential for examining users' mental models of digital libraries in an interesting light and would make an interesting study to compare our findings with. However, the methodology might have to be altered slightly to allow users to take actual photographs that express their thoughts and feelings of traditional libraries and electronic screenshots of particular digital library systems or other digital entities that express their thoughts and feelings of digital libraries. Overall, this is certainly a viable future research option.

5.3 Conclusion

Let us now revisit the fable about the six learned blind men and an elephant. This study has illustrated that usability problems with digital libraries extend far beyond the difficulty of ascertaining the 'nature of the beast.' Even if the blind men are told that what they are feeling is an elephant, they might become confused by the different breeds (the 'blurred boundaries of the term

'digital library'). Some of the men might hold the view that the elephant they are feeling is likely to be a traditional African breed, others a rarer and more exotic breed which resembles the traditional breed of elephants far less. But the difficulty does not stop there. Imagine if there were different ways to mount and ride these breeds of elephants (i.e. access, browse and search digital libraries), and if it was not always easy to climb up and ride an elephant even if it seemed as though it would be possible without any special techniques or equipment (just as access restrictions in a digital library are not always obvious at the outset). Now imagine an elephant keeper who provides varying levels of assistance to the blind men depending on the breed of elephant that they are feeling (analogous to varying levels of online help in digital libraries). There is little wonder that these issues might cause confusion amongst the six learned blind men (or digital library users).

We have argued for creating a pure breed of elephant (i.e. making multiple digital libraries searchable under a single front-end) to reduce such confusion, a breed that the men can mount and ride (access, browse and search) in the same way. The men could turn to the elephant keeper (digital library assistant or dynamic context-based help system) in case of difficulty and be informed if they are lacking in any of the special techniques or equipment to mount or ride the elephant before they try to climb onto its back (i.e. be informed of access restrictions at the outset). This, we argue is likely to remove much of the confusion.

Our study has therefore yielded some interesting insights into users' mental models of traditional and digital libraries. These insights have enabled us to make some practical suggestions for improving long-term digital library usability. Many of these suggestions overlap or work hand-in-hand with those made by Stelmaszewska and Blandford (2004) and implemented by Stelmaszewska et al. (forthcoming), despite the fact that we approached our research with a mental model focus as opposed to a traditional information-seeking focus.

We realise that continuing research into digital library usability is warranted, but regard our study as a step forwards for digital library usability. We suggest the need for future research into users' mental models of digital libraries, particularly regarding their use of analogies and comparisons between digital libraries and other traditional and digital entities. We argue that research of this kind also has potential for taking the field of digital library usability further forwards.

Bibliography

- A. Adams and A. Blandford (forthcoming). The developing roles of digital library intermediaries. Submitted to ACM/IEEE Joint Conference on Digital Libraries 2004 (JCDL04).
- R. Allen (1997). Mental models and user models in M. Helander, T. Laudauer et al. (Eds.) Handbook of Human-Computer Interaction, 2nd Ed., Elsevier Science, NL.
- L. Bainbridge and P. Sanderson (1995). Verbal protocol analysis. In J. Wilson and N. Corlett, Evaluation of Human Work. Erlbaum Associates, London.
- M. Bates (2002). The cascade of interactions in the digital library interface. Information Processing and Management 38, 381-400.
- H. Beyer and K. Holtzblatt (1998). Contextual design: Defining customer-centred systems. Morgan Kauffman. San Francisco, USA.
- A. Blandford and G. Buchanan (2003). Usability of digital libraries: A source of creative tensions with technical developments. IEEE Technical Committee on Digital Libraries Bulletin, 1(1), 2003.
- A. Blandford, S. Keith et al. (2004). Analytical usability evaluation for digital libraries: A case study. In proceedings of ACM/IEEE Joint Conference on Digital Libraries. 27-36.
- A. Blandford, H. Stelmaszewska (2001). Shooting the information rapids. In Vanderdonck, Blandford et al. (Eds.) IHM-HCI2001, Vol. II, 51-54.
- A. Blandford, H. Stelmaszewska et al. (2001). Use of multiple digital libraries: A case study. In Proceedings of the ACM-IEEE Joint Conference on Digital Libraries 2001. New York, NY. ACM Press. 179- 188.
- M. Boren and J. Ramey (2000). Thinking aloud: Reconciling theory and practice. IEEE Transactions on Professional Communication 43(3). 261-278.
- C. Borgman (1985). The user's mental model of an information retrieval system: An experiment on a prototype online catalog. International Journal of Human-computer studies (1999) 51, 435-452.
- C. Borgman (1996). Why are online catalogs still hard to use? Journal of the American Society for Information Science, 47(7). 493-503.
- C. Borgman (2003). Designing digital libraries for usability. In A. Bishop, N Van House et al. (Eds.), Digital library use, MIT Press, Cambridge 2003.
- A. Bostrom, C. Atman et al. (1994). Evaluating risk communications: Completing and correcting mental models of hazardous processes, part II. Risk Analysis, 14(5). 789-798.
- P. Briggs (1988). What we know and what we need to know: The user model versus the user's model in human-computer interaction. Behaviour and Information Technology, 7(4). 431-442.
- B. Buttenfield (1999). Usability evaluation of digital libraries. Science and Technology Libraries 17(3-4). 39-55.

- M. Burstein (1988). Combining analogies in mental models. In D. Helman (Ed.), *Analogical reasoning*. Dordrecht, Netherlands. Kluwer Academic Publishers.
- S. Card and T. Moran (1986). User technology: from pointing to pondering. In R. Baecker, J. Grudin, et al. (Eds.), *Readings in human-computer interaction: toward the year 2000* (2nd Ed., pp. 587-602). San Francisco, California. Morgan Kaufmann Publishers.
- J. Carroll and J. Olson (1988). Mental models in human-computer interaction. In M. Helander (Ed.) *Handbook of human-computer interaction*. Elsevier Science Publishers, B.V. (North-Holland).
- G. Christensen and J. Olson (2002). Mapping consumers' mental models with ZMET. *Psychology and Marketing* 19(6), 477-502.
- J. Clement (1983). Observed methods for generating analogies in scientific problem solving. *Cognitive Science* 12. 563-586.
- M. Cohen, B. Thompson et al. (1995). Rapid capturing of battlefield mental models. Technical Report 95-3, United States Army Research Institute, Kansas, USA.
- A. Collins and D. Gentner (1987). How people construct mental models. In D. Holland, *Cultural models of language and thought*, Hillsdale NJ, Lawrence Erlbaum Associates.
- N. Cooke and A. Rowe (1994). Evaluating mental model elicitation methods. In *Proceedings of the Human Factors and Ergonomics Society 38th Annual Meeting*, Nashville TN. 261-265
- W. Craik (1943, Reprinted in 1952). *Nature of explanation*. Cambridge University Press, Cambridge.
- G. D'Elia, C. Jörgensen et al. (2002). The impact of the Internet on public library use: An analysis of the current consumer market for library and Internet services. *Journal of the American Society for Information Science and Technology*, 53(10). 802-820.
- P. Doomen and K. Leuven (1995). *Internet browsing behaviour: How the Web is crossed*. Leuven, Belgium: Katholieke Universiteit Leuven, Faculteit Psychologie en Pedagogische Wetenschappen.
- E. Duncker (2002). Cross-cultural usability of the library metaphor. In *Proceedings of the ACM-IEEE Joint Conference on Digital Libraries 2002*. New York, NY. ACM Press. 223-230.
- J. Dumas and J. Redish (1999). *A practical guide to usability testing*. Intellect Books. Exeter, UK.
- K. Ericsson and H. Simon (1984). *Protocol analysis: Verbal reports as data*. Cambridge, MA. AP Professional.
- D. Gentner (1998). Analogy. In W. Bechtel and G. Graham (Eds.), *A companion to cognitive science*. Oxford, Blackwell Publishers.
- D. Gentner, B. Bowdle et al. (2001). Metaphor is like analogy. In D. Gentner, K. Holyoak et al. (Eds.), *The analogical mind: Perspectives from cognitive science*. Cambridge, MA. MIT Press.

- D. Gentner and S. Brem (1999). Is snow really like a shovel? Distinguishing similarity from thematic relatedness. In M. Hahn and S. Stoness (Eds.), *Proceedings of the Twenty-first Annual Meeting of the Cognitive Science Society*, 179-184. Mahwah, NJ. Lawrence Erlbaum Associates.
- D. Gentner and K. Forbus (1990). MAC/FAC: A model of similarity-based retrieval. *Cognitive Science* 19(2), 141-205.
- D. Gentner, J. Loewenstein et al. (2003). Learning and transfer: A general role for analogical encoding. *Journal of Educational Psychology* 95(2). 393-408.
- D. Gentner and A. Markman (1994). Structural alignment in comparison: No difference without similarity. *Psychological Science* 5(3). 152-158.
- D. Gentner and A. Stevens (Eds.) (1983). *Mental models*. Lawrence Erlbaum Associates.
- J. Greenberg, K. Bullard et al. (2002). Student comprehension of classification applications in a science education digital library. In *Proceedings of the European Conference of Digital Libraries 2002*, LNCS 2458, Springer. 560-567.
- F. Halasz and T. Moran (1982). Analogy considered harmful. In *Proceedings of the Conference on Human Factors in Computer Systems*, Gaithersburg, Maryland, USA.
- S. Harter (1997) Scholarly communication and the digital library: Problems and issues. *Journal of Digital Information* (1)1. Article No. 3.
- J. Holland, K. Holyoak et al. (1986). *Induction: Processes of Inference, Learning and Discovery*. Cambridge, USA. MIT Press.
- K. Holyoak and P. Thagard (1995). *Mental leaps: Analogy in creative thought*. Cambridge, MA. MIT Press.
- J. Johnson and A. Henderson (2002). Design: Conceptual models: begin by designing what to design. *Interactions* 9(1). 25-32.
- P. Johnson-Laird (1983). *Mental Models*. Cambridge, UK. Cambridge University Press.
- P. Johnson-Laird (1989). *Mental Models*. In M. Posner (Ed.) *Foundations of Cognitive Science*. Cambridge, USA. MIT Press.
- D. Jonassen (1995). Operationalizing mental models: Strategies for assessing mental models to support meaningful learning and design supportive learning environments. In J. Schnase and E. Cunniss (Eds.), *Proceedings of the Computer Supported Collaborative Learning Conference*, Bloomington, IN, October 1995.
- C. Katzeff (1990). System demands on mental models for a fulltext database. *International Journal of Man-Machine Studies* 32. 483-590.
- D. Kieras (1982). What people know about electronic devices: A descriptive study (Technical Report No. 12), Ann Arbor, MI. University of Michigan.
- D. Kieras (1988). What mental model should be taught: Choosing instructional content for complex engineered systems. In J. Psotka, L. Dan Massey et al, *Intelligent tutoring systems*. Hillsdale, NJ. Lawrence Erlbaum Associates.

- D. Kieras and S. Bovair (1984). The role of a mental model in learning to operate a device. *Cognitive Science* 8. 255-273.
- K Kurtz, C. Mao et al. (2001). Learning by analogical bootstrapping. *The Journal of the Learning Sciences* 10(4). 417-446.
- S. Kvale (1996). *Interviews: An introduction to qualitative research interviewing*. Thousand Oaks, CA. Sage Publications.
- K. Law, K Forbus et al. (1994). Simulating similarity-based retrieval: A comparison of ARCS and MAC/FAC. In *Proceedings of the Sixteenth Annual Conference of the Cognitive Science Society*, 543-548. Hillsdale, NJ. Lawrence Erlbaum Associates.
- D. Leary (1990). *Metaphors in the history of psychology*. Cambridge, UK. Cambridge University Press.
- B. Leiser (1992). The presence phenomenon and other problems of applying mental models to user interface design and evaluation. In Y. Rodgers, A. Rutherford et al. 1992. *Models in the mind - Theory, perspective, and application*. London, Academic Press.
- D. Levy (2003). Documents and libraries: A sociotechnical perspective. In A. Bishop, N Van House et al. (Eds.), *Digital library use*, MIT Press, Cambridge 2003.
- D. Levy and C. Marshall (1994). Going digital: a look at assumptions underlying digital libraries. *Communications of the ACM* 38(4).
- W. Loucas and H. Topi (2002). Form and function: the impact of query term and operator usage on web search results. *Journal of the American Society for Information Science and technology* 53(2), 95-108.
- G. Marchionini (1995) *Information seeking in electronic environments*. Cambridge University Press, Cambridge.
- W. Newman and M. Lamming (1995). *Interactive System Design*. Wokingham, UK. Addison-Wesley.
- F. Miksa and P. Doty (1994). Intellectual realities and the digital libraries. In *Proceedings of the Digital Libraries'94 Conference*, (College Station, TX, June 19-21), 1-5.
- N. Miyake (1986). Constructive interaction and the iterative process of understanding. *Cognitive Science* 10(2). 151-177.
- D. Nichols, M. Twidale et al. (1997). Recommendation and usage in the digital library. Technical Report CSEG/2/97. Lancaster University, UK.
- D. Norman (1983). Some observations on mental models. In D. Gentner and A. Stevens (Eds.), *Mental models*, LEA, 1983.
- D. Norman and S. Draper (1986). *User centred system design: New perspectives on human-computer interaction*. Hillsdale, NJ. Lawrence Erlbaum Publishers.

- P. Nürnberg, R. Furuta et al. (1995). Digital libraries: issues and architectures. In Proceedings of Second Symposium on Digital Libraries (DL '95) (Austin, TX, Jun).
- C. O'Malley and S. Draper (1992). Representation and interaction: Are mental models all in the mind? In Y. Rodgers, A. Rutherford et al. 1992. Models in the mind - Theory, perspective, and application. London, Academic Press.
- S. Payne (1991). A descriptive study of mental models. Behaviour and Information Technology, 10(1). 3-21.
- S. Payne (2003). Users' mental models: The very ideas. In J. M. Carroll (Ed.), HCI models, theories and frameworks: Toward a multidisciplinary science. San Francisco: Morgan Kaufman.
- M. Posner (Ed.) (1989). Foundations of cognitive science. MIT Press, Cambridge MA.
- J. Preece, Y. Rodgers et al. (1994). Human-computer interaction. Wokingham, UK. Addison-Wesley.
- A. Rutherford and J. Wilson (1992). Searching for mental models in human-machine systems. In Y. Rodgers, A. Rutherford et al. 1992. Models in the mind - Theory, perspective, and application. London, Academic Press.
- A. Sasse (1992). User's models of computer systems. In Y. Rodgers, A. Rutherford et al. 1992. Models in the mind - Theory, perspective, and application. London UK. Academic Press.
- A. Sasse (1997). Eliciting and Describing Users' Models of Computer Systems. Ph.D. Thesis, Computer Science, University of Birmingham, UK.
- R. Schumacher and M. Czerwinski (1992). Mental models and the acquisition of expert knowledge. In The psychology of expertise: Cognitive research and empirical A.I. Ed. R. Hoffman (1992). Springer-Verlag, New York, NY.
- C. Seale (1998). Researching society and culture. London, UK. SAGE Publications.
- N. Shadbolt and M. Burton (1995). Knowledge elicitation: A systematic approach. In J. Wilson and N. Corlett, Evaluation of Human Work. Erlbaum Associates, London.
- D. Slone (2002). The influence of mental models and goals on search patterns during web interaction. Journal of the American Society for Information Science and Technology, 53(13). 1152-1169.
- N. Stammers and A. Norcio (1993). Mental models: concepts for human-computer interaction research. International Journal of Man-machine Studies (38). 587-605.
- H. Stelmaszewska and A. Blandford (2004). From physical to digital: a case study of computer scientists' behaviour in traditional libraries. To appear in Journal of Digital Libraries.
- H. Stelmaszewska, A. Blandford et al. (forthcoming). Designing to change users' information seeking behaviour: A case study. In S. Chen and G. Magoulas (Eds.) Adaptable and adaptive hypermedia systems. London, UK. Information Science Publishing.
- M. Tauber (1988). On mental models and the user interface. In Working with computers: Theory versus outcome. G. Van der Veer, T. Green et al. (Eds.). Academic Press, London.

Y. Theng, N. Mohd-Nasir et al. (2000). Purpose and usability of digital libraries. In Proceedings of the ACM of the Fifth ACM Conference on Digital Libraries, San Antoniou, Texas, USA.

N. Van House, A. Bishop et al. (2003). Digital libraries as sociotechnical systems. In A. Bishop, N Van House et al. (Eds.), Digital library use, MIT Press, Cambridge 2003.

M. Van Someren, Y. Barnard et al. (1994). The think aloud method: A practical guide to modelling cognitive process. Academic Press, Cornwall.

S. Vosniadou and A. Ortony (Eds.) (1989). Similarity and analogical reasoning. London, UK. Cambridge University Press.

T. Winograd (1995). Digital vs. libraries: Bridging the Two Cultures. Talk presented at the 18th Annual International ACM SIGIR Conference on Research and Development Information retrieval, July 9-13 1995, Seattle WA.

R. Young (1983). Surrogates and mappings: Two kinds of conceptual models for interactive systems. In D. Gentner and A. Stevens (Eds). Mental Models. Hillsdale, NJ. Erlbaum Associates.

Appendix 1: Participant instructions and consent form

This consent form, along with instructions, was read to each participant and an opportunity was provided for them to ask questions.

Instructions

This study aims to examine your conceptions of traditional and digital libraries. You will be asked to use first the [digital] then the [traditional] library or libraries of your choice.

Your task is to find a document on the same topic of interest in both the traditional and digital libraries. The topic should be narrow and related to your studies but one that you have not used either type of library to find information about before. This may be a topic related to your Masters thesis. You should not aim to find the same document in both the traditional and digital libraries.

You will be asked to 'think aloud' while you complete the task. Try to say everything that goes through your mind. You are free to navigate and use the library (whether traditional or digital) as you see fit in order to complete your task.

The task will included some brief questions, both during the task and at the end. These questions and observations will be audio recorded and you may withdraw from the study at any time. It is important to emphasise that this is not a test of your ability to use either type of library, nor are there 'right' and 'wrong' ways to perform the task during the observation or answers to give to questions.

Please sign below to indicate that you agree to participate in this study, which will be audio recorded, and that you are aware that you may withdraw from the study at any time.

Name:

Signature: _____

Date:

Appendix 2: Final protocol used in study

Note that as already highlighted in this report, the success of the observation and interviewing process depends greatly on the craft skill of the researcher (to decide when and how to probe users for information) and far less on the precise protocol employed. However, in line with our argument for research transparency, we present our protocol here to promote clarity rather than to suggest that a rigorous protocol such as this is essential in mental model elicitation studies.

The final protocol consists of eight parts:

1. Thank the participant and ensure he or she is at ease and comfortable in the library surroundings as suggested by van Someren et al., 1994). Ask some ice-breaking questions about the participant's current studies and their last use of either traditional or digital libraries (where appropriate).
2. Read the instructions in appendix 1 to the participant and give the participant the opportunity to ask questions. Note that some of the wording of the instructions is also based on recommendations from the literature; "Try to say everything that goes through your mind" is the phrase recommended to explain the think-aloud procedure in simple terms (van Someren et al., 1994) "It is important to emphasise that this is not a test of your ability" [in this case to use either type of library] is suggested by Boren and Ramey (2000 amongst others).

If the question arises, explain that the amount of help that the researcher is permitted to give during the task is limited, however when in doubt they should try to do what they would normally do when searching for information in a library. If the question arises as to whether the user should choose a narrow topic area with the knowledge that items pertaining to this area are located in the current library, re-emphasise that the user must not have previously searched for the topic chosen in either the traditional or digital library, but other than this condition, they are free to do what they would normally do when looking for information in a library.

3. Invite the participant to think of a narrow topic related to their studies and allow them to take their time doing so. If they express doubts about finding any relevant documents because they perceived that their chosen topic was too narrow, inform the participant that they can broaden the focus of the topic if such a case arises explain that they will then be asked to state their new choice of (broader) topic. If they express doubts about finding relevant topics because they perceive that their chosen topic is too broad, inform the participant that they should choose a narrower topic if possible and broaden it as described above if necessary.
4. Half the participants studying MA Library and Information Studies should begin by performing the task using the traditional library and the other half should begin using the digital library. A similar crossover should be performed with the MSc Human-computer Interaction students. This will have been pre-decided for each participant and alters the order of the instructions given in appendix 1.
5. Ask the participant to start the task and thinking aloud when they are ready. When considering asking an intervening question, follow the questioning guidelines given earlier in this section.

6. Other researcher intervention should be discouraged other than for the following explicit reasons:
 - The participant is failing to think aloud or provide sufficient verbal detail of their task performance. In which case, the participant should be briefed with an example as to the relevant level of detail required of them. (van Someren et al., 1994) An example of a practice task that may be suited to this study is to ask participants to take a familiar walk through an imaginary building, such as the UCL building they most frequently attend lectures at, describing what they see. (Adapted from Posner, 1989).
 - The participant exceeds the expected task time of 30-40 minutes for each type of library. In which case, the participant should be informed that they have provided enough information and asked to move onto the next part of the task. (Dumas and Redish, 1999).
 - The participant becomes frustrated. In which case the researcher should prompt the participant with a question, but if their frustration persists, the participant should be informed that they have provided enough information and asked to move onto the next part of the task. (Dumas and Redish, 1999).
 - The participant does not indicate when they have finished a task. In which case, they should be prompted with the question ‘can you tell me when you’ve finished a task?’ (Dumas and Redish, 1999).
 - The participant asks a question. In which case, if the researcher chooses to respond, the response will also be a question (Dumas and Redish, 1999).
 - The participant verbalises a problem. In which case, the researcher will inquire deeper into the nature of the problem, where necessary and where it is unlikely to cause the participant to become flustered.
 - The participant asks a question already answered in the instructions in appendix 1. Boren and Ramey 2000 highlight that this is faulty role-playing and not faulty task performance and hence the researcher should re-read the relevant material from the instruction sheet and clarify if necessary (Boren and Ramey 2000).
 - The participant is unusually chatty and drifts off-topic. The researcher should turn the diversion back on track without being rude, for example by asking the participant to re-state their current goal: ‘Ok, so now you’re working on...?’
 - The participant makes an unclear comment. In which case, the researcher should use their judgement to decide whether a request for clarification is warranted and, if deemed necessary they should be as short and non-directive as possible (Boren and Ramey 2000).
 - The participant asks to withdraw from the study. In which case, the researcher should thank the participant for their assistance provided.
7. Should the traditional library or digital library task finish with at least five minutes to spare, invite the participant to think aloud whilst performing an additional task. The participant will be asked “how might you go about finding other related information/documents?” and will be permitted to use the relevant traditional or digital library as a prop. Time permitting, this question should be followed by “are there any other ways that you might go about finding related information?” Again, the library may be used as a prop.
8. Ask the remaining four post-observation questions highlighted in the previous section (types 2 and 3). Thank the participant for their assistance and give them a final opportunity to ask questions about the study.

Appendix 3: Transcripts

The eight transcripts are named with the following convention: The name begins with either HCI or LIS to indicate whether the participant was an MSc Human-computer Interaction or MA Library and Information Studies student. This is followed by either ‘DT’ (to signify that the participant first used the digital then the traditional libraries of their choice) or ‘TD’ (to signify traditional followed by digital). Hence the nine transcripts are named PILOT, HCIDT1, HCIDT2, HCITD1, HCITD2, LISDT1, LISDT2, LISTD1 and LISTD2.

Researcher questions and statements are in **bold**. Actions performed by the participant and comments implied by the researcher are in [square brackets].

HCTDT1

Have you decided on a topic? I was looking at something on ‘language patterns’ yesterday on Google, so I’d like to have a look a bit more on that. It [the topic] was originally thought up by Christopher Alexander, who is usually in design and architecture but I think there might have been studies applying the work to HCI [the domain of interest]. I don’t know if there’s anything on it though, but there might be . . .

Because this is an unspecified topic, I’m going to Google first of all because that’s the ‘biggest and best’ search engine in the world ever! [Laughs]. I’m going to type in ‘language patterns’ first of all to see if that comes up with anything. [conducts search]. These results seem a bit too broad, but I know that Christopher Alexander is the guy that has been attributed to coming up with the idea in the paper I read, so I’m going to type in his name as well [as the additional text in the search term box. Does so and conducts search]. This should narrow it down a bit more. **How did you go about finding the initial article by Alexander?** Umm . . . I was actually browsing for another book in the HCI section of this Science Library and I was reading along the titles and came across it by accident in a book by Heath and Luff. I’d heard of their names before [Heath and Luff], so I decided to look deeper in the book at the collections of papers. So I got that out and flicked through a couple of papers and they were useful in the end. It’s good that books are arranged in the same section, it let me find something else quite relevant. [Glances back at search results]. There’s a couple of links that look quite relevant, but I think I should search for things on an electronic journal. Usually I use my background knowledge to try and think of which electronic journals I am familiar with and which digital library it’s likely to be in. So if I was looking for an article that applies to HCI like this one, I’d go straight to the ACM. If it was more philosophical or psychologically oriented, I’d go to my Athens account and look in Ingenta, I think it is . . . but in the Athens there’s lots of individual electronic libraries and some of them have got certain stuff in and some of them have got other stuff in. I find it fairly hit and miss. You normally have to go in [to each digital library] and type in the name of the author over and over again until it might crop up.

So now I’d go the ACM because it’s an HCI topic and I think anything I find on there on my topic will be more highly related on there than if I used anything else. So I’ll type in ‘pattern languages’ again . . . [Loads ACM Digital Library homepage and conducts search]. **Why did you type in ‘pattern languages’?** Umm . . . Well I probably should have typed in ‘language patterns’ so it’s exactly like before [with Google], but I forgot. I know the topic I want is either ‘language patterns’ or ‘pattern languages’ and I can’t remember what I searched on Google [which search terms were used]. So I’ll just type it into Google again to see if I’ve got the terms round the right way. Yeah, it is ‘pattern languages’ . . . [Begins reading article titles out loud]. I’m reading the titles to see if there’s anything. [Pauses for a second]. So this is the guy [author] that wrote the article I read yesterday, so that’s interesting. [Reads abstract out loud (at speed)]. And perhaps this one? Yeah, I’ll probably have a look at these two. **How did you decide that those two might be interesting?** Reading the titles, just to get a quick overview. For example this title that I read just seemed too technical. The second one, ‘a debate on language and tool support for design patterns’ . . . that didn’t seem that relevant either because I don’t think it’s about pattern languages, whereas this one talks about pattern languages specifically in the title. To delve a bit deeper though, I read the abstracts then print off the whole document. So I’m quite happy with that [search]. And if I’ve read those [two documents deemed interesting], I might find they contain some useful references to follow up. And because I’m not too sure of a route [research direction] to go down yet, reading them might give me a better idea. **How would you go about finding**

similar articles? Well if there's a good book on this area, these two papers are likely to quote from it. That's also reminded me . . . you can do citations on here. You can press 'citations' and I think that when this paper is referenced in other, more recent papers, it brings up those papers. So this should give me papers written after August 2000 that cite the paper I'm looking at . . . [Presses 'citations']. Yeah, that's what happens. So now I can read through these and see if any of these are useful as well.

How do you think it decided the order in which to show you the results that you found on the previous screen? Umm . . . I think from using this system before it goes by 'relevance' and it's got this thing on the right-hand side. It looks like a pint of Guinness [laughs]. The more full it is, then the more relevant it should be to your search. I largely ignore that and just cycle through the first, sort of, couple of pages. I sort of take [the relevance scale] as a sort of implied rather than a hard thing to go by. When I've used this system before, not unless I'm searching for something very specific are they at the top. I mean they could be anywhere in the first 2 pages . . . **How do you think it's deciding which are 'at the top'?** Umm . . . I would've thought first of all . . . well I've only typed in two words, so to sort them out into priorities I'd first think that the two words would have to be . . . first of all in the title, perhaps . . . and then in the . . . article? So the words I've typed in are not the author's name or anything like that. So I'd then assume that it's an 'intelligent' type of system and that the order of the words matters to decide on a priority. Perhaps the ones very low down [the list] would only have one of the words in the title.

I've noticed on that screen that there's a link there saying 'save results to a binder' . . . what do you think that might do? I think I actually tried it before. Because if you're doing lots of searches and a relevance search . . . and it coughs up lots of relevant results and you don't have time to go through them all . . . and you don't wanna be typing in lots of combinations and variations of searches you've done before, then it'll save your actual search, or the search results to your personal binder and I suppose you could log in and see your binder and go straight to the searches rather than having to type in the searches again. I think the reason I was put off that was because you have to have your own personal ACM account and we've got our account as a group account through the university, so there's complications in doing that . . . **What are the complications?** Well I think you have to be a member of CHI [special interest group] to have access and I don't have a membership number and can't be bothered to go through the whole process of trying to get one . . . or pay for it. **You said that the binder might stop you from having to type in lots of combinations and variations of searches. What did you mean by that?** It wouldn't prevent you from doing it, but it would be a short cut. So you've taken a journey from A to B . . . say you're trying to find a paper or papers on a particular topic and have a number of words in mind . . . you might not always get what you're looking for with the first combination of words, so you might take a word out or substitute a similar word for another word and do different combinations and it could be quite a lengthy process. **How would you decide on the combinations that you would use?** Umm . . . I suppose there's different strategies. It's not just random. You do have to vary it a bit though. So the term that I'm looking for here, 'pattern languages' . . . that's fairly specific . . . but if you're looking for . . . I can't think of an example. But sometimes there might be a similar area when people have slightly different terms for the same thing. So you might type in some of those terms and it'll come up with articles with those terms in but you'd also have to try the other. Let's say 'pattern languages' did not return any relevant results. **What would be the next thing that you would type in?** I'd type in the author's name, Christopher Alexander. Or if typing in 'pattern languages' was too broad on the ACM, I might type in 'Christopher Alexander' as well [in addition to the other search terms, as done with Google earlier] in order to narrow it down. And if that didn't come up with anything relevant at all, then I might type in 'Christopher Alexander' and hope it brings back all the work done by him. So there's a strategy of narrowing and focusing. **Would you use the same strategy of narrowing and focusing when searching Google?** Yeah. I would. Google's really good because sometimes if there is a paper on the ACM, which is a web site, Google might even find it for you without you having to search the ACM directly. **Why do you use the same strategy in both Google and the ACM Digital Library?** Umm . . . because I think they both perform a similar operation in that you type in different words and it's trying to bring you relevant results. I think the process of bringing you relevant results is a similar thought of process in looking for words in the higher categories and then working down . . . if it just brought you back random stuff, then it wouldn't be any good!

I noticed that on the front page of the ACM, there was a new pilot service called CrossRef. It says it's a pilot project to implement full-text inter-publisher searchability and this is the interface for it. What would you imagine that it would do? [Reads full page of CrossRef description]. I think the key words there are 'full-text' and 'inter-publisher' . . . so it searches not just the title or the abstract, but the whole text and it would include other publishers than the ACM . . . Taylor and Francis perhaps. **In what other ways**

might this service differ from the ACM process that you have been using? I would've thought the ACM one actually searched the full-text as well. So perhaps it doesn't! Perhaps it searches only the title and abstracts. So that's one difference.

I'll do a search here [on the electronic catalogue] but I'm not as hopeful of getting anything particularly relevant because this is not a well-established subject. Although I think Christopher Alexander has written a book on the subject and I would be happy finding that. Sometimes finding a book on a [specialist] subject in a traditional library indicates that the subject is more established. So I'm typing in 'pattern languages,' but I know this is a real long shot. Aaah . . . 'the pattern languages of program design.' So I'm just looking through the 8 different things [search results] that it's brought back . . . syntactic . . . right, so this 'pattern languages of program design' . . . I wouldn't bother looking at that because I'm not interested in program design. That's too off the path that I want to go down. So I'll start the search again and type in 'Christopher Alexander' which is the author's name [but continues to search in 'all fields' rather than in the author field]. It's found 33 results. . . 'a city is not a tree' . . . I didn't know that was a book! **How do you think that it has ordered the list of 33 results?** I don't know really. It's looking for results containing 'Christopher' and 'Alexander' but I don't think it's recognised the author . . . I mean it's come out with articles with 'Christopher' and 'Alexander' in them, but I would have expected articles by Christopher Alexander at the top of the screen . . . but in the things [records] that it's found, both those terms are separated. I think it might be showing me variations of those two types of words rather than the actual phrase that I typed in [which was not technically a phrase]. [Continues to look through results]. That one doesn't look that good. **How can you tell if something looks good or not?** By looking at the title. Well, it lists title and author. I'm gonna click on that one [a record of a book by Christopher Alexander] because I know that's the guy [author that wrote the earlier article that had spurred participant to conduct a further search]. I'm gonna expand it [clicks to expand]. Displays full catalogue record. No, that's not what I want. I wanted something that would show me everything that author has written. But it doesn't look like I can do that . . . I'm going to the next page and I'll look for a book by Alexander and hope it's got 'pattern languages' in the title . . . [Presses 'next page' button]. Aahh . . . here we are. 'Pattern language . . . I just had a look at the other titles though, but they don't look relevant. [Notices that the book deemed relevant is in another library]. I must say though, it puts me off when a book is elsewhere because it's not like I want to get the book straight away or make so much effort, I would have preferred it if there was a way to order them so that I could view them [requested items] at my own leisure. **So how would you go about getting this book?** Well I'd note the location and the number of it and have to find out where the Bartlett site was and go there and have a look at it.

How would noting down the location and number help you? Umm . . . well when you're searching for a book in a library it's normally got a certain code because it's in a certain section. This one's in the 'Architecture' section. Then it's arranged alphabetically and in numerical order by code. The code here is BA 4LE. So it'd be organised first in As then Bs and the Bs might be divided down into BA, BB, BC. It's normally the author's initials or be a few something after that, but you don't usually use those because once you've gone down that far, they'll probably only books and you can just spot the one you want. It's kinda like a hierarchy going all the way down.

What would you do if you went to the Bartlett library and couldn't find this book? 'Do my nut' because I walked over there and couldn't find it! No, that's just a joke! I'd ask a librarian to help me find it. Although these libraries are quite big and there's not many librarians around. . . so if I went to the desk and said it's not on the shelf, they'd expect me to find it. I shouldn't have any problem locating where it should be on the shelf. And if it wasn't there, it should be out [on loan], otherwise it's lost and I'd probably report that if that's the case . . . but I'd also look on the desks around that area because it might be that someone's pulled it off the shelf and not put it back . . . and then look at this [the electronic catalogue] because it'll tell you if they think it's out [on loan] or not. If it [the catalogue] says it's in [the book is in stock] then it should be either on the shelf, travelling back to the shelves, or lost. Here it's happened where I've returned to get a book a number of times and it [the electronic catalogue] says that it [the book] is here, but it's not. So I reported it as lost by filling out a form. **How would you know if a book is 'travelling back to the shelves'?** You never actually know that for sure. You need to guess. You could ask the librarians and perhaps they would know on their system, but you'd probably assume it's on its way back to the shelves because it's more likely than being lost. Then return a few days later and if it's not there, assume it's lost and report it. [Pauses for several seconds]. **Have you finished your task?** Yeah, I reckon this is the only relevant book that I'll be able to get on the subject. I don't think there are any variations of this topic [written] by other people, so I've come to the end of the road.

Did you notice any similarities between using a traditional and digital library? I used the computer for both. I suppose it's quite funny because my search in the traditional library did not involve searching a physical space at all. It was all done through the computer, I was typing in key words to narrow down a topic I was interested in to relevant articles. And I suppose the way the system searches. I would say they are very very similar. I would say that Google and the ACM though, because that's their main sort of area of searching [they are dedicated to searching] their searches are much more effective than when using the traditional library catalogue. I've been on traditional library ones [catalogues] before and sometimes you'll type in one letter incorrect and Google will come up with a suggestion [of what the word you intended was], but the traditional libraries [electronic catalogue] might just say 'no results found' . . . which is annoying because you might not be paying attention and just think that there were no results. **Why do you think Google and the ACM are better at dealing with what you type in?** Umm . . . because that's their main bread and butter. If you're searching a traditional library then the computer, although not so much nowadays, are a secondary service and that's how you search for the articles . . . and there's only a limited amount of 'customers' using them [traditional libraries] if you like. Google is a worldwide thing and has the best minds working on how to make it successful and how to make it work better.

Did you notice any differences between using a traditional and digital library? One of the important differences would be the subject matter of what I'm looking for. In a traditional library, I'm looking for books so probably looking for searches under the title and the author because there's not a lot else that they would have entered into the library system. Whereas when I'm looking on Google, it can search through the text . . . and ACM . . . the abstract as well as the title . . . the full text of the papers . . . and there's a lot more of them [available documents] because they're all electronic. Another good thing is if you type in something similar to a book title, Google will cough up the Amazon link to it, and Amazon has almost every book on it [in the database] anyway. So even that [Amazon] is better than the traditional library systems, which are rather limited.

Did you find using the digital library similar to anything you have used in the past? Umm . . . like . . . I suppose . . . just like . . . dunno really . . . it comes back to the issue of 'what is a digital library?' because some people argue that Google isn't a digital library, it's just a search engine. But if you look at a digital library like the ACM, well that's just a search engine! So if you don't include Google as a digital library then I would say search engines are similar to a digital library, but I would class them as the same category because all you're doing is typing in words, trying to narrow down a topic which you're interested in, whether it be a paper, book or website, and finding it.

Did you find using the traditional library similar to anything you have used in the past? Because I've only searched on the digital library system [electronic library catalogue], in a crude way you might want to identify the traditional library system as a very bad search engine! But at the end of the day, you're performing the same actions and trying to achieve the same goal. **In what crude way would you say that a traditional library is like a bad search engine?** Well the Google system is a lot more flexible and powerful when it recognises mistakes. It's more intelligent. It suggests what you might have meant. It's searching a huge huge database so has to be more powerful to sort out the wheat from the chaff. It has to be better because it's got so much more to sort through. But the traditional library is not as good because . . . like we were down there [at the electronic catalogue terminals] when I typed in 'Christopher Alexander' . . . I would have thought it would have put those to words the same, in that order, together towards the top of the results . . . but it wasn't. That doesn't seem that sensible to me. Perhaps they're [records] are not ordered down there [on the electronic catalogue], or ordered in a way that is not useful, whereas Google and probably the ACM as well are good at those things [traditional search engine functions]. **Thanks very much for your time.**

HCIDT2

Have you decided on a topic? I was thinking of looking for how focus groups are used in HCI in terms of evaluating initial designs and stuff like that. **When did you last use a traditional library?** Last week to get books on scenarios . . . I looked at usability engineering . . . Rosson and Carroll [mentions author of one of the books he found]. **How did you go about finding those books?** I think I checked online just to see if the book was in because I've looked at the book before and knew it was relevant to the topic . . . then I popped in to take the book out . . . I checked beforehand from home on the UCL library catalogue to see if the library system said it was in [stock] . . . not that it always means it'll actually be in! I've had instances where it says the book is going to be on the shelf and it isn't. **What do you do in those cases?** Well usually, if you ever

ask any of the librarians, they'll just say that it should be on the shelves and ask you to look around because sometimes they're not put back in exactly the right places. But other than that, there's not much you can do really . . . see if it's in the recent returns . . . but usually it means the book's gone walkabout somewhere. In that case I'd just give it a few days and see if it's back, or possibly request the book so that I'm notified if it is returned . . . [Stumbles over words for a few seconds]. But I suppose it's just lost in the system. It's probably . . . well I get the impression, certainly at UCL, that library space and things like that are a problem so sometimes books don't get returned in the right place or the system gets out of sync . . . considering that you've got hundreds of thousands of books, there's probably a few where what it says on the system is not actually where the book should be. **How would you go about requesting a book?** I'd just log on to the system [library catalogue] and if you search for the book then you can make a request and I think it asks you the date . . . there's a date which I'm guessing you're interested in getting the book up until this date. So you just put in some date in the future and wait for the system to automatically e-mail you. Or you can ask them [librarians] the status, whether it's been returned or still on loan or whatever. **What did you last use a digital library for?** Early last week I was looking at some papers for my thesis on designing interfaces for televisions. **And how did you go about finding what you were looking for?** In that instance, I was using the HCI Bibliography, so I just put in 'television' as a key word and just went through all the papers, reading the abstract or just having a look briefly at the paper to see if it looked interesting.

The first thing I'd look at is probably the ACM Digital library 'cause I know there's a lot of papers on there that . . . I find that with a lot of papers . . . let's say you're looking for a certain paper and you find it . . . you might need to be registered with a certain site or you need to get them to send it [the article] back to you or something like that. Most of the time I'm not that concerned in registering unless I really really need to get a certain paper. I know with the ACM, I know you can download it all and view it all [have unrestricted access] . . . certainly on the university network anyway. I'd put in "focus groups" using quotes so that . . . well I'm guessing that it deals with it as one word and . . . I'm not sure . . . I'll put a plus . . . I'm never quite sure how the search . . . I wouldn't say random, but you seem to get funny stuff back from the ACM in terms of results. I'm not sure how exactly . . . whether it checks the keywords of papers or the titles or exactly how it brings back stuff that it thinks is relevant. Usually it's the case of putting in a few things and seeing what it comes back with. **What sort of 'funny things' does it show?** Just, I guess, unexpected results. Stuff that doesn't seem that relevant . . . I can't think of a precise example . . . but papers that you're not quite sure how it actually retrieved them from those search terms. **How do you think it might be retrieving them from the search terms you provide?** Umm . . . looking at key words of articles, searching those articles and seeing how many times those phrases come up and returning those ones where the phrases come up most higher up in the relevance list.

You'll often get a lot of stuff [search results] back and you'll have to go through, quite laboriously, looking at the titles and sometimes the abstracts to see which ones are relevant. Sometimes you don't get an abstract [in the search results] or sometimes it's a bit ambiguous, so then I'd just click on it and open the file. [Types in ' "focus groups + Evaluation' in the search box]. **What sorts of results do you expect the ACM to retrieve from those search terms?** I'm hoping it will bring back some articles where focus groups have been used to evaluate interfaces and prototypes. I'm hoping that by saying focus groups and eval . . . well actually, I'm not sure if the plus will be an 'or' [boolean operator] or an 'and.' I'll see what comes out. [Presses search button]. Here we've got 200 papers returned . . . [reads first article title]. Initially I'd just go through some of this stuff and see what I find interesting . . . year 2000 focus groups . . . I'm thinking that's about the year 2000 bug, so it won't be that relevant. [Finds an article deemed to be interesting]. This one looks interesting. So I'll click on that [article title] and hopefully get the abstract [no abstract is displayed]. No! Ok, so there's no abstract there . . . so I'd click on it [the file] to have a look at it. **Why do you think it didn't have an abstract?** Some of the stuff doesn't have abstracts. Maybe it's just the way it's been put on the system . . . I'm guessing because it's 1991 it's before they started computerising them . . . it's probably been put on [the article put on to the ACM library] at a later date. [Clicks on title and PDF file loads. The paper has no abstract and begins with an introduction]. I'm just reading the introduction. "The paper reports on what strengths and weaknesses these methods yielded." This is the sort of thing that I might be interested in. [Presses save button on Adobe Acrobat reader]. I know this icon means save and I'll give it a name similar to the title of the paper.

[Looks back at search results]. You have what looks like a pint of Guinness here [points to relevance bar next to each search result] which is meant to show the relevance scale, but I don't use that at all because it's not useful. Again, I can't see why . . . [reads title] 'automatic usability evaluation of user interfaces' . . . why I got that back using focus groups and evaluation as my search terms. I find it all a bit arbitrary. So usually,

I'll get something back [which I would deem relevant] and follow up the references. I'll just use Google, put in the title of that paper and it'll probably come back with the paper . . . even if the ACM has got it anyway. [Continues to read titles and short abstracts]. There seems to be nothing . . . very little of interest there . . . so possibly 'evaluation' is screwing up the results because it's coming up a lot in the results. So if I just use 'focus groups' . . . hopefully that will direct it even more narrowly . . . although you might get focus groups that are unrelated to evaluation. [Searches using "'focus groups'" as a search term]. [Looks at the top search result and laughs]. Still get that year 2000 bug article! [Begins to look through list of titles]. This time it's returned 44 results . . . [continues to read titles]. I'm slightly confused with this one because the title's in French [and abstract is in English]. It looks like it could be interesting, but let's see if it's in English. I think it'll be in English though . . . [Clicks on title]. No it's not . . . oh, some of it is. That's bizarre! I've never had that before! Not being able to speak French, I'll close that! Although it might be interesting looking at the references . . . 'Use of focus groups for idea generation' . . . these two [references] look interesting. I'll open a new window and using google, wack in that title [pastes in title within inverted commas, then clicks on the Amazon link in the search results]. I know that Amazon will tell me what the book's about . . . [reads Amazon summary of the book's content]. That looks interesting. I'll just check to see if it's available in the library. [Loads UCL electronic catalogue bookmark and clicks on library services]. I'm just putting in the title as my search terms. [Types in book title into search box and selects 'search within title' from the drop-down box and 'adjacent words']. It didn't work though [did not return any results]. **Why do you think it didn't work?** It seems to be that it comes back with weird stuff. . . it doesn't seem to actually search in the title . . . just words in the title. [Clicks back button]. Maybe I shouldn't have selected 'adjacent words' [changes radio button to 'words anywhere' and presses search]. So, the book's actually in the library. [Looks at the text 'Science (3/1)'] We've got three items, one out. If I click on that [the text 'Science (3/1)'] I can see that one book is available in the Anthropology area, though I have no idea where Anthropology is [does not notice the other book that is available in the 'Psychology' area]. I would make a note of this code, A9 MOR and then I think you can get a map of where the libraries are at each university and just go to that library and find the book. **How did you know that there was one available in Anthropology?** Umm . . . you see on the due date . . . oh, it says in Psychology there's also one . . . but this one isn't a one week loan like the one in Psychology, so you could take it out and wouldn't have to renew it every week. But if it was going to be a real pain finding the Anthropology library, I might just get the one from Psychology. I can't imagine Anthropology's a huge library, so I should be able to find it fairly easy. Anyway, going back to the results stuff . . . [returns to ACM results] . . . I'm just looking through some of the papers [resumes looking at list of titles and short abstracts]. There doesn't seem to be a huge amount [of relevant articles] coming back. In which case, I'll use the advanced search to limit it a bit more [clicks on 'advanced search button']. 'Must have' 'focus groups' . . . 'only search in' . . . [selects 'title' from 'only search in' combo box]. Actually, I'd expect to be able to search in keywords as well. But I can't. Hopefully this'll bring something more specific. [Searches and receives no results]. Let's try abstract. [Changes 'only search in' combo to 'abstract' and also gets no results. Finally changes it to 'all information' and searches]. It's returned some similar things . . . but the second result is about HCI and focus groups, which is good . . . so let's have a look [clicks to load document]. I thought it was some sort of paper but actually it's just a panel at some conference. I don't think it'll have anything useful on there.

Well I know that the HCI Bibliography [searches for 'HCI bibliography' in Google and follows the appropriate link] . . . will search through articles and papers and I tend to find that it's a bit more sensible than ACM. It seems to be more relevant . . . you don't seem to get so much stuff that is bizarre and arbitrary. **Why is it more sensible?** It's probably due to the way it searches stuff. It's just like with Google, you'll often get better results with that than with other search engines. It usually comes down to the way that they search for articles. **How do you think the HCI Bibliography searches for articles?** Umm . . . I think it's pretty similar to the ACM. So again, keywords and words in the abstract and title and things like that. It seems to be more the way you get stuff back . . . the way it's ordered as well seems to be slightly better . . . you don't have to go through so much to find articles to find what is actually relevant. **How is the way that it's ordered better?** Just in terms of more relevant stuff is higher ordered. I dunno if it's just that it's searching slightly less stuff, so you don't get that much back anyway. Maybe that's part of the problem with the ACM, it's just got lots and lots of stuff [the ACM digital libraries]. So again, I might just chuck in 'focus groups' [types in 'focus groups without inverted commas and presses search]. Straight away we've got something that looks quite interesting.

[Seems to stumble over actions and pauses]. **What were you trying to do?** I was trying to view the article. I'm not sure whether it'll actually let me view it. [Holds cursor over a small icon at the beginning of each record, which displays the text 'Link go view bookmark or article.' then clicks on the icon]. No, I don't think

it will let me. I'll just copy the title and search for it again using Google [pastes title into Google and uses the advanced search feature to restrict the results to PDF files]. When you searched on the HCI Bibliography you searched for 'focus groups' and didn't use inverted commas like you did on the ACM . . . Oh, I didn't do that consciously. I guess sometimes I use inverted commas, sometimes not. I probably used inverted commas originally because I was searching for focus groups and evaluation . . . I wanted to separate those two out . . . but searching just for 'focus groups' doesn't really need them.

On the ACM site at the top of the screen, there was an option that said 'save to binder.' Have you used that before? No. I'm guessing it means you can save some sort of link . . . you can maintain a link of interested articles and stuff like that . . . I usually find I just download any articles I find interesting, so in that sense I maintain my own binder really . . . my own list of articles. How do you think a 'binder' option like that might work? Umm . . . probably a bit like bookmarks. You can go back to stuff you've highlighted before. So instead of downloading an article, you could add it to the binder and then go back to it.

On the front of the ACM site there's a pilot service that they're running called 'CrossRef.' Have you used that before? No, let's have a look . . . [goes to appropriate page and reads out description of the service]. "CrossRef takes the full text of ACM journal articles along with several other participating publishers . . ." There's a Google icon there too. **What do you think searching with this service will do?** I guess much in the same way that Google works to search things . . . but I thought it was a full text search we were doing with the ACM anyway . . . maybe not . . . yeah, in the same way that Google searches the text of documents, it'll do the same thing with this. It won't just bring things back if the words were found in the keywords of the article. Also I guess that it will show things the way Google does and make articles that are highly referenced [cited] by other authors higher in the list. **Do you think there might be any similarities between what this service offers and the ACM search you've been using?** Umm, I guess so . . . apart from it's searching outside the ACM as well and getting back other library details as well. [Types in an example search 'focus groups' to see how it will work]. Because this isn't just ACM computer results, there's a lot on different journals that is irrelevant, like 'focus groups in Latino populations.'

The first thing I might do is do a quick search on the library catalogue. I'm guessing that there won't be books on that specific topic. There's probably gonna be more general stuff on 'HCI evaluation' . . . so I might just put in 'HCI evaluation' and select 'title' from 'fields to search' and not 'words adjacent' otherwise it won't come back with much. [Conducts search]. "Automated website evaluation" . . . no, that's not what I wanted. Umm . . . in which case . . . I know that there are HCI books in the library because I've taken stuff out from here before . . . they're around the Computer Science books on the 3rd floor . . . Shall we pop up and have a look? [Walks to stairs]. **How did you find out initially that the HCI books were on the 3rd floor?** We had an induction to the library. But some of the books in this library seem to be spaced around a little bit. There's a clump of HCI books by Computer Science, but some of the other HCI-related books are dotted around the other libraries. **Why do you think that is?** I don't know really. Bizarrely, one of the books, 'Usability Engineering' is actually in the architecture library! I think it's just the way . . . although all the libraries are controlled by UCL, maybe they're autonomous to some degree and the Science library will often hold the same books as other libraries. It's probably a space issue as well. **How did you first find out that things were dotted around various UCL libraries?** The catalogue tells you a code to show which library an item is at. You have to sort of decipher the code and find out which library. I'm more used to being in one big centralised library where it's easier to find stuff.

I know from experience that a lot of the stuff in this area is to do with HCI usability stuff . . . it's a case of looking in terms of the titles of books, and books that I recognise and just . . . so 'Handbook of Human-computer Interaction' has various chapters on stuff, including things on evaluation. [Picks up book]. So I'll look for focus groups in the index. Focus on users? No . . . nothing on focus groups. Maybe if I look in the contents . . . there might be something about evaluation techniques [reads out chapter titles from contents page]. No, nothing useful in here. [Puts book back on shelf]. Let's see what Preece have to say . . . [picks up book]. I've used this book before and if it's got stuff on focus groups, it may have references that will let me find other stuff [looks through index then contents]. There are a few things in here . . . but there's only just a few points . . . I might just jot down a few points. It's hard to know where such a specific topic will be covered. Usually I just refer to books that I've heard of or seen before . . . but I think I'd be better off looking for papers in the digital library really.

If you were looking for a specific book, how would you go about that? I'd use the online catalogue and initially put in the title. If that didn't work, then maybe try the author. But I know that the search brings back

a little code for the book, like these . . . [points at the spine of a book on the shelves]. I can't remember what you call them now. But you can use these codes to tell where the book is . . . although it's not always where it should be. **How can you tell where the book is from the code?** It's usually alphabetical. So the Computer Science ones probably start with CS and the last bit stands for the author and is also arranged alphabetically. Finding things with the location code usually works alright, but finding the relevant cluster of books is often the hardest thing. Not so much here, but definitely in Senate House [UCL library] where there's lots of corridors and it's difficult to find where that first bit of code is. **How do you normally find where it is?** The computer record will usually say which floor [the book is on], so usually it's just a case of going there and following the signs. You're just walking up and down looking at the signs for the relevant book cases and probably doing that a few times and realising that you've actually walked past it. Once you've found it, you can find your way back. It's just the initial time that's a problem.

Did you notice any similarities when finding information in traditional and digital libraries? Umm . . . I guess you might have been searching for similar things in both types of library . . . books and articles and in terms of cross-referencing and stuff like that . . . I think the main difference I find is that you get an awful lot of rubbish back when you're searching on a digital library. They're good when you've got something specific to look for though . . . a very specific example for example. Ploughing through lots of search results can be a pain. Whereas with a traditional library, you can generally find the area of the books you are interested in pretty quickly and then it's usually quick to flick through books and see what content might be interesting. So in some cases it can be a lot quicker using a digital library and in some cases quicker in a traditional library. **In what cases would it be quicker to use a digital library?** When you're after a specific article or when you can be very specific in what you want to look for, for example how focus groups might be used to evaluate mobile phones . . . you'd find that a lot quicker in a digital library than in a physical one. **In what cases would it be quicker to use a traditional library?** When you're not really sure where to find stuff or want something that's not so specific, such as finding out about focus groups in general. You might even want to look through books and learn more about the subjects to base future searches on . . . get a feel for the subject area . . . and you don't have to wait for stuff to download!

Did you find using the traditional library similar to anything you have used in the past? What in terms of other libraries or in terms of . . . **Feel free to interpret the question as you wish.** Ummm . . . it is in terms of using other libraries, most libraries operate in a similar ways. **Did you find using the digital library similar to anything you have used in the past?** Umm . . . a bit like a search engine. In fact . . . well yeah . . . in a sense, I see most digital libraries as a search engine. And Google could almost be viewed as a digital library . . . putting in a title of an article brings you back results that might help you to find it. I tend to use a digital library as a search engine . . . not as I would a traditional library so much . . . and not as a digital library [in its own right]. That's perhaps why I won't use binders and other stuff so much, because I don't really look at that sort of stuff. **What does using a digital library as if it were a search engine entail?** Umm . . . really I guess in terms of what I expect to get back and the look and feel [of the interface]. And in constructing queries. The way I used the quotation marks to separate 'focus groups' and 'evaluation' . . . that was because of experience in using search engines like Google, where I usually use quotation marks to do that. Also in terms of the way things are presented in order of relevance and being able to go back and bookmark stuff. **Are there any instances in which you wouldn't treat a digital library as if it were a search engine?** Umm . . . sometimes you'll get stuff back and you can't actually look at it just like you get broken links in a search engine. I guess with a digital library, it's not so much that the link is broken, but you don't have permission to view this . . . I guess in that case it's a little bit odd using it as if it were a search engine. **Thanks for your time.**

HCITD1

Have you decided on a topic? Usually when I use the traditional library, it's directed by something . . . either I know the book I'm looking for, or I know the journal that I'm looking for. I don't just do random subject searches much, because I use the Internet to do a subject search and then either find the journal online or go to a library that I know will have the journal. And in the case that it's a book, then it'll be on a reading list and I'd go and look at the library to see if the book is available. **What do you do to find information on something that you have not previously researched?** I would then do a subject search. So if I'm asked to choose a topic, I'll choose 'voice interfaces' . . . anything related to voice interfaces.

I'm just going to search the catalogue . . . I'll type in 'voice user interface' because those seem to be the key words for the subject . . . [Conducts search]. But it seems to have found an awful lot of hits. [Clicks back button on browser]. Oh, I thought I was doing a subject search, but I wasn't [chooses 'subject' from drop-down list and re-searches]. Oh, nothing's been found! Ok, let's select the findings where it returned 'voice' only, since there are some of those . . . [Clicks on 'voice' link and looks at search results for a few seconds]. No, I'm not getting anywhere. I'd better go back and search again. [Returns to search page of catalogue]. Try 'voice human factors,' again something to do with voice and HCI . . . could be 'voice' . . . could be 'speech' . . . could be 'audio.' I'm not quite sure . . . 'Words adjacent?' . . . no . . . **What does 'words adjacent' do?** I don't know. I assume it means it's looking for words to be together in the search, but I don't know how it works. I was hoping that it would have just searched subjects for what I was looking at. I'd assume that 'subject' is a data field in each record and that selecting 'subject' searches that . . . but again, I don't know. **What would be in the 'subject' data field?** A brief synopsis of the book. A summary of what it's all about, I'd imagine. Something like that. I find the search [in the catalogue] very difficult and extremely bad . . . umm . . . that's why I rarely use it. Is there an advanced search? It seems to have Booleans . . . [Reads instructions onscreen under search box]. 'AND and OR' . . . I can use those . . . I'll try 'voice AND human AND factors' . . . [Conducts search]. Ok, great . . . I found a book! Not on loan . . . here we go . . . 'human factors in voice systems' . . . and it's in Engineering GM 30 GAR . . . so looks interesting . . . I think I was very lucky to find it. **Why do you think you were lucky?** Because it gave thousands of results originally because it was treating each of my words individually and it was expecting me to use Boolean terms to actually be more clear about what I wanted and it didn't make it really easy. If you didn't know how to do that, you'd certainly have difficulty in finding things in the library. A lot of better search engines will generate much more reliable results, so my expectations are that if I use one [a search engine] that uses a particular [searching] technique, I'd assume that others, even in a digital library might work using the same technique . . . and this one doesn't. **Which techniques would work in a search engine that wouldn't work in the UCL catalogue?** Just typing it in and the most likely result coming up! I don't actually know the technology behind it, but if I type in 'voice human factors' in Google, I can be pretty sure that it will bring back things that are relevant . . . I don't understand how it gets it, but it does actually return useful results. The catalogue returns all the results with 'voice,' all the results with 'human' and all the results with 'factors' . . . it's almost like it's assuming I want to search for three separate things when I only wanted to search for one thing. That's how it appears to be working.

So I've made a note of the location . . . and I know how this works from before . . . I go up to the Engineering floor and I know the book's there and available because it tells me here [points]. So I'd just go and get it. **So how would you now go about finding it?** Engineering is on . . . one of the floors . . . but there's a little map outside. Then in Engineering I'd just browse the Engineering shelves until I find GM 30 GAR. I forget the exact [classification] system [and the way it works], but it's pretty clear once you get up there how it works. I mean it's all arranged alphabetically. I'd probably find 'G' then 'GM' then '30' . . . [Takes lift to Engineering floor].

C . . . D . . . G . . . It must be here somewhere, because there's signs on the shelves. Here we go, here's the book. [Pulls out book]. I would normally take this downstairs and take it out, but I can't because I haven't got my library card with me today. But yeah, I am unlikely to sit here and read it. **How would you judge if it was relevant or not?** I'd give it a flick. In this case I might look for authors or I might look for subject matter. In fact, I've got this book out once before for something else . . . and I actually found it by chance. I found it in a bibliography and I did a search, flicked through it, realised there was an author that contributed to it which I'd heard of, so I looked at that particular section quickly and then took it out . . . I just read the titles of the papers to get a feel for what they were talking about and then I took it out. **Supposing you wanted to find other relevant books, how would you go about it?** If I find a paper in a book that is useful or a good reference, I'll make a note of it and take it from there. I find bibliographies to be the most reliable way of finding material.

I always go straight to Google because I actually find much more using Google than using Athens, so Athens is my second stop. [Searches for 'voice user interface' using Google]. For some reason, lots of these links are dead. I think I need to use something a bit more direct. I'm just coming up with lots of general things. I think in this case I probably would try Athens actually . . . so I'll open a new browser window and I'd go to the UCL electronic catalogue and get to Athens through there . . . I never remember the address for Athens . . . so I selected the link to Athens resources from the library services. It's annoying that they don't have a link just going to Athens, but a link going to all the different journals [journal providers]. Science Direct? **What are you trying to do?** I just want to see a list of all journals so that I can decide on ones that might be

relevant. But I think I'll have to look for 'Web of Science' [digital library], but I've no idea how to get to it from this area of the website. [Scrolls down list of journal providers]. 'Web of Knowledge' . . . here we go . . . [Clicks on Link]. I've used this before and it seems to be pretty popular. It's quite often recommended by people for our subject area . . . my supervisor recommends it. But I find it pretty hit and miss to be honest. **In what way?** You don't always find anything useful. I have never really found anything where I'm like 'wow, this is just what I'm looking for' . . . I'm much more likely to find that in a bibliography than I am just doing a random search. I forget where I am as well. [Logs into Athens and is re-directed back to the Web of Knowledge]. It's going very slowly though, so I might try the ACM [digital library].

[Types in ACM URL and searches for 'voice user interface']. I'd expect to get something back from that because the ACM definitely has papers on my field. I wouldn't expect to get random, irrelevant stuff . . . I'd expect to get a list of journals that have 'voice user interface' in them . . . in the subject . . . **What do you mean by 'in the subject'?** Well, in the subject matter of the article. I know the subject matter doesn't always relate to the key words that you put in but I'd hope that the first page would have something useful on it. I think it's all down to the way that it does the searching, it's all down to probabilities. The top things on the list [of search results] mean that, for example, they are 90% likely that they've got it right [the content will be relevant to the key words typed in] and that percentage would reduce as you go down the list. I don't know why they do that though, because I've got no incentive to look at something where I'm only 10% sure that they've got it right.

Ok, so here are the results. [Begins to read titles and abstracts aloud] . . . 'using non-verbal' . . . interactive control . . . no . . . I'm specifically interested in designing interactive voice systems, so I wouldn't be interested in a lot of these titles . . . 'user interface design . . . dialogue design tool' . . . that would interest me, something about a design tool for a voice user interface. It's not exactly what I was after, but I'd probably get a copy of it. [Right-clicks and saves PDF]. And probably this one . . . this looks quite interesting too . . . [Saves another article after briefly reading the abstract].

I think I need to be more specific now [with search terms]. **Why do you say that?** Because I've used really general search terms so far . . . I mean all of these papers are relevant, but let's say I'm looking for something a bit more specific . . . like 'IVR design' . . . hopefully this will bring back papers that look at design issues surrounding voice response systems.

You mentioned earlier that it was presenting articles in order of relevance. Yeah, this relevance scale thing [points]. **How do you think that works?** Gawd knows! I have no idea! I don't find it particularly reliable to be honest, especially with the ACM library, which usually gives me stuff I don't want [irrelevant articles]. I don't rate its search engine that much! Things that it thinks are relevant aren't relevant, for me. Maybe it's just the way I'm searching, or maybe it's the search tool. But usually I'm more successful searching on the web. **Why do you think that is?** Because Google performs quite well. Even if it doesn't find you the journal you're looking for, it'll find you the citation, or at least something to do with it . . . and it'll usually be ranked quite high . . . and I've used the the advanced search enough now to know that if I'm targeting something quite specific, I can tell it to look for exact words and find relevant results pretty quickly. Also ACM results come up in Google as well, so it's kinda like searching a digital library anyway. I don't really think about the digital library side of finding articles, I just think of it as searching. If I'm searching of the web, chances are it has a text field and a go button and it will allow me to select a few parameters and that's the end of it . . . I don't really differentiate between a library search versus a search engine search or a search in Amazon or anywhere else . . . or looking for electronics or software or anything. **Are there differences in how search engines, digital libraries or e-commerce sites might handle your search?** I think the fundamental technology is similar but there are specific differences at the interface level in terms of options you can select . . . different radio buttons . . . and the different ways in which they classify the things in the database . . . I mean Google's just a free-for-all . . . it's very non-specific. Whereas if you go to the ACM or to Amazon you'd have to tell it that it's a book or a bit of music that you're looking for. So at the surface level they're different but behind the scenes I'd imagine they run on similar logic although the technology may be different . . . I mean whether it does a Boolean search automatically or whether you have to type in things for it [Boolean operators].

I'm just reading the titles to see if there's anything specifically of interest . . . nothing immediately pops out as helpful . . . I do actually read those little summaries. **You know we talked earlier about subject searches?** I'd imagine a subject search searches these summaries [abstracts] and the titles of the articles. Umm . . . this wasn't a useful search actually . . . it just hasn't seemed to pick up my term 'IVR' in any of the papers . . .

Why do you think that is? Because none of the results seem to be related to IVR . . . so either there aren't any papers on IVR, or I've done something wrong . . . or it's [the ACM] has done something strange! Maybe they called it 'voice response' or something. [Alters search to 'voice response design' and presses search button]. In fact, tell you what I'll do, I'll change it [the search terms] to 'voice response usability' because 'usability' is fairly specific compared to 'design,' which could be technology, or architecture . . . it could be in a different domain. And ACM's big, it's got all the different disciplines within it, so I'm just trying to focus in on usability related stuff. **How did you find out initially that ACM consisted of lots of disciplines?** I can't remember, I've known for quite a while. I just know that it's got special interest groups and there's billions of them, so I presume that all those groups write papers and contribute to the library.

The next thing I'd do if the Internet wasn't running so slowly is keep looking through the list of relevant papers and when I've found one, look through it . . . read the abstract and skim through the contents to find the relevant parts of interest . . . and I'd especially look in the bibliography, and if any of those references looked useful, I'd paste it into Google to try and find the article and the searching process will continue.

At the top of the screen of the ACM page, I noticed that it says 'save results to binder' . . . Never used it. How do you think it might work? I imagine that . . . I don't know . . . either you select particular results to stick in it, or it saves the whole search. I presume that it's customisable and offers you to either save all the results that you've found or save some of them. I presume. And I presume that you have to be registered in order for it to remember that they're your searches. So perhaps . . . I mean I've just got 7893 results from a search . . . I would imagine if I clicked 'save results to binder,' it'll save all these results to the binder. And I would imagine that maybe it would give me the option of filtering it slightly. Maybe it would ask whether I just want to save 500 [results] instead of over seven thousand. But I don't know for sure.

Did you notice any similarities in going about finding things in a traditional and digital library? Yeah, the premise is the same, which is that you're looking using terms that make sense to you and allow a certain amount of flexibility . . . either I go for 'exact match' 'full title' shebang . . . or I'll go for just part of a subject search . . . and both allow you to do that. Also if you don't know what you're looking for, I find them both as equally difficult to use as each other . . . but I still think Google is most effective. **Why are both traditional and digital libraries difficult to use if you don't know what you're looking for?** Umm . . . the traditional libraries in effect, because they've got really poor search software . . . I mean for me it's badly done [the software] and I just haven't bothered to figure out how to use it . . . I haven't invested much effort in this library because I know that it has very few books that are of interest anyway. The digital library is frustrating because when you're doing a subject search and you don't know what you're looking for, you know . . . you tend to look by subject and it's a hit or miss thing . . . you don't know if you'll find what you're looking for. **When you say 'look by subject', how would you do that?** First type in your key words into the field and see what happens. The alternative is that you can go speak to someone if you really need help, although I don't bother . . . but perhaps that's where a traditional library has a slight edge, because they can at least tell you where to go if you can't find where you are. **What would you do if you couldn't find what you were looking for in a digital library?** Umm . . . well . . . I don't know . . . if it was a subject area and I was doing subject searches, then I guess I would give up . . . unless it was really important. But I can't envisage not finding anything useful at all. But I think I would give up if I had lots of trouble, just out of sheer exhaustion.

Did you notice any differences in going about finding things in a traditional and digital library? No in essence, no. In results, yes. I found more use from the ACM results than when searching the library [electronic catalogue]. They present themselves as similar ideas, concepts [the electronic catalogue and a digital library]. So in that sense they're the same. Going and looking for the book itself is a different experience as you're physically going to a floor and taking books off the shelf and I have to take it out for a set period of time and return it, whereas with a digital library I can just save an article to my hard disk. That's all different.

This is the ACM front page and there's a pilot project on here that they're running called CrossRef. It says on here that their aim is to create full-text inter-publisher searchability and here is the screen to use it. What do you think this would do? [Reads text on the screen]. I would imagine it just searches the ACM plus other participating libraries and just gives you results and it's possible that the results will be slightly different if it's based on different search technology than the current ACM digital library. I don't know if it is, but if it isn't, I would imagine that if I typed in 'voice user interface' or whatever search terms I used before in the ACM, I would get exactly the same results, plus a few others. If they're any different, then

I'd assume that they're using different search technologies underneath. **Would you expect it to be different?** I don't see the point in doing it if it's not!

When using a digital library, did you find it similar to anything that you have used in the past? Like? I mean they're just like search engines, whether it be on a shopping website or whatever, just like I was saying before. **And did you find the traditional library similar to anything that you have used in the past?** The search experience is the same . . . the electronic search . . . and the physical aspect of it . . . umm . . . not off the top of my head, no . . . it's like other libraries . . . there probably is something . . . like in a record shop or book shop or something . . . that whole physical part of just looking for a book . . . but it's a whole different thing in a shop. It's a very different thing. **Thanks for your time.**

HCITD2

Have you decided on a topic? I'm going to look for something on qualitative data analysis as a broad thing and see if I can get something to do with dialogue analysis or something to do with conversation. I'm gonna click on search on the online catalogue and put in two search terms, 'dialogue' and 'analysis' to see what that comes up with, because I see those as the two most important words. [Conducts search]. I'd like to find out more about what each one [record] is about, so I'm gonna click on a number [beside each record] and see what that does . . . that gives me lots of information about when it was published and all that, which isn't really what I'm interested in. **What did you think it would do?** I thought it might give me a brief like of what the book was about, the main topics in the book. [Glances back at list of book titles]. But that one does really look interesting. But it's not in the library at the minute, so I might actually put a request on that. **How did you know that book wasn't in the library?** It's got 'site' at the end and it says 'items' [as the field heading on the results page] and it says 1 and 1 out, so there's one of them and one's out. So now I'll type in my library code and request it. [Does so, using the default cancellation date]. I'm going to go back to the main menu to find something that will be useful in this library. **So what did putting a request in for the book do?** I would imagine it sends a message to the computer or the database saying that somebody wants to look at it [borrow the item] so then it'll either send somebody a letter [the computer system] and ask them to bring it back if they've got it . . . and maybe they'll bring it back quicker, maybe they won't. And when it comes back to the library, there should be a message telling them to put it away [put the item on hold] rather than putting it back on the shelf.

Right, I've requested it and I'm going to go back to the search . . . I'm gonna look for things that are in the Science Library since I'm here [in the library], so I'm gonna reject anything not in this library. **How are you going to do that?** I'm going to look down this list here [points to screen] until I see something that's in this library and available. There's this one, 'the language of environment,' but I don't think that'll be relevant from the title, so I'm gonna keep looking . . . I'm reading through the titles . . . there doesn't seem to be anything [relevant] . . . oh, I'll have a look at that one . . . [Clicks on location hyperlink for item]. I don't know why I did that, because I clicked on this before and it didn't give me any extra useful information [in fact, she had previously viewed the full catalogue record of the item and not the location information]. **What information were you looking for?** Umm . . . maybe a little bit more about the book . . . it doesn't really give you much information about the context of the subject . . . I'm gonna go back a page to see if I missed anything on the previous page . . . actually, I'm gonna do another search and this time put in 'conversation analysis' and see if that helps . . . [Conducts search]. Ok, let's look through this list . . . most of them aren't in this library though . . . ok, there's one in here that looks ok, but that's already out . . . it says 1 item here and 1 already out . . . ok none of these look particularly relevant. Ok, I'm going to search for something else because it doesn't seem that many of these things are in this library, so I'll broaden it [the search] to 'qualitative data analysis' and see if it will help me. [Conducts search]. That didn't find a match, so I'll go back again and take 'analysis' off and I'm hoping that will have some more matches [refines search]. No, still no matches! I'm gonna now put another term and narrow the search this time by putting 'children conversation' . . . [conducts search]. Most of them again don't seem to be in this library . . . but this one called 'knowing children' could be quite relevant, so I'm gonna click on the site next to it . . . and it does appear to be in the library . . . so I'm going to write down the location . . . so it's in the Psychology search and it's got a shelf number of whatever . . . I'll just abbreviate 'psychology' as I know it's referring to the psychology section that I've been to already . . .

How will you know where to find it within the Psychology section? Things are shelved in alphabetical order and 'K' is somewhere in the middle of the books, so I'll use that as a guide. [Begins to walk to stairs].

How did you know how to find the psychology section the first time you used the library? There's a board at the bottom of the stairs and it tells you what floor all the different sections are on. **When you get to the Psychology section, how will you know where to look?** I'll probably just start by looking where I looked last time, and so I'll just have a guess alphabetically where the Ks are . . . so that section [points] should be just about the middle. I need K42 . . . so here's K30 . . . K30 . . . K32 . . . it continues over there [points], but I only know that from past experience. Ok, K42 books start here and I'm looking for SIE, which is to do with the author, so I'll look lower down . . . I can't actually find it . . . oh . . . [picks up book]. I've actually spotted it along the way, but it wasn't in the right place, and there's no thing on there [sticker with shelf mark on the spine of the book (the sticker was unusually on the front of the book, but remained unnoticed)]. Now I'll look at the contents page and see if there's any relevant chapters that I might be interested in. There doesn't seem to be a lot on the analysis of conversation . . . there seems to be a lot of developmental stuff, but not exactly what I'm looking for, so I'm not gonna take this book. **How would you go about finding similar books to the one you put back?** Umm . . . sometimes I'll use the online catalogue and just write a list of all the locations and the possibilities, sometimes I'll browse the section of the library that I've found an interesting book because I presume they're grouped by topic as well.

When did you last use a traditional library? Last week for researching my dissertation. **How did you go about finding what you were looking for?** This time I had titles of books to look for, because I had the references, so I could type in the titles into the catalogue and look for them that way. Some of them I had to request and the one's that weren't here, I typed in the author's name to see if they'd written anything similar that was available in the library. And that brought up an earlier edition of one of them, so I managed to get it.

Ok, to find something similar on a digital library I'd use the ACM because I'm familiar with it. Usually I just put a few terms in and just press search. So I'm gonna type in the same as I did before [in the electronic library catalogue] and see what I get. So I'll start off with 'dialogue' and 'analysis' and press search. [Conducts search]. I'm just going to read through the article titles and if any of them seem interesting, I'll read the little description underneath . . . this one looks interesting, but I can't tell whether it's relevant just from reading the title [no description was available] so I'm actually gonna click on the paper and read the abstract from the paper. [Clicks on PDF link and waits for paper to load in Acrobat Reader]. I still don't know if I'm reading the abstract [the paper did not have an abstract and instead jumped to an introduction]. Let's see if there's a conclusion at least . . . ok, even with what I've read it doesn't seem too relevant, so I'm going to go back to the list . . . [Continues to read titles and skim descriptions]. I'll click on this one to see if it's any good . . . no . . . ok, that one's more to do with computer systems that rely on voice recognition . . . this one says something about dialogue structure and coding schemes and although it's not really to do with my topic, it might be useful as I'm currently coding my data, so I'll click on that and see if that's relevant . . . the abstract looks quite promising, so I'm actually gonna read a bit more and see if it's relevant . . . and it does look relevant, so now I'll look at the method and see if it's something that I could use as a method . . . I'll print this off I think [sends paper to printer and retrieves it]. **How would you go about finding other relevant articles?** I'm going to go back to my original search list and put in 'dialogue' and 'coding' because I hadn't thought about looking for that term, but even some of the article I found a minute ago [on data coding] had stuff in it about dialogue structure . . . and I hadn't thought about using that term before! Maybe it'll be more relevant. So I'll do a new search and see if it brings up anything useful. [Conducts search]. Ok, it's brought back the one that I just looked at, at the top [of the results list], which is encouraging. Ok, I'm just looking to see if any of these other ones are relevant . . . There doesn't seem to be anything yet . . . **Why do you think that is?** Erm . . . I don't actually know! I think most of what I'm looking at is more about how dialogue has been coded and not a method to help dialogue coding. I'll keep looking for a bit longer and maybe I'll include 'methods' in my search terms and see if that will help . . . [does not type in 'methods'].

In fact, I'm going to keep looking until that relevance bar . . . if it's really full [as it is now], it means the results are really relevant, so I'm gonna keep going until it [the relevance bar] drops below the level it's at; at the moment. Usually, from when I've done it before, if it drops below half way, you're not very likely to find what you're looking for. **How do you think that the ACM decides what is relevant?** Erm . . . my guess is it must have inclusion of those terms that I entered . . . I don't know, maybe in the abstract or in the citations or the references . . . and maybe how many times it's [the search terms are] mentioned decides how far up the list to put them. [Continues to read titles and skim abstracts].

Ok, I'll look at this one because it's got 'method' in the title and I was already thinking that 'method' was going to help me in the next search . . . so I'll have a look at this, because it appears to give you a setting in which the method has been used, which could be quite helpful, so I'm gonna click on that . . . [Clicks on PDF

link]. Again, I'll start by reading the abstract . . . yes, it looks about how to define a coding scheme and looks good, so I'll print this . . . [Sends paper to printer].

At the top of the ACM screen there was a link that says 'save results to binder.' What do you think that might do? I've looked at this before and I actually don't understand it! I presume what it does is it makes a little folder of your searches, but I'm not really confident in using it, so I've never really tried it . . . Maybe, since there's quite a lot of results here . . . this is 200 . . . I presume it would save all those . . . but that's quite a lot to save in a folder, especially if you do more searches . . . so maybe it saves the ones you've selected and asks you to choose which ones you want to save to a folder. I'm not actually sure. I guess it would have to be categorised in some way with what I put as the search terms, so I'd imagine underneath that as a heading, it would have a list . . . actually, maybe it wouldn't . . . maybe you could click on that [the search terms] and it would bring back the results it's found already for you . . . so maybe the folder would just be a list of these search terms. [Clicks on 'save results to binder' hyperlink]. Oh no! You've got to log in! That's probably why I haven't used it before, because I couldn't be bothered to set up a personal ACM account. And I think you now have to register or subscribe or something, and I never know whether you have to pay or whether you don't have to pay . . . No, I think I'll leave this here.

There's a link here on the ACM home page to a pilot scheme called CrossRef. It says that the project is to implement full-text inter-publisher searchability and you can see the screen to use it here. What do you think that might do? Err . . . [Reads text on screen]. Let's see if this text will give me a clue. [The only relevant text to how it might work was already read out to participant]. What I think it might do is if you put in an article, it might tell you all other articles that have referenced that article . . . but in terms of a search, I don't know what you'd type in . . . **What would be the first thing you would type in to discover exactly what it did?** Erm . . . I could put in a general search term about an area, or I'd be tempted to put in an author's name that I knew of to see if it brought up similar articles. Actually, let's try it . . . I'll type in 'Drew' because she does lots of things on usability [conducts search]. This is showing me all the articles that the author's written I think . . . because this person is always included in the author's list [in the CrossRef search description]. So maybe it does do what I thought it would! Now I'd expect anything I click on to bring me the full-text of the article . . .

Did you notice any similarities between looking for things in a traditional and digital library? I think I tend to do the same thing in both . . . I'll think of a set of search terms to use first . . . but if I was using a traditional library that didn't have an online catalogue I'd be tempted to go straight to the shelves because I don't like using index cards. . . . I quite like browsing to be honest . . . you tend to find things by accident a lot more when you're browsing than when you're searching for something specific. Also I presume that a digital library is organised in a similar way in that it splits things up into articles and books and things like that and I suppose a traditional library splits things up into sections such as journals and books, so they're kinda organised in a similar way.

Did you notice any differences between looking for things in a traditional and digital library? I think with a digital library it's harder to find things that are similar because you have to actively search for similar things and try different search terms, but in a traditional library, you can browse . . . and you know that all those things have been put together because they are similar, so it's easy to find a few and quickly decide whether they are relevant or not. In a digital library, it's also more difficult to find if things are relevant because there's no contents really . . . but maybe that's an issue more to do with books, because a journal article won't usually have a contents, so maybe it's not that significant a difference.

Did you find using the digital library similar to anything you have used in the past? I guess it's a bit like using a search engine like Google whereas in Google though, you don't know where to stop . . . when your results stop being relevant . . . so it's good that digital libraries have some indication of relevance. **Did you find using the traditional library similar to anything you have used in the past?** I can't think of anything . . . maybe other libraries . . . **That's all. Thanks for your time.**

LISDT1

Have you decided on a topic? I'm going to look at architecture of libraries over the recent past and possibly new library building. Well I might just look generally first on a digital library that I've always found to be quite up-to-date and UK based . . . and it does often get more relevant results, so I'll just do a very basic

'library and buildings' search and see what happens. [Types in URL for Ariadne Digital Library and conducts search]. **What do you think will happen?** I think I'm gonna get a lot . . . well, not a lot of rubbish, because this site is quite specific to do with libraries, but I'm not sure it'll be ideal because I think this site tends to address quite recent issues which tend to be about digital libraries and electronic libraries and things, but you never know! These [search results] aren't looking very good, but I'll have a look anyway . . . [Clicks on one of the first titles and begins to read information in HTML-based article]. Ok, it's something about the University of Dundee's library. Ok . . . fine . . . ooops! **What happened there?** It doesn't like me using the back button, so I have to refresh the page all the time. [Continues to look down the list and click on any article that has a small chance of being relevant]. Ok, this is a similar article that might be useful . . . it's a good starting place. I'm just going to have a look at a few more [articles]. This looks like a very similar article about another university, so I won't have a look at that. **How did you know that?** Because I looked at the URL and saw that it has 'John Moore's' in there [in the URL itself]. [Continues to select from list of titles]. I'm not sure why this has come up [in the search results] . . . obviously there's something to do with 'building' in it . . . maybe not actual building [in terms of library building] but that's just useless! **Why do you think it might have come up?** I've only used two really basic terms, and 'library' is gonna come up all the time in these sort of articles and 'building' is the sort of word that can be used in lots of different ways. I'm just gonna look at this one [article] as well before I try something else [another search strategy]. Ok, this is more about building digital rather than a traditional library, which wasn't what I was looking for, but is still relevant in a lot of ways . . . it looks quite practical! I might just do a search for architecture as well . . . and see if the results differ much. This isn't a very specific search . . . but it's usually how I start off . . . [Conducts search].

Right, I don't think 'architecture' is a good term to use in relation to technical things, because obviously it's got its own meaning and I don't think any of these [results] are anything to do with actual, traditional library buildings. So I'm gonna leave this [search] now here. I might just now look on a journal indexing library, because I've used that in the past and it was useful. The other place I might look is the Library Association website, but I won't do that because it's gonna be more 'newsey' and I'm looking for published work rather than just news articles. So I'll use an indexing service like LISA [Library and Information Science Abstracts] now . . . although I have to think of how to go there! I'll try just via the UCL library services page . . . so I've selected the list journals for library studies, which I know are within the 'arts and humanities' heading. Although I didn't know about this [journal listing] service for ages . . . I don't think it's that obvious how to get into LISA. I knew they have got the physical print volumes of it, which I have used before, but they're not very easy to use . . . so our lecturers told us that we could access it electronically . . . but even so, we're [the MA LIS Students] are still a bit clueless . . . I think there was a leaflet that the library service produce actually that helps you with accessing LISA . . .

Ok, here's a list of different indexing services, I think. [Scrolls down and ticks 'LISA' checkbox and presses 'open' button]. This [LISA] is the one I want . . . but I don't think this is particularly easy to use. Once you've selected it, you then have to open it . . . but once you're in it's not too bad [to use]. Ok, I'm just gonna start really basic again and just do . . . I'm not actually going to use 'library' this time, because everything in LISA is to do with libraries anyway, so I'm just doing to do 'building and new' and limit it to 'English' because it's a massive database, so I'll just start with that . . . [Conducts search]. Ok! I've got 1,840 results! They all seem pretty . . . not bad! There's a few actual projects and a few others . . . generally with this [LISA], you have to be quite general and just trawl through them all [search results] to find what's relevant . . . or I do anyway. There's also a feature on this which I have used, but it does take a lot of time . . . called the index, which I might have a look at now actually. Although there do seem to be relevant things just coming from that search [continues to look at list of titles]. Actually, like before I'm going to do an 'architecture' search . . . but I'm not sure that word's very useful, but I'm going to do it anyway What's good about this [LISA] is that it saves a list of your previous searches, which helps you form a systematic search strategy. [Types in 'architecture' into search box]. Ok, I'm just trying to think of something to narrow it down [an extra search term to type in] . . . in fact, let's just try it [just the 'architecture' search], but I think it'll bring back hundreds. [Conducts search]. Yeah, 3000 results . . . so that's not very good! Ok . . . I'm going to use the index now. **What does the index do?** That's got an index of all the search terms that they [the LISA database] use] . . . it's basically the list of cataloguing terms that they file each abstract under . . . **How do you think they do organise the articles?** I think they . . . I don't know actually. I think they might have some sort of human person . . . well actually, they might do it electronically . . . they might get something to scan the abstracts and pick out relevant words, maybe the most common words . . . and then assign it to a category. I guess that's what they do actually . . . but they do [the index] seem to be very reliable, so perhaps humans

might play some part in allocating things to them . . . but actually, LISA is so massive that I'm not sure that that's possible.

I'm going to look at 'architecture' [in the index list] first and just see . . . because usually there's loads of combinations [classification headings based on more than one word]. So it shows an alphabetical list of the terms that they have allocated to these articles, which you can select and go and have a look in . . . Ok, usually it's the case that the most relevant articles are in the headings in which there's the biggest number of results, so then you have to think a bit . . . which I'm not very good at, because I always think I'm missing something . . . so I'd rather trawl through a few hundred results than keep getting them narrower and narrower and risk missing something. **Why do you think that the most relevant articles are usually classified under the more general headings?** I just think . . . I don't know . . . I just think that when they [the headings] get really specific, I don't know how they managed to classify them [the articles] there. So I just think you've got to make sure you're not missing anything. And whilst it's not so useful for the user to look through lots of results, I don't know how you can get round that really. I mean 'architecture-libraries' [the category] . . . there's only 5 results and obviously I'm gonna have a look at that, but I don't think it's gonna take me very far. [Clicks on the category heading and views individual abstracts]. No, none of those were relevant, so I'm just gonna go back and look at 'building' [conducts a new search]. I seem to be stuck using the same few terms! This time it's given me 8000 results, so that's not really very good! [Looks through results]. It becomes a bit annoying that all you can see is abstracts on an indexing service though. [Conducts another search]. On 'building' I had 8000 [results], on 'buildings' I had 4000! I guess sometimes the index can be good because it can help you find terms that you are struggling to find. But often you've thought of the relevant things anyway and these are just weird things! I think now I'd just start looking at physical things using the bibliographies. I might also look at online journals themselves, but I think that is often time consuming because you're searching in such a narrow . . . I mean perhaps you're searching in just one issue of a journal at a time. Often there's a journal which is specifically about a subject I'll be interested in, but I think for this one there might not be because it's quite a specialist area. I might find out though. **How would you find out?** I don't know! [Laughs]. I might just Google it. Umm . . . I suppose otherwise, just going through the UCL catalogue or looking through good, solid books that were relevant and looking in the references for any journal titles. [Searches alphabetical UCL journal listings for LIS]. It's not a comprehensive list, because a lot of printed journals, it's not possible to access them electronically. But it's a start . . . so let's just have a quick look through . . . No, although something possible to look at is this IFLA journal, which is the International Federation of Library Associations or whatever . . . because there has been a lot of library building . . . but I don't think it's a very good journal because it's freely available, and usually being freely available means they compromise on quality in the articles. There's nothing jumping out that's particularly relevant, so there probably isn't a specific journal. That's fine, at least I know! So the next thing I'd do is look on the library catalogue now. **Before we do, when you went first of all to Ariadne and LISA and you were searching for things, how do you think either or both of those was deciding on the order of which to show you results?** Yeah, umm . . . I guess it's . . . I don't know how they do their abstracting or whether it comes directly from the journal publishers or what, but they're probably doing it on number of occurrences of words. That's the only way I would think, but I don't really know much about how they do it. They do usually seem to be quite accurate though. **So where do you think it might look for occurrences of words?** I think only in the abstract because I think reproducing the abstracts is a lot less work, especially for an abstracting service like LISA . . . I'm not sure whether external publishers would even allow them [abstracting services] to have access to the full-text of all the articles anyway, so I think probably just from the abstract . . . which I suppose, people who write good abstracts will include the relevant terms in it.

I'm now going to have a look at the UCL electronic catalogue. I always just do a basic search. I'm not very good at advanced searching, I just think it takes too much time, so . . . I'll search for 'library architecture' and I think these results might be better because actual humans have catalogued them and they are qualified to do that . . . but my searching isn't obviously that good. [Conducts search]. So I got 277 results, which is quite a lot. But already, record 3 is about building disability friendly libraries . . . and there's a lot about actual architecture too . . . I'll just try to see why this title on 'Greek and Romans' has come up, because it seems out of place . . . so I'll just select the record by clicking on the link that shows where it's held . . . sometimes that's confusing actually, especially at first, because you've got another link [the number link to the left of the title] which just gives you more information about the book or item [full catalogue record]. So anyway, it looks like this Greek and Roman thing has come up because it is in a series of library initiatives, but I still don't really know why it came up . . . [Returns and looks through list of titles]. Record 20 is looking quite good . . . 'The Architecture of the British Library' . . . yeah, I mean it is quite general. I mean, you get over 20 results on a page, so I would look through all 277 results and I'd just select the records that I thought were

relevant rather than having to write them down . . . anything vaguely relevant, I'd just select them all and view the ones I'd selected at the end . . . then either print them off or write the locations down . . . and then start with other search terms and repeat the process. I'm not disappointed at the moment with these results, to be honest . . .

I'm just going to try 'library building' [Conducts search]. I've got 82 and there's a lot about general architecture . . . but I've now found some German resource in a library . . . oh, I've forgotten to select the ones I found interesting on the last page! [Goes back to select checkboxes]. Right, now I'll look through all of those 82 results from the previous search . . . **How do you think it's deciding on an order to show you these?** Hmmm . . . I'm not sure. I don't know if it might be to do with how near together the words that I've searched for are in the title . . . and other information . . . I know that it searches the whole record, because one of the first records that came up on my other search wasn't relevant at all and the word 'library' was really separated from the word 'architecture' . . . so perhaps it's not that [how near together words are]. I mean I'm only searching for two words, so I suppose . . . I don't know actually! But generally I do find records a long way down in the list that are relevant.

I think I'm finding a lot of fairly relevant things here which will be a good start . . . if I find just 5-10 records to go and start with, then that's good for me . . . [Continues searching results]. I've selected some. I now want to view the marked ones, so I'm selecting 'view selected' from those options. They're not in a very good format though, because it doesn't actually show me them all, it shows me a record at a time . . . although I think I've managed it before, but I can't remember how to do it! So I'll just write down each location . . . a lot of the records are getting the same class marks coming up, so that's good because I can just browse the relevant area when we go to the shelves . . . I'm just writing down an author and a class mark for each of the books that I thought was interesting . . . I'm not that worried about finding exact books though at this point, because this is just the start point [of the research process]. I know that I probably won't miss anything because they're all vaguely in the same place . . . [Writes down each location one at a time]. Oh! I've got absolutely no idea where the location of this book is [in stores], but I'll write it down anyway . . . actually, I won't . . . because I'm lazy . . . I don't know what 'NEL' stands for . . . and obviously I could find out by asking a librarian, but actually I've just realised that it's in Stores . . . and I think NEL is something to do with . . . somewhere in UCL anyway, but I don't think it'll be easy to find out where it is. **What do the other things that you've written down tell you about where the books are?** They all say 'Librarianship' and I know where that is. So I'd just go to that section and just browse. But I might do another search actually . . . no, I won't! **If you did do another search, what would you type in?** Well I can't remember what I typed in last time [laughs]. I think I did 'building' or did I do 'architecture' . . . oh, I think I've done two searches . . . I've done 'building' and 'architecture' so the only thing I'd do, if I was being more specific, is I'd type in the name of a new library that I know has been built, such as the Bibliotheque Nationale in France, because they might have books written about them.

How did what you've written down going to help you find the books? Because I know the area that we're going to [the Librarianship area], I'm just gonna go there . . . I'm not gonna probably even look at my list now . . . well, I might . . . I'm just gonna go and find the area, which is arranged alphabetically within the area . . . it's quite a small room, so it's obvious where to find things and easy to find your way around . . . and within the room, it's a classification that I don't really know much about called the Garside system and there's an explanation of it on the wall . . . I think it's a system made up here at UCL. [Walks into Librarianship room and looks at chart on the wall]. Oh, I've just noticed on the chart that there's a section on Library Architecture, and that's section L35 which is the section I found most of my books [deemed relevant] were in. So it looks like the sections arrange the books by subject on different aspects of librarianship, but I couldn't tell you any more to be honest.

So let's go to the architecture section . . . I know where each letter is and I know that L is where we are now . . . [Begins looking through titles and takes out list]. Oh, my first book isn't actually in this section, it's in N10, which is over here [points]. And N10 is more to do with National Library . . . that's because the book is about building the British Library, and that's a national library, so someone's decided to put it in the 'national libraries' section, which is fine. [Picks up book and returns to L35 section and starts methodically finding books on the list]. One of them's this old looking thing . . . often the books go out of date quickly in Librarianship . . . I mean this one's talking about libraries in the 70s, so unless you're having a historical perspective, it's not really relevant . . . you can sort of tell [the age and relevance of the book] from the last time it was borrowed. This is another book [picks up book] and without opening it, it already looks horrific . . . looks a bit dated! I'd want something more recent . . . this is a '75 publication as well . . . I mean sometimes

on the catalogue I do restrict my search to 'published since 1999 or whatever' . . . or if I don't, I just don't look at records that are published before then. But I'm sure I'll find something here to help me start . . . [Picks up another book, not on list]. Oh dear! This book looks very American because of all the glossy photos on the front. . . but it's a bit newer, so hopefully it's references will be far more up to date and lead to things relevant to the British library scene. That's why you're lucky if you find a book on this topic, you're probably more likely to find more in journal articles. But this is quite a good set of references in the bibliography and is a place to start . . . this section of books in general doesn't look particularly new, so I don't think I'd spend much time here . . . at all . . . [Walks downstairs].

What would you do if you couldn't find one of the things in your list, if you were looking for it specifically? That happened to me yesterday, and I found that they had moved the journals I was looking at last week to the stores, which was very annoying . . . but I didn't know that at first, so I looked to find it on the catalogue first, because you need to be sure first that it's not out or whatever . . . then I looked in the re-shelving areas and that's about it. I generally don't seem to bother telling anybody, because nothing seems to happen. But I would always check quite thoroughly first and if something was out on loan, or in stores, I'd put a request in using my lending card. **What would you do if you couldn't find something in a digital library?** Usually I just give up, it's very frustrating! That happened to me yesterday as well! I was looking for some publication that the British library did and it was on their website, and admittedly it was in 1998, but I thought it might still be there or perhaps in the British Library . . . but I've been to the British Library and looked on the catalogue and it's not there and it's very frustrating. So I've e-mailed them about it and they haven't got back to me! It is frustrating, it's awful, because you've got nowhere to go [for help]. At least in the [traditional] library, there might be something next to it that might still be relevant. You can get round it more I think with physical things . . . but when it's a digital library, I just feel hopeless! I have found sometimes, though, that things might be published somewhere else . . . so something might be published in a newsletter and then the author's made the content available to another journal and they've gone and published it, so that's one way of trying to find something, by looking at alternative places that it's been published. But some things you know you're just never going to find!

Did you notice any similarities when finding things in a traditional and digital library? Well I probably used the same search terms to start with. I think sometimes a digital library gives you more scope because then you can immediately click through and scan something quickly and see if it's relevant and if it is, then you feel happy pretty soon that you've made a good start . . . and also it can reveal abstracts, although sometimes they're a bit misleading, you can often identify other search terms from the abstracts and on LISA, it's got all those lists . . . it's got the index . . . but I don't think that's particularly helpful to narrow your search down, but it's something if you're really stuck. In a traditional library, you're not knowing if what you're finding on the catalogue is going to be relevant, but then there are still some really good quality resources that you are going to find in a traditional library and not in a digital library.

I noticed that when you were searching the library catalogue and when you were searching the digital libraries, at one point you typed in 'library and building' . . . and in the library catalogue you typed 'library building' without the word 'and' in between. **Was there any particular reason for that?** I don't know if . . . I generally think that the library catalogue doesn't always . . . I suppose it does do Boolean searching, but I wasn't thinking that it did . . . I don't know, I think with the library catalogue, I've found in the past that you're searching doesn't need to be really specific and also you're not going to return a lot of results, so I suppose I'm a bit more careless . . . and also I only ever do basic searching . . . I only ever use AND and OR or NOT [Boolean operators] and sort of like inverted commas, speech marks for a phrase . . . and I never use brackets and other things. But I always find on a library catalogue that I don't think about my search so much.

Did you notice any differences when finding things in a traditional and digital library? Umm . . . I always find on the library catalogue that there's fewer resources compared to all the individual documents held on a digital library, so your results are generally more accurate to what you're looking for . . . in a digital library, I think it's often hard to distinguish between words meaning something different [synonymous search terms] . . . I know you can say 'NOT' . . . but it's very hard to do that, so I often find you get a lot of double meaning in your results and perhaps they're not so relevant. But sometimes you get something really, really good . . . but I dunno, in a traditional library I tend to get more specific results . . . probably also because you get into the way of thinking of how people catalogue things . . . and we study cataloguing and I know . . . I know the general terms that cataloguing systems use, because you have to use the set standards, which are

generally the Library of Congress headings, so yeah . . . perhaps I'm more in tune with how they're cataloguing.

Did you find using the digital library similar to anything that you have used in the past? Umm . . . similar just to using search engine things . . . but then [digital libraries] are more specific, you know you're not going to spend hours just looking through rubbish things and also you know that you're going to be finding fairly good quality articles . . . and you know who they're by . . . and they'll reference things properly.

Did you find using the traditional library similar to anything that you have used in the past? Using the catalogue or the shelves? **Either or both.** Umm . . . well I obviously used my old university library, but not in such a good way. Now it's much more web-facing. So that makes it much easier to find what you're looking for. I think browsing for things in this library is also quite a lot easier than with a public library, because they've often got such large sections that it's quite difficult to find anything . . . so I'd say the traditional library, I feel more used to . . . because I find you can be 'a bit more free' with it all, you can just look around and browse . . . but I always feel when I'm looking around browsing through books that I'm not searching in the best way and that it's quite imprecise. I always know that there's this whole wealth of [printed] journals just sitting there, and I always know that there's a lot of information in there . . . and I think journal literature searching is one of the hardest things to do, the physical journals more so for librarianship because there's very few of them which are online . . . there's a lot, but they [digital libraries] mainly only show the last two years anyway, and often you'll want to go back further than that and the access can be really slow and confusing when using different journal providers, so I'd rather use indexing services like LISA and the physical journals themselves . . . I just find that a lot better. **Thanks for your time.**

LISDT2

Have you decided on a topic? I'm gonna look for 'indexing museum pieces' . . . either indexing or cataloguing them. So I'll start by going to library services and then electronic resources and then databases, because it's the only place that I know where to look really [selects 'Librarianship' from 'Arts and Humanities' subjects] There's also other things here [library electronic services]. . . e-books . . . e-journals. E-books I'm not interested in . . . web resources clicks on hyperlink and looks down list of sites]. These looks pretty boring. I assume they're just meant to be useful sites. [Reads list]. BUBL [some sort of information provision service] is useless. This might be good . . . 'Documents in Information Science' . . . [Clicks on link to DoIS digital library]. Let's try searching for 'indexing museum' . . . I've found them [the search terms] to be useful when searching LISA [Library and Information Science Abstracts database] in the past for my dissertation. Oh, nothing's found! **Why do you think that was?** I don't know, I'm looking to see if I've typed my terms properly . . . let's just try 'indexing' by itself. It might be that 'indexing museum' is too specific to bring back conference proceedings, which I assume these are, although I've never used this library [DoIS] before. [Presses search button]. It's annoying,, because it's found 183 [results]. Whatever I choose to search for will either return nothing, or far too much! Umm . . . ok, because that's too many too look through I'm gonna try searching for 'indexing and 'museum [types 'indexing museum into search box and presses search]. That's a bit more manageable. [Begins to read titles and notes an article of potential interest]. Possibly . . . I'm gonna have a look at this one . . . [clicks on article title hyperlink and looks surprised that an index of article titles from a particular journal is displayed].

Aaah, I expected it to take me to the document but it's taken me to another index . . . [begins to scan list of articles for the article deemed potentially relevant in the search]. I can't even find the one I wanted now, I don't think! I don't even think the one I was there . . . it was 41 volume 8 . . . [continues to scan down list for a few seconds]. Ok, well that's a right load of rubbish! That's completely put me off! But I might have a look at one of these [articles from the Journal of the American Society of Information Sciences]. I'm assuming that clicking on one of them will actually take me to the document this time. But actually maybe it won't. [Clicks on title]. So maybe what it's done is it's taken me to all the documents they've got [DoIS stores] from the American Society of Information Sciences. But why isn't it bringing up the one that I asked for? Maybe it's only got older ones [articles]. I got the impression that the articles were here [in full text] and not that it only lets you take a citation. [Continues to look down list]. That might be useful . . . 'Evaluating three museum installations of a hypertext system . . . [reads abstract].

That might be useful, although probably too based on end-users and whether it would be a system they'd wanna use. I'd have to take the journal reference and see if they've got it here . . . then find the actual article and photocopy it. [Returns to search page]. It says [above the search box] that there are this many

[thousands] of them [articles] that are downloadable. So I must be picking the wrong ones! I'm gonna search another way. I'm gonna type 'museum objects' . . . in fact, I might actually try 'museum' [conducts search]. This will look at it from another perspective. **So how would you know if a document is 'downloadable' from here or not?** I don't know. **How do you think it's arranged this list?** It thinks it's done them in order of relevance. I would imagine that's probably just the number of times that 'museum' comes up in the title, because I think that's the only thing that I asked it to search for [i.e. assumes a title search has been performed]. I'm not finding this anywhere near as easy to negotiate as I would with books and because I haven't found what I wanted straight away, I'm more inclined to call it a day with this one [digital library]. I'm gonna try 'museum' and 'objects' and that'll be the last search that I do. [Conducts search]. This one looks as if it might be ok . . . [Clicks on title and scrolls right to the bottom of the page. Notices a download link and clicks on the 'pdf' hyperlink, missing the command button to download the article initially]. I thought this would load the article, but it seems to just give me information about PDF. [Presses back button on browser and notices command button and clicks on it]. Ok, now I've asked it to download the paper. [Emerald digital library, the provider of JASIS loads in a top-hand frame on the screen and the PDF article begins to load in the bottom frame]. **What do you think it's doing?** It's just loading the article. [Pauses slightly at contents page and skims through the full text of the article]. It's probably too . . . because it's looking at how school students interact with objects in a museum . . . but maybe they'll be some useful references at the end. No, I've not found anything from those articles. I've found specific articles on my subject, so now I'd just abandon this library. I've used LISA and found other material that way and have tried a few other digital libraries through the UCL catalogue and have been unsuccessful. So I tend to just use LISA now. **How would you go about using LISA to find information on your dissertation?** In the same way as I did with this . . . I started with 'indexing' and 'museum' and 'objects' and that was too many [search terms]. But because I was finding things that were more applicable, and because it was easier to use . . . when I clicked on a link that I thought would take me straight to the document, it did take me to the document. It's more difficult to access, but the end-product is easier to use and more intuitive and I would do the same 6 or 7 searches that I've done here. I experimented a bit when choosing my topic using LISA and that's probably how I came to my keywords of 'indexing' and 'museum' that I've used with this library [DoIS].

When was the last time you used a library for your studies? Realistically, at least 2 months ago. I was using it to find . . . umm I tend to browse more than use a catalogue to search . . . we've got a staff library [where the participant works] and I tend to use that more than here, because I can just take books rather than checking them out. Also they're a lot newer than what's here as well. I don't actually remember last time I went looking for stuff though . . . I suppose it was when we did a 'classification' essay. I looked for things for that. **How did you go about finding what you were looking for?** Umm . . . I tend to search the catalogue – keyword search using 'all words' . . . and then generally I just use the classmarks that it gives me to browse . . .

Sometimes I look specifically for stuff, but half the time here things are not on the shelf when they're meant to be. And adding to that [problem] there isn't enough books for students on the course. I can't be bothered to look on the trolleys to see if it's being re-shelved or not. **So you use the classmarks to help you?** Yeah, so 'classification' [the topic of interest] will be under a range of classmarks. When go and look for those classmarks, I also usually have a look at other books on the shelf in the same area.

I tend to go straight to the terms that I want rather than look for general terms first. [Goes to UCL library catalogue and types in 'indexing museum.']. Through some of the research that I've already read for my dissertation [on the chosen topic] it has become clear that those [search terms] are the two sort of things that I'm looking for. I know that there are other terms I could use though . . . something like 'museum objects' or 'museum pieces' or something like that. I chose 'indexing' though because I know that museums are not at the stage of being classified or catalogued . . . information organisation is still in its infancy. [Looks though list of returned search results]. That's interesting actually, because there was nothing in Librarianship and I expected there to be. **How did you know that?** Points to the location field on the catalogue. Because I say here. Although that possibly might be it, 'Science' [Librarianship might be part of the Science Library collection]. [Clicks on 'Science'] It's in the archives . . . mmm [reads extended title]. 1979, it's probably a bit too old, and it's manuscripts rather than museum pieces. So that I'm probably not interested in . . . [Begins to look through remaining titles].

This one's no good either. Because it's in Archaeology [section of the library] and not Librarianship, it suggests it might not be very useful. To be honest with you, I can't see why it brought up 'indexing and museum' [why it brought up the record based on the search terms given, since the search terms were nowhere

in the title]. [Clicks on hyperlink before the title of the book in question, which displays the full library record]. Oh, here it is in the subject field . . . [notices 'indexing' as one of the listed subjects of the books and begins to read other subject categories]. Oh, that's interesting . . . museum registration methods [another subject category that the book is listed under]. I get a lot more information from the catalogue record . . . 'cause I kinda expected 'indexing' and 'museum' to come up in the actual title rather than in the subject field. But that one [book] might be worth having a look at actually. It does look old, but might be ok. **Why do you think that 'indexing' and 'museum' came up in the subject fields and not the title?** Because I asked it to do an 'all-fields' search, so it's not just searching the title fields . . . it's searching the subject fields as well. It's annoying that I can't get the classmark from this page! I have to go away from the full catalogue record and go here [points to 'location' field and clicks on 'Science']. [Takes out pen and paper and writes down relevant classmark]. I've got a location here and I would imagine that somehow that's a classmark. And if that book wasn't at the classmark that it was supposed to be, I would have a look at the other books in that classmark to see if there are other useful things there. I mean, possibly not though [there might not be useful things there] . . . that might be a random odd book [and not contextualised by the other books surrounding it]. I tend to use the classmarks as a guide for material that I would expect to be together. [Returns to list and mutters titles of other books]. Now this one I'm quite interested in because it's got here [in the extended title of the book] 'Museum Documentation Association,' which is one of the organisations that have been involved in attempting to catalogue and classify museum pieces, so that might possibly be quite interesting. [Looks at full record of this book]. It might be a bit . . . you see it's got subject headings 'industry,' 'social history' . . . so it might be a bit too abstract. But that's worth having a look at as well. **How would you know how to find the books you've said you're interested in?** Umm . . . I'm not entirely sure I do! I'm assuming that's Institute of Architecture [Referring to the first part of the book's classmark]. I'd go and ask at the desk. I'd ask what they're for [how to interpret the classmarks].

I don't think I'm gonna look any more . . . I can't think of any terms to search for that would be broader and still be useful. As far as I'm concerned, these [search terms] have got at the root of where I wanna search. **What terms might you use that would be broader but not so useful?** Umm . . . I could maybe try 'indexing' on its own. Maybe 'cataloguing,' 'classification,' . . . but I would imagine they would bring back far too many results . . . [Searches for 'indexing' and selects 'title' from the drop-down box]. I'm searching only in the titles to limit the search so that I don't get the ones that have just got 'indexing' in the subject field . . . it's brought back 94 [results]. It would be useful to limit these somehow. [Clicks on 'filter' hyperlink and selects items only in the Science Library]. Right, I've put the filter on to see if there's an easy way that I can reduce them from 94 . . . now I've got 69 . . . by telling it to look just in the Science Library, where I know that 'Librarianship' is.

I would imagine a lot of these [filtered results] are going to start bringing up the same classmarks and a lot of them will be in librarianship. [Clicks on an interested title]. So that's K50 [the final part of the classmark after the initial 'Librarianship']. I'd take the classmark and look at the books on the shelves. You really don't have enough information on the catalogue to determine whether they'll be useful or not, so you just take a few approximate classmarks and go and physically look on the shelves. I find browsing is much more useful than searching for specific things on a title. **What's making you choose which records to base your approximate classmarks on?** I chose the first one [record] because it's 'Abstracting and Indexing' . . . it's a general text, so that's more theory . . . which is probably the basis of indexing, which is what I'm looking for. I picked this one, 'Beyond Book Indexing' because a lot of indexing will be about books, not museums. I'm really not interested in that, I want to look at some of the complications when using materials other than books. [Still makes a note of the location of the item despite deeming it unrepresentative of the kinds of results expected from the search]. You see, museum pieces are still mostly indexed by their name, which you can't do if you want to enter details about them accurately into a library catalogue and mount it on the Internet. [Continues to look through titles]. This one I'll probably have a look at . . . it's called 'Indexing in Theory and Practice' . . . it's another theory one and it's very recent as well . . . yeah, K50 again you see! [Continues reading down list of titles]. Ones like this without a year showing I don't tend to bother with because they're either not catalogued properly or so ephemeral that they don't even have a year. [Continues reading titles]. Aaah, that might be useful . . . 'Object Recognition' . . . it's old, but still . . . oh that's interesting, it's in 'ENGINEERING' . . . so maybe although the title of the book looks highly related to what I want, the title might be completely misleading. But it's worth having a look at. [Clicks on location details]. 'Transit store' . . . I don't exactly know what that means . . . maybe it's being taken either to or from the store . . . but I don't know where the store is. I'd ask.

This one looks useful because it's conference proceedings and you tend to get different perspectives and it tends to be what librarians and information professionals are actually doing in practice. I'd be tempted to have a look at that one, although the classmark suggests that maybe it's not exactly what I'm looking for. **Why does it suggest that?** Because I would expect it to be the same classmark as the others [that were deemed potentially useful], around K50 . . . it's L85. It may be that it's more along the lines of basic classification rather than indexing. But I would have a look. Now I'll go and have a look, particular in the K50 area. And if I find things in those books really useful, I'll use the bibliography to find more things.

[Walks immediately to Librarianship room]. **How did you know where the Librarianship room was?** I've been here before. **How did you find it the first time?** I think I just followed the signs that said it was downstairs . . . or it was just the induction we had at the start of the course. This is where I think the useful stuff will be [quickly finds the K50 shelf area and picks one of the books found earlier on the electronic catalogue]. I'm just scanning through the book to see if there is anything useful in it . . . I usually start at the contents and then if something looks good, I'll just jump in and look it up. This one looks a bit too basic actually. It's looking at the need for indexes, which is slightly outside my scope. [Picks up a book not found earlier on the catalogue]. This is more related to what I'm looking for . . . 'vocabulary control' . . . with indexing museum pieces there is no set standards for indexing, which is what that means. Like when I put in the two terms 'indexing' and 'museum' [into the electronic catalogue], it brought back things from the subject fields as well as from the title fields. This is one of the things that is still being established in museum indexing. So this might be useful. [Puts book to one side and looks through other books from the same section in a similar manner and discards most of them as not specific to the topic or too basic for Masters level]. I'm just going to look for that other book that I found in L85 . . . [Soon finds L85 section on the shelf]. I think this was it. [Skims book in a similar way to others, beginning with the contents page]. This reference looks interesting . . . If we took the journal article here, then I would bother to find it . . . if it's easily available. Otherwise I wouldn't follow it up at this introductory stage [of research into the chosen topic].

How did find the K50 area? It's alphabetical. When we came into the room, we were close to the 'Ls' and obviously it's before that. **You mentioned before about 'vocabularies' . . . does a traditional library a vocabulary?** Up to a point, yeah. Whereas with museums, the Science Museum and a Museum of Popular Culture might not have any cross-overs in the way things are indexed . . . with books, there is far more crossover than with museum pieces where you're trying to describe what something is as well as what it's about. I'm not surprised that there's not very much on this in book form, because it's a new subject area. I think I'm better off going back to LISA [Library and Information Science Abstracts database] and looking for more journals. I'm done here. [Begins to walk downstairs]. **When you typed your search terms on the electronic catalogue downstairs, how do you think it was deciding what results to bring back?** It was following the search terms that I put in. I told it to search for 'indexing' in the title. I don't know how it was actually managing it. I typed some search terms in and it brought me some search results back. I don't think about it any further than that.

Why did you choose to use the same starting search terms when searching both the electronic catalogue and the digital library? Umm . . . because I think they're the best ones to use for what I'm looking for and they seemed to be the most applicable from when I was experimenting with keywords when using LISA in the past. They brought back the most hits, but most importantly the most relevant hits. **Did you notice any similarities when going about finding things in a traditional library and in a digital library?** What, in terms of approach? **Feel free to interpret the question as you wish.** The way I use a traditional library is I tend to find a general physical area and then browse, and you can't do that with a digital library. That's why I prefer using material in book form. Because another thing that's happened is that the standard of cataloguing and classification of books is much higher than in digital libraries, which is why even with something specific like a specific digital library for Librarianship, you'll find kinds of things that you'll think 'this really isn't applicable to me' and when you try and narrow your search . . . ummm . . . I was getting nothing that would be directly applicable. **Why do you think there is a difference in standards of cataloguing and classification between traditional and digital libraries?** Umm . . . because I think digital libraries are still new. People have been arguing about how to go about classifying books for a hundred years . . . and you can be a lot more approximate with a traditional library . . . you can physically place things together that are useful, whereas with a digital library you can't. It just doesn't work in the same way. I think you have to be a lot more specific when you're looking on digital libraries because you can't see 'oh, it's roughly over there . . . I'll go and have a look.' Umm . . . and because of that, you have to spend a lot more time [searching digital libraries] and most of the articles didn't have the option to allow me to scan read them straight away, whereas something I do in a traditional library is that I pick up a book when I think it might be useful and scan read it.

You haven't got the option on a digital library and that makes me a lot more choosy about what I think might be relevant in a digital library. For example, in that article I just found [on DoIS], I might take down some of those citations, but I would take down a lot less in a digital library than I would from a book that I thought was relevant]. **Did you notice any differences?** I tend to be a lot more reluctant to widen my search . . . I mean I did end up widening my search [when using DoIS] but I knew I'd end up getting junk results. That's why I tend to start my searches in digital libraries, and in the library catalogue, but starting specifically and then broaden things out.

I think a lot of what happens online is that it's almost 'free-text searching' I don't know where . . . the two search terms that I asked it [DoIS] for . . . I would imagine it's only searching in the title for those. Whereas on the library catalogue it could search the subject field. Now it may well be that all these articles are indexed by subject field as well, but I doubt it, because there's just so many of them. It may well be that digital libraries don't really index things at all . . . maybe when you ask it to search, it's just doing a free-text search every time . . . it's just looking for those words in the text of the document. Effectively it's doing its own dynamic classification, which makes it [digital libraries] so much harder to use. But because things in a digital library are not physical, you can't put them in the same . . . can't apply the same methods or standards that you can with books on a shelf.

Did you find using the digital library similar to anything else that you've used in the past? It's similar to LISA . . . and I've also ended up using other similar things, because I've worked out that when I clicked on the link [in DoIS] and it didn't actually go to the journal article that I wanted, but it went into a more general index of articles under that journal title . . . so yeah, I've used similar things [digital libraries] and that's helped because otherwise I would've not been able to work out what it was doing and why it [the computer system] was doing it. **Is using a traditional library similar to anything you have used in the past?** Umm . . . I guess so. I've been through 5 or 6 years of universities and have used different libraries, but I usually approach it in the same broad way . . . I find the classmark and browse the area. I find there's very little point in only getting one specific classmark for a book that I want, because you might go and look at it and then it's not as applicable as you would like, or it's just not on the shelf. **Do you consider LISA to be a digital library?** Yeah, I guess so, although it's hard to decide where a database ends and a digital library begins. It's like trying to distinguish between a librarian and an information professional, there's a very blurred distinction. **Thanks for your time.**

LISTD1

Have you decided on a topic? I'm going to look for something on 'designing children's' libraries.' I'm going to go to the UCL library services website. Probably the first thing I'll do is click on the library catalogue and do a basic search . . . and then probably go for 'design of childrens libraries.' [Types into search box and presses search]. It's not found anything, so I'll try something a bit broader. I'll try 'Childrens libraries' . . . I've just got rid of the 'design' from it to narrow it down a bit. And yeah, there's quite a lot here . . . there's 44 records. But at least I can sort of find the general area where the children's stuff is I suppose.

I'm just looking at this . . . children's [begins to read titles and clicks on a title within a second or so]. **What has that brought up?** I just had a look at this book about children's libraries. It's not in the library, because it says 'long overdue' but I could take down the name of the shelfmark so I know the general area where the children's books are. If I knew that this book was definitely relevant, I'd probably print out the record. But as it's long overdue then I'll just make a note of the location [takes out paper and pen]. I'm just gonna look quickly through these records [returns to list of search results and briefly scans them]. That's no good . . . library services . . . there seems to be quite a lot of books that are generally about library services for children. Some of them might have chapters on about the design or sections . . . but you can't really tell from this [electronic catalogue]. I'm just looking through all the records again . . . it's being really slow [pauses for about a second, then presses reset button and returns to enter new search terms]. Let me try something a bit more . . . ummm . . . I can't think of anything to go in there [in the search term box]. **How do you decide what to type in?** I'm thinking of key words really that will describe the subject. But I don't think this 'design' [search term] is going to come up with anything. [Types in 'childrens libraries design' and presses search button, notices there are no results and presses back button on browser]. That was 'childrens libraries design.' I suppose you could do 'layout.' Umm . . . let's try 'layout' [again notices no results and goes back]. No . . . I think with the books it's gonna be a case of going to the section and looking at the books really. 'Cause you can't find individual chapters doing this [searching in an electronic library catalogue]. I'll just try

'childrens libraries' again . . . Let's go onto the next page . . . that one looks quite good. 'Managing library services for children and young people.' [Clicks on title]. Yeah, none of those [multiple copies of the book] are on loan, so that looks like quite a good one.

[Picks up pen and paper again]. Now I'm writing down the location of this book. It might have something about the design of the children's library in it. Because it says in the title it's a practical handbook . . . so it probably covers all the different bases. Umm . . . it looks as though all the books are in the same sort of area [looking at similar broad topics perhaps]. I suppose I could try something a bit more general like 'library interior design' . . . let's try that.

[Types into search box and clicks search]. Oh . . . 'interior design for libraries' . . . that looks quite good. But they're not in this library. I'll have a look at this one [clicks on title]. I'd probably print that out and at another time go to the Bartlett library . . . I don't know where that library is, so I'd have to find out where it was. That does look quite good, and it's a standard loan, which is good . . . Ummm . . . I can't really get much more information. **What more information would you want?** Ummm . . . I dunno . . . a bit more of a description of it. But I don't think they do that sort of thing [provide an abstract or description] here [on the electronic catalogue]. That does look quite a good one . . . and this one as well. 'Library interior layout and design' and that's in the Royal Free library, so again I'd have to print this out and find out where it was and sort of see. If it's too far away, I'd get them to bring it here. **How would you get them to do that?** I'd ask at the desk, but I'm sure they must do books between the different sites. I dunno. I haven't actually done . . . I've done inter-library loans, but not actually had a loan from another library on the UCL site. If it's within walking distance, then I'll go there, because it's quite interesting to see what different libraries have to offer anyway.

I'm just gonna try a different search, 'library layout' to think around the topic. I think it's brought back the same sort of things though really . . . that one's the same . . . that one's a different one . . . that one looks quite interesting. It's in the stores though, so it's really old. There's one here, 'circulation in library design' . . . that looks quite interesting. It's a bit old though. If I was wanting to write about the design of contemporary children's libraries, then something from 1971 isn't going to be that useful. It's also just a general library design book, so it might not have stuff about children in it anyway. But it looks quite interesting. I'd probably go upstairs and have a look now and see what I could find, and if I didn't have any luck, then I'd come back down and just carry on on this [electronic catalogue].

How would you know where to go upstairs? It gives you the location, it's the 'librarianship' room and I know where that is because I've used that before and I've got the shelf mark, so I'll just go and have a look for those two [shelf marks] on the shelf and see what other books are there too [in the same shelf mark area]. And then have a flick through the chapters and stuff and if I don't have any luck then I'll have to come back down here.

What did you last use a library for? I used it this morning because I was trying to find stuff for my dissertation. Articles and things. **How did you go about finding what you were looking for?** I used the Internet to start with. It's [the dissertation is] about the image of the librarian in the media, so the Internet is a good place to start. Then you look down the references and find the books. I also use LISA, which is an electronic database of librarianship abstracts.

[Walks immediately to the librarianship room]. This is the librarianship room. So I'll just have a look round . . . [Goes immediately to relevant area]. SK5 . . . SK5 . . . [part of the book's locator]. Here we go. I was looking at the class marks on the books so I could find where SK5 is and I found it . . . which was quite quick! [Looks at broad area on shelf]. So this looks like it's all the children's libraries stuff . . . and yeah, let's have a look . . . [quickly scans book titles and picks out a couple of books]. These look quite good . . . I mean, this is the one I found, isn't it? [earlier on the library catalogue] and noted down the location. [Note the participant did not look for the book specifically]. SK5 BLA [checks that it was the book she had written down]. So I'm just gonna have a flick through the contents . . . yeah I mean this has got about display and promotion and stock related issues, so I think that chapter looks quite relevant. That one's ok. [Picks up second book and looks through content]. **Why did you choose this book?** They've got multiple copies of these, so obviously they're good books on children's libraries and they look like general . . . and they're quite thick. [Picks up a far thinner book to contrast with]. I mean thin things like this are gonna be far more specific, aren't they? [Puts thin book back on the shelf]. So I'd probably start off with the bigger ones and then just sort of look around. **So what does it tell you if there's multiple copies of a book?** It's probably on the reading list or is

a core text . . . and it's in high demand, if they've got so many copies of it . . . so it's probably a good place to start. It covers quite a few bases and stuff. The ones that don't have loads of copies are more specific so they might not cover the design. There's also a lot of reports here, but they're very specific. That book would be a good place to start really [a book with multiple copies on the shelves on children's libraries]. [Looks at contents pages of two other books with multiple copies]. It depends how much space I have on my library card. If I had space I might just get a few out . . . you can look through the references and things like that and find other relevant articles and books and stuff. But if I only have space for three books, then I'd just sit and look at them and make sure that they had stuff that I was sure was relevant to what I'm looking at. When you're just starting off [researching a particular topic] you're not really sure [of what is relevant], are you? [Looks back at shelves]. It doesn't look as though there's a huge amount of literature on this topic. [Begins to mutter book titles]. I'd start off with the books, but then I'll probably look at the journal articles too. But you'd need to use the databases for stuff like that really.

[Picks out another book from the shelf and looks at contents page]. This has got sections on all the different things like schools' libraries and mobile libraries. At first glance, there doesn't look like there's anything specifically on the design. But it's got huge amount of references, so it might be a good one. It all depends if my essay was on children's libraries within public libraries. If it is, then books like this [pulls out books from shelf] would be relevant.

If it was more about schools' libraries, then this one [pulls out another book] would be more relevant. Ok, it's [the search for information on this topic] has not been very successful so far! But I probably would take a few of these general ones home because I find reading at home a bit easier and more relaxed really. And hopefully I'll get the references in these and follow up the references. I suppose you could scan the titles of the [printed] journals and see if there was anything relevant, but I think using the computer will give me better results, since this is such a specific topic.

So now I'm going to the 'electronic journals' section of the UCL library catalogue. I click on 'journal title' and I'll just do a keyword search because I don't know any specific titles of journals that will help me with my topic. I'm gonna put 'child' . . . I dunno if you can do this [wildcard searching] on this [electronic catalogue] actually. Usually if you put a star [asterisk character on the keyboard, referring to 'child*'] it just covers everything like child's, children on the end there. I'll put that star on it just to see . . . [Types in 'child* library*' and presses search button]. No . . . 'no exact match.' I know you can do that [wildcard searching] on the Internet search engines, but whether you can do that on here, I'm not sure. I might just try 'childrens libraries.' [Types 'childrens libraries' into search results and presses search button]. No, no results. It's too much of a specific thing [topic of interest] really. Umm . . . 'children and libraries?' No. I don't think there's gonna be a journal that's so specific. So I think I'll try the e-journals. [Navigates through UCL catalogue to 'e-journals section']. I'd probably go for the subject . . . libraries is in 'arts and humanities I think' [Clicks link and verifies that the category is correct]. Yeah. There's a separate section for library archive and information studies. I'll just have a quick look down to see if there's anything specific to my topic. [Scrolls down the list of librarianship journal titles]. There's nothing specific. [Notices a journal with the word 'young' in the title]. I suppose 'young' is another word for children. Maybe I could have searched using that. Right, I think I'm going to use a database then. [Closes the browser].

I'm gonna use the LISA database . . . it's got abstracts in library information, so you can look up articles and it'll give you an abstract. It doesn't give you the full text, but it'll tell you the specific journals to go to. I'm just gonna log on that. [Speedily loads UCL electronic catalogue, navigates to the list of arts and humanities databases as used above and clicks to log in to the LISA database]. I'm going to put a tick by that one [ticks 'LISA' tick box from a selection of several possible abstract collections to choose] because it's for my subject. It's provided through another server and I find that a bit confusing really, because sometimes I just click on that [the documentation for the ERL server that provides the abstract service] by accident. But anyway, that list was all the databases that were available through this access.

There's lots of different ways of searching. I'll probably just do a really general one to start off with, so the words 'childrens libraries' [types into search box and presses search]. Oh my God! There's loads on here! It's found one thousand and . . . there's just loads! I'll need to be more specific. And they're all in different . . . [Presses back button on browser and laughs]. And I forgot to specify 'English' [instead of searching with the default of 'all languages']. Ok . . . I've searched for 'design of childrens libraries' and I've told it to find them 'anywhere' within the 'abstract.' [Pauses for a split-second to read title] And it's come up with one [result] which looks quite interesting. It gives you the author and the source and the abstract . . . the ISSN . . .

so I'd e-mail that to myself or print it out and check to see where I can get this source from. So I'll minimise that and open up the library catalogue again and look for 'library management,' which is the journal title that the article is in. [Returns to e-journals section of the UCL library catalogue as done previously and types in 'library management' in the search box and presses the search button]. No, they haven't got it.

I'd probably try COPAC, which is about seven libraries . . . including the British Library . . . and is a catalogue of all the academic libraries. That will help me find out where I can find 'Library Management.' This [COPAC] takes ages though, so I'll get rid of that [minimise the window] for a minute . . . I think it will be an interesting article though. **How do you know what it might be interesting?** If you just read through the abstract, it mentions the North American Children's Library design and [begins to read section of abstract] "the library's appearance is now recognised as marketing services to children." So it seems to be exactly about the appearance of the children's libraries. [Presses back button to go back to full list of search results and looks at the search terms LISA has based the search on, which are shown in bold at the top of the list of search results]. Oh, I've just noticed they've put a thingy there [points at the apostrophe that LISA automatically placed in the term 'childrens']. **What have they put?** [Fumbles over words, but continues pointing at apostrophe]. **An apostrophe?** Yeah. I dunno if that's gonna make a difference to the way I was searching. I might try searching with an apostrophe to see if that makes any difference. [Returns to search page and types in 'children's libraries' in the search box]. **Do you think it will make a difference?** Umm . . . if it reads it exactly as I've written it then . . . yeah, I think it might make a difference! Well, I'll have a go. [Presses search button]. Yeah, that has narrowed it down a bit actually. There's 502 [search results] where there was like 1,044 or something before. But these are just general children's libraries articles. It's [the LISA database is] quite good because all your searches are listed below, so you can go back and just click on that [points to earlier search for 'designing childrens libraries' which only yielded one result and types in new search term 'designing children's libraries' and presses the search button]. The apostrophe didn't make any difference this time [because the same one result was returned]. **Why do you think that is?** Well this one it only found one result didn't it. And this one [the search for 'designing children's libraries'] is very specific to designing children's libraries. My English isn't that great. Maybe you'd cover more without the apostrophe. It depends on the English of the person who's written the article as well.

You might just need to get some general articles on children's libraries and see whether there are any sections in them on the design of the library. I'd just sit here and browse through the . . . I mean I wouldn't go through them all [all the 504 suggested titles that LISA had displayed earlier]. I'd imagine the ones towards the top are most relevant. So I'd browse through the first 30 or so. But that other one [the article in 'Library Management'] I'd definitely try to get hold of, because that looked quite interesting. **How do you think LISA determines the relevance of your results?** Well it'll look to see how often what I've searched for appears in the . . . I suppose it just looks in the abstract. [Looks back at search results]. It's also got here 'young adult' . . . I don't know . . . you start off looking for 'children's libraries' and then you start to think that there might be something about 'young adult libraries.' So you could try . . . [Types in 'young adult libraries' into the search box and presses the search button]. There's 8 [results] here . . . [begins to read titles]. Most of them tend to be about information that's in the library rather than about the physical layout of the library. Let's try just a general 'physical layout of libraries' . . . [Looks at first title in result list]. Yeah, that looks quite interesting, but it's not just children's it's about the whole of the library. You get records and you look at them and it gives you other ideas of search terms to use, so I'd probably keep doing that until . . . but then again, there doesn't seem to be much on this topic!

What would you do if you couldn't find anything that you were looking for in a digital library? I'd probably try the Internet and that is a huge . . . it's not catalogued or classified, so it's not technically a library but . . . you might find something on the Internet. There are other library [pauses mid-conversation and returns to list of librarianship e-journals used earlier and this time browses the list alphabetically instead of entering keywords to search for]. **What are you looking for?** It's called 'Ariadne.' It's got . . . I don't know if it's an electronic journal. It's got librarian articles and stuff. But I haven't looked at it for ages. There it is! Yeah. It's like a magazine and it has got quite a lot about libraries on it. [Looks at search box]. What shall I go for? . . . 'design of children's libraries.' I suppose I'd start with the most specific ones and if I'm not having any luck, then I'd broaden it out. **What makes a search term specific or broad?** Well this is just specifying 'design' and 'children's libraries.' Something a bit broader would be 'layout of libraries' or 'interior design of libraries.' I'm just specifying the children's bit of it [the search result]. [Looks at results]. Yeah, this is quite good actually [Ariadne]. This has got full text articles. Ariadne is like an online magazine thing. The other one [LISA] was a database. This is like an online journal, I suppose. [Selects the full-text of

one of the articles to demonstrate the full-text feature of the database, then begins to read the abstract]. It's got some bits that look useful! [Seems surprised]. But it's not spectacular.

What would you do if you couldn't find what you were looking for in a traditional library? I'd probably ask the librarian I suppose . . . if I really couldn't find what I wanted and I'd tried on the catalogue and the databases and stuff . . . yeah, I'd say 'I'm looking for information on this topic and I can't seem to find anything.' Maybe actually I'd go home first . . . take some books out and have a look properly, then I'd probably ask the librarian on the second attempt, 'cause when you don't know anything about the topic, it's a bit vague for you to say 'oh, I can't seem to find anything on the design of children's libraries.' I'd want to tell them, 'I've got these books out, I've found these references too . . . can you help me to follow them up? Or what do you think would be the best way of taking this further?'

I think now I might look at some other journals. [Goes back to alphabetical list of e-journals used earlier]. I could try some of these . . . **How would you decide which ones were relevant?** Well from previous experience. Oh my God, there's loads! I haven't really used that many before . . . I mean some of these are just common sense . . . I mean archival science isn't going to have much on my topic. They should really give you a description though really. I suppose if you click on it [the journal title] it'll give you a description. [Clicks on a journal title]. It's not really giving me a description. **What would you expect it to give you in a description?** It would be quite good if they have like a general introduction . . . it's as though they expect you to know which sort of areas that journal covers. **How do you think you could find out which particular areas this journal covers?** You could just go to the Internet and have a look if there's a website for it . . . so I'd just go to Google [types in Google's URL in the browser and types in 'Collection Management' in the search box]. I've put these [inverted commas] around the title because it'll find those two words together like that. [Presses search]. Here we go! So here we've got the catalogue . . . [Clicks on a URL that appears to refer to a digital library database, but gets a '404 Error Page not Found' message. Repeats a couple of times]. That's useful, isn't it! Joys of the Internet! I think this must be the people that publish 'Collection Management,' but their page isn't working! **What would you do if it was working?** I'd get at this homepage and just read through what sort of issues it covers. It is just a case of trail and error really, isn't it! [Quickly clicks on a URL further down the search results which leads to the SwetsWise digital library].

I don't think I've used this one [SwetsWise digital library] before. Maybe I have . . . no I haven't! I'd search for 'design of children's libraries,' but I don't think it's gonna have much, to be honest [perhaps because participant was referred here by searching for 'Collection Management' journal, which was also deemed unlikely to be of use]. Oh, no . . . it's found no difference. Now I'll just go for 'childrens libraries' actually, without the apostrophe. [Looks around at the interface]. I haven't used this library before, so I might be a bit of a thicko on this! I don't know if I'm using this right, actually. I've probably just left it [the search] really general [by searching for 'childrens libraries']. I have a feeling I'm doing something wrong because it's finding nothing at all, which is a bit unusual. Mind you, it's on 'Collection Management,' so I'm unlikely to find an article about collection management of children's . . . I think I'm barking up the wrong tree really. I seem like a really bad student, don't I! But I haven't really used many of these [digital libraries]. It just seems like there hasn't been very much written on this topic. Now I'd probably try Google again to see what I can find on there . . . I'll start with something very specific such as 'designing children's libraries' and see what happens. **Thank you, I think I've got a good idea now about how you go about finding things using both types of library.** I think I started out quite specifically [in the digital libraries] but I wasn't having much luck, so I broadened it out, but I was coming up with things that were too general . . . it wasn't really . . . it was general things about children's libraries. So then I narrowed it down again and realised that there isn't a huge amount of literature on this subject and, if there is, it's just sections of chapters within books or sections of journal articles. But to find complete pieces on this topic seems to be quite tricky to me. LISA is really comprehensive and that had only one article on the design on children's libraries, so it's probably a specialist area. But I should have been a bit more systematic really. Maybe when I narrowed it down again, I should've given it [the chosen search terms] a bit more thought really.

What do you think would have happened if you went through exactly the same process of using search terms that you did in the electronic library catalogue when using one of the digital libraries? Umm . . . I think I was using similar things, wasn't I? I think I would have had more of a comprehensive search pattern. I suppose I should have kept a note really about how I did it first time. Mind you, I did use similar terms really. I don't think it would have made a huge difference really. **Are there any ways that it might have made a difference, although not a huge difference?** Umm . . . maybe I'd feel happier. I feel that now I

should go back and check through again. I would have felt that I had done a more thorough search. For example, I don't know if I tried 'layout' on all of them. But I guess you don't do all your searching in one go . . . you go away, see what you've got . . . come back again. I'll take in what I feel I've missed out on this time and put those terms in next time.

Did you notice any similarities when you were searching in the traditional library to when you were searching in the digital library? Similar search terms, using 'design,' 'layout,' . . . umm . . . you're both typing search terms into a box and clicking 'go' . . . so they both start off similar. But using the traditional library then moves over and you're browsing through books and looking at indexes, contents pages . . . looking through chapters, whereas this one just sort of stays online . . . and you're just looking through lists of abstracts and things.

Did you notice any differences between the traditional and the digital way of finding things? Umm . . . you don't really look through contents and index with this [digital libraries]. Online, when you're looking through databases and stuff, your search terms have to be pretty spot on. I don't think I found any eBooks, but with eBooks I would think that would be very similar to looking through hardcopy books . . . you know, the pages and the sections and stuff. With this you move from the UCL and try different catalogues and then go to Google, whereas with books you're following up references. It's all finding information, but it's a slightly different process.

Did you find the traditional or digital library similar to anything else that you have used in the past? What, like searching for things on Amazon? **Feel free to interpret the question however you like.** Umm . . . I suppose the digital . . . well it's not really very similar though is it? . . . no, I don't think it is similar really to Amazon . . . I mean you can look through things on Amazon using search terms, but it's a lot more simple though. **If you did search on Amazon, would you search in a similar way?** You'd search for titles really, wouldn't you. With Amazon, you sort of know . . . 'I'm looking for a video of Harry Potter' or whatever . . . you have an idea in your mind. I suppose you could do a general search on 'Michael Jackson's music' or whatever, but on here [the digital library] I don't know the names of any of the books . . . or any of the articles. With Amazon, you could do a subject search, but usually you know the title of what you're looking for. So there are vague similarities, but not really. **Thanks very much, that has been really useful.**

LISTD2

When you last used a library, what did you use it for? To look at things for an assignment I had to do in XML **How did you go about looking for those things?** Generally, I come in here [DMS Watson library] anyway, so when I want a book from the library, I come in here . . . look on the normal computers . . . put in my UCL details . . . 'cause I always want to check my e-mails as well. I log onto the library catalogue and try to find the book from there. Then I note down the shelf location, go and look at the shelf . . . and see if the book's there. **Is there ever cases that you have to find your information another way?** It hasn't happen so far. If the computers weren't available or the system were down, I would ask at the enquiry desk.

Have you decided on a topic? I'm going to look for documents on Children's book publishing and maybe the development of children's book publishing in the last 10 years or something . . . it has to be some developments with regards to electronic publishing for example. Ok. Shall we begin? The first thing I do is look on the library catalogue here on one of the computers, or I log onto the computer and look from there. So I go to my own information . . . my sign in. and put my barcode in [Clicks on 'log in' button and enters barcode on the back of library card]. I generally only do basic searches. Umm . . . in this case, I don't know the author, I only know the topic . . . so I search for 'subject' [Clicks on subject filter in UCL electronic catalogue] and put 'children book' [Writes in search box]. **What made you decide to put 'children book?'** Umm . . . I didn't wanna put 'children's' because the 'apostrophe s' will probably give the database difficulty with the searches. I try to put simple terms. Because I'm looking for 'children's book publishing,' I'm still trying only two terms because I have searched on this catalogue before, and if you do more than two words, it will probably not find anything . . . [Presses search button] Ok, let's see . . . 'literature and the young child.' [Begins to read down the list of titles]. That was written in 1984. It's probably a bit old if I want to look at developments in the past 10 years. I'm just doing down the list of the 6 entries that it suggests to me . . . and I think I'll do another search and go back [presses back button on browser] and try searching on 'children book publishing.' . . . yeah, it doesn't really give me any results. So [laughs] I'll try 'children publishing' . . . ahhh [looks at titles] there we go. We have one book from 1998 called 'publishing in Britain since 1945.' It

seems pretty good. Let's see where it's located. [Clicks on location link] and take down the shelf location [takes out pen and paper and writes]. **How did you know which one was the shelf location?** From experience I guess. It says at location 'LIBRARIANSHIP,' which I know is at the 1st floor, that's basically the room it's stored in . . . and D281 is the shelf location. REY is short for the author.

So [looking at location details of 'publishing in Britain since 1945'] that looks pretty good. [Looks at second and final suggested title, which is written in a foreign language and laughs]. There's also a foreign book listed, which is completely irrelevant it seems. But also, having found one which seems fairly relevant, there might be other books on the shelf at the same location. So I would be pretty happy with that [search] and go off to the shelf and have a look. [Clicks on book title]. It seems there's one . . . it's not on loan, so I'll now go and try and fetch the book.

[Walks immediately to librarianship library]. So I'm looking here in the librarianship library and looking at the shelf number D281 . . . 2 . . . 8 . . . 1 . . . which is here. Now I look for 'R' . . . and here is the book that I identified from the database and I just want to have a look how far it goes in terms of . . . if I want to look at the development of publishing in the last 10 years, then I would have to know if there is anything that refers to that. [Looks through index followed by contents page]. There's something called 'children's books and the media' which might be something fairly recent. In general, I'd say this is a pretty good start . . . I would now take some time to read the preface . . . and just skimming through, I think there might be something useful in here. It's specific to Britain, so that's fair enough, which initially I thought in general [choice of topic to find], but since we're in Britain [laughs]. I'm just looking at the shelf in the same section if there's a similar book, or more general on book publishing which might have something about children's book publishing in it. There are plenty of book here. Umm . . . there's one further up . . . 'book publishing' . . . 'book business' . . . [Gets stool to reach shelves and takes down both books]. I'm just taking another book; 'inside book publishing.' Let's have a look how old this is . . . it's from 1994, so that would cover what I wanted. [Picks out a newer edition of the same book]. This is the 3rd edition, which is newer than the one I just grabbed before and it's 2002 . . . so I'm just having a look at the index to see if it's got anything on children's books. . . . yeah, it has. 'Children's publishing . . . age bands . . . yes it has quite a few things that are relevant . . . so I'll take that book as well . . . I'm just looking for further books . . . this one looks quite old . . . yeah, from '81, so I think these two books is probably a good start. I would go through the initial one that I found and see if there's any recent developments there and generally get an impression on children's book publishing. And I'd look at the more general book 'inside book publishing' because it has a section on children's publishing. So I'd read these and then see if I could find something further if I need to.

Generally, if I use the Internet to find anything, I go first to Google and see if that gives me any links to any relevant sites. I can't offhand think of a digital library for children's books, or that would have any relevant information, so maybe that's a good idea to do a Google search . . . [Selects Google from bookmarks]. Right, I'm now in Google.co.uk and I will probably look for . . . maybe we should look for digital libraries . . . [Begins to type 'digital' in the search box]. No actually, maybe if I look for 'children's book publishing' . . . no, that wouldn't make sense . . . yes I would look . . . I'm confused now! **What are you confused about?** I'm not actually looking for children's books. Mmm . . . 'cause I'm looking for children's book publishing . . . so . . . it raises the question, what is a digital library? But anyway . . . let's see . . . let's just put 'children book publishing' and see what it comes up with. [Types into search box and presses search button]. I wouldn't know what constitutes a digital library in this case . . . there are plenty of suggestions of links to Internet sites to Children's book publishing . . . children's book resources. That might be something. Let's say you wanted to find an article from a published journal on your topic. **How would you go about that?** Ummm . . . if I wanted to look at a journal . . . the 'Bookseller' or something [name of a journal] . . . but I know you need to subscribe to that unless you use it from UCL . . . so in that case I could use the UCL electronic journal database to see if I find something there. Let's go to UCL [Selects UCL library homepage from list of bookmarks]. Then 'library services' . . . then 'electronic journals.' I would probably . . . in this case I would probably look for the bookseller and see if that's in the journal section of the library . . . so I go for alphabetical order of all the titles that the UCL library has [links to] in electronic form . . . the 'Bookseller' is B . . . [Clicks on 'B' link and reads relevant part of list]. Book history . . . [Scans for required journal]. [Laughs] It doesn't seem to be here. But 'book history' [discovered because it was close to where 'Bookseller' would be in the alphabetical list] . . . let's have a look at that. [Clicks on journal title]. I'm now in an electronic journal database called SwetsWise and I guess I'll search 'articles' . . . it gives me the option to search articles. [Selects articles from drop-down list]. **Why would you have gone to the 'Bookseller' if it was on the list?** Because that's a journal that I'm familiar with and know that it probably covers all areas of book publishing, including children's book publishing . . . but it wasn't there . . . so . . . search for . . . umm . . .

. try 'children book publishing' within what fields? Abstract? Keywords? Let's try 'all fields.' [Selects 'all fields' from drop down-list]. And I'll select 'all subscriptions' and maybe restrict the year from 1995 to 2004 . . . although that's not exactly ten years, but never mind . . . and hit search and see what it comes up with. [Presses search].

There seem to be 8 search results. And it suggests actually the same book that we found in the library – 'Children's book publishing in Britain since 1945.' And umm . . . there's a table of contents . . . [Looks at brief abstract included with search results]. This must be an article about it [looking at the book review referring to the book found earlier in the traditional library]. I'm not entirely sure how this particular database works. [Clicks on 'Order article' link]. Looking at an electronic journal database, I would expect there to be an article about the book . . . maybe a short write-up or something . . . What I can see is a table of Contents . . . which I don't understand what it gives me . . . nothing related to children's books apparently! So I go back. [Presses back button on browser]. It gives me details about the book. Umm . . . the author . . . the publisher . . . I'm just clicking 'Publication' and that doesn't get me anywhere! Not very good! To be honest, I'm not what to do with this particular record . . . but since I have the book already, I'll have a look further at what else it [Sweetwise] can offer me. 'Children's literature in education.' I'm just clicking on that link to see what that will give me . . . it's showing me who the publisher of this article is . . . [Clicks on Publisher's name] And it leads me to a different database [actually the publisher's own homepage] . . . at this point I would not look at this further. It doesn't seem to give me what I want. It doesn't actually link to any proper articles as far as I can see . . . [Presses back button and returns to Digital Library].

Hang on . . . some of these articles [but not all] have a link for 'full text' . . . I only just saw that! I've found something. The second suggestion is 'Thursday's Child: Readings in Children's literature and education' and it gives me a link to 'full text,' so I'll click on that and see what that brings. [Clicks on link]. And it opens a PDF file . . . Aha! And here we have it! We have 16 pages of PDF file. I would probably now read through the introduction or the conclusion, just to see if this has any relevance to what I'm looking for, which is children's book publishing in the last 10 years. I think it's just an excerpt of the actual book. Given time, I would read bits of it and see if it's relevant. Well that's good! Now I know how it [the Digital Library] works! I'll look further at those 8 search suggestions . . . [Begins to read titles in order]. I've seen the other two, so I'll look at the 3rd suggestion, 'Electronic books for children in UK public libraries.' Hmmm . . . could be relevant, not exactly. Let's see what the next one is . . . [Mutters titles]. 'Adult agendas in publishing African folk tales for children' . . . that wouldn't be specific to the UK, but might be worth having a look at. Again, clicking the full text opens a PDF file . . . and it is a short write-up. [Begins to read abstract]. But it seems to be very specific to South Africa at first glance, so I probably wouldn't pursue that. It doesn't really give me any developments in publishing rather than specific . . . I'm just checking out 'electronic books for children in UK public libraries,' which was the 3rd suggestion. [Clicks on article title]. Ok, that leads me to a different digital library . . . Emerald . . . or maybe it's just a publisher of the book . . . **Why do you think it did that?** Ummm . . . they probably own the rights to this article or whatever it is . . . let's see . . . electronic books for children in UK public libraries . . . Umm [Glances at article information on screen] . . . the journal the article is coming from is 'The Electronic Library' . . . so Emerald is the electronic library for this particular journal. Let's see if I can actually read the article [scrolls to bottom of page]. 'Please choose a format' . . . so I have the choice to read this in HTML or PDF and I'm choosing 'PDF full document.' It says 'request document' . . . I'm not sure if that means I would have to pay for it. The initial record gives me information also about when this article was published – in 2001 and it's 19 pages . . . so I'm expecting 19 pages . . . I'll try to request this document, but I don't think it will give it to me! [Clicks on 'request' and pauses for about a second]. And it doesn't do anything! Oh no, patience! There you go! [in a surprised tone]. Electronic books for children in UK public libraries . . . which is not exactly what I was setting out to look at, but it might be a good start. And actually I'll have a quick look if there's a contents page. **And now?** [Looks for an automated contents page within Adobe Acrobat Reader software].

There isn't really a contents page, I'll have a look at the first page. That's probably best. There's keywords, there's an abstract . . . which I would read through quickly [begins to read abstract]. It looks like a very relevant article and I would definitely read all of this. I think it would be a good start for investigating this topic further. **What made you choose a PDF format over HTML?** Generally PDF you can navigate easier than HTML. I'm never so sure what it actually shows you when you choose HTML. **What do you expect it to show you?** Text, just not formatted . . . [Clicks on HTML and submit]. Oh, it is actually formatted! Ok, I was wrong! The HTML version is even better than the PDF version because you can also copy and paste from this . . . into a Word document perhaps. In this case, it's well formatted and much easier to use than the PDF version. In general I don't like PDF versions, but you're just so used to getting articles in PDF format

and it's very difficult to copy and paste, if you're allowed at all, from PDFs. So this HTML version is actually really good! I probably would print this out rather than read it on screen . . . because then I can take it away and read through it and highlight things. Although the HTML version would give me the chance to read it onscreen and copy or print the relevant bits.

Now that I'm in Emerald, I might see if I could do another search in this particular digital library on . . . [Pauses] I could define it a bit more but . . . [Types 'recent developments' into the search box]. Recent developments? . . . that's stretching it a bit! [Changes search term to 'children book publishing']. **What made you choose those words?** I do want to look at recent developments in children's book publishing, so if I put in developments and children and publishing in the digital library that deals with book publishing, I would hope to find a result. Rather than having an entire sentence of 'recent developments in children's book publishing,' which probably wouldn't provide me with a good search result . . . Even this one though [searches for the phrase she has just mentioned] . . . it's brought back only three terms. It actually ignores 'recent' and gives me a result for 'developments' and 'children's' and 'publishing.' **Why do you think it did that?** There might not have been anything in key term or in the actual article that says 'recent.' I have one article that it suggests to me . . . [Begins to read abstract]. Exploring the legal and ethical dimensions of United States federal involvement in public school improvement . . . that doesn't seem relevant to me. I might have a quick look, just to see what kind of further information it gives me . . . [Continues to read abstract]. But it's more about schoolbook publishing I would say. Ok, so that wasn't very good! I could try another search . . . you can actually search for phrases [selects 'phrase' tick box]. Let's just try 'recent developments in children's book publishing.' That's now a phrase I'm searching for . . . yeah, as I expected . . . there's nothing found. Umm . . . I've changed it now to 'children's book publishing' to see if that gets me any further, bearing in mind that I have found already one article . . . Ummm . . . I've just come back to general search. [Presses back button and un-selects 'phrase' tick box]. **So why did you un-tick 'phrase'?** 'Cause that wasn't really a phrase. Maybe to widen the search. And it gives me 2 results, which are different to the ones I found first . . . the first is 'children's book prizes' . . . that might not be relevant at all . . . and 'who next? a guide to children's authors' . . . that might be of help so I'll have a quick look what that says further. [Clicks on article title and reads abstract]. It's just a review of the book, 'Who next' . . . so it won't be very extensive. But if the write-up was relevant, it would be worth getting hold of the book. What I could do is see if I could find this book in this book in the library . . . or maybe it's somewhere online . . . I doubt that though, because it's fairly recent. The price is £14 . . . it gives me all the details, so I would now go off to Amazon and look if maybe they have it.

How do you think it was judging the relevance of the search results it was returning? I think it probably has key terms linked to the article and these key terms might include 'children's books' or 'children's and book' and 'publishing' No, actually, looking at that [the abstract] I could also search with 'history of children's book' as a search term to get more relevant detail . . . [returns to the original question]. Children's book publishing is fairly general anyway. So anything that has to do with children's books could contain all these terms.

When you started doing your first set of search terms, and you did 'children book publishing,' you also did the same set of search terms when you used the electronic catalogue. **Did you notice any similarities or differences in the way that the electronic catalogue and the digital libraries dealt with those terms?** Well the electronic catalogue didn't find anything when I used three search terms and yes, I had to narrow it down to . . . I think I used 'children publishing.' I did realise that the library catalogue doesn't cope with 3 word terms very well. You have to be more specific in the catalogue. In the digital library, you can probably use many more search terms . . . and again it gave you the chance to even search by phrase, although that didn't get me any results. Umm . . . so yeah, I mean the library catalogue is much more restrictive in terms of searching. You have to be more specific than when you look on a digital library. **Have you got any ideas as to why it might be more restrictive?** [Laughs]. Ummm . . . first of all there's probably less records and umm . . . it's a smaller . . . you have to be more restrictive because . . . you have less space . . . less . . . library staff have to go through so many books in restricted time . . . so there's restrictions on time as well as on space . . . and disk space as well . . . and it's probably a very defined set of terms that are being used for particular books to catalogue them. And again the [electronic catalogue] search engine is probably not as refined as it is on the Internet. That's probably the main reason actually [laughs] . . . the software is not as good and is probably not as up-to-date. Whereas on the Internet you can use the full-text of the whole article as a basis for the search . . . the electronic catalogue is probably only searching on key terms. [Laughs] I dunno, but that's my guess!

You mentioned the need for librarians in the library if there are any technical problems. Yes, I would imagine they have paper records, so they could tell me where to find relevant books if the system goes down without me having to go from shelf to shelf. **What if those books that you found in the electronic library were not on the shelves?** It did say it was supposed to be on the shelf, so first I would go down here, where they put the books for re-shelving and look on the re-shelving shelf [laughs] and if it's not there, ask the staff if they can locate it for me. If it's on loan, I would place a hold on it so that I could have it next. **What would you do in a digital library if you couldn't find what you were looking for?** There wouldn't really be much I could do, I would imagine. I have never sent an e-mail to anybody to say . . . I dunno! But there is not much you could do! You might know people that search better . . . and they you would maybe speak to them . . . but in this setting, I wouldn't go to a librarian or whatever to see if they could help.

When you started to change your search terms and you were entering the long phrase . . . Mmm hmm . . . You mentioned that it might be appropriate in this case to search for the entire phrase . . . Yes, it had the option to search for a phrase instead of key terms . . . probably you'd use it if you couldn't be too specific for what you're looking for. But again, they hardly ever . . . in my experience, return any results. But yeah, I would try it to see if it gives me any results because it's an additional way of searching. Just because it's there really.

Did you notice any similarities when you were finding information in the traditional and digital library? Yeah. It had a record of the same book that is here in the library, which I initially found using the same search terms . . . Well not exactly, because I had to restrict my search terms for the library catalogue. But there was a record of it on the digital library as well. That would indicate to me that it's a fairly relevant book then!

Did you notice any differences between the traditional and digital library way of finding things? Well it linked me to a further . . . the digital library or the digital database I used linked me to another digital library, which then helped me to find other articles related to the topic. So, basically there is the potential not only to consult one database but to consult several digital libraries for the same topic, whereas here in the UCL library you are confined to the stock that UCL has. **How would you go about searching multiple digital libraries for the same topic?** On the Internet? Mmm. Well it's pretty much relying on that the libraries link to each other . . . or, then again, going back to Google or similar search engines. They might suggest links to several digital libraries for the same topic or similar books and similar topics . . . so search engines are a pretty good way to gather different information from different resources.

Did you find the traditional or digital libraries similar to anything you have used in the past? Yes. **What is it similar to?** Do you mean searching different things on the Internet? I might have misunderstood the question. **Feel free to interpret the question however you like.** It's more like if you have a large group of friends and you're speaking about a similar topic and you get different feeds from that, so that I would think is a similarity to digital libraries or generally searching on the Internet. You get suggestions from several sources, rather than from the library catalogue, just from the one source. You're not just restricted to your own knowledge. **Thanks for helping.**