
# Ariadne: An Interface To Support Collaborative Database Browsing

Mike Twidale, Dave Nichols, Gareth Smith and Jonathan Trevor[1]

**Cooperative Systems Engineering Group**

**Technical Report** : CSEG/3/1995

[1]GMD-FIT.CSCW, Schloß Birlinghoven, D-53754 Sankt Augustin, Germany

CSEG, Computing Department, Lancaster University, LANCASTER, LA1 4YR, UK.
Phone: +44-524-593041; Fax: +44-524-593608; E-Mail: cseg-info@comp.lancs.ac.uk

# ARIADNE: AN INTERFACE TO SUPPORT COLLABORATIVE DATABASE BROWSING

M.B. TWIDALE, D.M. NICHOLS, G. SMITH and J. TREVOR*

*GMD-FIT.CSCW, Schloß Birlinghoven, D-53754 Sankt Augustin, Germany

**Abstract—** This paper outlines issues in the learning of information searching skills. We report on our observations of the learning of browsing skills and the subsequent iterative development and testing of the Ariadne system – intended to investigate and support the collaborative learning of search skills. A key part of this support is a mechanism for recording an interaction history and providing students with a visualisation of that history that they can reflect and comment upon.

## INTRODUCTION

The use of library resources has been stereotyped as a solitary activity and this view is reflected in database systems which do not have any social facilities. The actions of other users are hidden from the information searcher restricting her awareness of other searches and effectively preventing collaborative activities. However, users of physical libraries engage in frequent collaboration beyond the recognised user-intermediary reference interview. This paper describes research aimed at supporting this end-user collaboration both in the digital libraries of the future and within existing systems.

An overview of the information science literature is given followed by descriptions of studies undertaken observing information searchers. We discuss how the learning and practice of searching skills is affected by the features of the information systems. The different types of collaboration found are described and were used as the basis for the design of the Ariadne system – an interface to support collaborative browsing. The evolutionary development of the facilities of Ariadne is described together with usage by students in several contexts.

## INFORMATION SEARCHING

As the information economy expands the successful searching of databases is becoming an important transferable skill that will be expected of all graduates and researchers. However, the inability of users to effectively utilise online resources is well documented (e.g. [5, 16, 28]) and will become an increasingly important obstacle to the success of the imminent digital library [14]. Common problems include: retrieving zero hits [9], retrieving hundreds of hits [15], frequent errors [4], little strategy variation [11] and locating few of the relevant records [10].

Information systems are complex and it is entirely appropriate that novices learn a minimal subset of the available facilities to enable them to do some limited information searching. Unfortunately this can lead to users who are confident in their use of the system, but have settled into sub-optimal work patterns. Users may settle into these patterns either because they are unaware of the more sophisticated methods or because they choose not to learn and practice them, due for example to cognitive overload [23].

Information searching is a generic term for all kinds of information retrieval activity, one form of which is *browsing*. Browsing involves a search for information whose nature is difficult to precisely specify in advance. That is, the search goals evolve during, and as a consequence of, the search process [3]. Browsing involves the tactics of composing particular searches and strategic issues of how to combine searches, managing the evolving goalstack and controlling the quality of information obtained. It may occur by physically wandering through bookstacks or searching through an index (card or computerised). Both librarians and users have stressed the importance of serendipity in the browsing process [21] – relevant records are frequently found through informal mechanisms.

There are three types of learning that can occur during browsing: learning about the subject area (say, history), learning about the specific database system and learning about system-independent browsing strategies (e.g. [1, 2]). These three aspects are interlinked– learning about information searching tends to be unsuccessful if it is abstract [8]. However, as the number and variety of online systems increases it is precisely these abstract browsing skills that are crucial to effective information searching.

However, browsing is not limited to books or their electronic representations – you can also browse for people [6, 22]. For example, upon seeing a colleague in an unexpected part of the library, you might choose to ask what she has found there. Similarly, upon seeing someone in 'your'

area, you may decide to introduce yourself as someone also interested in that field. A computerised library that is accessed remotely will lack these advantages unless we take steps to re-introduce them into the system [19, 20].

## COLLABORATIVE ISSUES

The most visible example of collaboration in a physical library occurs at the enquiries desk – where library staff attempt to help users with their searching problems [18, 24]. Unfortunately, if the problem involves an electronic search of, say, the library catalogue, the user will generally have to leave her terminal in order to seek assistance and consequently the problem will be presented out of context. Even if the user retains her workstation, the system will usually fail to record most of her activity – at best, the 'hits' will be recorded.

Our informal observations of activity in libraries [26] also reveal a surprisingly large amount of collaboration between users, particularly as they work at OPAC (Online Public Access Catalogue) and CD-ROM terminals. Pairs and small groups collaborate around a single machine and people lean over and ask their neighbours for help an point at each others screens. Students can observe and learn from the browsing techniques of others, discuss issues with co-learners or with subject experts, and also be aware of the activities of others that may be of interest and relevance to one's own work. Using the person at the next terminal to you is just as appropriate an information searching strategy as finding an interesting book next to the one you're currently looking at.

From an educational stance this is intriguing: collaborative, situated, authentic, motivating learning happening almost spontaneously. The kind of activity we as educators normally struggle to encourage. Even more galling, it occurs *despite* the technology rather than because of it: the systems themselves have few, if any, built–in features to facilitate collaboration.

We wish to build on this existing collaboration, by providing systems that do offer functionalities that encourage and enhance collaboration. Although offering many benefits, the status quo is by no means perfect. As might be expected, learning from peers has its problems – not least a plateau effect in the learning of skills.

Collaborative working implies a need to share information: both the end *product* (the 'hits') and the *process* (the search strategy/tactics). Similarly there is a need to share this information with the librarians, for whom inspection of the search *process* can reveal not only gaps in the user's

browsing techniques but also an indication of their degree of searching sophistication.

*Exploratory studies*

Building on information gleaned from the literature and interviews, with subject librarians and a small sample of users, we created an exploratory environment to study collaborative browsing. The aim was to undertake a rapid series of studies whose results would inform the design of our subsequent system. Consequently it was important to be able to quickly create a number of experimental environments by combining existing computational tools.. We were particularly keen at this stage to investigate potential interactions between a relative novice and a more expert user such as a subject librarian.

The following collaborative scenarios were investigated sequentially, each involving keypress recording to enable subsequent analysis:

- Two users sitting round a single screen and accessing a database together. The novice operated the system and the expert offered comments and suggestions. This was the simplest form of interaction and the one most similar to the kinds of interaction already observed in the library.
- Remote synchronous collaboration via Unix *talk*. Each user independently accessed the database and send messages using talk, including text selected from their database window.
- As above, but with the expert able to see the results of the novice's interactions with the database in an additional window.

For our investigations, volunteers were asked to bring along an authentic task: a search problem they were intending to tackle anyway. Databases at the Lancaster University Library, the BIDS* Service and the MELVYL library system of the University of California, were accessed via telnet according to the requirements of the user. The system recorded the actions of the searcher and the sessions were also videotaped.

Note that the third scenario was developed as a consequence of undertaking the earlier studies: it became clear that it was important for the expert to be able to see what it was that the user was doing, and ideally, to have a record of what they had done in the past.

The detailed results of the study are recorded elsewhere [27]. Here we note the key features that informed the development of our system:

---

* Bath ISI (Institute for Scientific Information) Data System is a bibliographic database.

• Users pointed at objects on the screen to establish a common referent.

• The occurrence of several 'common errors' [25]:

- spelling mistakes

- case and punctuation mistakes

– failing to note or exploit help information on the screen

• Browsing of excessively large numbers of results.

• There were several timing problems. The expert would attempt to correct some action and the searcher would misinterpret the response as referring to another concept. This then led to a further problem as the intervention would be applied to the wrong aspect of the search.

• Ambiguity of messages. As with timing problems messages were interpreted as referring to items other than their intended ones.

• Separable expert connection. It was found to be extremely helpful for the expert to have a separate connection to the database so that he could perform independent searches.

• Results could be pasted into the talk window using X Windows. This sharing of results was effective and quick although the formatting of the results sometimes cause problems.

Although collaborative browsing is possible using pre-existing tools it is clear that in order to fully take advantage of the potential benefits it offers specifically-designed software is required. Our experiments indicate the removal of ambiguity should be a key feature of such software.

However, just as importantly, the study led us to conclude that remote synchronous collaboration had a number of complicating factors that makes it currently unwise to develop systems to support it. By contrast, remote asynchronous collaboration appears to be far more important, for the following reasons:

• Synchronisation is difficult to arrange: people have to coordinate their schedules.

• 'Talking' in real time via text suffers greatly if one or both users has relatively poor typing skills.

• To be effective in this context, remote synchronous collaboration needs at least an audio link and possibly a video link, in addition to sharing the database system interaction. This adds greatly to the complexity and cost of such a system.

• Remote *asynchronous* collaboration offers great convenience to the participants. They can choose when to work on the problem and can work at their own pace.

• Co-located synchronous collaboration, while having the inconvenience of requiring the arrangement of a convenient time, offers such a better quality of collaboration that users are prepared to use it.

• Collaborative systems need to be integrated into existing work practices. Not everyone with whom you will wish to collaborate will have access to all the sophisticated functionality of the most advanced systems. We need to allow for many different ways of using the systems. An asynchronous approach offers more variety of usage types.

## ARIADNE

We were concerned with developing a working prototype in as short a time as possible in order to use it to further study the operation and requirements of the activity. Hence we focused on a system that could be developed initially for co–located synchronous collaboration and easily adapted to remote asynchronous collaboration.

The Ariadne system consists of two parts: recording the searcher's actions and then replaying a visualisation of the search. The recording of the search is invisible to the user who simply interacts with the database as normal. The user's input is associated with the output of the database to produce *command-output* pairs which form the basic elements of the search playback. The visualisation of the search represents these pairs as cards containing the user's command, a miniaturised thumbnail of the database's output and an annotation indicator. The thumbnail can be expanded by clicking on it (see Fig. 1).

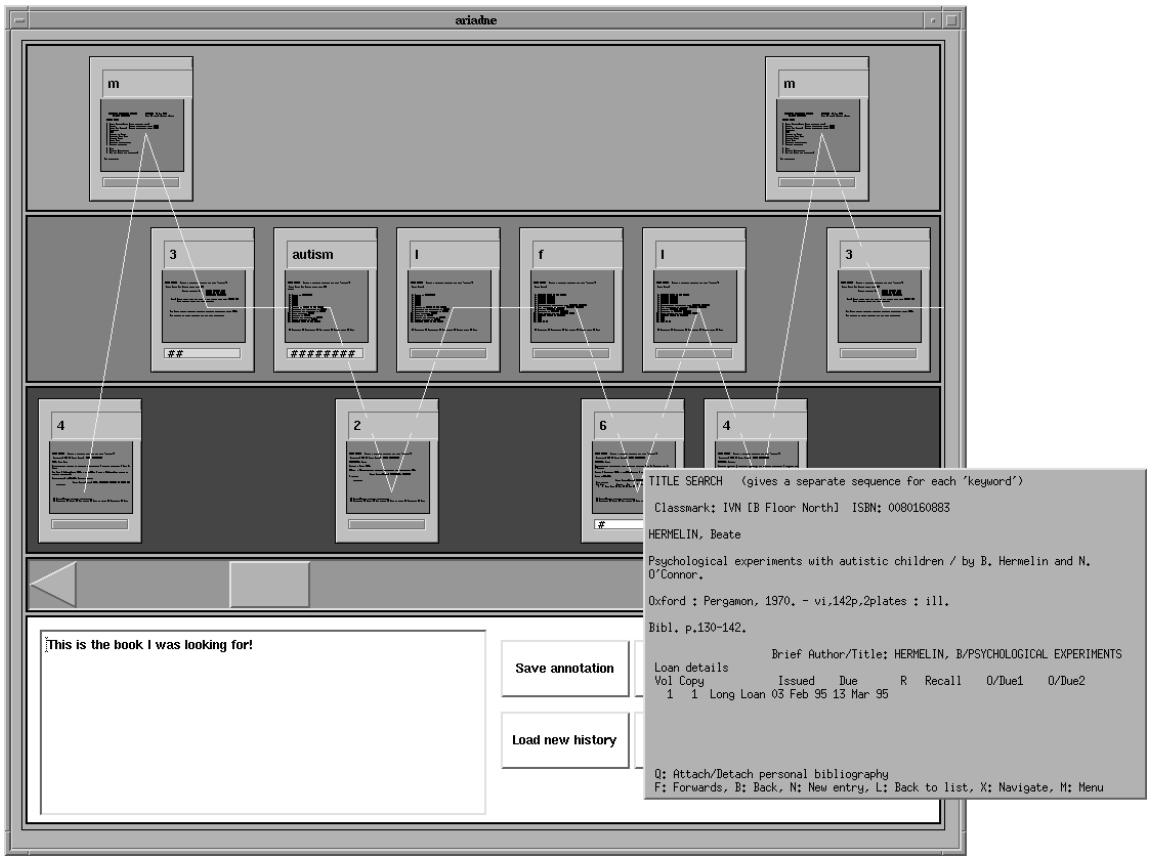


Fig. 1. The Ariadne interface.

The browse area of the interface depicts the history of the browsing activity by showing the sequence of cards. It has three levels to give a two-dimensional representation of the searching activity. We are experimenting with the metaphor of 'diving' into a database by composing queries and going down to actual data entries. A session consists of numerous 'dives' into detail, interspersed by 'higher level' activities of composing and combining searches, selecting display options etc. The position of a card in a level is determined by a set of rules specific to the database/library system used in the search. For example, screen shots of top level menus are located in the highest level, whereas individual book references are positioned in the lowest level. Users can override the system representation by moving a card up or down through the levels. The cards are linked by a 'chalkline' to emphasise the chronological ordering of the search.

The bottom part of the interface permits the user to read, create and modify annotations associated with a card. Cards with annotations attached are distinguished by having a differently coloured annotation box which also displays an indication of the size of the annotation.

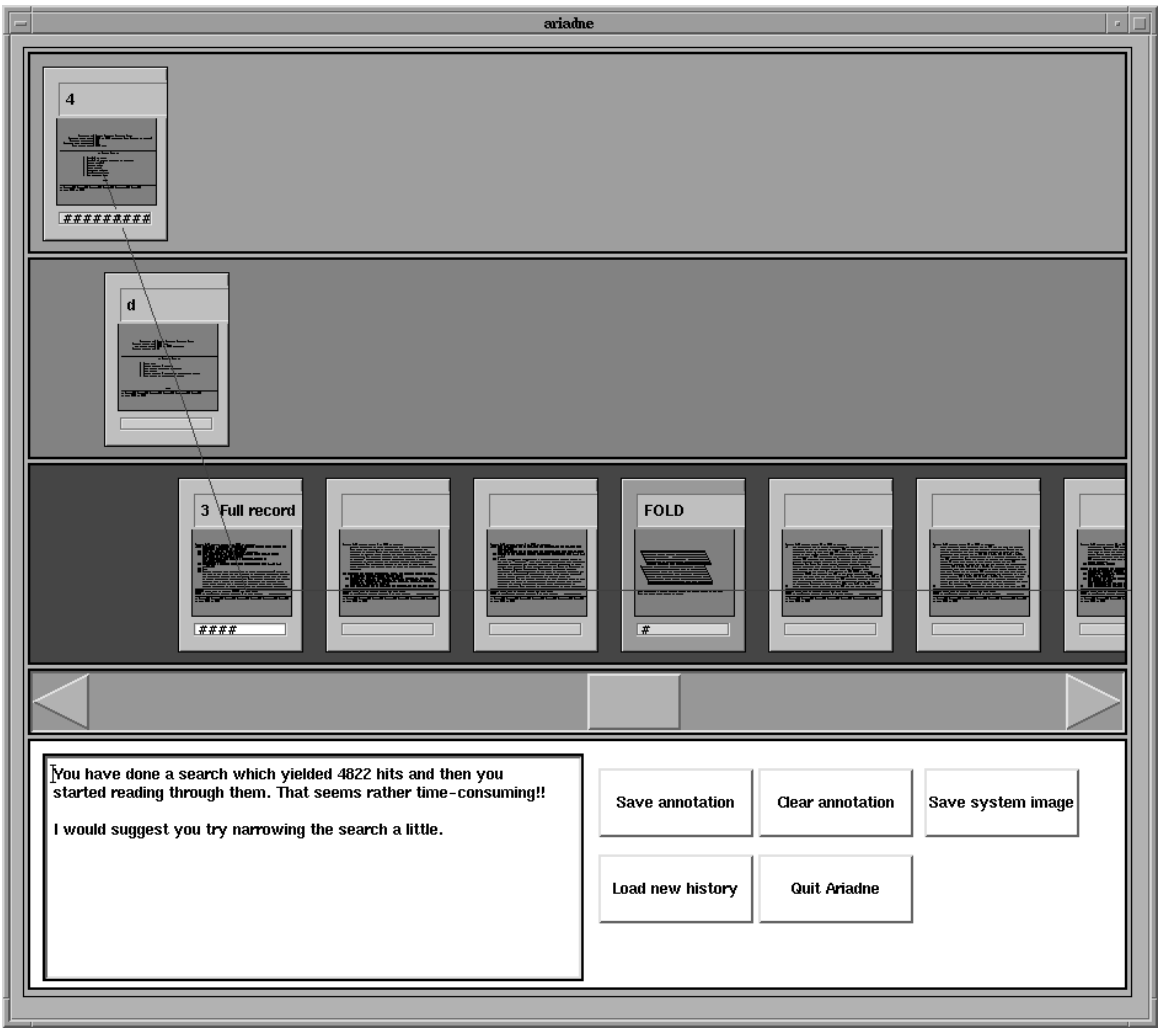


Fig. 2. The Ariadne interface showing an annotated and folded search.

A search session may involve a large number of interactions with the database. Consequently there can be many cards in the scrollable browse area. In order to make sense of a search, it can help to group together and temporarily hide a sequence of cards in order to focus on the larger picture. This is known as *folding* (see Fig. 2). A new card appears denoting the presence of a folded region. Folds may be annotated and nested in other folds and, along with annotations may be saved for future reference or for sharing with others.

The visualisation of the search process provided by Ariadne is a means for searchers to reflect on their activities. Reflection in information searching, as in other domains, is facilitated by making explicit 'the student's problem-solving processes - their thrashings, false starts and restarts, and partial successes' [7]. Access to a representation of the intermediate states of the search process, such as in Ariadne, is crucial for effective post-problem reflection [13, 17].

Searches performed via computers are more easily recorded than those using traditional methods – although existing systems tend not to preserve all the available information. This recording enables searchers to concentrate on the domain-related aspects of the search rather than on remembering which searches have been done and which remain to be performed [23]. This process of recording and visualisation is similar to that done by Algebraland [12] – which generates a tree structure of a student's solution of an equation. Algebraland also allowed users to annotate their solutions with domain terms whereas Ariadne permits free-text annotation of a card, as shown in Fig. 2. Ariadne's visualisation of a search can be used as a common referent in educational situations – such as collaborative learning amongst searchers or coaching by an information intermediary.

## STUDIES WITH ARIADNE

With any innovative learning environment such as Ariadne, we believe that it is vital to undertake a continuous formative evaluation of the system. Observations and discussions with users interacting with a prototype can help us to a greater understanding both of the nature of the educational domain that we wish to support and the mechanisms we should employ to support it. Given an example environment, even novices can offer valuable suggestions on how to improve it. So far 35 volunteers have used the system. As in the exploratory studies, students were asked to bring along an authentic task. We are concerned that the activity we observe be as realistic as possible in order to test that our system can provide the functionalities that people need and can understand. The contexts of use vary from sets of four Psychology students undertaking a group report-writing assignment to individual students of Women's Studies researching for a dissertation for a Master's degree. We have also undertaken studies of a relatively expert information searchers from the Computing Department. Some of the volunteers chose to return and continued using the system for up to five sessions. Sessions were recorded on either audio or video tape. We are not aiming to undertake controlled experiments but rather an opportunistic investigation of the nature of learning and teaching information searching techniques and the evolving requirements of a system to facilitate this.

Given this approach, it is not appropriate for the experimenter to be a passive observer. On the contrary, we have been active in engaging the subjects in conversation about what they wished to

do, how they were going to do it and what they understood about what they had done. As noted, the use of Ariadne is in two parts: the data capture phase which operates just as when conventionally using the library databases and the visualisation/reflection stage using the Ariadne interface. In both parts the experimenter explained and answered questions on how to use the interface. In order to maximise the degree of interaction (and also in order to offer some recompense to the volunteers for giving up their time), the experimenter occasionally acted as an expert browser in order to undertake the educating/facilitating kind of interaction often performed by an information intermediary such as a subject librarian. The aim here was, as before, to explore the requirements, functionality and usability of Ariadne, but this time from the perspective of such an information professional. Consequently, in analysing the usage studies it is inappropriate to discuss the degree to which subjects were successful in their searches. Rather we are mostly concerned with the problems that arise and how Ariadne can help in resolving them.

The functionality of the system has been continually evolving and the interface has been refined during the course of the studies. Coupled with our attempt to get volunteers with as wide a range of backgrounds and abilities, this means that we can only give tentative pointers as to the effect of using the system, and mostly these concern its promise:

- The recording of the interaction allows us as researchers to obtain a growing set of data about the behaviour of users when browsing databases.
- Even complete novices to the use of bibliographic databases can understand the concept of the process representation. They are happy to use the scroll bars to review what they or others have done and to open up a card to read its details.
- Subjects found it difficult to remember what they had done in a previous search interaction (which may have been a week previously).
- Even within a single session, subjects (individuals and groups) forgot what they had done and what they had said they were going to do next.
- Both individuals and groups could use the record to review their actions and comment on what they had done and what they were intending to do next.
- The record serves as a powerful memory aid for re-orienting people when beginning a subsequent session. This re-orientation can be done either by an expert or even by a novice or novice group.

• Typing errors can scale up into strategic errors. The user tries a sensible strategy, makes a typo which leads to the query yielding no hits, or inappropriate ones, and then abandons the strategy because they are unaware of their error. In such cases, the interaction record is useful, particularly, as in the case of a very experienced searcher we observed, when the user is quite convinced that they did *not* make a typing error.

Many of the classic errors that have been noted and analysed in the literature [25] were made by subjects when using the library databases. One particularly notable problem was their lack of systematicity: they would often combine or generalise searches (a powerful browsing strategy) but fail to consider applying the technique to all their data, often because they got side-tracked by a particularly interesting finding. The visual record is especially useful in such circumstances for pointing out that they have not yet exhausted all the possibilities.

Many students appear to have only a very superficial understanding of what a database is and consequently how it can and should be searched. Their mental model seems to equate the query language and search engine with an intelligent librarian. Consequently they seem to assume that the system will take account of syntactic and semantic variation. An example is a student who did not realise the searching on 'attitude' would fail to catch entries that contained the word 'attitudes'.

The record can also be used as an effective teaching tool. It provides a vocabulary for discussing the concepts and skills of information browsing. Users can point to a sequence of actions and discuss what was done, whether it was effective or not, how it might have been done differently, and how the same technique could be done in another context, or even in another database. For an expert, the record is a very efficient means of determining the level of understanding of the user. Certain patterns of behaviour become dramatically evident. For example, the common student error of performing a query which yields a huge number of hits and then proceeding to laboriously read them all is made very clear, as Fig. 2 illustrates.

The record can be used to summarise a sequence of actions. So far this has only been observed in the case of the expert giving the novice(s) an overview of what they had done, allowing a degree of abstraction and permitting a dialogue on how to generalise the strategies that had been displayed. The scrolling and folding options are particularly useful in allowing this kind of abstraction. We intend to provide mechanisms to enable users to also be able to undertake this kind of reflective activity for themselves. Subjects could understand the idea of folding and annotating cards.

However, as we have only recently improved the interface for applying these and provided a simple means of saving and loading folds and annotations, we do not have much data of people using them in an educational context.

We found that on occasions when the experimenter was acting as a supportive expert (such as a subject librarian), it is all too easy to misinterpret novices' actions. In such circumstances, the record can also support an expert's faulty memory of a novice's actions. Even an expert sitting alongside a novice can forget or misinterpret what has been done. A subsequent attempt at tutoring will naturally be very unproductive in such circumstances

Subjects were good at exploiting the interesting results that arose serendipitously. This is an important generic browsing skill, particularly where the goals of the search evolve as the search progresses and more information is found [3, 21]. In the studies this occurred when the student(s) were trying to determine the precise area of their study after having chosen a general theme. Often they would find something that sparked their interest and the theme of the searching activity would be changed. By contrast students were very poor at being systematic. This was particularly noticeable when moving up their goalstack. Often they had a complex strategy that was composed of a number of queries. One of the query steps would lead to an interesting result. They would side-track to investigate this result, but on returning to the main strategy, fail to resume at the correct point, missing out some issues that they were yet to investigate.

Subjects were very keen to have printouts of what they had done. This is lacking in some existing systems, but even those such as BIDS which do permit the recording of hits obtained require the students to explicitly decide in that session that they want the details. Unfortunately novices may not know whether a set of hits is worthy of note or not. Consequently they must either laboriously save everything, or risk ignoring items which subsequently they decide would have been useful. It is possible in Ariadne to obtain a printout of every screen obtained in the interaction.

## CONCLUSIONS AND FUTURE WORK

Based on a series of studies of the issues and problems that arise in learning browsing skills and focusing on the neglected collaborative aspect of database browsing, we have developed the prototype system Ariadne. This has been developed iteratively, along with a series of observations of its usage by individuals and groups working on authentic tasks. The results indicate that a system

that permits the recording, visualisation, discussion and sharing of the process of a search is usable even by novices and offers great potential in proving the learning of generic information searching skills.

We intend to continue the development of Ariadne, focusing on improving the ease of use of its interface and adding functionality to enhance its ability to facilitate collaborative reflection and learning. In particular the next stage to be investigated is how to enable users to share and discuss their searching activities asynchronously with others. This will allow us to build on the existing collaborations observed in library settings while allowing the greater possibilities for collaboration over time and distance afforded by the move to digital libraries.

*Acknowledgements*— Financial support for this research was provided by the Higher Education Funding Council's JISC New Technologies Initiative. We would like to thank Andy Colebourne for his assistance during the experiments.

## REFERENCES

1. Bates, M.J. Idea tactics. *J. Am. Soc. Inf. Sci.* **30,** 281-89 (1979).
2. Bates, M.J. Information search tactics. *J. Am. Soc. Inf. Sci.* **30,** 205-14 (1979).
3. Bates, M.J. The design of browsing and berrypicking techniques for the online search interface. *Online Rev.* **13,** 407-24 (1989).
4. Borgman, C.L. End user behavior on an online information retrieval system: a computer monitoring study. *ACM SIGIR Forum* **17,** 162-76 (1983).
5. Borgman, C.L. Why are online catalogs hard to use? Lessons learned from information retrieval studies. *J. Am. Soc. Inf. Sci.* **37,** 387-400 (1986).
6. Chang, S.J. and Rice, R.E. Browsing – a multidimensional framework. *A. Rev. Inf. Sci. & Technol.* **28,** 231-76 (1993).
7. Collins, A. and Brown, J.S. The computer as a tool for learning through reflection. In *Learning Issues for Intelligent Tutoring Systems* (Edited by Mandl H. and Lesgold A.), 1-18, Springer-Verlag, New York (1988).
8. Core, J. Time dependent amnesia, intelligent agents and interfaces for information retrieval. Paper presented at *ALT-C '94*. University of Hull, U.K., (September 1994).
9. Dickson, J. An analysis of user errors in searching an online catalog. *Cat. Classifn Q.* **4,** 19-38 (1984).
10. Fenichel, C.H. The process of searching online bibliographic databases: a review of research. *Libr. Res.* **2,** 107-27 (1980).
11. Fenichel, C.H. Online searching: measures that discriminate among users with different types of experience. *J. Am. Soc. Inf. Sci.* **32,** 23-32 (1981).
12. Foss, C.L. *Learning from errors in Algebraland.* Technical Report IRL-87-0003, Institute for Research on Learning, Palo Alto, CA (1987).

13. Foss, C.L. *Problem-Solving Processes as Retrieval Cues.* PhD Thesis, Department of Psychology, Stanford University (1987).

14. Gauch, S. and Smith, J.B. Search improvement via automatic query reformulation. *ACM Trans. Inf. Syst.* **9,** 249-80 (1991).

15. Graham, T. The free language approach to online catalogues: the user. In *Keyword Catalogues and the Free Language Approach* (Edited by Bryant P.), Bath University Library, Bath, U.K. (1985).

16. Jackson, A.H., (Ed.), *Training and Education for Online*. Taylor Graham, London, 1989.

17. Katz, S. and Lesgold, A. Implementing post-problem reflection within coached practice environments. *Proceedings of the East-West International Conference on Computer Technologies in Education (EW-ED'94)*, Crimea, Ukraine, 125-30 (1994).

18. Kuhlthau, C., Spink, A. and Cool, C. Exploration into stages in the information search process in online information retrieval: communication between users and intermediaries. *Proceedings of the ASIS Annual Meeting (Vol. 29)*, 67-71 (1992).

19. Levy, D.M. and Marshall, C.C. Going digital: a look at assumptions underlying digital libraries. *Commun. ACM* **38,** 77-84 (1995).

20. Reich, V. and Weiser, M. Libraries are more than information: situational aspects of electronic libraries. *Ser. Rev.* **20,** 31-7 (1993).

21. Rice, J. Serendipity and holism: the beauty of opacs. *Libr. J.* **113,** 138-41 (1988).

22. Root, R.W. Design of a multi-media vehicle for social browsing. *Proceedings of the Conference on Computer-supported Cooperative Work (CSCW '88)*, Portland, OR, ACM, 25-38 (1988).

23. Rudd, J. and Rudd, M.J. Coping with information load: strategies and implications for librarians. *Coll. Res. Libr.* **47,** 315-22 (1986).

24. Taylor, R.S. Question-negotiation and information seeking in libraries. *Coll. Res. Libr.* **29,** 178-94 (1968).

25. Tenopir, C. To err is human: seven common searching mistakes. *Libr. J.* **109,** 635-36 (1984).

26. Twidale, M.B. and Nichols, D.M. *Situated Observations of Library Users.* Internal Report, Computing Department, Lancaster University (1995).

27. Twidale, M.B., Nichols, D.M., Mariani, J.M., Rodden, T. and Swayer, P. *Issues in Collaborative Database Browsing.* Technical Report CSCW/14/94, Computing Department, Lancaster University (1994).

28. Yee, M.M. System design and cataloguing meet the user: user interfaces to online public access catalogs. *J. Am. Soc. Inf. Sci.* **42,** 78-98 (1991).