SUPPORTING STUDENTS' CONSTRUCTION OF HYPERMEDIA

by

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A Doctoral Thesis

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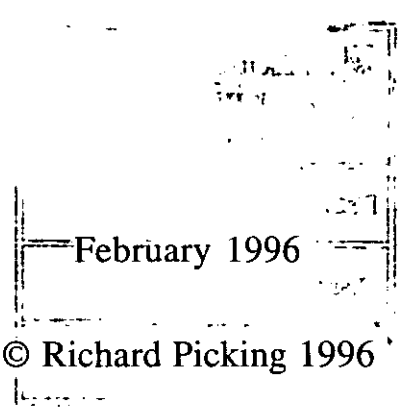

February 1996

Cos I've been standing at the station
In need of education in the rain
You made no preparation for my reputation once again

Noel Gallagher, 1995

Abstract

This thesis considers the proposition that hypermedia may be employed effectively in higher education. More specifically, the question of its use by undergraduate music students to assist in writing essays and dissertations is investigated.

The work begins with a review of general issues relating to educational hypermedia, such as its history, application, design and architecture. A user-centred approach to hypermedia development is advocated, and after critique and analysis of the literature, a framework for human-computer interaction for educational hypermedia is proposed.

A case study is reported which serves to facilitate the undertaking of original research, as well as to evaluate the proposed framework. Other environments are also selected to carry out more generic research. Both reading strategies and writing strategies are investigated, and the results from these studies are used to conduct a repertory grid analysis of students' approaches to and perceptions of essay and dissertation development. The outcome of this experiment concludes with a proposal for a structural model of essay and dissertation development. Analysis of the model suggests the need for further survey analysis of task-artefact usage in specific educational domains, and experimental studies into electronic document manipulation and the reading of music from computer screens are investigated with respect to the case study environment.

The implications of the research carried out in this thesis have assisted in and helped to justify the design of the prototype system HECTOR (***Hypermedia, from Essay Conception TO Realisation***). It aims to support students in their research, planning and writing of essays and dissertations. HECTOR has been evaluated in the field, and the results of this go some way to supporting the hypothesis of the thesis — that hypermedia can be employed effectively in higher education.

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To name every person to whom I am indebted would require a separate volume for this thesis. I feel I should express my personal gratitude to a few individuals, however: Fif for his support and encouragement, Dave for *Bird Lives*, Geoff for his advice and mentorship, and my brother Phil, for the much needed nights of escape.

For all their help and interest, I will be eternally grateful to the staff and students of the City of Leeds College of Music, especially Graham Hearn, Philip Greenwood and Nicholas Read. Thanks also to those from Staffordshire University and the University of Central England for their willingness to participate in and support my research.

And last, but most, there are two people who have influenced me beyond compare:

Cliff, who has proved to be much more than I could ever have hoped a supervisor to be

Cheers! ;-) ...

... and Liz, for everything.

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Chapter 1
Introduction

Homer's heroes were certainly no braver
than our Trio, but more fortunate: Hector
was excused the insult of having
his valor covered by television.

from Moon Landing by W.H. Auden

When the concept of hypertext came to prominence, it was scrutinised with some scepticism by the popular media, for example:

> The hyping of hypertext has, understandably, aroused some suspicion among the computing industry's ever-growing brood of cynics.
>
> *The Guardian, 24 Mar 1988*

Indeed, what happens when the *rtext* is taken from Theodore Nelson's term has also occupied academic writers (e.g. Raskin, 1987; Nielsen, 1995). Hypermedia is now nevertheless an established method of human-computer interaction in higher education. Its niche is located in the retrieval of documents from very large information sources, such as from the World Wide Web on the Internet. However, educational hypermedia has had a fairly rocky history. Whether the rock will prove ultimately to be a rising meteor or a falling brick is still an issue of debate (Pickering, 1995; Floridi, 1995).

This thesis investigates the design and use of hypermedia in the domain of music history education. As it focuses on a case study, any recommendations for the advance of educational hypermedia will be difficult to apply generically. However, the thesis takes the premise that every application is necessarily domain specific. Nevertheless, the research methods employed during the case study may be considered suitable in other educational scenarios, and the lessons learned from the whole exercise may provide initial pointers for future designers.

1.1. Hypertext, hypermedia and multimedia

The definitions of the terms hypertext, hypermedia and multimedia have been the subject of some argument and confusion ever since they were conceived. The Oxford English Dictionary of New Words exemplifies the problem:

> *Hypertext* and *hypermedia* are concepts which computer scientists have been working on since the sixties, but which were perhaps too far ahead of their time to gain much popular currency until the eighties. Then, with the general public becoming increasingly computer-literate and demanding ever more sophisticated sources of information, and the necessary hardware becoming ever cheaper to produce, *hypertext* and *hypermedia* (sometimes called *multimedia*) were presented very much as the next step after the database and the personal computer, CD player, etc.
>
> *OED of New Words, 1991 (159)*

Fischer and Mandl (1990) attempt to separate hypermedia from multimedia, whilst providing a pedagogical argument for the former:

> Hypermedia are *virtual* media. The prefix "hyper" in hypermedia distinguishes this type of media from multimedia. The difference is based upon the depth and richness of the information contained. Hypermedia are also different from multimedia because the learner decides how much of this virtual richness he or she wants to use. Thus the effectiveness of hypermedia depends upon the accessibility of the given *hypermedium* as the source of information in an efficient and meaningful manner based upon his/her prior knowledge and learning skills.
>
> *Fischer and Mandl, 1990 (xix)*

Allen and Hoffman (1993) refer to the authority granted to users as a differentiating factor:

> Hypermedia is often associated with *multimedia*, but we think the two can be distinguished by the relative degree of authority that is extended to users over the creation of links, paths and networks. In multimedia, the authors of a particular product are generally responsible for determining the way in which information units will be sequenced or arrayed. It may be useful to think of multimedia and hypermedia as two ends of a continuum that is defined by the degree to which a user has authority and/or responsibility for establishing links, paths or webs of relationships.
>
> *Allen and Hoffman, 1993 (261)*

Popular writers often use the terms interchangeably (e.g. Cotton and Oliver, 1993). It is clear however, that certain types of interactive multimedia cannot exist within the domain of hypermedia. Interactive video for example, does not necessarily allow much user control or choice. Multimedia can be arranged in hierarchically structured menus, or even sequentially. This thesis recognises the need to differentiate between hypermedia and multimedia, as the attributes of depth, richness and user authority advocated above, are regarded as fundamental.

The difference between hypertext and hypermedia is now well documented. However, some prefer to use a single term. McKnight, Dillon and Richardson (1991) for example, use *hypertext* as the generic. With the increase in mixed media technology however, the term *hypermedia* is becoming more common. This thesis will use the terms interchangeably, with no preference between the two. It is regarded here that they are synonymous.

1.2. Research approach

All research has an ontological and epistemological basis. The most *conventional* philosophical maxim in the western world is the validity of positivism (Guba, 1990). However, it is argued here that an exclusively positivist approach is problematic in the research of human-computer interaction (HCI). As HCI is a multidisciplinary subject, researchers in this field should also be cognisant of methods from all related disciplines, such as those employed in the social sciences.

Which method to employ in what situation is very much dependent upon the underlying research philosophy and epistemology of the researcher. A *Skinnerian* behaviourist would doubtless reject any approach which does not reflect a positivist paradigm. The view of the author is that no particular paradigm is the right one. Rather, different situations lend themselves to different approaches, and each instance should be evaluated according to whichever approach may provide the most useful outcome. In this sense, the author is adopting a constructivist stance, as Guba elucidates:

> As a constructivist I can confidently assert that none of these four [positivism, post-positivism, critical theory and constructivism] is the paradigm of choice. Each is an alternative that deserves, on its merits ... to be considered. The dialog is not to determine which paradigm is, finally, to win out. Rather, it is to take us to another level at which all of these paradigms will be replaced by yet another paradigm .... That new paradigm will not be a closer approximation to truth; it will simply be more informed and sophisticated ...
>
> *Guba, 1990 (27)*

This *new paradigm* is still an issue for methodological research. Until it is *discovered*, the constructivist can only adopt a pragmatic stance. The studies reported in this thesis demonstrate the use of a range of quantitative and qualitative research methods, including surveys, interviewing, observation, experimental design and data analysis. The bulk of work is of an applied variety, as a case study forms the ongoing theme of the thesis.

1.3. Outline of the thesis

This thesis will chart the brief history of what many people believe to be the electronic manifestation of a post-modernist society. Unfortunately, hypermedia may be a victim of its own philosophy, as it could be argued that a de-structured medium may easily result in chaos. It may be also a victim of its own technological inertia. Many computer-based innovations are driven by their gluttony for more and more features, with little or no regard for the potential detrimental impact upon the end users (take the problem-ridden launch of Windows'95 as an example).

The review of literature in educational hypermedia will attempt to approach this problem by considering the salient issues which designers of educational applications should consider. These can be summarised as: the users, tasks, information, pedagogy, the educational domain, the interaction and evaluation issues. An agenda for research into an appropriate domain, that of music education, is then proposed.

The issues summarised above are considered in more detail, in the form of an ongoing case study based within the City of Leeds College of Music (CLCM). Students from CLCM participated in a number of original studies, as did students from other higher education institutions. Reading and writing strategies are investigated using a variety of research methods, resulting in the proposal of a model for essay and dissertation development, from conception to realisation.

A research prototype named HECTOR (***Hypermedia from Essay Conception TO Realisation***), based on this model was designed and evaluated, concluding with a consideration of the hypothesis that hypermedia can be useful in music education. The conclusions of the thesis verge on the cautious, as it is very difficult to apply general recommendations in such a highly complex working environment. Nevertheless, this work is regarded as a step forward towards improving the lot of the hypermedia user.

This introduction ends with another extract from a W.H. Auden poem. It articulates the trauma that many hypermedia users endure. It is a response to Theodore Nelson's optimistic interpretation of Coleridge's poem *Xanadu*. In the author's opinion, *Atlantis* is still easier to find.

Assuming you beach at last
Near Atlantis, and begin
The terrible trek inland
Through squalid woods and frozen
Tundras where all are soon lost;
If, forsaken then, you stand,
Dismissal everywhere,
Stone and snow, silence and air,
O remember the great dead
And honour the fate you are,
Travelling and tormented,
Dialectic and bizarre.

from Atlantis by W.H. Auden

Chapter 2
Hypermedia in education

2.1. Introduction

Hypermedia is one of the more recent technological innovations to be applied to the field of learning and education. However, unlike earlier approaches such as computer-assisted instruction (CAI) which aims to reinforce learning, hypermedia attempts to widen students' scopes of learning. Nielsen (1995) affirms this position:

> Hypertext is well suited for open learning applications where the student is allowed freedom of action and encouraged to take the initiative .... On the other hand, hypertext may be less well suited for the drill-and-practice type learning that is still necessary in some situations.
>
> *Nielsen, 1995 (101)*

The advantages offered by hypertext in this context apply particularly to the more mature student, according to some educationalists:

> ... regardless of individual reaction, the schools exist to pass on what the experienced feel that the young need to know. In this early context, a more authoritarian and didactic approach can legitimately be taken toward the teaching process. But as the student matures, a greater burden of responsibility for the assimilation of knowledge should, within the limitations of good learning practices, be democratised.
>
> *Marshall, 1988 (4)*

Certainly, advocates of hypermedia would maintain that it can meet the following aims:

> The essential aims of teachers in higher education are (1) that students should learn to think and work independently, and (2) that students' study should be made more effective.
>
> *Beard and Hartley, 1984 (110)*

Given Nielsen's assertion that drill-and-practice approaches are "...still necessary in some situations", it follows that there are situations where hypermedia approaches are undesirable. More constraints are suggested by Norman:

> ... I don't believe it can work for most material. For an encyclopaedia, yes; or a dictionary; or an instruction manual. But not for a text, or a novel.
>
> *Norman, 1988 (235)*

Norman does not attempt to categorise literary material, but if his observations are to be taken to their logical conclusion, there is an implication of some kind of spectrum or continuum of literary styles. At one end of the spectrum might be the styles for which hypertext would be applicable. Presumably, at the other end would be novels and other *sequential* fiction (figure 2.1). The question immediately arises as to where the boundary between *hypertextability* and non-*hypertextability* lies. If this notional boundary does actually exist, where do other text styles lie in relation to it — for example, biography, academic journals, magazines and so forth?

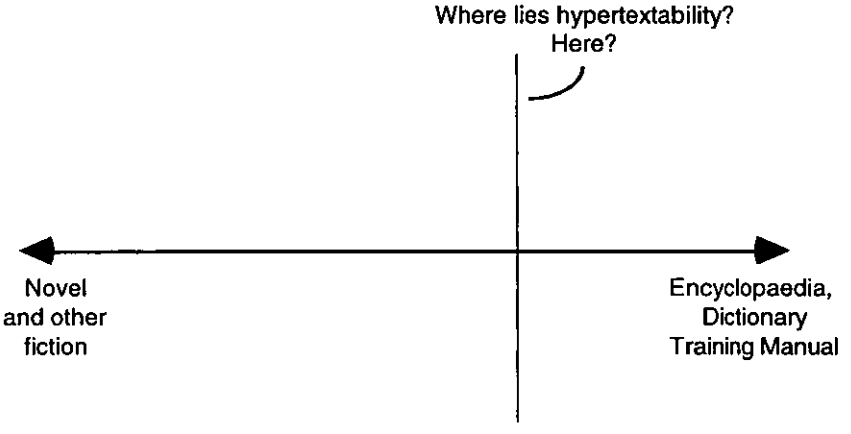

Figure 2.1: A continuum of text styles?

Rather than a continuum as such, Wright and Lickorish (1989) suggest a categorisation of discourse structures:

- *Highly cohesive text structures* (displaying strong linear properties).
- *Modular text structures* (composed mainly of independent modules of information).
- *Hierarchical and matrix text structures* (composed of inter-related and highly structured modules of information).
- *Multi-theme text structures* (containing several accounts of broadly related subject matter).

Contrary to Norman's argument, Wright and Lickorish do not reject a hypertext for any of these categories — rather, design guidelines are suggested vis-à-vis linkage styles, destination appearance and navigation support for each form.

Wright and Lickorish concentrate on design issues such as the use of windowing, screen display size, button functionality and so forth. Given that different kinds of discourse structure exist and will continue to be developed in hypermedia, it would also seem sensible to consider how users read and learn from such diverse forms of presentation, and perhaps more to the point, what the users actually want to *do* with them.

If hypermedia can apply to a much broader spectrum of discourse structures, the potential for applications in educational is widened significantly. Proponents of progressive CAI argue that learning can be based on a *discovery* approach (Elsom-Cook, 1990). Bearing in mind the interactive and presentational impact of modern computer technology, it is understandable for them to suggest that hypermedia is an ideal environment for all kinds of students to learn in. Even the most formal of subjects such as mathematics can be enhanced by the use of animated graphs, discovery learning (Papert, 1980), historical references and so forth. At the other end of the spectrum, arts subjects have textbooks which exhibit hypermedia applicability — for example, cross references, pictures and diagrams. The Perseus Project (Crane, 1987; 1988), a hypertext implementation of a classical Greek literature course, is testimony to this.

All this demonstrates the diversity of opinion amongst academics as to the domain of education where hypermedia could effectively be incorporated. The constraints of educational approach and of information structure are other factors to be considered. Views range from general scepticism towards educational hypertext (McKnight et al., 1991; Whalley, 1993) to ethereal approaches suggested by Moulthrop (1989) and Bolter (1991).

The latter authors describe an array of imaginative hypermedia projects including hypertext novels, and suggest that certain classical literature (for example the works of James Joyce) demonstrate characteristics that could be *hypertextualised.* The overall impact of hypermedia upon the world of education will not be influenced by the availability of advanced technology alone. Whether hypermedia is a sociologically or pedagogically sound concept is still a point of controversy. It is sometimes important, whenever excitement prevails, to step back for a while and review the ongoing situation.

This review will take a pragmatic look at developments in educational hypermedia. An overview of hypermedia's history is not presented, as this is already a very well-documented area (e.g. Conklin, 1987; Nielsen, 1995). Instead, a survey of recent attempts to incorporate hypermedia into the educational domain will be presented. Problems and issues relating to the design of interfaces for educational hypermedia will be discussed. Arguments pertaining to the pedagogical issues which may be addressed by developers will also be detailed. In conclusion, a research agenda will be presented along with a proposed vehicle of study.

2.2. A review of the development of educational hypermedia

Although Vannevar Bush's hypothetical *Memex* machine was intended as a generic information retrieval device, the example scenario given in his seminal paper (Bush, 1945) is in the context of learning:

> The owner of the Memex, let us say, is interested in the origin and properties of the bow and arrow. Specifically he is studying why the short Turkish bow was apparently superior to the English long bow in the skirmishes of the Crusades.
>
> *Bush, 1945*

It is perhaps stretching a point to suggest that hypertext was originally conceived with educational applications in mind. Whalley (1993) rejects the notion entirely:

> An important starting point in any consideration of the hypermedia is the recognition that they were not purposefully designed for education. The principal foci of this technological drive have been the efficient retrieval of information and entertainment.
>
> *Whalley, 1993 (7)*

Nevertheless, hypermedia has been used extensively in educational domains. Authoring environments have been developed specifically for education, as well as the production of specialised educational hypermedia applications. What now follows is a review of developments in each of these areas.

2.2.1. Authoring Environments

When faced with the task of authoring a hypermedia application, one is spoilt for choice with respect to the selection of an appropriate development platform. Hypermedia authoring environments such as HyperTies (Shneiderman, 1987), Guide (Brown, 1987), Intermedia (Yankelovitch et al., 1988) and Storyspace (Bolter and Joyce, 1987) support rapid and efficient hypermedia authoring. Some more generically orientated application development environments such as Toolbook, HyperCard and NoteCards (Halasz, Moran and Trigg, 1987) lend themselves quite readily to hypermedia development, as long as authors are familiar with the programming techniques. Less recognisably hypermedia (but even more common) software development environments have been successfully used to author hypermedia applications, such as Visual Basic (VB), Visual C++ (VC++) and Macromedia Director, although such applications tend to be presentation based. Presentation software such as Netscape and Mosaic have spawned a plethora of support software for their underlying HTML (HyperText Mark-up Language) structure. Another type of hypermedia environment which needs to be classified separately is that of *open* hypermedia, typified by the Microcosm project (Fountain et al., 1990; Davis et al., 1992; Hill and Hall, 1994).

All of the above authoring environments have been used to develop educational hypermedia. Whilst not an exhaustive summary, they do represent a cross-section of currently available hypermedia authoring environments. For the sake of the ensuing discussion, each of these types of environment will be classified and described as follows:

Authoring Environment	**Examples**
Hypermedia authoring environments	HyperTies, Guide, Intermedia, Storyspace
Application development environments	HyperCard, Toolbook, VB, VC++, Director
Hypermedia presentation environments	Mosaic, Netscape, MacWeb, StrathTutor
Open hypermedia environments	Microcosm

Table 2.1: Hypermedia authoring environments with examples.

2.2.1.1. Hypermedia authoring environments

It was not until the advent of Intermedia that a hypertext framework was developed specifically for use in an educational environment. Intermedia was originally designed for use by undergraduate level students. It was used extensively at Brown University in the USA particularly by English Literature students working with George Landow and by Biology students working with Peter Heywood. Intermedia supported collaborative work as well as providing authoring facilities for users. Intermedia has been cited as *the textbook of the future* (Cunningham, Duffy and Knuth, 1993), but unfortunately is now defunct. Its achievements were indeed commendable by any standards, but because it was essentially a research project (running on Apple equipment under the UNIX operating system), its demise was inevitable.

Dubbed by many as the poor person's Intermedia, Storyspace has many of the facets previously pioneered by the developers of Intermedia. It has suitably impressed the academics at Brown University to an extent where it is now regularly used in Intermedia's place.

Perhaps the most well-known hypermedia authoring environment is Guide. Guide is particularly useful for hypertext authoring as it is relatively easy to convert manual text to a hypertext format. However, it is not so straightforward to incorporate graphics and multimedia. Guide has been used nevertheless, for computer-assisted learning in some higher education institutions in the UK.

The advantages of hypermedia authoring environments include the ability rapidly to create consistent and well-presented hypermedia documents. A general criticism however, is their restrictive interface. Authors cannot easily, if at all, customise the presentation. Whether this is a problem in educational hypermedia is debatable. Certainly, in early education, where much relies upon the engaging quality of the presentation, this would be a disadvantage. Perhaps in higher education it is not so much of an issue.

2.2.1.2. Application development environments

Perhaps the most important impact in the brief history of hypertext and hypermedia was the release of Apple's HyperCard in 1987. Although not specifically designed for hypermedia, the notion of linking cards to one another lent itself quite readily to hypermedia authoring. Supplied free of charge with every new Apple Macintosh, HyperCard has been introduced to a vast number of users. At the time, it proved to be especially useful to non-

programmers, as simple systems could be put together without the need to resort to complex program scripting whatsoever. Hence, for the first time hypermedia development could be experimented with by educationalists, psychologists, sociologists, graphic designers and so forth. In other words, the people whose views on hypermedia were most needed were now able to make a tangible contribution to the field.

Although HyperCard has raised awareness of hypermedia (and rapid prototyping of user interfaces), it is certainly no panacea. There are inherent problems with highly accessible development environments simply because anyone can now produce systems without possessing the necessary design skills. There is little constraint on designers to conform to consistent presentations, and with the advent of more HyperCard*esque* products (e.g. Toolbook, Supercard, Visual Basic, Macromedia Director) there seems to be more need than ever for interface design awareness. The irony of this is that HyperCard does not impose the user interface guidelines published for Apple based products by Apple themselves! The Microsoft Windows programming environments, Visual Basic and C++, at least provide programmers with basic interface design guidelines, although authors really need to be experienced computer programmers to reap the full benefits of these environments.

Even with such limitations, the majority of commercial hypermedia and interactive multimedia applications have been created using authoring environments such as HyperCard (e.g. Beethoven's 9th, Mozart Dissonant Quartet) and Visual Basic (e.g. Microsoft Dinosaurs, Microsoft Gallery). The emphasis of these products is very much on presentation — there is little or no provision for readers' annotations or link authoring. In this respect, it is arguable whether such products can be termed hypermedia at all.

2.2.1.3. Hypermedia presentation environments

An early educationally-oriented application of the hypermedia presentation environment concept was StrathTutor (Mayes, Kibby and Watson, 1988). This differs from other presentation environments, as most links are created not by the application's authors, but automatically at run-time. Two types of computed link are provided by StrathTutor: firstly, the frame *physically* closest to the current one is accessible; and secondly, the frame *semantically* closest to the current one. Semantic links are calculated by using a computational model of memory called MINERVA, proposed by Hintzman (1984; 1986).

More recently, the advent of the World Wide Web (WWW) has made an undoubtedly high contribution to the almost exponential growth of Internet users. Presentation environments such as Netscape and Mosaic provide users with a relatively usable window into the Internet void, although they are by no means ideal (Kellogg and Richards, 1995). However, their hypertext links and annotation facilities do provide users with the sense of a hypermedia interface. Such interaction still exhibits structural difficulties, as organisation and manipulation of documents is very crude.

Students in higher education form a large population of WWW users, and a number of universities provide useful bibliographic information which would normally be difficult or time consuming to obtain using traditional library methods. Many higher education institutions are experimenting with making courseware and student work available on the World Wide Web, although there are still problems with access and copyright.

2.2.1.4. Open hypermedia environments

MICROCOSM is perhaps the most complete and potentially useful *true* hypermedia system. Its conception was based on the recognition that most hypermedia systems (including those discussed above) were fraught with problems of practicality and usability. These problems have been summarised by Fountain et al. (1990) and are discussed below:

• *Authoring effort required.* Certainly, application development environments require a large effort on the part of authors, as there is little or no built in hypermedia support. Hypermedia authoring environments require less effort, although most document linking must be developed manually. Authoring is much less of an overhead for hypermedia presentation environments, although linking is still node specific and somewhat crude. MICROCOSM provides a generic link feature, which allows multiple links to be generated automatically between similar nodes. From the point of view of initial authoring, this is a significant advantage.

• *Hypertext systems are closed.* At the level of document manipulation, all of the previously discussed environments are closed. One cannot for example, link a HyperCard node to a Guide node. They are essentially autonomous systems. Application development environments such as Visual Basic and HyperCard, allow some interactivity between themselves and other packages at the document level, and Apple's scripting environment can also provide a limited sense of openness. However, MICROCOSM is *designed* to be open — it even allows communication between several packages which were not designed

with open hypermedia in mind. MICROCOSM effectively supervises this communication by sending messages and acting on events relating to the appropriate applications. In this sense, it is almost like an extension to the underlying operating system of the computer, as opposed to an application in its own right.

• *Proprietary document formats.* The majority of closed hypermedia environments maintain a completely unique model of their data. An exception is that of hypermedia presentation environments which rely on standards such as HTML and HyTime (Newcomb, Kipp and Newcomb, 1991). MICROCOSM (and Intermedia before it) is not concerned with hypermedia specifics within documents, as it stores all links separately. Consequently, documents not originally designed in a hypermedia format can be efficiently represented in MICROCOSM, whilst still maintaining their original structure and layout.

• *Problems with read-only media.* As has been previously mentioned, most commercially available hypermedia applications are available exclusively on a read-only basis. This is due in part to the distribution of large documents on CD-ROM, although there is no reason to deny users write access to databases which can communicate with this read-only medium. Hypermedia presentation systems allow a limited amount of annotation, but unless users have access to original HTML document formats, little else can be done in terms of reader authorship. Hypermedia authoring environments, such as Storyspace and Guide, attempt to break down the barriers between readers and authors, by providing readers with much the same linking and structuring facilities that the original hypermedia authors had. In this respect, MICROCOSM is the same.

MICROCOSM has been used effectively on a number of courses at the University of Southampton, where it was originally developed. It is also the document management system for the Mountbatten archives, held by the Hartley Library at the same site. Hall, Hutchings and Davis (1994) cite the importance of their open hypermedia system for education:

> The onus is on the user to interrogate the system in order to answer questions such as "What other information do you have on subject X?". Most other systems take the opposite approach: they announce to the user "I have information on subject X". It is the user rather than the author who dictates the degree of interaction.
>
> *Hall, Hutchings and Davis, 1994 (22)*

2.2.1.5. The architecture of authoring environments

It could be argued that the reason why MICROCOSM is more of a complete hypermedia environment is due to its comprehensive architecture. Various authors have proposed hypermedia architectures, the most well-known of which adopt a three-layered model (Campbell and Goodman, 1988; Halasz and Schwartz, 1990; 1994), although more recent work has favoured a seven-layered approach (Lowe, 1995). Kacmar (1993) proposes a two-layered model, although he suggests that it is most useful for applications where linear text is to be converted to a hypertext format. Indeed, he describes the three-layered approach as *pure* hypermedia. These three layers are essentially as follows:

• *A user interface level*, where user interaction aspects are considered and where information is presented to the reader. Where reader annotation and authoring is available, such facilities will be provided here.

• *A hypertext abstract machine (HAM) level*, where information relating to nodes, links and the relationships between them are stored.

• *A database level*, where documents, images, films and so forth are stored in their original format. The database level also manages more traditional database issues, such as user access, storage optimisation and information retrieval methods.

Of the hypermedia environments discussed, MICROCOSM is the only system which is conscious of all three layers of this architecture. Its architecture is summarised overleaf, in the form of a diagram.

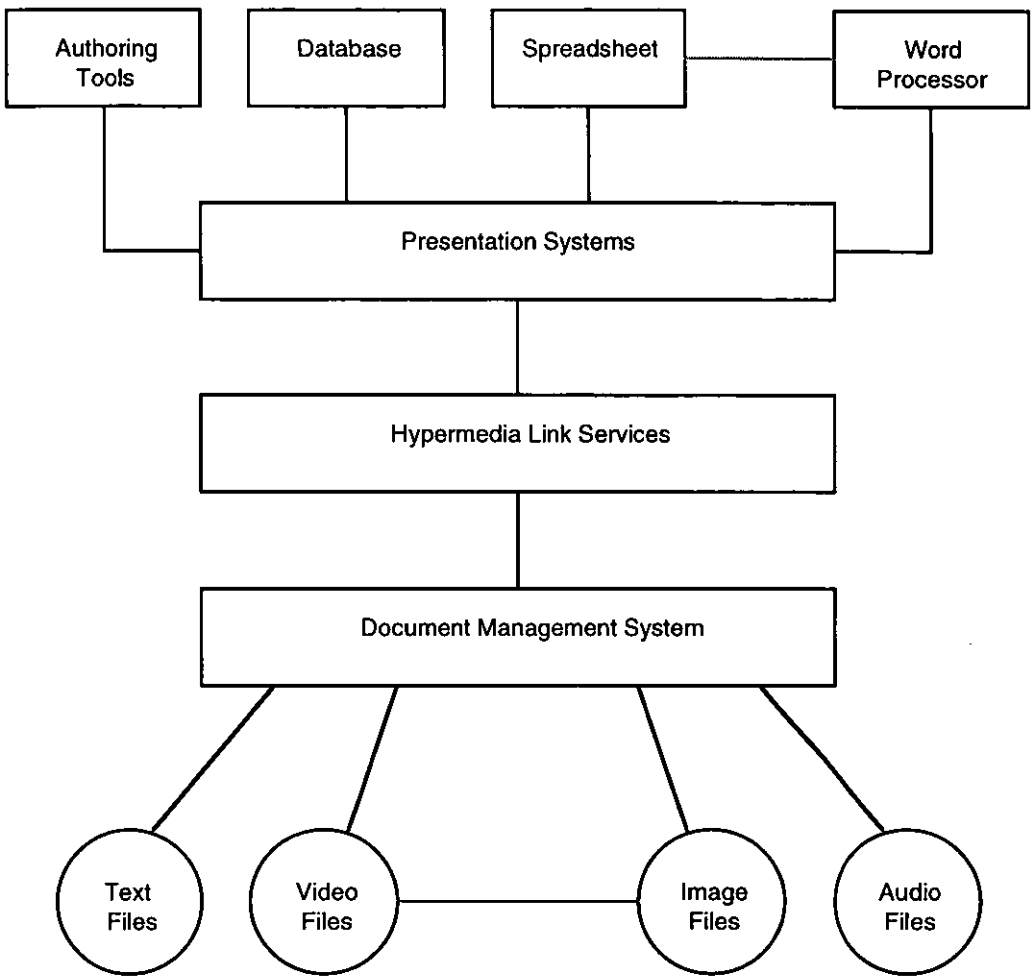

Figure 2.2: Architecture for MICROCOSM, displaying three layer model (from Hall et al., 1994, p.7).

A standard architecture for hypermedia environments enables wider incorporation of traditional documents and reduces authoring effort. It can enable the hypermedia goal of reader/writer fusion by separating the user interface from the rest of the system. Application development environments such as HyperCard and Visual Basic may be utilised at the user interface level, a number of proprietary databases can supervise the database level of the three-layered model, but the hypertext abstract machine (HAM) is the most important integrating factor of the architecture. Specialised software such as MICROCOSM is required to store hypermedia information and to integrate the levels below and above the HAM.

2.2.2. Educational hypermedia applications

Nielsen (1995) provides an overview of early instances of educational hypermedia applications, such as Palenque (Wilson, 1988), a system to help teach children about Mexican archaeology, the Shakespeare Project (Friedlander, 1988), aimed specifically at drama students in higher education, the Perseus Project (Crane, 1987; 1988), which supports the study of the Greek classics, A la Recontre de Phillipe (Hodges, Sasnett and Ackerman, 1989), to assist French language learning, and a hypertext support system for teachers in higher education (Leggett, Schnase and Kacmar, 1990). Nielsen argues that it is difficult to differentiate what might be termed educational hypermedia applications from other, related application areas such as research and reference orientated products. Whilst by no means exhaustive given the extensive effort dedicated to hypermedia development, this review considers more recent examples which were specifically developed for augmenting teaching and learning (Marchionini and Crane, 1994). As they are relatively recent, the majority are still in the research domain.

2.2.2.1. Earthquake education

Terremoti (Frau, Midoro and Pedemonte, 1992) is an educational hypermedia application which educates students in the identification of geological models of earthquakes and methods of protection against them. It is designed very much for ease of use, adopting a highly visual museum metaphor. The user is able to browse the museum by *opening* virtual doors and by querying a virtual agent, who takes the role of a helpful curator. A number of navigation aids are provided, including a hierarchical overview, a museum map and an index. Reading material such as an anthology of contributions from experts in seismology is included, as well as a dictionary of terms.

Terremoti was evaluated to consider whether a hypermedia system such as this could enhance the students' learning. Students were monitored whilst using the system in two modes — *self-service mode*, where they were encouraged to browse through and familiarise themselves with the system, and *task-guided navigation*, where students were asked to use the system to solve a specific problem. The findings of the studies indicated that good user interface design and provision for alternative information access facilities were not by themselves enough to provide a significant improvement in learning. The authors argue that other elements must be considered, such as diagnosis, reinforcement, feedback and motivation. In other words, presentation is only one element for good educational hypermedia design.

2.2.2.2. Medical education

The Management of Sexually Transmitted Disease (Kidd et al., 1992) is an application which aims to complement undergraduate medical education, postgraduate family medicine trainee education and act as a reference and continuing medical education tool for practising general practitioners. It exhibits multimedia features by relying on videodisc technology to provide 12,000 images which cover all areas of clinical medicine.

MSTD was developed in StackMaker, an extension to Apple's HyperCard. StackMaker provides a set of tools to help automate the conversion of text to hypertext. It also provides navigation tools which include a contents list, an index and graphical browsers.

2.2.2.3. HyperCourseware

HyperCourseware (Norman, 1992) is an application which seeks to accommodate the *electronic classroom*. Norman (1994) explains that it:

> ... instantiates in hypermedia form the traditional materials of education such as the syllabus, lecture notes, exams, and class roll as well as interactive methods for group discussion, exchange of ideas, student polling, feedback, and collaborative group note-taking.
>
> *Norman, 1994 (35)*

In this respect, Norman suggests that the conventional elements of classroom instruction should be maintained, as opposed to introducing novel environments for the computer. It can be adapted for any educational domain which is based on this traditional mode of teaching. Student evaluations of the system were positive, and the use of the classroom metaphor was shown to be productive.

2.2.2.4. Chemistry education

Hyperequation (Kumar, 1993; 1994) is a prototype hypermedia system which provides alternative, process-orientated methods of assessment in chemistry education. It has been tested by high school chemistry students, who were asked to use it to help them solve chemical equations. Hyperequation also provides teachers and assessors with aggregated breakdowns of student performance. Both expert and novice users were found to have balanced more equations using Hyperequation than by the traditional pen and paper method. Although Kumar expresses satisfaction with these initial results, he warns that the pedagogical techniques involved might not transfer easily to other scientific disciplines.

2.2.2.5. Sociology education

The Lab Design Project (LDP) (Honebein, Chen and Brescia, 1992) is a hypermedia system designed to support the teaching of research skills to graduate sociology students. It adopts a situated learning approach, where students are encouraged to experience undertaking research on the sociology of a building. Learners are able to *explore* the building, in order to obtain an appreciation for its design. They are also provided with other artefacts, such as blueprints, floor plans, photographs, and transcribed interviews with users of the building. Students try to solve research problems by linking information together from these artefacts. The authors of LDP maintain that the computer-based medium is methodologically sound, as groups of students walking around the real building would change the culture of that building.

2.2.2.6. Mathematics education

The Renaissance Project (Harding et al., 1995a; 1995b) complements mathematics teaching for students of GCSE to A-level standard. It supports a range of multimedia modules, including historical biography, as well as more instructionally-oriented material. Although no formal educational evaluation has taken place at the time of writing this thesis, initial reports suggest an enthusiastic response from the teachers and students who have used it.

2.2.2.7. Language education

Cyberbuch (Chun and Plass, 1995) is an application which provides student readers of German texts with hypermedia facilities. These include the provision of advance organisers (Ausubel, 1960), a notebook for annotations, audio recording facilities, game play as well as various multimedia resources to help reinforce the learning of vocabulary. The design of the system is underpinned by theories of cognitive learning styles, which suggest a hierarchical approach to knowledge representation.

Chun and Plass also report on two studies where the usability and behavioural usage of multimedia were investigated respectively. They recorded a positive opinion from the users in terms of their initial reaction to Cyberbuch. Although students who used the multimedia links performed slightly better in vocabulary tests than the control group who didn't have access to them, the improvement was not statistically significant.

2.2.2.8. Discussion

This review concentrates on only a relatively small proportion of recent educational hypermedia applications. A seemingly exponential growth in applications has resulted from the realisation that, with even more pressures in education resourcing, there may be a technological solution *out there somewhere*. A number of initiatives have been launched, such as the Teaching and Learning Technology Programme (TLTP), originated in February 1992, which has funded 76 major projects in the United Kingdom, many of which involve significant usage of hypermedia. This has resulted in the publication of hundreds of papers and reports. A significant review of TLTP projects is beyond the scope of this thesis, as there are simply too many of them to consider. As the initiative is still ongoing at the time of writing this thesis, it would also be difficult to review the success of individual projects. The interested reader is directed to the TLTP Newsletter, which is published quarterly. Detailed information can also be obtained by accessing the TLTP World Wide Web pages on the Internet (http://www.icbl.hw.ac.uk/tltp). Other initiatives include the Computers in Teaching Initiative (CTI), Flexibility in Course Provision (FCP) and the Effective Teaching Assessment Programme (ETAP).

The brief review of recent applications nevertheless raises a number of issues in educational hypermedia design. Most experienced hypermedia developers emphasise the dangers of relying purely upon the available technology to provide a reasonable learning experience. Holistic considerations of human-computer interaction are essential facets of good design.

Pedagogical and domain issues are also identified to be of importance. For example, some applications follow an instructional approach to the educational process, whereas others are more constructional (Hay et al., 1994). The pedagogy may be dependent upon the educational domain, as well as the tasks that users are expected to perform.

Users should be regarded as the hub of the design process, and careful evaluation of their impressions of a system and their performance are imperative. It matters not how well a system can be justified against cognitive or other psychological theories — if users reject a system, their performance and the effectiveness of their work will deteriorate.

As these issues are so crucial, what now follows is a more detailed analysis of a number of the identified human-computer interaction issues for educational hypermedia.

2.3. Human-computer interaction for educational hypermedia

As hypermedia involves a high degree of communication between the user and computer, it is important to recognise the integral role which human-computer interaction (HCI) plays. HCI is very much a multi-disciplinary subject, drawing from practice and theory in such diverse disciplines as computer science, psychology, graphical design, linguistics and engineering. It would seem sensible therefore, to identify some terms of reference specific to HCI issues in educational hypermedia.

Most contemporary HCI textbooks agree that the central issues of the discipline concern the users, the jobs and tasks they perform, the tools they use to perform those tasks and the environment they work in. The psychology of users is studied, their tasks are analysed, tools are selected or designed and the environment they work in is optimised. Most aspects of the HCI process are modelled (user models, task models, user interface prototypes etc.), with a significant amount of empirical evaluation taking place throughout. A general discussion of HCI is outside the scope of this thesis, and the interested reader may wish to consult texts such as Dix et al. (1993) or Preece et al. (1994) for a detailed introduction. However, new publications in HCI are very common, as are new innovations, so it would be unwise to identify a seminal text.

2.3.1. Users, tasks and information

In terms of HCI in hypermedia, McKnight et al. (1991) have identified three central issues: users, tasks and information. They consider reading to be the major task which users perform within a hypertext environment, and discuss physical and psychological aspects of users as readers. They also attempt to classify information in order to identify whether certain texts are appropriate for hypertext representation. Nielsen (1995) proposes five usability parameters for hypertext systems, that they should be: easy to learn, efficient to use, easy to remember, few errors and pleasant to use. Nielsen admits that these parameters are fairly generic, however. More detailed work in the assessment of tasks on users' interaction with hypertext has been undertaken by Hutchings et al. (1993). They conclude that patterns of interaction tend to be task driven, rather than by individual preference, although the tasks set by the researchers were predominantly of an information retrieval nature.

2.3.2. Interaction

It could be argued that the advent of the direct manipulation interface style has heavily influenced the development of hypertext and hypermedia systems. More generally,

interaction styles where the user controls the dialogue between human and computer have been adopted by a vast population of non-expert end users. The success of the WIMP (Windows, Icons, Menus and Pointers) interface is arguably mainly responsible for this, but an indication of how rapidly such advances in human-computer interaction have taken place is to consider how recently the *early* breakthroughs were made (Smith et al., 1982), notwithstanding the pioneering work of innovators such as Douglas Englebart and Ivan Sutherland in the early 1960s. It was realised at about this time that in order for non-expert users to maintain this control, interface metaphors could be usefully employed (Carroll and Thomas, 1982). Various metaphors have been successful in this respect. Perhaps the most well-known of these is the desk-top metaphor (e.g. for operating system tasks) and the book or stack of cards metaphor (e.g. for information space navigation/presentation).

It would seem that there are certain specifics within the scope of hypermedia which might warrant a more focused consideration of HCI issues. Interaction issues generally accepted as being idiosyncratic to hypermedia include the *lost in hyperspace* problem (Elm and Woods, 1985; Conklin, 1987, McKnight et al., 1991), the cognitive task scheduling problem (Conklin, 1987), knowledge representation problems (Gordon et al., 1988) and problems associated with reader motivation (Hammond and Allinson, 1989).

In terms of Norman's (1988) gulfs of execution and evaluation, hypermedia's problems relate largely to bridging the wide evaluation gulf. For example, it may be difficult for users to evaluate where their link execution has taken them. It is considered important to carry out a more methodical review of interaction issues in hypermedia, and to do this the more detailed interaction framework proposed by Abowd and Beale (1991) will be used.

2.3.2.3. Abowd and Beale's interaction framework

The interaction framework is shown below in diagrammatic form:

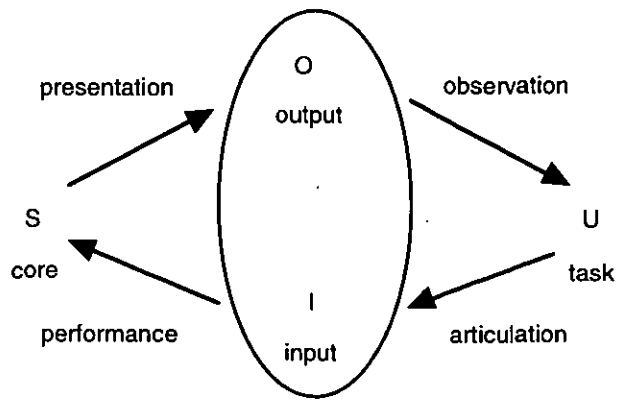

Figure 2.3: Abowd and Beale's interaction framework.

The framework is essentially an extension to Norman's model, with a notional divide at the user interface. The right side of the diagram relates to user issues, and considers the user's input (articulation) through the interface, and the ultimate evaluation (observation) of actions. The left side of the diagram considers the system's enactment (performance) of the user input, and its subsequent output (presentation) of the resultant computation.

A simple description of a task within this framework might be where users articulate their requirement to follow a link by moving a mouse pointer over some active text and clicking on that spot. The system would recognise the input and activate the hypermedia engine to perform the set of actions related to that link. This might be to update a history list and access the target page of the link. The new page might then be presented to users via the computer monitor, which can then be observed by them.

A more detailed discussion of the interaction framework and its implications for hypermedia now follows. Each stage of the framework will be considered separately.

2.3.2.3.1. Articulation

The typical method of articulation of hypermedia tasks is the point and click approach, as exemplified above. The active areas on screen are usually embedded within textual description or pictorial spaces. Most systems indicate active areas explicitly, for example by underlining text, or by colour coding graphics. Storyspace provides an exception by

forcing users to hold down a function key to view where link anchors reside with the text space. The argument for this design is that users are less likely to wander aimlessly through the hypertext, as they need to make an explicit cognitive decision to follow an argument. In this way, it is maintained, users will be more motivated to use hypermedia in a structured and thoughtful way. Implicit links, as provided by Intermedia and generic links, as provided by Microcosm, also do not display anchors explicitly, although these are examples of automated links, rather than where authors have defined links themselves.

Hypermedia is not purely about following links. Several other navigation articulations have been implemented in hypermedia systems. For example, users can follow and retrace trails via maps, history lists, bookmark lists and so forth. Again, the point and click method is usually adopted for these approaches. Navigation aids will be discussed further when the presentation and observation phases of the interaction framework are considered.

The most sophisticated hypermedia systems provide authoring or at least annotation facilities for users. Annotations are articulated in many forms, for example pop-up notes in Guide, separate pages in Netscape, separate windows in Intermedia and post-it notes in Workscape (Lucas and Schneider, 1994; Scott, 1994). Pop-up notes tend to be created via menus, but are subsequently articulated by the point and click method. More complex authoring is often supported by menu-based facilities, although hypermedia languages such as HTML are often typed exclusively from the keyboard.

Hardware for hypermedia articulation usually includes a powerful personal computer or workstation, with a pointing device and keyboard as a minimum, although some earlier systems such as KMS and HyperTies, as well as modern hypermedia presentation environments, allow keyboard-only input. Some multi-sensory hypermedia articulation has also been considered, especially for special-needs users, for example Hyperspeech (Arons, 1991).

2.3.2.3.2. Performance

The way a system performs the user's requirement depends largely upon the hypermedia authoring environment where the application was originally created. The most important aspect of system performance from the user's point of view in this respect is that it should be as invisible as possible. In other words, the performance should seem instantaneous and any translation from user language to system language should be hidden.

Perhaps the most clear example of system performance in hypermedia is that of the hypermedia presentation environment. What happens *behind* the presentation can be shown by comparing what the user sees, and the HTML representation of the system's view of the text:

```
<TITLE>Charlie Parker Story</TITLE>

<H1>The Charlie Parker Story</H1>
<HR>

<H2>A profile of one of the greatest, but most tragic, jazz musicians in history</H2>

<HR>
<IMG SRC="Bird.gif">
<HR>

<B><A NAME="contents">Contents</A></B>
<UL>
<LI><A HREF="TheCharlieParkerStory#shortbiog">Short Biography</A>
<LI><A HREF="TheCharlieParkerStory#family">Family and Friends</A>
<LI><A HREF="TheCharlieParkerStory#musicians">Fellow Musicians</A>
<LI><A HREF="TheCharlieParkerStory#places">Clubs, Towns, Cities etc.</A>
<LI><A HREF="TheCharlieParkerStory#misc">Music and Stuff</A>
</UL>
<HR>
<P>
<H2><A NAME="shortbiog"><A HREF="TheCharlieParkerStory#contents">Short Biography</A></A></H2>
<P>
<H3>1920</H3>
Charles Parker Junior was born on August 29th 1920 in Kansas City, Kansas.
```

Figure 2.4a: System's view of an HTML document.

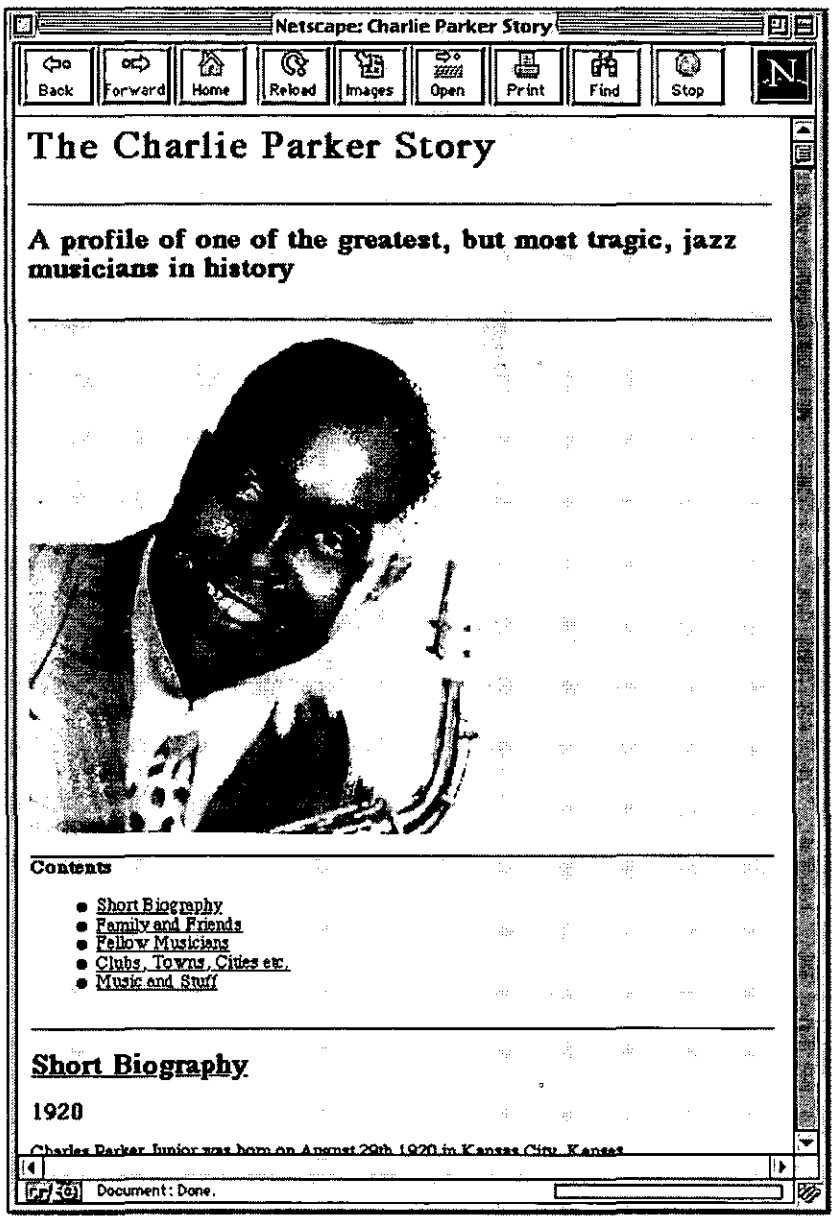

Figure 2.4b: What the user sees.

When the system is performing its work, any unavoidable delays in presentation should be made explicit to users. This is particularly important in World Wide Web applications, where there may be noticeable delays between server access, and in very large hyperspaces, where local database access may be time consuming. Common techniques for providing

users with this feedback include changing the screen pointer to a watch or egg timer, or displaying an animated iconic wait signal. Access delays can be minimised by caching previously accessed documents, or not yet accessed documents which are related to the current line of enquiry.

2.3.2.3.3. Presentation

The presentation phase is probably the most complex aspect of hypermedia interaction. The very nature of hypermedia entails a significant degree of visual presentation. Not only should users be provided with high quality displays of their current line of enquiry, research into navigation in hypermedia highlights the importance of alternative views. These include overview diagrams (Fairchild, Poltrock and Furnas, 1988), fish-eye views (Furnas, 1986), history lists, backtracking facilities, the use of metaphors and augmented reality (Bedersen and Druin, 1995). All of these initiatives arise from the problems of hypermedia navigation and manipulation.

When faced with the task of providing navigation facilities to relieve users' sense of disorientation, as well as the requirement to represent knowledge and information in a rich and meaningful way, the issue of screen space becomes significant. It seems ridiculous to talk about desk-top metaphors, when no worker would be expected to carry out paper-based office or scholarly duties on a two-dimensional space the size of a thirteen inch computer display. How we expect people to work efficiently on computers of that size, even with such innovations as windowing systems, is something which is often overlooked. HCI researchers have demonstrated the improvements users experience with large display monitors (Reisel and Shneiderman, 1987; Hansen and Haas, 1988), and even though they are much more expensive, if we are to provide advanced hypermedia interfaces, larger monitors to support their complexity must be considered a necessary investment.

Which media and when to present to users is an issue which has attracted recent research in the domains of hypermedia and multimedia (Alty, 1991; Faraday and Sutcliffe, 1993; Sutcliffe and Faraday, 1994). Marmolin (1992) suggests a set of simple user-centred guidelines, where media selection is based on the knowledge and experience users have of the problem area. Where users demonstrate expertise and need to perform analytical tasks, textual representation of information is regarded as most appropriate. Conversely, concrete representations (pictures etc.) are regarded to be more suitable for inexperienced users, who may find such media appropriate to support exploration of information. Media mix is

recommended for users who exhibit knowledge and experience between these two extremes. Figure 2.5 summarises Marmolin's guidelines.

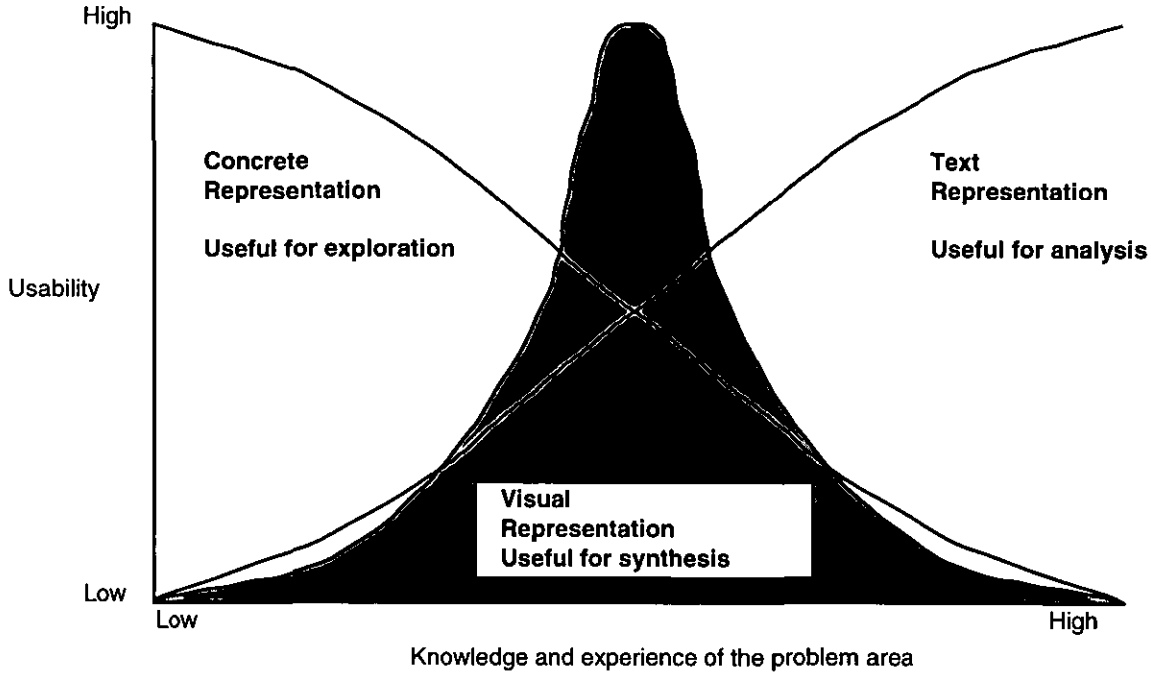

Figure 2.5: Possible uses of different media: from Marmolin (1992).

2.3.2.3.4. Observation

How users interpret the computer's response to their input articulation is essentially the concern of the observation phase in the interaction framework. This could mean simply the highlighting of a text object immediately after it is clicked on, or the indication of the extent to which a piece of digital video has been presented. What is important for users of any interactive system is that they should be able to evaluate the current state of the system accurately and effectively. In a hypermedia system, it is important to allow users to observe both the position of locality within the hypermedia database, as well as the information they are interested in viewing.

Awareness of screen design guidelines, such as those proposed by Smith and Mosier (1986) and Rivlin, Lewis and Cooper (1990), is of importance, especially for hypermedia systems, where screen clutter may induce cognitive overload. The use of multi-sensory output to enhance users' evaluative capacity is also an issue for applied research (Gaver, Smith and O'Shea, 1991), and hypermedia may benefit from such initiatives.

2.3.3. The pedagogy of educational hypermedia

If hypermedia is a special case, educational hypermedia is even more so. Education has a value system which is often at odds with other aspects of society, such as in the private sector. In most countries, it is primarily run by the state, so is seldom off the political agenda. Pedagogical and philosophical arguments abound amongst academics, politicians, students and parents alike. Coupled with these problems, education is in a seemingly constant state of flux, especially in the further and higher education sectors. Technology has played a significant role in the changes experienced by the educational sector, and where or if hypermedia can make a useful contribution may not depend solely on its demonstrable effect. If hypermedia is perceived to be too liberating (can one teach the three R's with a hypermedia system?), for example, it might be deemed inappropriate in a positivist society.

2.3.3.1. The democracy question

Discussions of the philosophy of approach to working with hypermedia products is still confined to academia. It could be propounded that hypermedia lies within the liberalist domain (the democratising argument). However, the term is so loosely applied that many products are referred to as hypermedia simply because of their presentation component. The *electronic book* approach can easily be identified with by more traditionalist educators who have been used to paper-based methods. In this respect however, there is a possibility of hypermedia simply duplicating (often badly) the functionality offered by more traditional media, as McKnight et al. (1991) explain:

> ... hypertext might merely be the latest in a long line of 'computer solutions' in education and any apparent benefits may be due to little more than novelty value.
>
> *McKnight et al., 1991 (119)*

Nelson and Palumbo (1992) characterise hypermedia systems in education as exhibiting one of three types. The first characteristic *Knowledge Presentation* concentrates on the presentation component of the application as exemplified by the *electronic book* (Nelson and Palumbo use the term *efficient electronic libraries*). The second characteristic identified is *Knowledge Representation.* Systems exhibiting this type attempt to make explicit the relationships between nodes and links and the information contained therein. High-level tools such as graphical browsers and knowledge maps (semantic networks) typify such systems. The third type of system is one which provides *Knowledge Construction.* Such systems allow users to contribute to the authoring of the hypermedia itself, through the building of nodes and links, annotations, collaborative on-line discussion and idea processing and so forth. In this way, users can control their environment of learning. They have the facility to participate in a much more intimate relationship with the information they manipulate. This classification of educational hypermedia systems has parallels with the classification of hypermedia authoring environments proposed in section 2.2.1.

Although Nelson and Palumbo imply that their three system characteristics are mutually exclusive, it is argued here that for hypermedia to be truly *democratised,* they should exhibit not one, but all three. The electronic book, with no more functionality than its paper-based counterpart than static hypermedia links does not *open up the knowledge domain* (Duffy and Knuth, 1990) except perhaps via its multimedia form. It is arguable whether the learner will be any more able to *explore and search out issues,* the other most basic pedagogical argument for hypermedia put forward by Duffy and Knuth. They go on to argue that books promote linear modes of thinking, whereas a well designed hypermedia system allows less cause and effect approaches. Books don't have to be read linearly — neither do electronic books. However, it is apparent that the way in which both these media are presented encourages readers to adopt such a strategy. Given the effort required to develop even the most humble of hypermedia, it is important that such systems are able to offer added value to the learning experience over and above that provided by separate traditional educational media (e.g. books, videos, journals). In this respect, learners should be able to manipulate, control and contribute to the evolution of the hypermedia database. In other words, the learners should be active participators in their involvement with the hypermedia, rather than passive readers or browsers.

2.3.3.2. The role of authoring

In order to provide a framework for learner participation and contribution to the hypermedia environment, it would seem natural to provide some form of authoring and/or annotation facility. However, the provision of authoring facilities is not without its problems. Dyer (1989) raises the following questions with respect to both undergraduate and postgraduate courses:

> • Is hypertext a creative authoring medium?
>
> • In what educational context might hypertext be appropriate and in what context might it be counter-productive?
>
> • What effect might hypertext have on traditional assumptions about scholarship and the authoring of research material?
>
> • What educational benefits can be derived from the use of hypertext as an authoring tool for art and design students?
>
> *Dyer 1989*

Dyer gives an account of conversations with his students regarding hypertext authoring. Although no instance is given in the paper of such practice in the curriculum, he cites the:

> ... numerous instances where students who have already come to appreciate the potential of this new medium in the studio and have asked if they could submit a hypertext document in place of an essay or thesis.
>
> *Dyer 1989*

Dyer goes on to present his arguments and problems with hypertext authoring by students and its subsequent assessment. His main problem appears to be that essays and theses are traditionally based on the establishment of a point of view or argument. In other words a thesis should be uniquely authored and present a logically unfolding narrative. Since hypertext documents permit multiple routing and are often designed to transfer control of narratives to users, difficulties may arise when attempting to assess quality of research through evidence of personal authorship. Another problem is that there appears to be no standard method of assessing computer-based documents. Dyer concludes by mentioning that research at Coventry is addressing the following questions:

> What special abilities are exploited by and stimulated by the production of a standard essay/thesis which must demonstrate research (detective work?), digestion of source material, marshalling of evidence and the setting out of a carefully argued 'case' through a single linear narrative?
>
> If the skills that this type of authoring engenders cannot be delivered through any other form of presentation, particularly through hypertext authoring, then —
>
> What special cognitive skills and educational benefits can be delivered by means of hypertext authoring?
>
> *Dyer 1989*

Gloor et al. (1990) considered the features of hypermedia authoring systems for Computer Aided Instruction (CAI). They cite the following *well-known* evaluation criteria for (hypermedia) CAI programs:

> • Availability of 'learning by discovery'
>
> • Availability of a 'learning environment'
>
> • Possibility for the student to expand the learning environment himself
>
> • Individualisation of learning (e.g. concerning learning speed, learning contents, learning sequences etc.)
>
> • Real multi-user capabilities as:
> — individual annotations of documents which can be stored separately from the document and are not available to other students
> — communication capabilities for CSCW and electronic discussions
>
> • Control of the learning progress. (In a book the structure of the teaching material is projected on the sequential structure of the textbook, i.e. in a hypermedia document we need guided tours, travel holiday metaphors etc. in order to guide the student).
>
> *Gloor et al., 1990 (337-338)*

Gloor et al. make a distinction between learning from hypermedia (with a static system) and learning with hypermedia (where modifiability is essential). It is also suggested that in order for hypermedia design to be successful, cooperation between experts from diverse domains is essential.

Dowling (1992) presents the pedagogical issues and arguments with respect to hypermedia authoring in education. Dowling discusses the fundamental problems of CAI — mechanised learning, technology driving the learning process and so forth — and presents a particularly interesting analysis of the Intermedia project. From the student authoring point of view, Dowling is not convinced that undergraduates are confident enough to form correspondences (links) across information spaces, although only anecdotal evidence is offered:

> In my own experience, this confidence comes only after the first year or two of undergraduate study, if at all.
>
> *Dowling, 1992 (174)*

Dowling discusses differing reading strategies and interpretation of texts in the humanities subjects, and concludes that diverse approaches should be considered in the design of hypermedia systems. However, the problem is how to present an argument without imposing an opinion on the reader. Dowling considers this by presenting several points of view through human agents who offer their allegiance to the reader by attempting to present convincing arguments. The reader can switch allegiances at any time, or compare other agents' points of view. Ultimately (it is hoped), readers will form their own opinions. One other aspect of Dowling's work is that the development of electronic essays is encouraged. Students can write comments in notepad windows whilst in the process of analysing a literary work. A *make essay* icon will, on selection, concatenate all notepad comments for easy editing into essay form:

> The advantage of this system is that a student can work piecemeal at a text, at different times and on different aspects, as students tend to; only when h/she [sic] is ready to write the essay (or a deadline looms) need they be gathered, looked at afresh and synthesised.
>
> *Dowling, 1992 (189)*

Whether this is actually how students typically develop assessed work is a contentious issue which requires further investigation. However, Dowling adds that student response to this approach has been very positive. He concludes by making a comparison between his approach and that of Intermedia:

> Unlike Intermedia, my programs try to explore within a text, which is why the approach is tentatively called 'Intext' rather than hypertext .... 'Intext' attempts to go beyond data shuffling (browsing and searching) to the more critical activities of hypertext: integrating and angling.
>
> *Dowling, 1992 (193)*

2.3.3.3. Hypermedia and constructivism

The implication that learners should be involved in the evolutionary development of hypermedia brings into mind the ideals of constructivism, a philosophy of education which has evolved from the work of Jean Piaget, amongst others. Constructivism has more recently been suggested as a paradigm for hypermedia systems (Honebein et al., 1992; Cunningham et al., 1993; Allen and Hoffman, 1993) and for collaborative work on the Internet (Yakimovicz and Murphy, 1995).

Cunningham et al. (1993) argue that theories of learning and communication have been traditionally dominated by a communication metaphor, where the messages are passed from transmitters (e.g. textbooks, lecture material, computer-based media) to the receivers (i.e. learners). They describe constructivism (which they regard as synonymous with experientialism and semiotics) where:

> ... instruction is less a process in which knowledge is communicated to learners, and more a matter of nurturing the ongoing processes whereby learners come to understand the world in which they live.
>
> *Cunningham et al., 1993 (20-21)*

In other words, knowledge is an active process of *construction*, not the receipt of information from external sources.

Their view of the pedagogical goals of constructivism is summarised overleaf:

• *Provide experience with the knowledge construction process*
Experience of alternative world-views should be encouraged, often involving the use of metaphors for learning.
• *Provide experience in and appreciation for multiple perspectives*
Dialogue should concentrate on pragmatic negotiation.
• *Embed learning in realistic and relevant contexts*
Learning should take place in real-world contexts. Learners should be able to apply relevant information from one scenario to another in the form of high-level abstractions.
• *Encourage ownership and voice in the learning process*
Learners should be empowered. The role of educator should change from that of direction to consultation.
• *Embed learning in social experience*
Social interaction is crucial to intellectual development. It is argued that learners can move beyond their normal learning abilities by sharing experiences, working with others and so forth.
• *Encourage the use of multiple modes of representation*
Different modes of representation beyond traditional textual approaches can enrich the learning process by enabling learners to view information from different perspectives.
• *Encourage self-awareness of the knowledge construction process*
Cited by Cunningham et al. as the most important of all the above goals.
The opportunity to reflect on one's knowledge construction and learning, thereby modifying one's own views or influencing others', is essential.

Although Cunningham et al.'s explanation of constructivism is not the only one recently provided in the context of educational technology, (Cognition and Technology Group at Vanderbilt, 1993; Jonassen, Mayes and McAleese, 1993; Simons, 1993), theirs is perhaps the most closely focused on educational hypermedia issues. Cunningham et al. go on to say that in a constructivist learning environment, the instruction is not contained in any learning resource. Resources are simply tools for knowledge construction. They note the incompatibility between the traditional textbook and constructivism because such a medium purports to be a source of knowledge, rather than an information resource. The nature of a textbook, with its development of theme and argument imposes the view of the author upon the learner. This is in direct conflict with the more analytical approach supported by the constructivist school.

They argue that hypermedia are more suitable because of their non-linear, modular structure. A feature of hypermedia essential to support the constructivist approach is that of learner authoring. Cunningham et al. realise that the management of potentially new and complex technology by learners is a major concern. However, they argue that this is a price worth paying, as learning to manage complexity is an essential part of the learning and instructional process.

The debate between advocates and critics of constructivist approaches to education will no doubt continue ad infinitum. McKnight, Dillon and Richardson (1993) admit they are not sure there is a right or wrong answer but they do support the merits of considering conflicting paradigms. Jonassen et al. (1993) argue that constructivism is best employed in advanced learning (university level) situations. Perhaps an important question for designers of hypermedia products is: *Does it really matter?* Can we design hypermedia that can be used by educators and learners to support alternative or shifting paradigms? We view the world from different stances, so why not microworlds? In fact, this is an argument that has been presented by constructivist thinkers:

> ... we would like to suggest ... that knowledge of the knowledge construction process entails a strong sense of responsibility for the state of the world in which we find ourselves. If many worlds are possible, then worlds can change. We have within our capability the constant renewal of our world view.
>
> *Knuth and Cunningham, 1993 (186)*

This pragmatic view leads to the question: why can't we build hypermedia systems which are able to be interpreted in varying ways, to support pedagogies of diverse schools of thought? This same constructivist approach can be argued with respect to users: why can't we build hypermedia systems which can mean different things to different people? — a stance aptly illustrated by the following quote:

> The earth is round and flat at the same time. This is obvious. That it is round appears indisputable; that it is flat is our common experience, also indisputable. The globe does not supersede the map; the map does not distort the globe.
>
> Maps are magic. In the bottom corner are whales; at the top, cormorants carrying pop-eyed fish. In between is a subjective account of the lie of the land. Rough shapes or countries that may or may not exist, broken red lines marking paths that are at best hazardous, at worst already gone. Maps are constantly being re-made as knowledge appears to increase. But is knowledge increasing or is detail accumulating?
>
> A map can tell me how to find a place I have not seen but have often imagined. When I get there, following the map faithfully the place is not the place of my imagination. Maps, growing ever more real, are much less true.
>
> And now, swarming over the earth with our tiny little insect bodies and putting up flags and building houses, it seems that all the journeys are done.
>
> Not so. Fold up the maps and put away the globe. If someone else has charted it, let them. Start another drawing with whales at the bottom and cormorants at the top, and in between identify, if you can, the places you have not found yet on those other maps, the connections obvious only to you. Round and flat, only a very little has been discovered.
>
> *from Sexing the Cherry, by Jeanette Winterson*

2.3.4. Educational domain

The domains and situations of learning will impact upon the suitability of hypermedia for educational applications. A computer-assisted learning system for a mathematics course would probably have significantly different design criteria from one aimed at a fine arts course. It may be the case that hypermedia might not be suitable at all for a particular educational domain, as Hammond (1993) explains:

> For the author of educational artefacts, it is a fact of life that human learning is extraordinarily varied. An exploratory approach might be optimal in one situation but counterproductive in another; in a third it might be appropriate to give the learner the choice of whichever approach suits best. Learning is not unitary; there is room for a spectrum of approaches to CBL in general and to learning from hypertext in particular. Generic prescriptive guidelines for educational design have only limited utility, and the author must take account of many of the characteristics of the learning situation and how people are likely to learn from the artefact in question.
>
> *Hammond, 1993 (53)*

This recognition of the uniqueness of the educational domain should not be overlooked. It has implications for all of the human-computer interaction issues already discussed. For example, the media mix in a presentation, the metaphor for the overall interaction, the tasks users are expected to perform and the information they manipulate. However, it is important to consider the educational domain as a whole, as a reductionist approach to the design of educational technology is perceived by modern educationalists to be a dangerous one (Winn, 1993).

2.3.5. Evaluation

The evaluation of hypermedia systems has been widely discussed in the published literature, although there seems little consensus of opinion as to how best to undertake evaluation measures. When Conklin wrote his seminal paper *Hypertext: An Introduction and Survey* (Conklin, 1987) he introduced a set of features or abilities which a hypertext system may be able to provide. These criteria were evaluated against eighteen product development systems which professed some hypertext functionality. Although this was probably the first evaluation ever undertaken of a range of hypermedia products, it was not based on a human factors approach. The exercise considered authoring environments as opposed to products developed in those environments, and was intended for developers rather than end users.

Marchionini (1990) proposes a multi-faceted framework for evaluating hypermedia-based learning. The problems of evaluating *any* form of learning are described. One particular problem relevant to hypermedia is that most current methods of learning evaluation are confined to directed learning. Marchionini defines hypermedia systems as *enabling* rather than *directive.* Another problem of evaluating highly interactive systems is that the quality of interaction is as important as the product of the learning. Marchionini argues that assessment of hypermedia-based learning must consider both the process of learning as well as the outcomes of learning. He goes on to say that, given the complexities of evaluating hypermedia systems, a multi-faceted methodology is required. This approach, he argues, will enable several perspectives to be taken of the analysis of users' behavioural patterns, thereby diminishing the chances of misinterpreting data.

Unfortunately, evaluation in any educational domain is difficult by definition. Issues of metrics, ethics and methodology are all problematic, although a number of other authors have considered the evaluation of hypermedia products, including Teshiba and Chignell (1988), Perlman et al. (1990), Nielsen (1990a) and Marchionini and Crane (1994). Even in

a difficult environment, the importance of usability evaluation of interactive systems cannot be over-emphasised, and hypermedia is certainly no different in this respect. However, research suggests that general awareness of the concept is not widespread (e.g. Dillon, Sweeney and Maguire, 1993).

2.3.6. A framework for educational hypermedia

This discussion of HCI issues for educational hypermedia has highlighted some common ground with other interactive applications, such as the need to take account of users, tasks and evaluation, but it is argued here that there are certain specific aspects which should be considered, such as the pedagogy, the richness of information, specific aspects of interaction as well as the educational domain. Consequently, a framework for HCI in educational hypermedia is proposed and is summarised below:

• *Users, tasks and information*: according to earlier research by McKnight et al. (1991), the users of the hypermedia system, the tasks they perform and the information they use, are all regarded as essential components of the framework.

• *Interaction*: how the users interact with a hypermedia system in terms of the articulation, performance, presentation and observation (Abowd and Beale, 1991) is especially pertinent to the problems and issues of hypermedia design.

• *Pedagogy*: the methodology of teaching is something which is often overlooked by educational technologists. Designers must be aware of the pedagogical issues and implications of their educational hypermedia system. Political concerns are also important, as any new application may have to conform to the philosophy of the organisation or governing body of any particular educational institution.

• *Educational domain*: as the review of educational hypermedia systems has demonstrated, different educational domains lend themselves to different educational approaches. These approaches are driven also by the tasks which students are expected to perform, but from a more holistic point of view, the subject discipline may have specific implications for the hypermedia design.

• *Evaluation*: no matter how strong the theoretical underpinning of a hypermedia system, a system must be properly evaluated with its intended users. In education, evaluation is a complex issue, as ethical and practical concerns are particularly problematic.

2.4. Towards an agenda for research

This literature review has resulted in the proposal of an HCI framework for educational hypermedia. Research is now required to investigate the viability of this framework. In order to do this, a suitable scenario is identified. Hypermedia is regarded as a rich environment for user-centred design, primarily because of the amount of depth and user control a well-designed hypermedia product can provide. The uniqueness of music education is particularly suitable in this context.

Musicologists have utilised the power of computers for many years. For example, the Computer Music Journal has been in existence since 1976. Computers were identified as being of benefit in music as early as the sixties, however. Hewlett and Selfridge-Field (1991) have categorised the evolutionary relationship between musicology and computing by selecting three *paradigms* of development.

The *sixties paradigm* was characterised by large scale projects, often supported by government and commercial agencies keen to plough funds into glamorous, computer-based initiatives. Expectations were often too high. Several projects failed as the reality of the software crisis of the late sixties emerged. One of the most successful, and certainly the most well-known, was DARMS (Digital Alternate Representation of Musical Scores), which was supported by Columbia University and the Ford Foundation between about 1966 and 1976. This project was concerned with the generation of musical notation from encoded data. It was considered that such an approach would enable large-scale publishing of musical works at low cost.

The *seventies paradigm* continued the trend towards high quality, low-cost music publishing. Also, analytical tools were developed with the now more accessible computer programming languages. Multi-faceted systems with a view to computer-assisted learning of music were proposed, although most of them were built for institutions' local needs, as opposed to commercial benefit.

The *eighties paradigm* coincided with the universal move from mainframe to desk-top computers. Off-the-shelf systems were marketed, leading to widespread availability of music software. Perhaps the most important development in the eighties however, was the advent of the Music Instrument Digital Interface (MIDI) standard. This standard provided a universally recognised approach to computer-assisted music publishing, composing and documentation. Other recent initiatives in computer music include HyTime (Newcomb et

al., 1991), which contains ISO standards for hypertext supporting music reproduction and publishing, although many musicians still prefer older, more established approaches.

Hewlett and Selfridge-Field consider the current issues as they were in 1991 and the prospects for computing in musicology for the future. Amongst the many possibilities they identify the emergence of CD-ROM as an important technological development. They specifically identify the creation of multimedia educational products in this context. Many commercial music CD-ROM *edutainment* products have since been marketed, including Mozart's The Magic Flute and Brahm's German Requiem (Warner New Media), Beethoven's Ninth Symphony (The Voyager Company), The Jazz Multimedia History (Compton New Media) and Composer Quest (Dr. T's Music Software).

Interactive multimedia has relatively recently commanded the attention of a number of music educationalists. Edwards and Holland (1992) have a number of chapters dedicated to the use of interactive multimedia in music education. The TLTP Music Consortium has provided various projects for fourteen UK universities in the fields of musicianship, studio techniques, manuscript study, music analysis, mediaeval music, the cultural context of 19th and 20th century music and opera.

The focus of this thesis investigates hypermedia authoring by undergraduate music students. Authoring is in the context of assessed work (i.e. essays and dissertations). The research is based upon the specific educational topic of biographical study that, by definition, encourages students to rely upon multimedia sources.

Research has been undertaken in liaison with the City of Leeds College of Music (CLCM), which specialises in contemporary musical forms, especially jazz. The college supports approximately 300 full-time undergraduate students. With the assistance of students and academics at the College, a prototype hypermedia system has been developed.

The remainder of this thesis tells the story of the research and development of the hypermedia prototype. Each attribute of the HCI framework is considered at some point in the various studies that follow.

Chapter three considers the usage of biographical material in paper form. A survey was conducted which compared the use of biographical material between music students and American literature students. Although biographies are often written in a certain literary

style, and are usually structured in predictable ways, the two groups of students were found to use them quite differently. This investigation of reader strategies identifies issues relating to the educational domain and the potential users within it.

Whilst chapter three deals with reading strategies, chapter four concentrates on investigating writing strategies. Analysis methods for this investigation are considered, resulting in a study to evaluate traditional task analysis in a writing scenario. The chapter concludes that more human-centred methods are required to gain insight into what is very much a personal, individualised activity.

Following on from this, chapter five reports a study into using the phenomenological technique of repertory grid analysis to develop a model of essay and dissertation development. Classification relating to the typology of activities involved, as well as attributes of the process are described. Artefacts to assist the development of essays and dissertations in a computer-assisted domain are discussed.

Chapter six considers computer artefacts for essay and dissertation development in more detail. A survey of experienced computer users was carried out immediately after they had finished a final year undergraduate dissertation. From the survey, the most appropriate artefacts in both traditional and computerised media were identified.

Chapters seven and eight report studies to consider specific hypermedia artefacts for the educational domain of music history study. Chapter seven investigates navigational issues, whilst chapter eight considers the advantages and disadvantages of reading music from computer screens.

Chapter nine describes the prototype hypermedia system which was designed as a result of the research reported in previous chapters. Design decisions are justified with regard to earlier work in the thesis.

Chapter ten reports an evaluation of the system which was carried out at the City of Leeds College of Music. Implications for future work with respect to the results of this exercise are discussed, and general conclusions and further work are considered in chapter eleven.

Table 2.2 summarises how each chapter relates to the proposed framework for human-computer interaction in educational hypermedia, and also serves to act as a summary of the research agenda.

Chapter	Study	HCI attribute(s)
3	Survey of usage of biographical material	educational domain
		users
		pedagogy
4	Analysis of approaches to writing	tasks
5	Analysis of essay/dissertation development	educational domain
		users
		tasks
		information
		pedagogy
6	Survey of use of technology for writing	interaction
		tasks
7	Study of navigational techniques	interaction
		users
		evaluation
		educational domain
		tasks
8	Study of reading music from screens	interaction
		users
		evaluation
		educational domain
		tasks
9	Description and justification of prototype	all attributes, except evaluation
10	Evaluation of prototype	evaluation
11	Conclusions and further work	all attributes

Table 2.2: Outline of original work and research agenda.

Chapter 3
Student usage of biographical material

3.1. Introduction

The literature review in chapter two has identified a number of problems with educational hypermedia design. This chapter begins to address three of these issues: the user population, the educational domain and the pedagogy employed within that domain.

At this point in the thesis, it is important to focus on the specific domain of interest, that is music in higher education. However, it is equally important to consider how this domain compares with other, related areas. Music students are not the same as other students, but how different are they? We need to answer this question to have an idea of where to pitch (no pun intended) a hypermedia system, in terms of its presentation, its structure and its media mix. To produce some kind of taxonomic structure of educational domains and their implications for hypermedia design however, would constitute a PhD in its own right. It was decided instead that a survey comparing reading strategies of reading biographical material used by music students and those used by students from another arts discipline (American literature) would provide some evidence for justifying a specialised system for music education. Reading strategies are described by Harri-Augstein, Smith and Thomas (1982) as:

> ... the ways we read. Suppose for example, we pick up a book and read it straight through — that is one possible strategy. If we read, then make notes for a bit, read a bit more and so on, then that is another strategy.
>
> *Harri-Augstein, Smith and Thomas, 1982 (13)*

3.2. Survey overview

This cross-sectional survey attempts to compare students of music and literature in two ways: why they read biographical literature, and how they read it. The educational domain is also considered in two ways: by comparing students' views as to whether they consider complementary media to be useful for their subject, and whether they sought other material to further their research. The survey was piloted with a class of second year BSc (Hons) Modern Studies students at Staffordshire University. Some modifications to the wording and the format of the survey were made as a result.

3.3. Method

3.3.1. Targeted respondents

A total of 100 survey forms were sent to two institutions. Fifty forms were sent to the Head of American Literature at the University of Central England in Birmingham (UCE), and another 50 were sent to the Head of Jazz History at the City of Leeds College of Music (CLCM). Forms were then handed out to second year students of American Literature at UCE, and second year students of Jazz History at CLCM. Students were advised to return completed forms to the appropriate lecturer.

3.3.2. Survey format

An example of a completed survey form can be viewed in appendix A. The survey was split into two parts. Part A contained some general questions such as "How old are you?", "What is the title of the biography?" and "Who is the author?". This section also contained the central question of why the student read the biography. Part B contained specific questions relating to the book's structure and its features. It was considered to be of some interest as to how photographs, illustrations and diagrams were organised, as well as the presence and reader reliance upon tabular information such as the contents page, tables of illustrations and indexes. The central questions of how respondents read the book, whether they considered complementary media to be potentially useful, and whether further information was sought were presented towards the end of the survey form.

3.4. Results

Overall, 58 forms were returned. Forty five forms were returned from UCE, providing a response rate of 90%. The response from CLCM was however disappointing. Only thirteen completed forms were returned, providing a response rate of 26%. In the forthcoming discussion of the survey results, overall percentages will be expressed for the sake of comparison between the two samples. However, it is acknowledged that the conversion of absolute values to a percentage has little validity for such small samples.

The low response rate may be indicative of an observation made during a later interview: that music students at CLCM tend to gather biographical material from other sources, such as the *New Grove Encyclopaedia of Jazz* (Kenfield, 1988), album sleeves, magazines and so forth (a more detailed discussion of this interview is covered in chapter five). It is possible therefore, that only about a quarter of music students actually read biographies. American Literature students at UCE are required to read biographies as set texts.

3.4.1. Part A results

Respondents' ages ranged from 20 to 39 at CLCM and from 18 to 59 at UCE, although the vast majority in both cases were in their twenties.

A range of biographies was volunteered, although in the case of the literature students, 33 respondents (73%) volunteered the same book, *Bitter Fame*, by Anne Stevenson (a biography of Sylvia Plath). This was, it transpired, their most recently set text! Consequently, there were exactly the same number of different books volunteered by music students as by literature students, a figure of twelve.

This fact had an obvious impact on the reason given as to why the biography was read. Thirty literature students (67%) answered that they read the book because it was a set text, three (7%) answered that they read biographies for a hobby and twelve students (27%) answered that whilst they didn't normally read biographies, this particular subject interested them. No music students read biographies for a hobby. Nine students (69%) answered that they were interested in this particular subject, and the other four answered that the reading was necessary for research into coursework.

3.4.2. Part B results

Overall, eleven students (19%) indicated that there was no contents page in the biography which they read. Of the students who indicated that there was a contents page, 20 (34%) said they used it to help them refer to sections of the book. This left 27 (47%) who knew the contents page was there, but chose not to use it. Three music students and seventeen literature students used the contents page — percentage levels of 23% and 38% respectively.

Sixteen students (28%) indicated that there was no index in the biography they read. Of the students who indicated that there was an index page, eighteen (31%) said they used it to help them refer to sections of the book. This left 24 (41%) who knew the contents page was there, but chose not to use it. Six music students and twelve literature students used the index — percentage levels of 46% and 27% respectively.

Of 44 students who indicated that these photographs/illustrations were present in the biography, 37 (84%) said they were grouped together in a large block. Four students said that the photographs/illustrations were presented at points relevant to the narrative at the time, and three indicated a combination of the two.

The photographs/illustrations tended to be studied mainly before and in the course of the text being read. Eight from eleven music students studied them before, one after and five in the course of reading the biography, representing percentages of 73%, 10% and 45% respectively. The figures for the 33 literature students were 24 (73%), six (18%) and 31 (94%) respectively. Students were informed that they could select more than one answer to this question, if appropriate.

Twenty one students indicated that there was a table of photographs/illustrations, and of these only six (29%) indicated that it was of any use.

Nine music students (69%) indicated that they felt the medium of film would help them to appreciate learning more about the subject of the biography. The figure was exactly the same for the medium of music. Three students (23%) would like to have seen high quality pictures or graphics, and one student suggested that a CD-ROM would be a good idea.

Thirty literature students (67%) indicated that they felt the medium of film would help them to appreciate learning more about the subject of the biography. Only six (13%) felt this way for the medium of music. No students were interested in high quality pictures or graphics. Fourteen students (31%) felt that audio recordings would be useful, particularly of the subject of the biography reading from his or her own works.

Two music students (15%) read the biography as if they were reading a novel, that is from cover to cover, without referring to the book again once it was finished. The figure for literature students was ten (22%). Eight music students (62%) read the whole book, but spent some time browsing through sections in advance of and even after reading them. The figure for literature students was eighteen (40%). One music student (8%) read the whole book, but non-sequentially. The corresponding figure for literature students was seven (16%). Two music students from (15%) didn't finish the book, and ten literature students (22%) also never completed their biography. Reasons given for not completing a book included: "I ran out of time", "I wasn't the least bit interested in it", "I read only the areas of relevance to my work" and "I had to return the book to its owner".

Seven music students (54%) indicated that the biography encouraged them to seek further information concerning the life story of its subject. The figure for literature students was 28, a percentage figure of 62%.

3.5. Discussion of results

The disappointing response rate from the music students at CLCM is understandable and can be explained. However, the low number of returns has a clear implication for the interpretation of the results. Whilst any standard error of the sample size cannot be calculated due to the qualitative nature of the data, one must remain sceptical with respect to any conclusions drawn from this discussion. Consequently, what follows is an observational comparison between two ways in which biographical material is used in higher education, and the different reader strategies employed.

3.5.1. Reasons for reading biographical material

As mentioned in section 3.4.1., the fact that literature students studied biographical material as set text had an obvious impact on the reasons given for reading the work. The music students favoured using biographical material for background interest or for supporting material in a wider study. As will be seen in subsequent discussion, these reasons may have an effect on the strategies employed in the manipulation of the text. For example, a biographical work which is studied for literary criticism is likely to be read much differently from one which is essentially a source of reference. This may be stating the obvious, but as Hammond (1993) points out, this is the kind of thing that can be easily overlooked:

> ... the hypermedia designer needs to think carefully about how learners will use his or her system. Learning is not the same as retrieving information, and depends on subtle interactions of the learning context, the materials, the tools provided and the learner.
>
> *Hammond, 1993 (66)*

3.5.2. Usage of contents and indexes

More literature students used the contents page than music students (38% versus 23% respectively). The figures were reversed for index usage (27% versus 46%). This adds weight to the observation that music students read biographical material as a source of reference. They probably use the index more to track down specific events in the life of the subject of the biography.

3.5.3. Reliance upon photographs and illustrations

The fact that the vast majority (84%) of respondents indicated that photographs and illustrations were grouped together in a large block is probably an indication of efficiency measures employed by the books' publishers. It is much cheaper to produce photographs in particular in this way. As the paper has to be of better quality to print photographs, they

have to be produced separately from the rest of the narrative. Subsequent insertion of photographs into the appropriate place in the narrative would be a cost overhead. Also, blocking of pictures saves paper, as unrelated photographs don't need to be separated. A computerised biography would not need to be constrained in this way.

Most students studied photographs/illustrations before they read the book (73% for both music and literature students). The aesthetic appeal of pictures, as well as their ability quickly to tell a story (provide an overview) makes them an attractive feature of a biographical work. The figures for those students who studied pictures after finishing with the book were also similar (10% and 18% for music and literature students respectively). However, there was a large discrepancy between the two groups of students with respect to studying pictures in the course of reading the text. Ninety four percent of literature students did this, whereas the figure for music students was only 45%. This is a difficult phenomenon to explain, but perhaps a more intensive reading (in the case of literature students) encourages the reader to consult pictures more often in some way.

3.5.4. Alternative media considerations

In order to consider whether a hypermedia system could enhance students' learning of a subject, it was considered important to survey the views which they have with regard to the usefulness of alternative media for biographical study. Biography is after all a very rich subject. If video or audio recordings have been made of the person of interest, such media can only add to at least the aesthetic appeal of the subject material. It was widely expected that respondents would indicate a positive attitude to such a possibility. Both music and literature students felt that film would be a good medium for helping them to appreciate or learn more about the subject of the biography (69% and 67% respectively).

Music was deemed to be equally important by music students — surprising, as one would have thought that it would be regarded as more important!

No literature students regarded high quality pictures to be of interest, whereas 23% of the music students considered them to be of potential use. Music scores fit this description. A computerised solution for these students would necessitate high quality display technology (although not necessarily colour).

3.5.5. Reading strategies

The question of the reading strategies indicated by the respondents is perhaps the most central issue of this survey. Whilst one can draw inferences from the usage of contents pages, indexes, photographs and so forth, and one can identify implications from reasons given for reading the biography in the first place, the reading strategy employed provides a direct indication of the way the information was manipulated.

Figure 3.1 shows a histogram of the reading strategies employed by respondents.

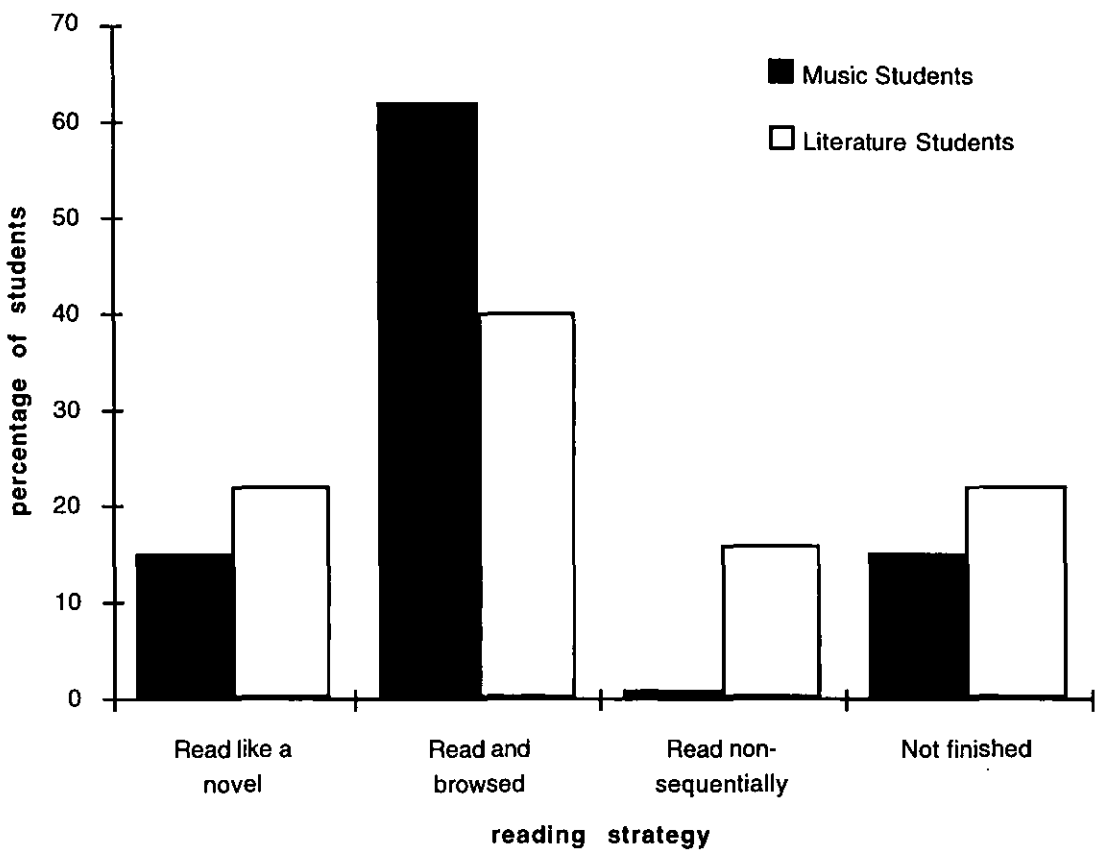

Figure 3.1: Reading strategies employed by survey respondents.

To clarify the horizontal axis of figure 3.1, the question's wording relating to the reading strategy employed by a respondent was as follows (please refer to appendix A, question seven):

• *Read like a novel* corresponds to: "I read the whole thing from cover to cover — just as if I was reading a novel. Once I'd got to the end, I put it down and didn't bother looking at it again".

• *Read and browsed* corresponds to: "I read the whole book, but I spent some time browsing through sections in advance of and even after reading them".

• *Read non-sequentially* corresponds to: "I did read all of the book, but I didn't necessarily start at the beginning and finish at the end. Some chapters/sections in the book particularly interested me so I read them first".

• *Not finished* corresponds to: "I didn't finish the book".

As can be seen from the histogram, a higher proportion of literature students read the book like a novel than music students, whereas a higher proportion of music students read and browsed. This result appears to contradict earlier assumptions that music students only read biographical material for reference purposes alone. If this were the case, one would expect a higher figure to have either not finished the book, or to have read non-sequentially. In fact a much higher proportion of literature students read the book non-sequentially. Also, a higher percentage of literature students did not finish their book than their music student counterparts. These results warrant further investigation. Let us consider students' reading strategies combined with the reasons given for reading the book in the first place (figure 3.2).

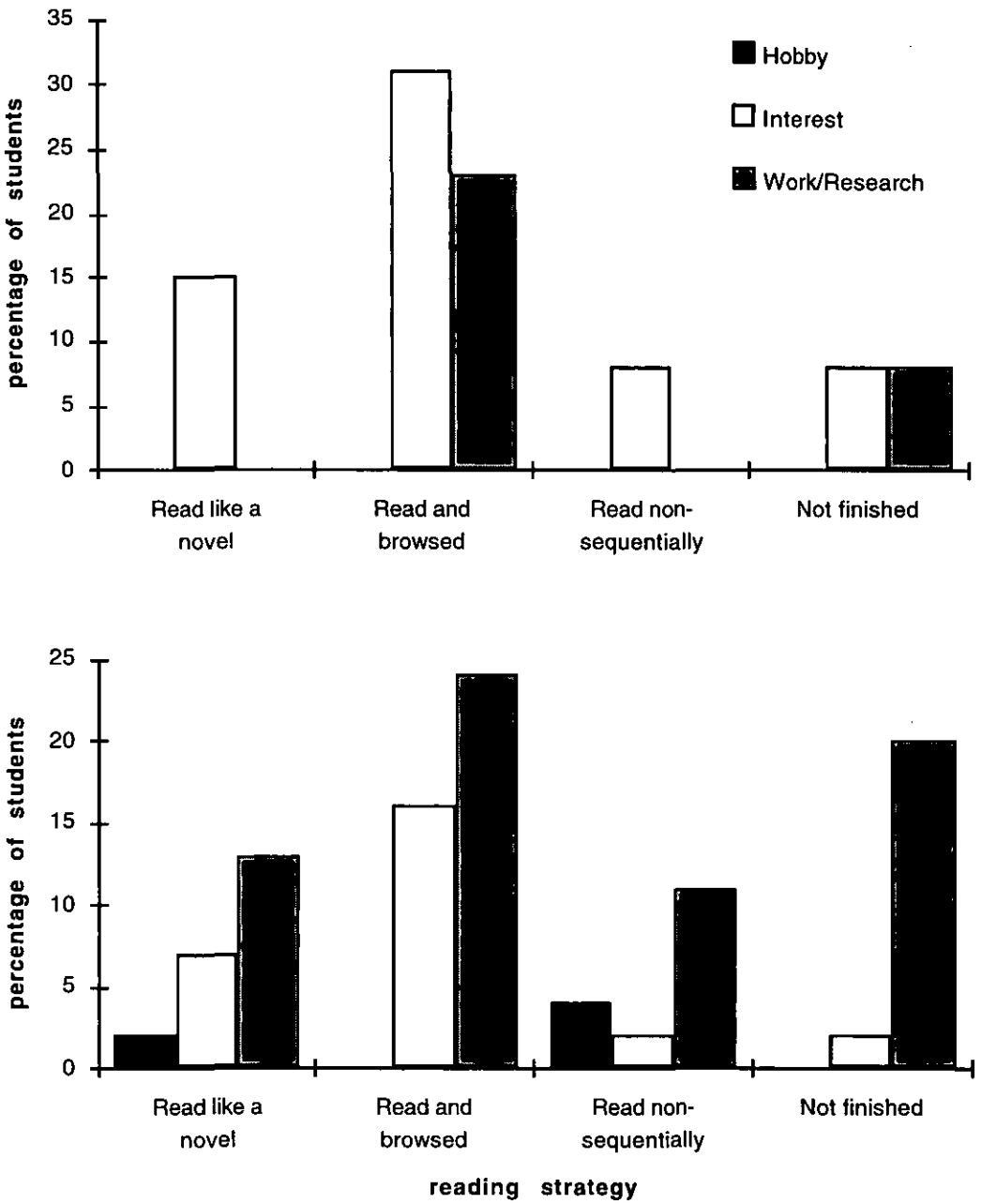

Figure 3.2: Reading strategy employed by respondents, categorised by reason given for reading book. The top histogram displays the music students' responses, and the bottom histogram displays those of the literature students.

The histograms show a whole range of strategies employed across each group of students. The most popular strategy in each case is the *read and browsed* approach. No students who read for a hobby adopted this strategy — in fact the most popular strategy was reading non-sequentially (albeit from a very small sample of 1%). Those students who read out of interest favoured the *read and browsed* approach, as did those who read for work purposes. The next most popular reading strategy for those students who read for work purposes was the *not finished* approach. The most popular reason given from the literature students for not finishing the book was that they had run out of time. It is likely that these students *dipped in* to the book or skim read to find the most relevant issues for their essay, as opposed to reading the book like a novel. In retrospect, perhaps this aspect of the reading strategy should have been investigated more thoroughly. A similar observation applies to the strategy of reading non-sequentially — again, those students who were time-constrained by submission deadlines of coursework found this strategy almost as appealing as those who read their biography like a novel (11% and 13% of the literature students respectively).

3.6. Conclusions and implications for further research

This chapter considered aspects relating to the educational domain, the potential users and the pedagogical issues of the framework for HCI in educational hypermedia. This was conducted in the context of reading styles via a survey of students in higher education.

The survey presented has highlighted a number of differences across two related fields of learning in arts subjects. Whilst the paper media were essentially of the same type across both groups, the way in which they were manipulated was very different. This observation highlights the importance of careful design of a potential hypermedia representation. The opportunities for alternative media presentation and structure should take into account reader strategies, as well as the goals of users. The large number of students who did not finish their book is something which must be recognised and catered for. There could be many underlying reasons for students not completing tasks of this nature — unrealistic deadlines set by course tutors, poor organisation on the part of students, boring or trivial coursework are just a few possible reasons. However, whatever the case, hypermedia features such as the provision of overviews, timelines, associative indexing and searching may help students who may be under pressure in some way. The danger is that important points may be missed or glossed over if such approaches become common. Whalley (1993) summarises this point succinctly:

> Non-linear hypertext is obviously a good way to package information for efficient information retrieval and is useful for some forms of interactivity. However, because of its fragmented nature, it is not a suitable medium to form the core of teaching materials.
>
> *Whalley, 1993 (16-17)*

The results of the survey suggest that biographical hypermedia for music students should be interesting for readers who want to read the material sequentially, but should also provide features to facilitate browsing and referencing activities. Purely non-sequential hypertext would not be very useful.

Writing strategies typically adopted by students will now be investigated. It is recognised that music students are essentially reluctant readers (as was demonstrated by the low response rate for this survey), and they are probably reluctant writers too. They are essentially musicians and prefer to stay that way. This difficulty, along with their limited experience of computers, represents a real challenge for the hypermedia designer.

Chapter 4
An investigation into writing strategies

4.1. Introduction

The study of the writing process has been of interest to cognitive psychologists for some time. Many models have been proposed, the best known of which include those by Hayes and Flower (1980) and Scardamalia and Bereiter (1987). The advent of computer-supported writing tools has reopened a number of debatable issues and there are a host of differing academic stances in this area. On the one hand, post-modernist thinkers champion the liberating opportunities that hypertext authoring environments may offer (Landow, 1992; Cunningham et al., 1993), whereas caution and scepticism are advocated by others (Hammond, 1993; Whalley, 1993).

A number of computer-supported writing tools have been developed, for example gIBIS (Conklin and Begeman, 1988), PHI (McCall, 1991) and SEPIA (Streitz et al. 1992). Such tools tend to be focused particularly at the cognitive level of writing, and in this respect they are based very much on cognitive models of the writing process (Buckingham Shum and Hammond, 1994). They do not consider the influence that other artefacts may have upon writing strategies, for example the availability of research material and alternative media requirements. Certainly, in education, reading and writing go hand in hand, as one must read to learn before demonstrating any newly acquired knowledge (usually in the form of a written piece of work).

This chapter considers writing at a more strategic level. As discussed in chapter three, a reading strategy describes issues such as whether a book is read cover to cover or in some other way (Harri-Augstein et al., 1982). In this respect, a reading strategy is concerned with the structure and organisation of activities during the course of reading a text. Correspondingly, a writing strategy is described here as the structure and organisation of activities during the course of *producing* a text. It is assumed that text production begins with the conception of the work, as opposed to when pen first meets paper, or finger first hits keyboard. Consequently, such activities may actually include background reading, as well as more direct writing activities such as referencing, redrafting and writing up. Therefore, in the context of learning, there must be at least some overlap between reading and writing processes.

It is important to identify suitable techniques for analysing writing strategies. A number of well-documented task analysis methods have been successfully applied in other areas of human-computer interaction. The applicability of some of the better known methods to analysing writing strategies will be discussed. An original study which assesses the applicability of perhaps the best known task analysis method, Hierarchical Task Analysis (HTA) is also presented. The chapter will conclude with recommendations for analysing the writing strategies of music students.

4.2. Task analysis techniques for analysing the writing process

A plethora of definitions for task analysis exist, many of which contradict each other. Indeed, in the one book devoted exclusively to task analysis in the domain of HCI, the editor takes a very tentative stance:

> As the editor, and someone who has been using task analysis since the early eighties, I have tried to encourage [such] diversity and not to impose my own views on the other authors. Thus the book does not start with a straightforward definition of task analysis, and I am less confident of offering one now than when I commenced this project over a year ago.
>
> *Diaper, 1989a (11-12)*

For the sake of coverage however, as well as providing clarification for the unfamiliar reader, Dix et al.'s (1993) simple definition will be adopted:

> Task analysis is the process of analyzing the way people perform their jobs: the things they do, the things they act on and the things they need to know.
>
> *Dix et al., 1993 (221)*

Task analysis (TA) was originally conceived during the fifties and sixties to help identify training and/or retraining programmes (Johnson, 1992). In this respect, its methodological foundation was based very much on behavioural studies (e.g. psychometric tests). This approach has weaknesses in cognitive psychological terms, as Johnson (1992) explains:

> ... it has difficulty in analysing such tasks as writing a report, designing a house, or writing a computer program, which are all highly cognitive tasks.
>
> *Johnson, 1992 (152-153)*

However, McKnight et al. assert that hypertext is task orientated:

> ... when talking about hypertext we are referring to people using information to perform some task.
>
> *McKnight et al., 1991 (43)*

TA techniques developed further with the advent of Hierarchical Task Analysis, or HTA (Annett et al., 1971). Later task analysis methods, such as Task Analysis for Knowledge Description (TAKD) (Johnson, Diaper and Long, 1984) and Knowledge Analysis of Tasks (KAT) (Johnson and Johnson, 1990; 1991) have recognised that cognitive psychology has an important role to play in this field. A number of other methods exist, including Task Action Grammar (TAG) (Payne and Green, 1986) and Analysis for Task Object Modelling (ATOM) (Walsh, 1989). However, a broad appreciation of the subject can be provided by briefly describing three established approaches — HTA, TAKD and KAT.

4.2.1. Hierarchical Task Analysis (HTA)

HTA attempts to describe tasks as sets of hierarchically arranged procedures. The fundamental constructs involved in the method are plans and operations. In HTA, a task can be described purely in terms of these constructs. An example of a simple diagrammatic representation in HTA is shown in figure 4.1.

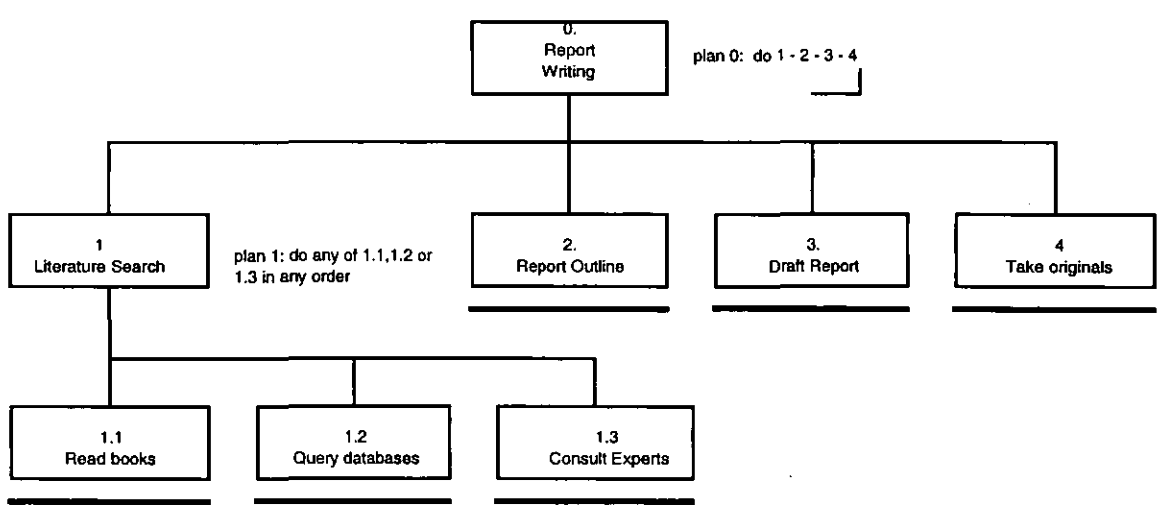

Figure 4.1: Example HTA (in this case, the task relates to report writing).

The process of performing an HTA is relatively straightforward. However, experienced HTA analysts emphasise the level of skill involved and the importance of task redescription and refinement (Shepherd, 1989). Shepherd summarises the rudiments of the HTA method using a flowchart (figure 4.2), although he acknowledges that this is an over-simplification of the approach.

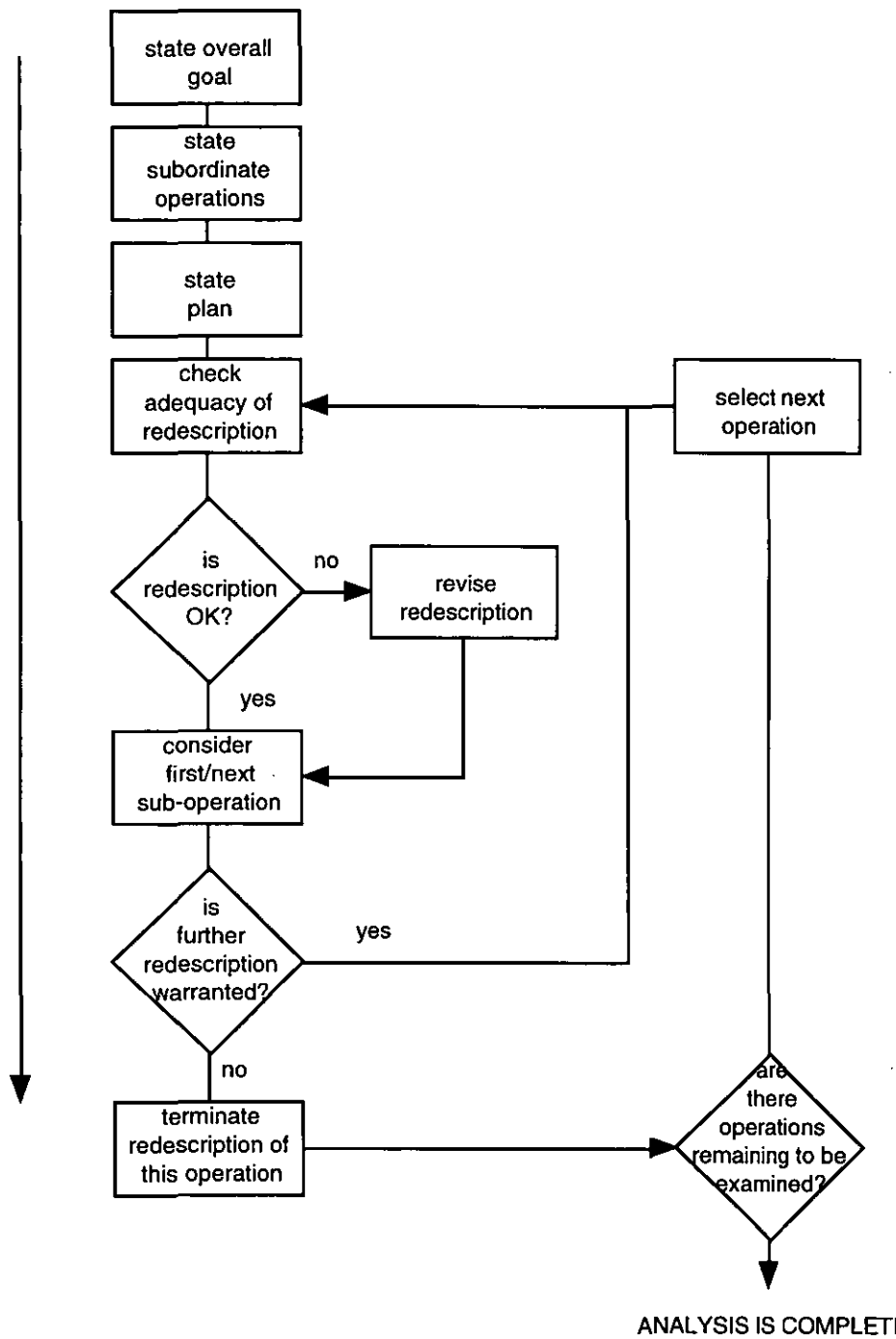

Figure 4.2. General strategy for HTA (from Shepherd, 1989).

4.2.2. Task Analysis for Knowledge Description (TAKD)

TAKD was originally developed to identify training requirements for young trainees in information technology. As with HTA, TAKD represents task structures hierarchically, in what it refers to as a task description hierarchy (TDH). This structure is then expressed in the form of a textual knowledge representation grammar (KRG). Rather than being based purely on operations and predetermined plans, TAKD attempts to represent the knowledge which individuals must possess to perform tasks correctly. In this sense, it is closely mapped onto established cognitive models (Diaper, 1989b).

The TAKD method begins with the analyst constructing a list of all objects relevant to the task, and a list of all actions that must be performed to carry out the task. The TDH is then constructed such that each action and each object can be uniquely described via its route through the TDH. Routes are converted to formal KRG sentences, which can provide the analyst with information relating to the importance and complexity of individual actions and objects within the task framework. A detailed description of the method is provided by Diaper (1989b), along with a report of a pilot study which investigated readers' annotations of academic documents, the intention being ultimately to develop a hypertext environment using the TAKD approach.

4.2.3. Knowledge Analysis of Tasks (KAT)

KAT is a method which was developed from the theory of task knowledge structures (TKS), proposed by Johnson et al. (1988). A TKS is a representation of task performers' knowledge about the tasks they have learned and carried out. It enables such task knowledge to be expressed in terms of a person's knowledge of goals, procedures, actions and objects (Johnson, 1992). Goals are organised into a goal structure, procedures are organised into a procedural substructure, whilst actions and objects are organised into what TKS theory terms a taxonomic substructure. The most important (central) elements and the more representative (typical) elements from each substructure are identified — KAT carries this out by using various investigative techniques (e.g. structured interviews, questionnaires or experimental techniques). A comprehensive overview of TKS and KAT, along with a detailed worked example is provided in Johnson (1992).

4.3. Assessing the suitability of a traditional task analysis technique for writing strategies

4.3.1. Introduction to study

It would be all too easy to select a TA method arbitrarily in an attempt to analyse a given task domain. However, task domains vary considerably, and it would be dangerous to apply arbitrarily a TA method to an area of such complexity and richness that could not be adequately expressed. It could be argued that some tasks cannot be analysed at all, even with *cognitive psychology aware* TA methods — for example, painting a picture or composing music. Such creative activities are highly individual, as well as being difficult to articulate by individuals. The question here is: whither writing?

To help answer this question, a study was undertaken to assess the suitability of HTA for analysing writing strategies. It was found that students had difficulty expressing the complexity of writing essays using this method, and regarded it as unsuitable for the task domain.

4.3.2. Experiment overview

This study asked students to use HTA to develop task structures for describing writing strategies. More specifically, the task of writing a final year undergraduate essay was investigated. HTA was chosen for this exercise (as opposed to TAKD or KAT, for example) for two reasons. Firstly, the group of students had prior experience of hierarchical decomposition in computer program design, and secondly, it is relatively simple and quick to develop HTA structures (Carey, Stammers and Astley, 1989).

It is recognised that a more knowledge-based TA method would probably have been more suitable than HTA. However, the hypothesis for this study was: can a traditional task analysis method be applied to writing strategies? It was not possible to consider a more generic hypothesis by way of a study, as all TA methods would have to be considered. The intention here was to carry out what is essentially a pilot study to add weight to the discussion and critique of TA methods in general when applied to writing analysis.

Another potential problem in the design of this experiment was the subject population. Music students were not chosen as they had no experience of HTA. Also, as the author was unable to group simultaneously music students and students who did know HTA, the study was based on writing strategies employed by non-music students. As has already been

observed, it is known that music students have a different approach to reading strategies than other students, and there is no reason to expect that it wouldn't be the same for their writing strategies. Again however, this is essentially a pilot study, and no recommendations will be given for the design of a hypermedia system as a result. The recommendation drawn from this study will centre on the selection of an appropriate method for investigating music students' writing strategies directly.

4.3.3. Method

4.3.3.1. Subjects

Eleven subjects were selected to carry out this study. All were final year undergraduate students on the BSc (Hons) Technology Management course at Staffordshire University. The subjects had three years experience of developing simple computer programs on the course, and had used hierarchical decomposition to design and document computer programs throughout this period of time. As part of their final year human-computer interaction syllabus, they were taught rudimentary aspects of task analysis. They were also trained to use HTA, and had experience of using HTA to describe procedural tasks, such as using a telephone or a photocopier. Their course had an emphasis on developing communication skills, and consequently they were considered to possess relatively strong interviewing techniques.

4.3.3.2. Procedure

Subjects were asked to work in pairs. There was one group of three subjects due to the odd number of the sample. The procedure for the study required subjects to role play. One subject took on the role of task analyst (two in the group of three), whilst the other played that of a student about to write a final year essay. Of course, it was easier for the latter role to be played, as the students were all experienced essay writers. The analyst interviewed the student, and together they developed an HTA diagram following the procedure previously described in section 4.2.1. Subjects were allowed 25 minutes to develop their work. After this period of time, they were asked to swap roles. This provided a total of ten HTA diagrams. All students completed the analysis with time to spare. In a real situation, the analysis would need to be much more iterative, detailed and therefore time consuming, but it was considered that subjects would gain sufficient insight into the method's suitability in this domain. Once the role playing was over, the subjects were asked a series of questions

to establish their level of training in essay writing skills, as well as their opinions of HTA's usefulness for analysing essay writing. All data were collected at the end of the hour long session.

4.3.4. Results

It was soon realised that there were clear differences between virtually all subjects' HTA diagrams. The most obvious observational variations were at the lowest level of granularity i.e. the *leaf nodes* of the diagrams. This was not entirely unexpected, as it was impossible for subjects to apply any kind of quantifiable redescription stopping rules (Annett et al., 1971), given the time constraint imposed by the experiment. A number of observed similarities were apparent however, at a higher level of abstraction. As HTA does not provide a means to combine task descriptions from different subjects to form a generic task description (Carey et al., 1989), relevant aspects of Johnson and Johnson's (1991) generification process were adopted to collate the data provided by subjects in this study.

4.3.4.1. Generic actions

At the highest level of abstraction below the overall goal of writing the essay, a number of generic actions were identified. Like terms were grouped, according to Johnson and Johnson's generification technique. Following further guidelines from this technique, a threshold frequency of eight was chosen. This was regarded as intuitively sensible, as the next most frequent action occurred only twice. The generification process provided a total of four generic actions at this high, strategic level. They were as follows, along with the number of HTA diagrams on which they appeared:

Generic Action	Action(s)	Frequency (n=11)
Research	Literature Search Research	11
Plan	Composition Outline Plan Structure Essay	11
Develop	Rough Draft Develop Proof-read	8
Write Up	Complete Essay Final Stage Essay Writing	11

Table 4.1: Generic actions identified from the group of HTA diagrams.

4.3.4.2. Generic plans

Again, generic plans were only observed at the higher level of abstraction. Within the context of the generic actions already identified, two plans were apparent. The first was a purely sequential process through the research, plan, develop and write up stages respectively. The second was similar to the first, except that iteration took place within the first three stages. Four students indicated a sequential approach, whilst the other seven followed a more iterative pattern.

4.3.4.3. Post-session debriefing

Once the HTA exercise was completed, subjects were asked whether they ever had tuition in essay writing techniques. Those who answered in the affirmative were then asked whether they used these techniques in their writing strategies.

Five subjects had previously received tuition, but not during their undergraduate career. Most of these subjects had a vague recollection of English classes at school where essay writing was taught. Three of the five students said they still used the techniques.

Finally, subjects were requested to provide their views as to whether they felt HTA allowed them to communicate how they actually wrote an essay, and to give reasons for their answer.

Seven of the eleven subjects felt that HTA was not useful in this domain. A typical sample of reasons provided for this answer follows:

• *I believe the complexity and variety of methods employed by individuals means that a standard set of tasks and sub-tasks are hard to establish. In this instance, this is very much in evidence.*

• *HTA helped, but it's too rigid. Essays are not always written the same way.*

Three subjects felt that HTA did prove useful, as the following examples explain:

• *Yes, in terms of how an individual does it. Different people research and write reports differently. HTA gives a skeleton of how a report* could *be written.*

• *Yes, but HTA should be used to develop your own style for such things as essay writing. Would be good for developing guidelines, standard layouts etc.*

One subject took a noncommittal stance:

• *Yes, because it shows you how to write a structure for essay writing, but no because each individual develops their own style. It's good to show the main points of essay writing, but not for an experienced essay writer.*

4.3.5. General discussion of results

The last comment in section 4.3.4.3. aptly summarises the collected observations of most subjects. Some students felt that HTA could be used to specify high-level aspects of writing strategies. As another subject commented, HTA provides a "... skeleton of how a report could be written". Subjects' observations are supported by analysis of the HTA diagrams. There was virtually no similarity between any HTA diagrams at the lower levels of the hierarchy. This was evident for both plans and actions.

The generic actions of **research**, **plan**, **develop** and **write up** were identified by the author. There was no opportunity to verify these actions with subjects, so there is a degree of author subjectivity here: However, the approach does concur with other investigations (Branthwaite, Trueman and Hartley, 1980). The two generic plans of **sequential procedure** and **iterative procedure** demonstrate aspects of variance in writing strategies. However, as a number of subjects commented on the rigidity of HTA and the complexity of essay writing, there must be a suspicion that HTA forced subjects into over-simplifying their plans.

Some subjects identified the applicability of HTA to the development of training programmes and of writing guidelines. Most subjects had minimal, if any, tuition in essay writing, so perhaps their lack of formal training in this area provides an opportunity for HTA in education.

What is apparent in these results, is the difficulty which procedurally orientated methods like HTA have in describing complex processes. There is no reason to assume that more modern TA methods would provide a much better analysis, as their descriptive mechanisms also tend to rely strongly on a hierarchy of procedures.

4.3.6. Conclusions and implications for further research

This chapter specifically considered task analysis issues with respect to the framework for HCI in educational hypermedia. The investigation undertaken highlights the complexity of writing strategies in this context — they are highly individual and are difficult to express by those individuals. In this sense, writing is essentially a phenomenological activity. The suitability of what might be termed rationalistic analysis, such as the task analysis methods discussed, to specifying writing strategies, is highly questionable. Other authors have questioned such approaches in similarly phenomenological activities (e.g. Lea, 1991; Buckingham Shum and Hammond, 1994). Buckingham Shum and Hammond suggest that:

> ... the absence of a strong methodological tradition such as that found in the social sciences has some part in contributing to the current situation ...
>
> *Buckingham Shum and Hammond, 1994 (645)*

Lea applied a method from this field (repertory grid analysis) to demonstrate a richer analysis of the use of computer-mediated conversation. Such an approach will now be considered for the analysis of writing strategies.

Chapter 5
Using repertory grid analysis in the design of a hypermedia system

5.1. Introduction

This chapter reports a study which investigates the suitability of hypermedia for a particular task domain, that of essay and dissertation development and for a particular population, that of undergraduate students of contemporary music. Although a number of specialised computer-based writing and argumentation environments have recently been developed, for example gIBIS (Conklin and Begeman, 1988), WordProf (Ferraris, Caviglia and Degl'Innocenti, 1990), PHI (McCall, 1991), SEPIA (Streitz et al., 1992), MediaText (Hay et al., 1994) and the CLASS Project (Gunn, Granum and McAleese, 1995), none of them have considered a specific educational domain.

It is important to consider appropriate analysis and design techniques for such a specialised area. Methods to facilitate the development of hypermedia systems are not yet fully established, and it could be argued that typical approaches have placed too much emphasis on technology-centred design. This study takes a more user centred, constructivist view, and also considers the importance of knowledge elicitation in the design process. To this end, repertory grid analysis (Kelly, 1955) was employed to elicit students' approaches to essay and dissertation development. The data were computer analysed and the results have been interpreted to formulate a model of essay and dissertation development in the scenario of the music college. Implications for further research and development are considered, particularly relating to the suitability of hypermedia for this domain.

5.2. The repertory grid technique

Traditional techniques to elicit domain knowledge for user-centred design include interviewing, questionnaires, surveys, group discussion, cognitive walkthroughs and so forth. The majority of these approaches are generally qualitative in nature or in the case of surveys, they lack the quality of human dialogue and psychometric validity. Whilst the value of all of the aforementioned techniques is beyond question, in many cases a lack of quantitative analysis may call into doubt the very integrity of user-centred design itself. The repertory grid technique, although highly user centred, does provide data that can, based on a degree of quantitative assumption, produce useful and representative results.

The repertory grid technique (or rep grid for short) was conceived by George Kelly in 1955 as part of his Personal Construct Theory (PCT). It was originally used exclusively in the field of psychotherapy to:

> ... enable clients to explore the pattern of their deepest thoughts and feelings about the people closest to them.
>
> *Thomas and Harri-Augstein, 1985 (18)*

Kelly's intention was that repertory grid techniques would be used iteratively in helping clients to articulate and clarify their situation. The technique has been since applied in several other areas, for example in magistrates' decision making (McKnight, 1981), knowledge engineering (Shaw and Gaines, 1987; Shaw and Woodward, 1988), learning strategies (Thomas and Harri-Augstein, 1985; Harri-Augstein and Thomas, 1991), job analysis (Hassard, 1987), decision making (Shaw and McKnight, 1981) and computer-mediated communication (Lea, 1991).

Most non-clinical applications of the technique tend not to adopt an iterative process. This study uses rep grid analysis in a non-iterative way, as the objective is to identify a model for further investigation. As such, it constitutes one aspect of a broader methodology.

The technique aims to build a model of a particular domain of knowledge by enabling subjects to verbalise how they perceive certain factors within the area of interest. These verbalisations are known as *constructs* in Kelly's terminology. The factors are termed *elements*. A construct is a bipolar dimension, where each pole represents the extreme of a particular view or observation.

Let us consider an example to illustrate the rep grid approach. We might be interested in how people feel about certain disciplines at an athletics meeting in order to help us schedule the event. The repertory grid technique could be used to elicit how individuals rate each discipline. Each element in this example would represent the various disciplines such as 100m, javelin, 110m hurdles, discus and so forth. Example constructs might be *boring ... interesting, fast ... slow, international interest... local interest* and so forth.

Constructs are best elicited from individual subjects in a 1:1 situation with the researcher. Once each construct is decided upon, the elements are rated on an interval scale from say one to five, where one might indicate *boring*, five then indicating *interesting* and so forth. As more and more constructs are generated and rated, a picture can be built up of an individual's views of the domain. An example grid for the simple athletics meeting scenario is shown below:

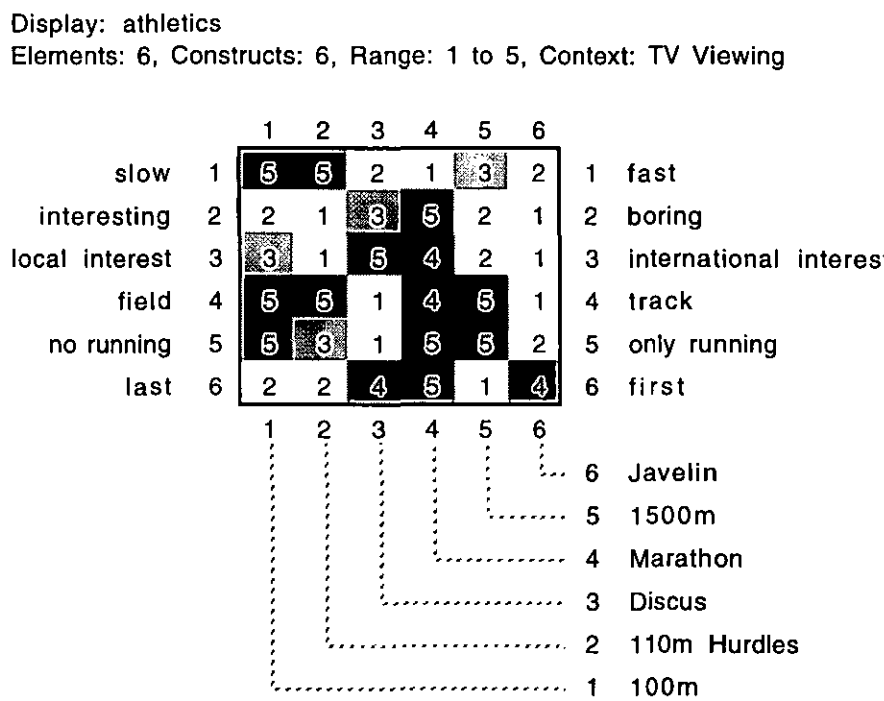

Figure 5.1: Example grid for athletics meeting.

If a number of subjects are interviewed using the rep grid technique, certain norms can be identified, thereby providing a degree of shared subjectivity across the given population. Also, a broader range of constructs might be elicited, good for identifying typicality within a subject population, as well as reducing the significance of obscure idiosyncrasies.

Repertory grids are usually analysed by computer, as the mathematics involved is complex, especially as the number of constructs increases. Computer analysis can group together related constructs and elements, providing researchers with meaningful and representative information regarding the domain of interest.

5.3. Experiment overview

The repertory grid technique was used to elicit user knowledge and identify tasks in the context of essay and dissertation development. The objective of this exercise was to establish how a particular user population would classify the activity of essay and dissertation production. It was assumed that certain activities are common to most authors in this field, such as literature research, making notes, writing up and so forth. In order to establish a more acceptable degree of commonality however, a group interview was arranged with some members of the user population at The City of Leeds College of Music (see appendix B). The interview was conducted informally and was loosely structured. It was recorded on cassette tape with the permission of the subjects. The transcript was analysed, and in conjunction with recommended essay development activities, for example Watson (1987) and Clanchy and Ballard (1993), what might be termed the base elements of this group's essay production activities were identified. These activities were then used as the basis for the repertory grid exercise. The nine provisional elements are listed below (in no particular order):

- write up essay
- write draft/rough copy of essay
- make notes
- plan research
- plan essay
- analyse essay titles
- read books/articles
- study music text
- listen to music

It should be noted that the subject group for the interview was different from the subject group for the repertory grid experiment. Prior to the case study experiment at the City of Leeds College of Music (CLCM), the method was piloted with four experienced essay writers. During this exercise, timing, content and procedure were refined.

5.4. Method

5.4.1. Subjects

A total of twelve volunteers were originally recruited, but three were ultimately unable to attend. Consequently, nine second and third year undergraduates at CLCM were each paid £5.00 to contribute one hour of their time to the study. Of this group, five subjects were in their second year (three male and two female), whilst the other four were in their third and final year (all male). The second year students had no experience of dissertation writing. The third year students were approximately three quarters of the way through theirs. Dissertation topics ranged from the modern jazz genre, such as Chick Corea to the contemporary progressive genre, such as Brian Eno.

5.4.2. Procedure

The first fifteen minutes of each period was spent settling the subject down and introducing the research objective and procedure. It was explained that the intention of the exercise was to "... find out how people classify the activity of essay and dissertation production". The subject was informed that the ultimate aim of the research case study was to develop computer-based tools to aid essay production, incorporating the range of media which they use, such as music, music scores, biographies and so forth.

Once the subject was familiar with the background to the study, the method of repertory grid analysis was introduced. It was explained that the method could be used to help people "... classify their knowledge of *things*". Such *things* could be "... cars, musicians, activities, sports, painting ..." and so forth. The subject was then told that repertory grid analysis could be used to classify his or her view of essay writing activities, that is how *they* do it.

A very simple example of repertory grid analysis was then stepped through using fictitious people as elements and opinions of their personalities as constructs. Once the subject was confident about the method and procedure, the data collection exercise was begun.

In order to allow each subject as much personal input as possible, the provisional elements were displayed before the first construct was considered. The subject was asked whether any of the activities were not consistent with their approach, and whether they could

suggest alternatives or additional activities which described their development strategy more accurately. Of the nine subjects, seven modified their elements to some degree. This aspect of the study will be considered in more detail when individual grids are discussed.

Because the most difficult activity for subjects to perform in a rep test is the identification of constructs, an initial *like ... dislike* construct was suggested by the researcher. This approach has worked successfully in the past (Lea, 1991). This construct was not used in the aggregated (FOCUS) analysis, but was considered useful for individual analyses.

The technique of triads (Bannister and Mair, 1968) was used to help subjects articulate their own constructs. This technique presents three elements, and the question is put to the student: "In what way are any two of these three elements similar, but different from the third?". In this way, a construct can be identified. It should be noted here that many constructs were identified without recourse to the triad technique. Consequently, it could be said that triads were used as a tool to facilitate the elicitation, as opposed to some studies which have adopted the technique as a central mechanism for construct identification.

An example of an elicited grid is shown below:

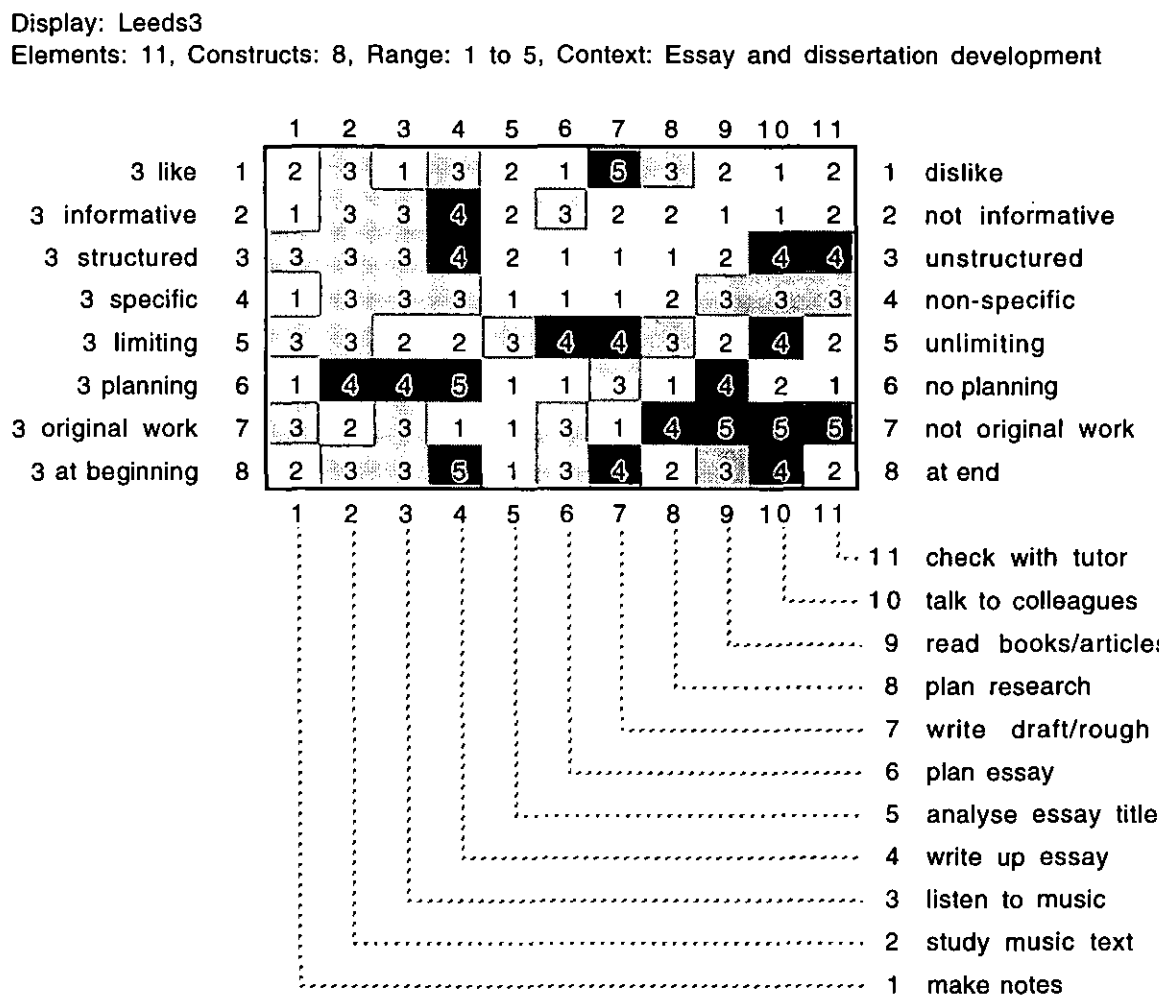

Figure 5.2: Example grid for subject 3. Shading simply provides immediate differentiation between construct ratings.

A total of 57 constructs were identified by the nine subjects. This figure does not include the nine *like ... dislike* constructs. The highest number of constructs suggested by any subject during the one hour period was eight, the lowest, four, with a median of seven.

5.5. Results

The results of the study were analysed using RepGrid 3, described in Gaines and Shaw (1993)[1]. Although a grand total of 66 constructs were elicited from the nine subjects,

[1] The author would like to express thanks to Professor Brian Gaines of The Centre for Person Computer Studies, at University of Calgary, Calgary, Canada for permission to use RepGrid 3 for this study.

RepGrid 3 only supports a maximum of 50 constructs for a FOCUSed grid (i.e. an aggregated factor analysis). To accommodate this shortfall, the construct *like ... dislike* was omitted from the FOCUS analysis as this was the one construct selected by the researcher. A SOCIOGRID analysis, which identifies similarities and typicality across a range of subjects, revealed that subjects three, four, eight and nine were the most dissimilar across the subject population (figure 5.3).

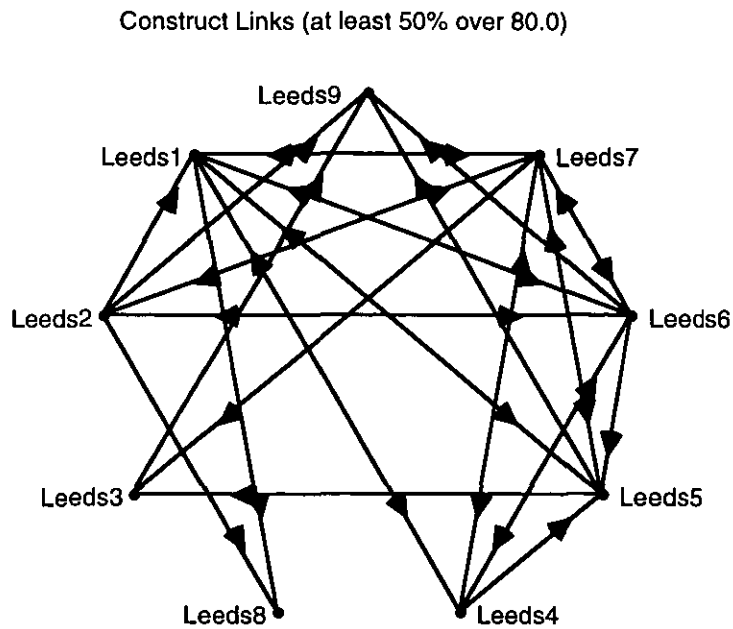

Figure 5.3. SOCIOGRID analysis of individual subjects.

In the light of this, along with the relatively small number of constructs elicited from subjects eight and nine, these two were omitted from the FOCUS analysis (eight and nine were not the last two subjects to be interviewed — subject identifications were in fact re-indexed to improve the clarity of the experiment's elucidation). The FOCUSed grid therefore, compared seven subjects with nine elements and a total of 48 constructs. An 80% cut-off was used in construct matching so that related ideas which were tightly clustered could be more readily identified. A 60% cut-off was deemed sufficient for element clustering for the FOCUSed grid, as a representation of relationships between all task elements was required. The grid is displayed overleaf:

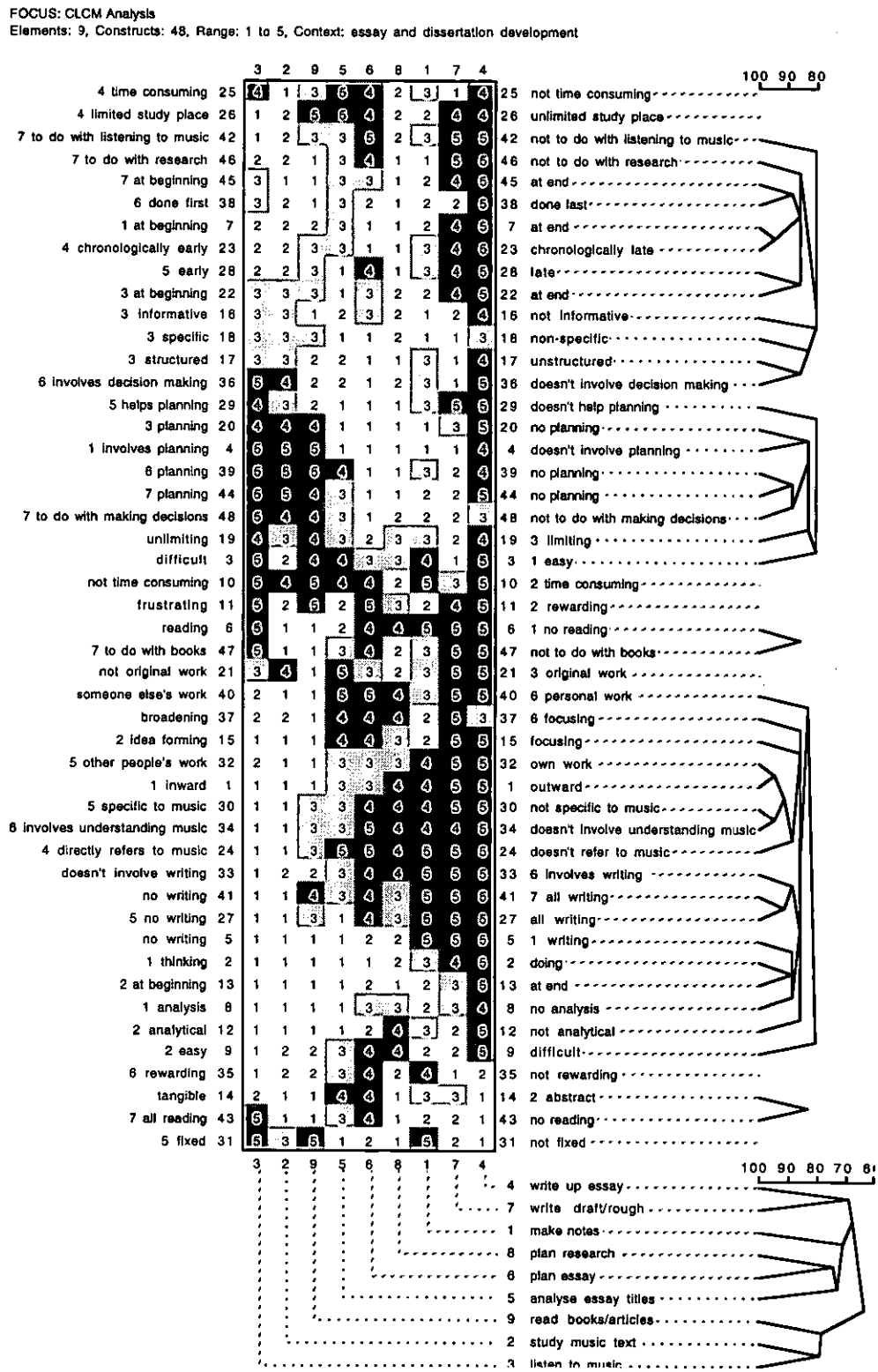

Figure 5.4: FOCUSed grid. Numbers against constructs indicate subject identity.

The constraint imposed by the software was disappointing. However, as previously mentioned, the discussion of results will consider all individual cases. These analyses also consider subjects' individually proposed elements. Table 5.1 lists the modifications suggested by each subject:

Subject number	**Added element(s)**	**Subtracted elements**
1	Discussion with colleagues	None
2	Talk to others	None
3	Talk to colleagues Check with tutor	None
4	Interview subject of dissertation	None
5	None	None
6	None	None
7	Highlight information	Analyse essay titles
8	Check with tutor Writing to informed people	None
9	Transcribe music	Write draft/rough copy Plan research

Table 5.1: Individual subjects' modified elements.

During the repertory grid analysis interviews, notes were made by the interviewer when relevant general points about the essay and dissertation process were raised by subjects. These included matters relating to the use of video, biographical issues, usage of library facilities and so forth. These points will be considered in more detail in the next section.

5.6. Discussion of results

5.6.1. FOCUS analysis

The FOCUS analysis produced three large clusters of related constructs. With reference to figure 5.4 from top to bottom, the three clusters range from 42 to 36 inclusive, 29 to 3 inclusive and 40 to 9 inclusive. These clusters cover 37 of the 48 constructs elicited, or 77.1%. This suggests that the majority of constructs related to the subject of essay and dissertation development might be describable in the context of these clusters. To do this effectively, the clusters should be given some form of identity.

Cluster 42-36 contains six almost identically synonymous constructs (45 to 22 inclusive). These constructs relate directly to the chronological sequence of the nine activities. This would infer a commonality of approach as far as this aspect of essay and dissertation production is concerned. However, one of the seven subjects, whilst proposing the *at beginning ... at end* construct, had a different perception of the timing of activities. This subject's construct therefore does not feature in the 42-36 cluster. There are six other constructs in cluster 42-36 which should be considered. Construct 46, *to do with research ... not to do with research* emphasises the proportion of research which is carried out early in the essay/dissertation development. Construct 42, *to do with listening to music ... not to do with listening to music* has a similar chronological implication. Constructs 16, 18, 17 and 36 form an interesting *sub*-cluster in this range. The implication here is that a higher range of thought processes are required for earlier activities, whilst later activities are more mechanistic.

Cluster 29-3 is immediately recognisable by the abundance of *planning ... no planning* type constructs. The other three constructs in this cluster of eight again add weight to the differences in complexity of activities perceived by the subjects. Constructs 48, 19 and 3 indicate that activities which are not planned don't involve decision making, are *limiting* and are *easy*.

Cluster 40-9 is the largest and perhaps most enigmatic of the three clusters. It is impossible to identify a single predominant construct amongst the 17 in the set. A more critical analysis at the 90% cut-off level reveals three *sub*-clusters. 32-24 identifies the medium of music, its *inward* nature and the fact that in this scenario, the music relates to *other people's work.* 33-27 refers to the degree of writing involved in each activity, and finally 5-8 reveals a multi-faceted *sub*-cluster which incorporates all aspects of the clusters previously

discussed, including the maverick *at beginning ... at end* construct. Analysis of the *sub*-clusters 32-24 and 33-27 suggests a degree of media (music, text) involvement in cluster 40-9. Other constructs in this cluster indicate the way in which media might be used, for example on an *idea forming ... focusing* scale (construct 15) or on an *analytical ... not analytical* scale (construct 12).

The repertory grid approach can help us identify what might be termed a vocabulary for describing the activities (elements) involved in the essay and dissertation writing process. At the lowest level of granularity, this vocabulary is exhibited in the wording of the constructs. However, any attempt to describe the writing process in such micro-detail would be unwieldy and in places self-contradictory. The clusters identified in the FOCUSed grid provide a much clearer picture. The large clusters 42-36, 29-3 and 40-9 offer us a potential three-dimensional model of the writing process in this scenario. Hence, if appropriate verbal descriptions of each of these dimensions can be identified, we would be able to describe each activity in terms of a three-dimensional vocabulary. Clusters 42-36 and 29-3 are immediately identifiable by the predominance of chronological and planning constructs respectively. We can therefore provide two of the dimensions of the model without much trouble: **timing**, with a range from beginning to end, and **planning** with a range from simple to complex. The latter scale has been inverted as it is regarded as more sensible to indicate a low score for simple planning and a high score for complex planning (this range also takes into consideration aspects such as decision making, specificity etc.). A definition for cluster 40-9 is not so readily distinguishable. However, this cluster does incorporate several constructs which relate to communication activities, such as reading, writing and listening. If we were to call this dimension **communication**, we would be hard pressed to identify a simple range which would describe the relevant communication activities. Communication has in fact several dimensions such as direction, bandwidth and channel. However, for the scenario in question, we can simplify the issue. Given that the communication is essentially a dialogue between student and artefact, we could describe that dialogue firstly by the direction of communication (reading and listening are *inward*, writing and speaking are *outward*) and secondly by the range of media used for an activity. For example, listening to music is very much an inward activity and uses only the medium of music. On the other hand, reading aloud is both an inward and outward activity, using the media of text and speech. Hence, we can describe communication in this scenario on a *u-nary* scale, ranging from inward to outward. The mid-point on the scale signifies both inward and outward activities, such as reading aloud. The extreme points on the scale represent activities communicated in the direction indicated, such as reading on one extreme

and writing on the other. Other points on the continuum would indicate combinations of communication activities (figure 5.5). As a generic description, this scale of communication is inadequate, but the nature of the activities in this scenario is such that it will suffice.

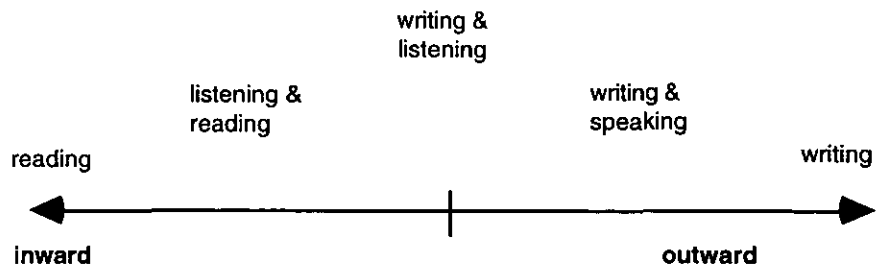

Figure 5.5: Simplified communication scale with example activities.

Combining the dimensions **timing, planning** and **communication** produces a three-dimensional space within which the activities involved in essay writing may be represented. By taking the mean of subjects' ratings in the FOCUSed grid for each of the three major clusters, we can derive a vector for all nine activities. For example, activity 4 (write up essay) scores mean values of 4.67 for cluster 42-36 (timing), 1.62 for cluster 29-3 (planning) and 4.82 for cluster 40-9 (communication). This provides us with a vector (4.67, 1.62, 4.82) which can be plotted in the three-dimensional space as shown in figure 5.6.

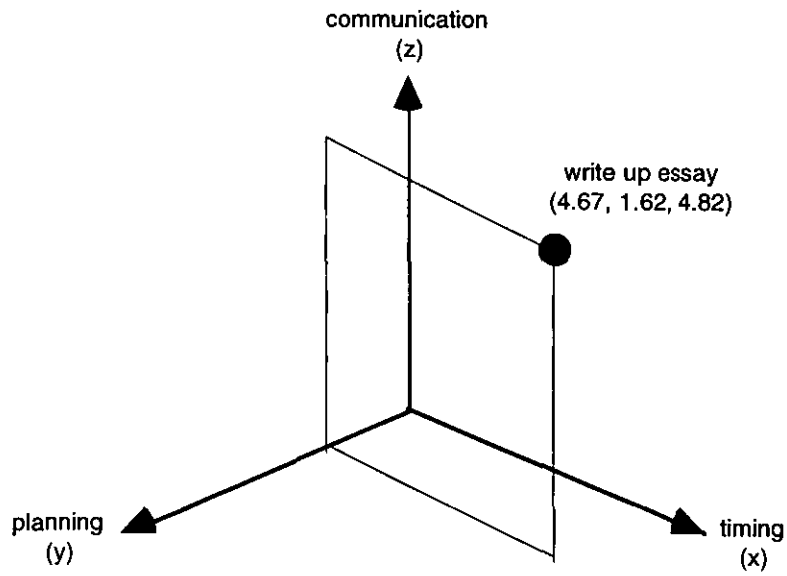

Figure 5.6: Model of essay and dissertation development displaying one activity.

We could go on to plot all nine activities in the same way. However, such a representation would be very difficult to visualise in the two-dimensional medium of paper, so the overall model has been translated into a more readable graphical form as shown in figure 5.7.

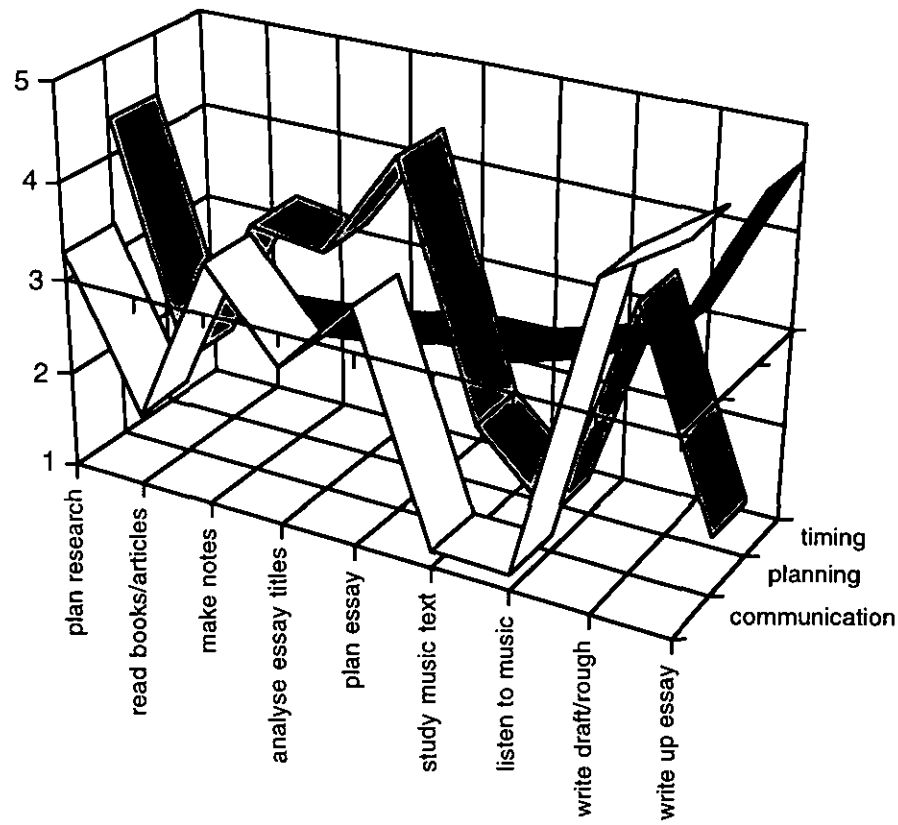

Figure 5.7: Complete model of essay and dissertation development with nine common activities.

Figure 5.7 shows the nine development activities on the horizontal axis, ordered by their mean score on the timing scale. Hence, this model shows the activity **plan research** to be the first activity and **write up essay** the last. The model's three-dimensional space is represented as three separate plots — one each for **timing, planning** and **communication**. The mean scores for each activity are represented on the vertical axis.

The chronological order of the activities is interesting in that six of the nine activities score a mean of between 2.08 and 2.67 (**read books/articles** to **listen to music** inclusive). The *plateau* in the middle of the timing plot is indicative of this. Although the activities are listed in order of their mean score on the FOCUSed grid, it would seem very difficult to propose that these activities have a distinctly different place on the timing scale. This could

mean that the activities are conducted at around the same time, or that different people do these specific activities in different orders and the scores average out, or that they are carried out in an iterative fashion, and therefore are not truly represented on a linear scale. Whatever the reason, what is clear is that there will be significant interaction between these activities.

Considering the communication scale of the activities, it appears that given the variation of mean scores within this range, a considerable diversity of media are utilised at effectively the same stage of the development process. For example, **study music text** and **listen to music** are essentially inward activities, whilst **making notes** and **plan essay** are more outward than inward. The other two activities, **read books/articles** and **analyse essay titles** fall on the inward side of the scale.

The implications of the above observations are two-fold: firstly, that activities which are performed *in parallel* will have impact upon each other, and therefore interaction and interchange between components which support such activities should be supported, and secondly, that the predominantly inward nature of these activities means that inward media (text, music, pictures etc.) are important to support and inter-relate.

Another interesting observation of this particular subset of tasks is the similarity between the **communication** graph and the **planning** graph. It would seem that outward activities require a more complex planning strategy than inward activities. The fact that outward activities require original production of work may go some way to explaining this observation.

5.6.2. Individual analysis

So far, discussion has concentrated on the aggregated FOCUS analysis of seven of the nine subjects. The elements in this analysis were limited to those common to all of those subjects. What now follows is a brief discussion of individual grids. The discussion will focus on the elements suggested by subjects, those omitted, as well as on the *like...dislike* construct which was not incorporated into the FOCUS analysis. Consideration of subjects' comments and general points relevant to the scenario is also given. Table 5.1 lists those elements added and subtracted by individual subjects.

Subject one suggested the concept of peer discussion as an important element of the development process. This notion was also supported by subjects two and three. Other subjects identified other human communication-orientated activities such as talking to tutors, writing to informed people and interviewing the subject of the dissertation. The phenomenon of dialogue in the essay and dissertation development process may be more common to a college environment which is still relatively intimate in terms of cohort size, staff-student ratio, student motivation and subject material. Nevertheless, its importance in terms of both educational value and students' personal and professional development cannot be over-emphasised. The irony here is that the electronic replacement of environments where such dialogue takes place (libraries, seminar rooms, student common rooms, bars even) may be highly disadvantageous. The social impact of computers on education is a fundamental issue, but is beyond the scope of this thesis.

The two other elements added to the individual grids relate to the highlighting of information during research and the transcription of music. Whilst highlighting information is probably done by most students within the context of reading and making notes, it is perhaps surprising that transcribing music was not suggested by more than one student. This could be explained by the observation that most students have access to music text relating to the subjects of their work already. However, there is no reason why music transcription software could not be included within an integrated computerised system. The advantages offered by such software include high quality publication facilities, transposition switches and playback through MIDI (Musical Instrument Digital Interface) equipment, amongst others. The provision of music text processing alongside alphanumeric text processing is also desirable for this scenario. One student mentioned this specific point during the pilot interview.

Where the added elements fit on the proposed model of essay and dissertation development is only possible by inference, given the lack of any reasonable sample size in this context. We could infer that the communication orientated elements (e.g. **talk to others, check with tutor**) will be on the mid-point on the **communication** scale (both inward and outward), take place during the early/middle stages of development and have a small degree of planning. The **highlight information** activity would probably be similar to **make notes** and **transcribe music** has similarities with reading music and making notes, an observation supported by the grid elicited from the subject in question.

Only two subjects decided to omit elements from their grid. One subject considered that the element **analyse essay titles** was not relevant to her, as she had no choice of essay on the course she was studying. Another subject cited his *spontaneous* method of writing essays as justification for not writing a draft/rough copy or planning his research. Whilst this subject was in the minority for the sample, his development strategy does highlight the difficulty of accommodating individual styles. This observation suggests the need for a flexible approach to any solution.

The *like...dislike* construct was interesting to the extent that subjects invariably preferred research-orientated activity, and disliked the writing up process the most. From a design perspective, it is desirable to find ways to make the writing-up phase more enjoyable and more motivating. Computers may help in this respect, and this is a matter for further research.

A number of general comments and points were raised by the subjects in the course of the rep grid interviews. Some of the more relevant issues are discussed below.

The use of video in the course of the subjects' work was identified as interesting, but only in a peripheral sense. One subject mentioned that those videos which were available are not in depth enough for specialists. Perhaps if such video material was in existence, it would be put to better use in a higher education context. The high cost of video production may deter film makers, given such a small market. A computerised solution may help to the extent that relevant shots may be accessed directly from a CD-ROM, as opposed to a student having to search laboriously through a video tape for footage of interest.

The procedure involved in planning research and analysing essay titles was relatively common and in some sense well-structured amongst the subjects. Most students' first point of call is a comprehensive, specialist music dictionary, for example The New Grove Dictionary of Jazz (Kenfield, 1988). Artists, eras, genres and so forth are researched broadly, further references are taken and notes are made before more detailed work is considered.

Subjects were asked how they would structure an artist's biography. The general consensus in this respect was that in the context of a dissertation, biographical material is more rigorously structured than the literary equivalent. Music students at CLCM consider three aspects in this respect: influences, technique and contribution.

5.7. Implications for hypermedia for essay and dissertation development

This study has attempted so far to model the process of essay and dissertation development. From the model, we can identify aspects of the process which might be considered suitable for at least some form of computerised support. The analysis of the model has revealed a number of observations, which are summarised below:

- Most activities do not fit a set pattern on the timing scale.
- There is significant interaction between a number of these activities.
- A number of media forms are used and their inter-relationships should be supported.
- Outward (e.g. writing) activities are more demanding, require more planning and should be appropriately supported.
- Inward activities (e.g. reading) are less structured, but require careful design consideration to maximise the learning potential.
- Individual development strategies should not be undermined.

A solution which supports the interaction, media inter-relationship, lack of set pattern and individual strategies highlighted by the repertory grid analysis is regarded as *the* fundamental issue of this study.

Artefacts which support essay and dissertation development activities in the music scenario reflect the multiple media forms relied upon by students. They include familiar material such as books, records (cassettes, compact discs too), magazines, journals, past dissertations and videos. Support environments include audio equipment, desk-top processing systems, video recorders, library resources and so forth. Technology is relied upon here albeit in diverse forms — a multimedia solution may provide a useful integrating factor. Certainly, any computerised solution would have to support multimedia artefacts in order to match the capabilities available at present.

As described in chapter two, hypermedia has been applied with varying degrees of success in educational scenarios. Nevertheless, given the findings of the repertory grid analysis, there appears to be a strong case for considering a hypermedia solution to support essay and dissertation development — the reliance upon various media forms, the need to support individualised approaches, the high degree of association within both media and information as well as the perceived advantages that an integrated system may provide.

The model of essay and dissertation development also provides pointers for structuring prototype user interfaces for the scenario. For example the FOCUSed grid forms a hierarchy of related activities (figure 5.8) which may act as a rough starting point for a structural hierarchy. The three dimensions of the development process model may also provide structural design pointers. For example, the close relationship between the study of music text and listening to music is apparent. These activities should be supported accordingly — perhaps to the extent of synchronisation.

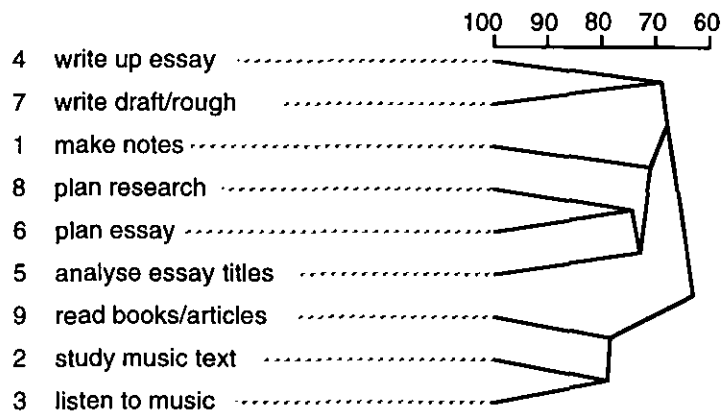

Figure 5.8: FOCUSed grid for the nine common elements (activities).

5.8. Towards a typology of activities

The three-dimensional model of essay and dissertation development allows us to describe each of the common activities in an identifiable framework. For example, the activity **plan research** involves both inward and outward communication (3.29/5 on that dimension), a high degree of planning (4.37/5) and occurs relatively early in the development process (1.42/5). In order to further clarify the framework for this scenario, observational analysis of the FOCUSed elements grid (figure 5.8) suggests that are three types of activities. This family is presented and discussed below.

5.8.1. Type I activities

This type includes three activities: **read books/articles**, **study music text** and **listen to music**. Their characteristics are common to the extent that they involve little planning, predominantly involve inward communication and occur at early or middle stages in the development process.

5.8.2. Type II activities

This type includes four activities: **make notes**, **plan research**, **plan essay** and **analyse titles**. Their characteristics are common to the extent that they involve a high degree of planning, involve both inward and outward communication and occur at early or middle stages in the development process.

5.8.3. Type III activities

This type includes two activities: **write up essay** and **write draft/rough**. Their characteristics are common to the extent that they involve some planning, involve predominantly outward communication and occur at the later stages in the development process.

Although this typology may appear simplistic, defining some form of framework is likely to help in the consideration of implications for further research. In particular, aspects of task support for essay and dissertation development activities may be identified in the form of artefacts which reflect the characteristics of the typology. Whilst the notion of computerised tools for writing has been considered in the past, for example Mitchell (1987) and Coxswain (1989), there appears to be a lack of research into the identification of a framework for their selection. This is an issue for further research. A preliminary overview of artefacts within the simple typology identified in this study is discussed below.

5.8.4. Artefacts for Type I activities

Activities which involve a relatively small amount of planning typically exist within a fairly loosely structured environment. Imposing structure upon performers of such activities, particularly in a creative domain such as authoring, could prove stifling and ultimately destructive. Hence, resources such as rigorously structured databases and programmed learning material would be undesirable task support artefacts. This observation is reinforced when one considers the broad research-orientated activities which are typically undertaken during the earlier stages of essay and dissertation development exemplified by this type.

The inward nature of type I activities incorporates both reading and listening. In this respect, one would expect an integrated solution to be supported by some form of multimedia architecture. An example of such integration might be the combined study of music text with listening to a recording of the music. Another example where film or

photography may prove at least aesthetically beneficial in conjunction with sound might be where a particular piece of music is inspired by another person or place, or more obviously where the music is part of a film score.

Artefacts which clearly support type I activities include books, music media (compact discs, vinyl records etc.), video, music text and so forth. A crucial implication for research here is the identification of how such artefacts may be represented in a computerised domain, and how they should inter-relate.

5.8.5. Artefacts for Type II activities

Whilst type I activities demand little structure, the high degree of planning involved with type II activities implies that a more rigorous design is required.

The observation that both type I and type II activities occur at early to middle stages of the development process infers that there may be some interaction or parallelism. It may be therefore, that there is a need for some kind of cross-referencing or more structured relationship between the two. The effect of planning upon practice and vice-versa has long been a contentious issue. Differing schools of thought exist — see for example Suchman (1987) and Newell and Simon (1972) for conflicting views. The design of computerised artefacts will depend on some understanding of this dichotomy. The artefacts themselves may play a role. For example, a sophisticated text processor which supports outlining functionality may encourage users to take an evolutionary strategy, whereas a pen and paper approach may encourage a more structural plan because of the extra work involved in continuous redevelopment and evolution. In the scenario of essay and dissertation development, further research may help to clarify these issues.

Advocates of *new* approaches to writing, particularly the hypertext lobby, encourage a reevaluation of traditional approaches to document authoring and reading (Landow, 1992), whilst others take a more cautious stance (McKnight et al., 1991; Whalley, 1993). Such caution is especially wise in a learning environment, from both an ethical and pedagogical stance. It would be difficult to expect students to change their underlying learning strategies simply because the technology is available for them to *deconstruct* an accepted and (usually) highly successful process.

Whether computerised planning tools should reflect more traditional development processes, or promote new strategies is certainly an issue for research. One could take the problem further by asking whether there is a need for computerisation at all in this context. An evaluation of currently available artefacts should be undertaken (e.g. outlining software, note-taking and annotation facilities) to establish a clearer picture of these issues. For essay and dissertation development in the music study scenario, it may be that unique computerised artefacts are required.

5.8.6. Artefacts for Type III Activities

These activities are, in terms of the proposed model of essay and dissertation development, much more detached from those belonging to types I and II. What little planning there is appears to take place during drafting activities. This could conceivably overlap with the note-taking activity, as well as bearing some relationship to evolutionary development as reflected by outlining artefacts. The communication is predominantly outward, but there may be a need to copy or duplicate information already produced at earlier stages.

An essential characteristic of the writing-up phase exemplified by the model is that of the focusing of previously undertaken work. Whilst research-orientated activities are *broadening*, the writing-up-orientated activities are *focusing*. The nature of the finished product clearly necessitates writers to concentrate on this aspect. A research issue here is whether computerised artefacts truly benefit performers of these tasks.

5.9. Conclusions and implications for further research

This chapter considered a number of attributes from the proposed framework for HCI in educational hypermedia, namely: the educational domain, the users, the tasks they perform, the information they rely upon, and the pedagogy employed in their learning. The reported study has enabled these issues to be integrated by providing a model of essay and dissertation development based on what might be termed traditional activities of working. In the traditional framework, technology is relied upon, but there is little or no integration between the activities and their associated media. This may cause problems from the point of view of inter-communication between activities. It is proposed that the model identified can help to form initial guidelines for an integrated solution. The chronological organisation of activities, their complexity and reliance upon considered thought and planning, and the media employed in each case, form a vocabulary for describing essay and dissertation development activities.

A computerised interactive multimedia solution of some form has been identified, primarily because this platform is the only option currently available which adequately supports the need to integrate sound, graphics (music text) and the narrative form. The use of film is possible with this technology but students do not rely heavily on this mode of delivery — it is regarded as reinforcing or of background interest, as opposed to central to the development process. This phenomenon was observed as an outcome of the preliminary interviews with students, as well as during the repertory grid interviews themselves. In this sense, video integration is not important, but may be a desirable, interest-capturing extra. However, other activities such as the study of music text, listening to music, reading books/articles and making notes are highly integrated and inter-related. In this respect, it would seem sensible to consider a hypermedia environment, where these activities could be integrated in an associative framework.

At this stage of domain analysis, the repertory grid technique has proved to be highly useful in eliciting subjects' knowledge, preferences, attitudes and development methods. The ability of the rep grid technique to support a quantitative analysis of the domain has been invaluable in the identification of a basic framework for a user-centred solution.

Chapter 6
Computer-based essay and dissertation development artefacts

6.1. Introduction

It is now necessary to consider the potential for various computer-based essay and dissertation development artefacts to complement the model of essay and dissertation development proposed in chapter five.

It has long been a problem for human factors specialists to identify appropriate electronic media to replace traditional media where research was originally carried out in the traditional domain. However, we must begin somewhere, as Buckingham Shum and Hammond illustrate with a particularly relevant example:

> Basing a tool around a model derived from an analysis or meta-analysis of the work process as performed without computational support (e.g. writing or collaborative drawing) is a powerful first step to designing appropriate technology.
>
> *Buckingham Shum and Hammond, 1994 (645)*

Rather than arbitrarily select candidate artefacts however, this chapter presents a survey of student usage of and attitudes to computerised and non-computerised artefacts. The intention is to consider which artefacts are best left in the paper medium, and which should be redesigned for the computerised domain. After all, paper is a medium, and there is no way that any media should be completely discounted as a role player in a multimedia environment.

6.2. A survey of research and documentation resources used by students

6.2.1. Survey overview

As most music students are unfamiliar with a wide range of computer systems, it would seem rather unwise to survey their usage of and attitudes to computerised artefacts in the domains of reading and writing. A better idea would be to investigate students who are familiar with such technology. Consequently, students from the School of Computing at Staffordshire University were surveyed. It was realised from the beginning that there

would be an undoubted mismatch between current usage and attitudes of these students and their music college counterparts. Therefore, it was decided to adopt a high degree of scepticism in the consideration of any remotely marginal results.

The survey was piloted with a class of final year BSc (Hons) Technology Management students, and some modifications were made to the wording of the survey as a result.

6.2.2. Method

6.2.2.1. Targeted respondents

A total of 68 students of human-computer interaction at Staffordshire University were each issued with the survey form. As the exercise was conducted in a class situation, the response rate was 100%. The respondents were final year students of computer science, information systems and software engineering. All were in the process of completing their final year project. The project is a mandatory and major piece of work, which involves the production of a medium-sized dissertation (typically 15,000 words). The vast majority of students on the course desk-top publish their own work.

6.2.2.2. Survey format

An example of a completed survey form can be viewed in appendix C. The survey was split into two sections: computer-based resources were considered on the first page, followed by non-computer-based resources on the second.

Each section of the survey listed a number of resources of the relevant type. For example, computer-based resources included word processing software, electronic mail and electronic diaries, whilst non-computer-based resources included hand-written notes, photocopying facilities and academic journals or books.

Respondents were asked to indicate their usage of each resource. A range of possible answers were offered to respondents, as well as the provision for an alternative explanation. Students were also encouraged to provide comments relating to any of their answers.

At the end of each section, respondents were asked to circle any of the resources which they regarded would be more beneficial to them in the alternative domain. For example, a respondent might consider a diary to be more beneficial in the computer-based domain, or

paper-based mail might be preferred to electronic mail. Of particular interest for this group of respondents were those instances where non-computer-based resources were preferred over their computer-based counterparts. It is assumed that Computing students have a generally positive attitude to computer technology, so any deviation from this is likely to mean an even larger level of rejection from novice users.

6.2.3. Results

The results of the survey are summarised in figure 6.1.

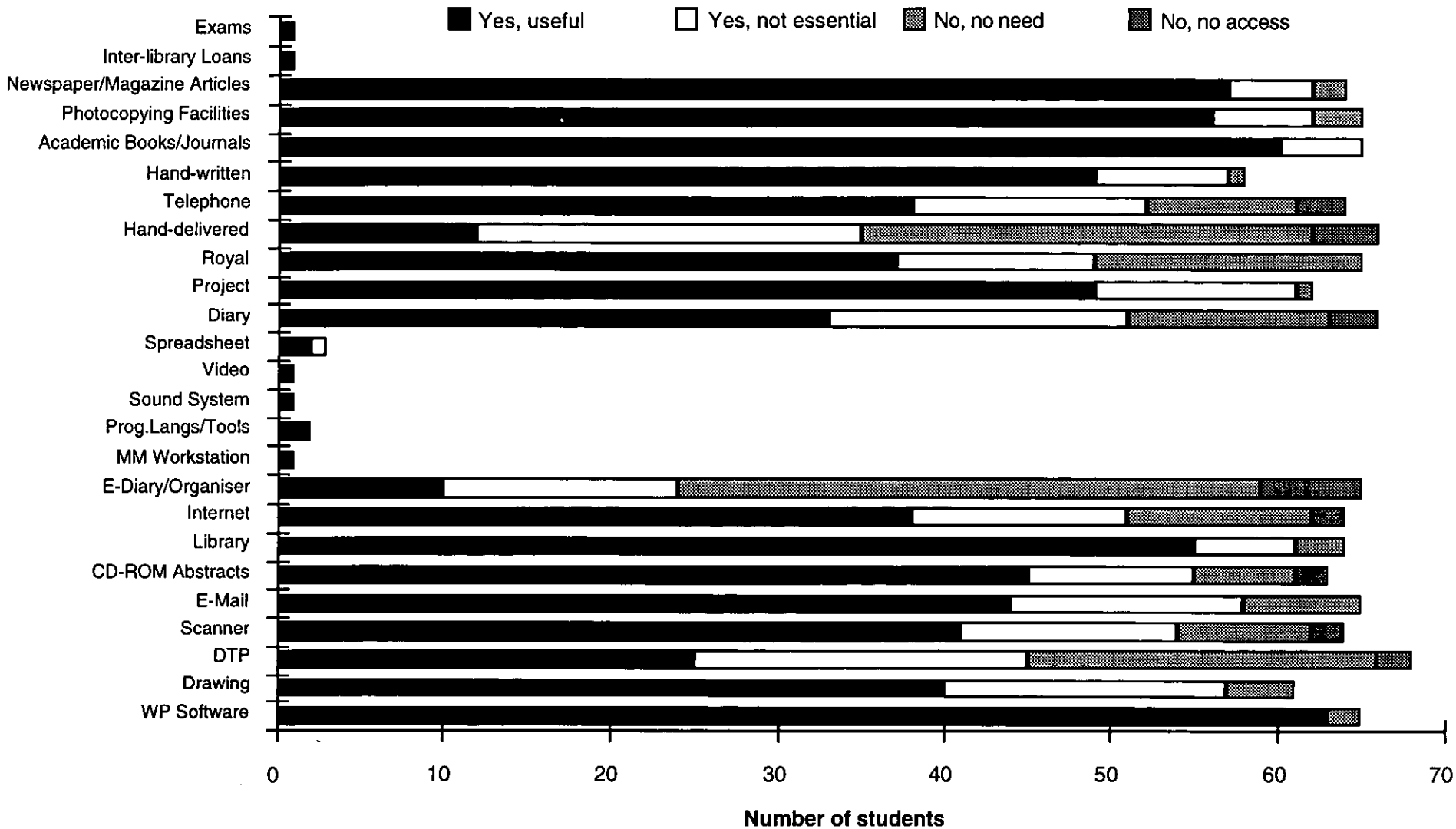

Figure 6.1: Resource preferences indicated by survey respondents.

6.2.3.1. Computerised writing artefacts

Word processing software was naturally the most popular of the computer-based resources. This reflects the students' trend towards self-publication of their dissertations. The library database was a popular resource, as were CD-ROM abstracts, with 93% and 80% respectively of respondents indicating that they regarded these as essential. E-mail is widely used in the School of Computing, and students indicated their reliance upon it (65%). The digital scanner was also regarded as useful for this group of students (60%). Drawing packages and desk-top processing packages were not as popular as word processing software (59% and 37%). The Internet was regarded as essential by a small majority of respondents (56%), although another 19% used it. Electronic diaries and organisers were not relied upon to any extent (15%). Only a small number of other computer-based resources were volunteered by respondents, including spreadsheet software, sound systems and programming languages.

6.2.3.2. Non-computerised writing artefacts

Academic books and journals were the most popular non-computer-based resources (88%). Newspaper and magazine articles were close behind, as were photocopying facilities (84% and 82%). Hand-written notes and project planning were regarded as essential by the same proportion of respondents (72%). The Royal Mail and telephone communications were regarded as similarly important (54% and 56% respectively), whilst hand-delivered mail was not considered essential (18%). The majority of respondents used diaries (75%), although less than half regarded them as essential (49%). Only two students volunteered other non-computer-based resources: one mentioned inter-library loans, whilst the other cited past exam papers as a useful resource.

6.2.4. Discussion of results

The results of this survey will be discussed in terms of the artefact typology described in chapter five. The main resources (or artefacts) can be tentatively grouped according to this typology as shown in table 6.1.

Type I artefacts	Type II artefacts	Type III artefacts
Newspapers/magazines	Hand-written notes	Scanner
Photocopier	Telephone	DTP package
Books/journals	Hand-delivered mail	Drawing package
Hand-written notes	Royal Mail	Word processor
Internet	Project Planner	Hand-written notes
Library database	Diary	
CD-ROM abstracts	E-diary/organiser	
Scanner	E-mail	

Table 6.1: Resources grouped according to typology.

6.2.1. Type I artefacts

Overall, type I artefacts were regarded as the most essential resources. Non-computer-based type I resources tended to be more popular than their computer-based equivalents. Considering that this group of respondents are computer-literate, one would expect the results to be even more favourable towards non-computer-based resources for music students. However, all computer-based type I resources were still popular, and given the expected ensuing rise in Internet usage (Nielsen, 1995), one might expect the balance to shift within the relatively near future.

6.2.2. Type II artefacts

Hand-written notes are still a very popular tool for recording, organising and developing written work. As they are so versatile, it is not really possible to categorise them. Consequently, they are assumed to transverse the proposed typology. As far as type II artefacts are concerned, hand-written notes were the most popular along with project planning. As note-taking is used very much in planning activities, this is perhaps no accident.

Activities involving human to human communication, such as telephone conversation and e-mail, are assumed in this case to be within the type II domain of the proposed typology. Most human-human communication in the context of dissertation development will involve queries and discussion, which can be regarded as having an organisational effect upon the process. The importance of computerised human-human communication artefacts was emphasised by the respondents, with e-mail scoring higher than the Royal Mail, telephone and hand-delivered mail. This observation has implications for computer-supported collaborative work, even in this specialised case of students producing an individual end-product.

The lack of popularity of computer-based diaries and organisers was surprising for this group of respondents. If computer science students prefer paper-based diaries, one would expect music students to.

6.2.3. Type III artefacts

The word processor was by far the most popular resource. Current products such as Microsoft Word and Word Perfect support basic drawing features, so perhaps for written work they will suffice. This perhaps explains why other type III resources, such as DTP packages were not so popular. It is recognised however, that the terminology may have been regarded by some respondents as ambiguous. Some students might regard a package such as Claris Works to be a word processor, where in fact this product encompasses painting, drawing, spreadsheet and database facilities. The scanner was regarded as important, perhaps due to the perceived requirement by students to include photographs and other pictorial examples in their literature reviews. Music students would probably also benefit from such a facility, particularly for scanning musical scores, as well as photographs and pictures, although issues of copyright are problematic in this context.

6.3. Conclusions and implications for further research

This chapter considered the usage of artefacts to support tasks which users of information technology typically employ in the context of essay and dissertation development. The attributes from the framework for HCI in educational hypermedia which relate to this include the tasks users perform as well as their interaction with those artefacts.

There are clearly a range of artefacts which could support essay and dissertation development in both computer-based and non-computer-based forms. The reported survey has attempted to identify suitable artefacts for a computer-based domain. It appears that there is a strong case for computer-based artefacts of types I and III, according to the proposed typology. Type II activities are not so clearly represented, however. Nevertheless, most advanced word processors do offer limited planning facilities in the form of outliners. However, there is little evidence that such facilities are regularly used at this level.

Type I activities may be adequately represented by computerised books, hypertext interfaces to the World Wide Web, such as Netscape, and appropriate CD-ROMs. Such applications have potential usability problems however, especially in the domain of hypertext, where issues of navigation and media manipulation are particularly contentious.

The specific model of essay and dissertation development for music students proposed in chapter five raises the question of specialised type I artefacts. In particular, an artefact is required which enables the simultaneous reading of and listening to music. Behavioural aspects of reading music from screens need to be researched to design a suitable artefact.

The absence of good type II artefacts suggests a gap in the provision of essay and dissertation planning resources. Whether essay plans are produced hierarchically, or in the form of argumentation structures is beyond the scope of this thesis. However, there is a case for providing novel planning tools which support either of these approaches.

The next chapters will consider the design of special artefacts for music education. Firstly, the issue of hypertext and document manipulation tools will be considered. This will be followed by an investigation into the behavioural aspects of reading music from screens.

Chapter 7
Comparing computer-based document manipulation techniques

7.1. Introduction

When Vannevar Bush wrote his visionary manifesto for what we now call hypertext (Bush, 1945), one can only wonder whether he ever imagined that the success of descendants of the memex machine would be threatened by problems of manipulation and navigation. Indeed, apart from "... provision for consultation of the record by the usual scheme of indexing", sequential paging using "... supplemental levers", a special button which "... transfers him immediately to the first page of the index" and of course "associative indexing", the hypothetical memex user had no other navigation aids. It is perhaps ironic that only three years after Bush's publication, another seminal text would demonstrate the likely existence of cognitive maps (Tolman, 1948). Given the knowledge imparted by Tolman, it is intriguing to consider whether Bush would have considered additional navigational features such as an overview map, bookmarks or a history list. In more recent times an enormous research effort has been committed to alleviating or at least minimising the problems of manipulating and navigating non-sequential electronic documents. Nielsen's annotated bibliography (Nielsen, 1990b), although dated due to the speed of research and development in this area, provides several references. Nevertheless, an interesting statistic is that, of 276 bibliography citations given by Nielsen, over a quarter of them are specific to manipulation and navigation issues.

The adoption of the metaphor-based hypermedia system (e.g. the travel metaphor and the book metaphor) has made a clear impact upon the choice of document manipulation and navigation facilities. One possible drawback of this approach is that to ensure a realistic representation through the metaphor, there is likely to be a requirement for a plethora of individual interaction techniques. In the case of the book metaphor for example, techniques include sequential paging, index referral, informal browsing, bookmarking and cross referencing. The impact of computerisation has led to extensions to such sets of techniques, for example direct search/retrieval and hypertext. This may result in users experiencing cognitive overload, or becoming disorientated as a result of the spatial metaphor being employed in the first place (Stanton, 1994). If a metaphor is to be adopted for novice users, however, care must be taken to choose interaction styles that do not contradict it (Carroll, Mack and Kellogg, 1988). It is also important to be aware of the possible effects that individual interaction techniques may have on each other, as well as on the user.

Techniques to aid the manipulation of a computer-based document were tested by a group of 38 novice users. The subjects were given a period of time to browse the document (which employed a simple book metaphor), and were subsequently given a set of goal-related tasks in a question/answer session. The techniques tested were sequential paging, index referral, text find and embedded hypertext links. In the latter case, three differing types of link mechanisms were assessed and compared with each other. It was found that sequential paging and index referral were the most commonly used of the techniques. Text find was employed more for goal-related tasks than for browsing. The hypertext link technique was generally unpopular, especially for goal-related tasks. In order to establish the importance of the text find technique, the effect on reading strategies without this facility was also investigated. For browsing operations, an increase in paging and a decrease in hypertext linking was observed. In the case of goal-directed searching, an increase was observed in paging and index referral techniques.

7.2. Experiment Overview

Results of an experiment that compared techniques for reading an electronic document employing a book metaphor are presented. A group of 38 novice users (undergraduate fresher students beginning a Technology Management honours degree course at Staffordshire University) was chosen as the subject population. The application presented to the subjects was a short biography (comprising 50 HyperCard cards) of the late jazz musician Charlie Parker. The presentation medium was predominantly text based, but some graphics were included. The application was written in HyperCard 2.0. Subjects each used an Apple Macintosh LCII, with keyboard and mouse available as input devices.

No on-line help was available to the subjects, as it was considered potentially distracting given the short time frame of the experiment (one hour). Instead, a paper-based help sheet was issued to each of the subjects. The help sheet contained screen shots with annotated descriptions of the manipulation tools and features.

Techniques available to the subjects were as follows (refer to figure 7.1):

• *Sequential Paging*: next page, previous page and last page functions were made available. A single click on the appropriate button initiated the paging function. Paging functions were provided throughout. In this respect, the biography could be read from beginning to end in a purely sequential fashion. Consequently, movement to and from index pages was also counted as a paging manipulation.

• *Index Referral*: indexes were grouped according to subject within the biography as opposed to the more traditional alphabetic approach. There were four sub-indexes: a chronological calendar, a list of people who played an important part in Parker's life, a list of places integral to the biography and finally a list relating to Parker's music. Indexes were accessed via a simple pull-down menu at the top of each screen (the screen displays in figure 7.1. do not show this menu). When a student clicked on the index entry, control was passed automatically to the associated page within the biography.

• *Text find*: this technique was made available to only half of the subject population. Automatic text finding is an extension of the normal functionality of a paper-based book and therefore is potentially problematic from a metaphorical point of view. It was therefore decided that the effect on navigation strategies (especially goal-directed searching) of denying users access to a direct search method should be investigated.

• *Embedded Hypertext Link*: a hypertext link anchor was indicated by bold highlighted text within the body of the biography's narrative. Three types of link mechanism were tested through roughly equal division between the 38 subjects. Description of the mechanisms follow:

• *Simple jump style*: when the user single-clicked on the selection, the target page was jumped to immediately. Twelve subjects were allocated this method.

• *Pre-jump link anchor definition*: a single click on the link anchor displayed a definition of the link anchor. An option-click[2] initiated the jump itself. Thirteen subjects were allocated this method.

• *Pre-jump link target definition*: a single click on the link anchor displayed an indication of the target destination. As for the pre-jump link anchor definition, an option-click initiated the link. Thirteen subjects were allocated this method.

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[2] An option-click is an Apple Macintosh convention, where the option key is held down in combination with a mouse click.

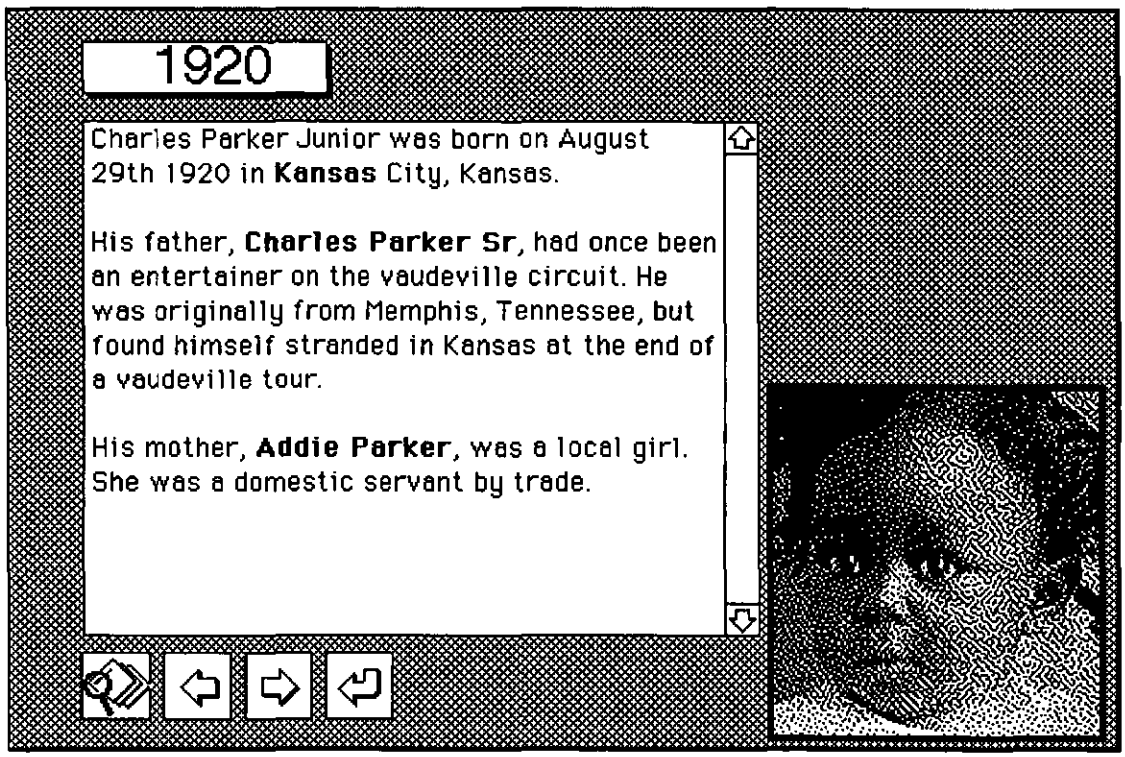

Figure 7.1a: Typical screen showing navigation icons in lower left corner.

Hypertext links are indicated by bold text.

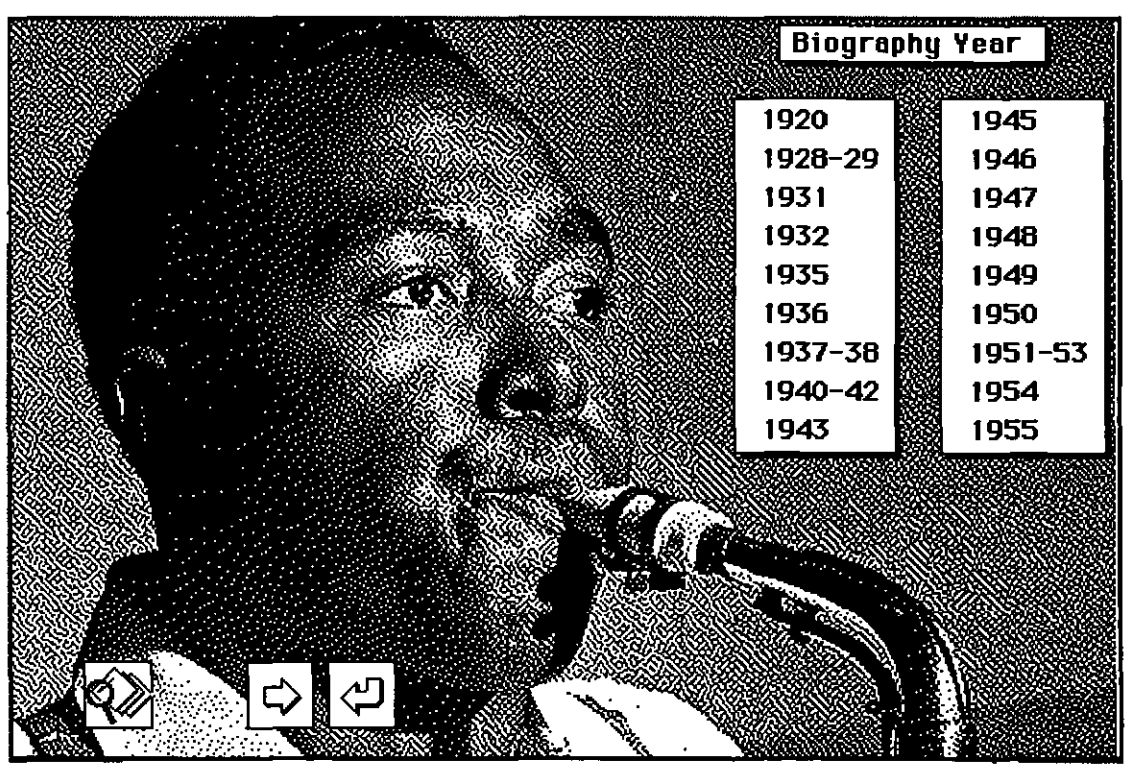

Figure 7.1b: Index Referral.

In this example, the user clicks on a year in order to access the page of interest.

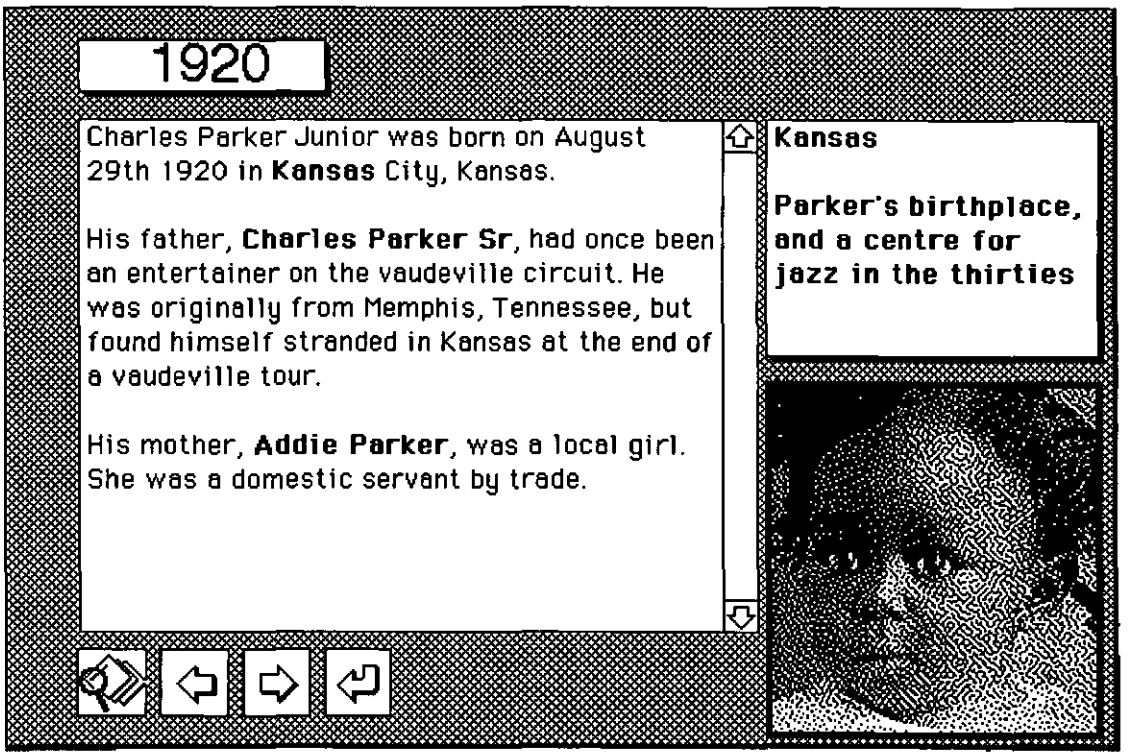

Figure 7.1c: Example of Pre-jump link anchor definition.

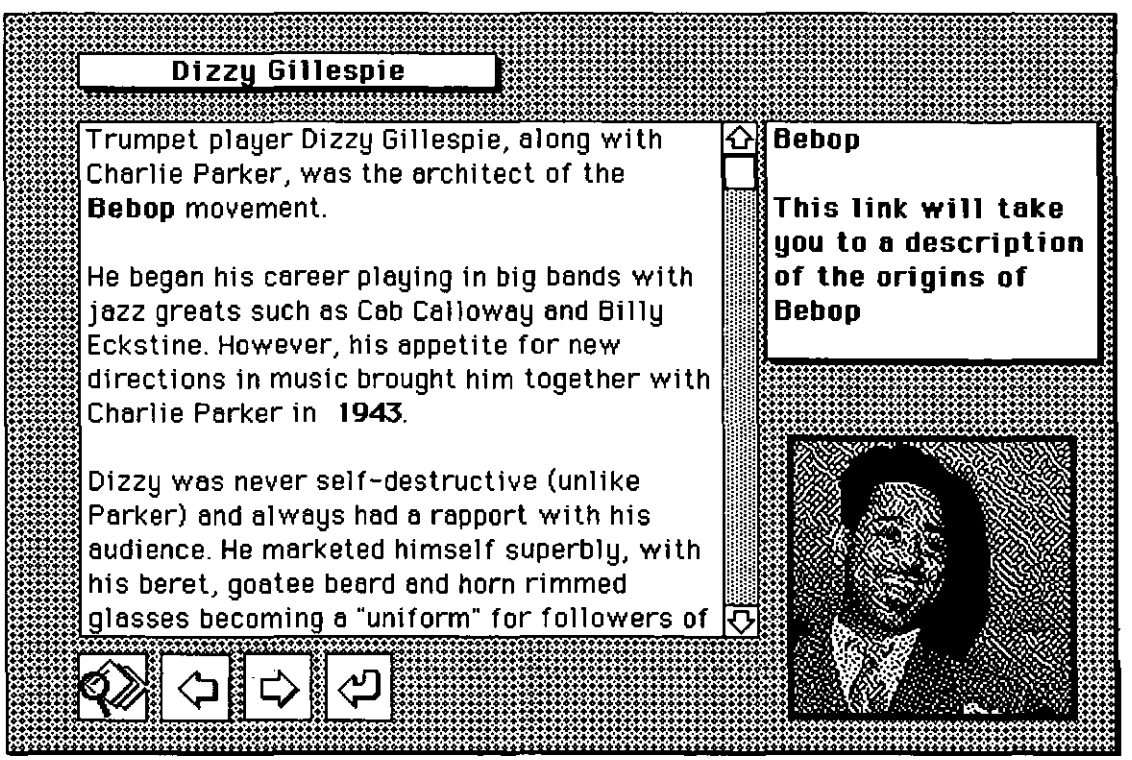

Figure 7.1d: Example of Pre-jump link target definition.

A method of logging was employed to record system events. Each event was numbered as well as being time-stamped. Examples of some logged events are listed below:

180 21:46:13 Card Biography Year Index Opened
181 21:47:47 Searched for Mood
182 21:47:48 Card 1948 Opened
183 21:47:49 Search Successful
184 21:48:00 Card Music Index Opened
185 21:48:01 Selected Music Index Menu Item Parker's Mood
186 21:48:03 Card Parker's Mood Opened
187 21:48:59 Card Music Index Opened

Within the context of this study, groups of one or more system events constitute single user manipulations. For example, the above system events 181 through 183 inclusive constitute one manipulation (i.e. a successful text search). System events 185 through 186 represent an index referral manipulation. System event 187 is a last page manipulation.

The subjects were tested in two contiguous hour-long sessions. The first group of nineteen subjects was given access to all of the navigation techniques previously described. The second group was denied access to the text find mechanism. The hypothesis for this comparison was that the denial of the direct search method would affect the searching strategies employed by the user. It was expected, for example, that users would adopt a higher proportion of embedded hypertext functions as a consequence of text find denial.

7.3.1. Procedure

Subjects were given twenty minutes to familiarise themselves with the application and with the biography itself. During this time, they were encouraged to explore and browse through the document.

After this initial period, a set of goal-directed tasks were presented in a question/answer session. Ten questions relating to the biography were asked at three minute intervals. In order to complete each task, specific facts had to be located within the document, for example: *What was the first name of Charlie Parker's mother?* and: *When did Charlie Parker die?* The question selection was pre-tested via an informal pilot study prior to the experiment delivery. The study ascertained that the answers to questions were readily located in the document. Questions were also designed such that their solutions were

located in one and only one location. It was therefore expected that the vast majority of subjects would answer all questions correctly given the three minute time limit.

The final ten minutes of the one hour session was dedicated to a subject de-briefing. Participants were asked their subjective views of the package and their impression of it as a possible alternative learning environment to that of the traditional paper-based approach. The Likert scale (Likert, 1932) was employed to allow subjects to offer their interpretation of the following three conjectures:

a) The package was well presented and usable
b) The package caused a high degree of frustration
c) The package would be more useful in a learning environment than a paper-based text book

The five grades offered on the Likert scale are: strongly disagree, disagree, no opinion (neutral), agree, strongly agree. For the purposes of analysis, the grades were allocated interval values between one and five.

7.4. Results

The overall average number of manipulations per subject in the hour-long session was 76.7. For those subjects who were permitted the use of the text find facility, the average was 64.4. In the case of those who were denied the facility, this figure was substantially greater (88.9). This result was expected, especially for goal-directed searching tasks. The usage of the techniques is represented in figure 7.2.

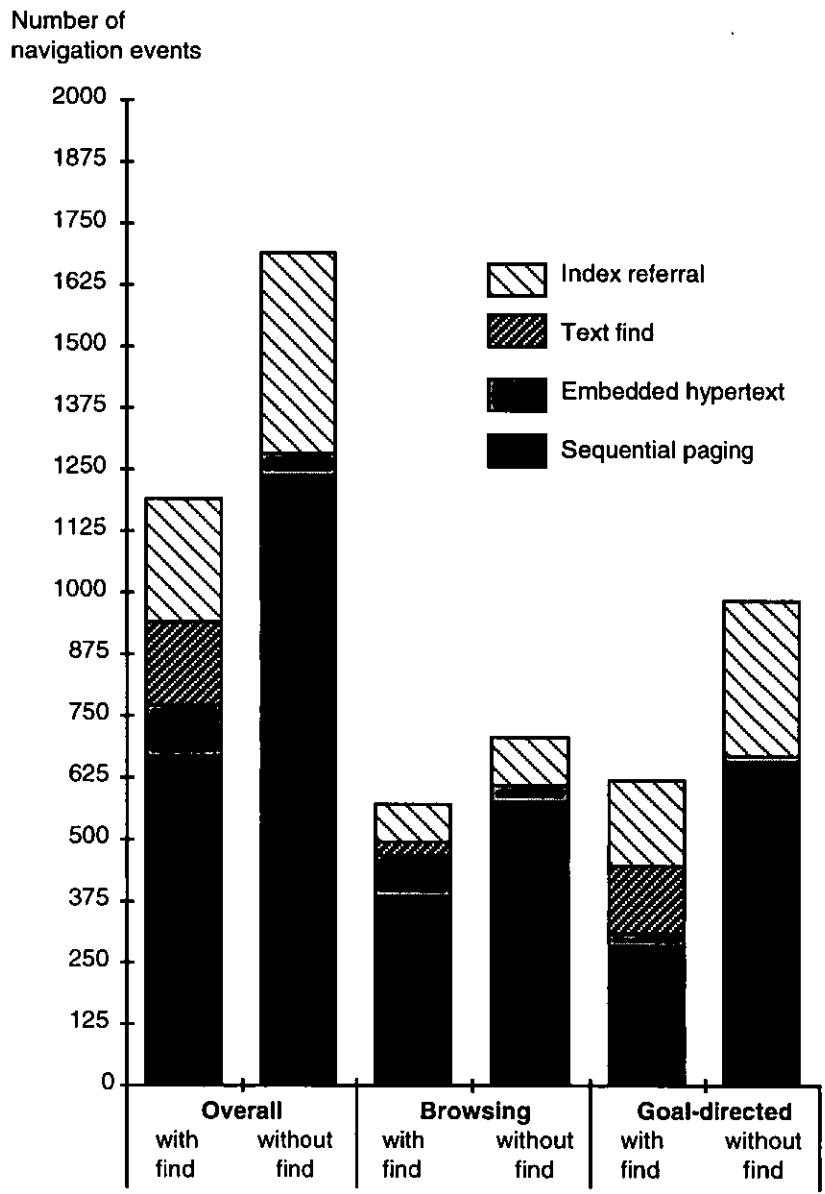

Figure 7.2: Relative usage of navigation techniques under differing conditions.

It can be seen that overall, paging is the most popular of the four techniques, followed by index referral. Text finding was more popular than hypertext linking (when it was available).

For browsing activities, embedded hypertext was as popular as index referral when text find was available. However, for the group which was denied the text find facility, hypertext linking was surprisingly less popular.

For the goal directed searching task, text find was understandably popular, though it was still not as popular as paging. Index referral techniques were also employed more than they were for browsing activities, whereas hypertext linking was employed less for goal-directed searching than for browsing (4.0% versus 14.0% with text find — 1.1% versus 4.7% without text find).

A more formal analysis was performed to assess the significance of the text find facility on manipulation strategies. The usage of each of the three other techniques was analysed using a set of two sample independent t-tests. The first sample in each case was the group of 19 subjects who had access to the text find facility. The second sample was the group of 19 subjects who had access to this facility denied. The null hypothesis H_0 for each of the tests was: that the denial of the text find facility would cause no significant change in the amount of usage of the specific technique. The overall effect, the effect on browsing and the effect on goal-directed searching were all independently analysed. This produced nine separate sets of results. The null hypothesis was rejected if t>t(36;5%). Table 7.1 summarises the results.

Null Hypothesis relating to:	Overall
Hypertext Link	+2.72
Paging	-3.86
Index Referral	-2.90

Null Hypothesis relating to:	Browsing
Hypertext Link	+2.52
Paging	-2.40
Index Referral	-0.91

Null Hypothesis relating to:	Goal-directed searching
Hypertext Link	+1.31
Paging	-2.96
Index Referral	-2.89

Table 7.1: Results of two sample independent t-tests.

Circled values indicate significant results — t(36;5%) = 2.02.

The results indicate that there was significant overall change in the usage of all three techniques. The surprising result is that, contrary to expectations, there was a significant decrease in the usage of embedded hypertext links when text find was denied. This was however, only significant for browsing activities. Index referral was used significantly more overall, but was not significant when tested for browsing in isolation.

The analysis of the three differing mechanisms for hypertext link initiation resulted in an Analysis of Variance (ANOVA) as shown in table 7.2. The null hypothesis proposed that there was no difference in the amount of usage of link initiation between the three hypertext link styles. It should be noted that in the cases of pre-jump link explanation styles (i.e. pre-jump link anchor definition and pre-jump link target definition) a link was only counted if the jump was actually performed. The ANOVA could not reject the null hypothesis with $[F(2,35) = 3.28, p < 0.05]$.

Source	SS	df	MS	FR
Between link types	45	2	22.5	1.5
Error	529	35	15.1	
Total	574	37		

Table 7.2: ANOVA for assessing whether there was any significant difference between the usage of the three hypertext link styles — $F(2,35;5\%) = 3.28$.

The results of the post-session debriefing produced a largely positive response from the experiment's participants. There was no significant difference between the impressions indicated by the group of subjects who were denied the use of the text find facility and those who were allowed it. There was also no significant difference across the groups of subjects who were using different hypertext linking mechanisms. Using an interval transformation of the Likert scale in the range one to five, the means and standard deviations for the three conjectures were as follows:

a) The package was well presented and usable

Mean: 3.47 Standard Deviation: 0.29

b) The package caused a high degree of frustration

Mean: 1.86 Standard Deviation: 0.25

c) The package would be more useful in a learning environment than a paper-based text

Mean: 4.46 Standard Deviation: 0.21

7.5. Discussion of Results

The overall results of this experiment indicate that certainly novice users appear to prefer navigation techniques that map directly onto the equivalent paper-based method, that is paging and index referral. This is presumably because they are more familiar with such techniques. The other techniques (text finding and embedded hypertext linking), which effectively extend the book metaphor, were not so popular.

The surprising result demonstrated by those subjects who were denied the use of the text find facility was its negative effect on embedded hypertext usage. The cause of this significant difference is not clear, but an analysis of the number of manipulation strategy changes revealed that subjects who were permitted the use of the text find facility changed techniques more often than their counterparts (every 3.1 manipulations on average as opposed to every 4.3 manipulations). However, the number of available state changes is twelve for four techniques as opposed to six for just three techniques, so one would expect at least some difference.

One possible explanation for the low use of hypertext linking when text find is denied could be related to the under-determination of the interface (Thimbleby, 1990). Figure 7.3 represents a graph of the strategy shifts undertaken by two typical subjects — subject (a) was permitted text find, subject (b) was denied it. The higher number of manipulations performed by subject (b) is clearly indicated. The diagram also illustrates the often lengthy period that subject (b) spends executing one strategy. When under pressure to perform tasks for which a useful subset of tools is not available, as in the case of the lack of provision of text find, it is perfectly reasonable to expect subjects to experience a certain sense of frustration, or even panic when faced with time constraints. In this situation, a subject is less likely to think in a coherent and considered way. Hence, rather than searching for goals, a more appropriate description might be *groping*! In such a situation, the question arises as to whether a user is less likely to change strategies because of a kind of *mode lock* induced by frustration, disorientation and/or anxiety. Such emotions may have been exacerbated by the three minute time limit for the question/answer sessions — however, the success rates were not significantly different between subjects who were denied text find and those who were allowed it (7.2/10 versus 7.8/10 average number of correct answers). Canter, Rivers and Storrs (1985) don't suggest stress as a factor for characterising user navigation — but perhaps alternative strategies may arise when users are in varying psychological states? Such conjecture would obviously need further study in order to be validated.

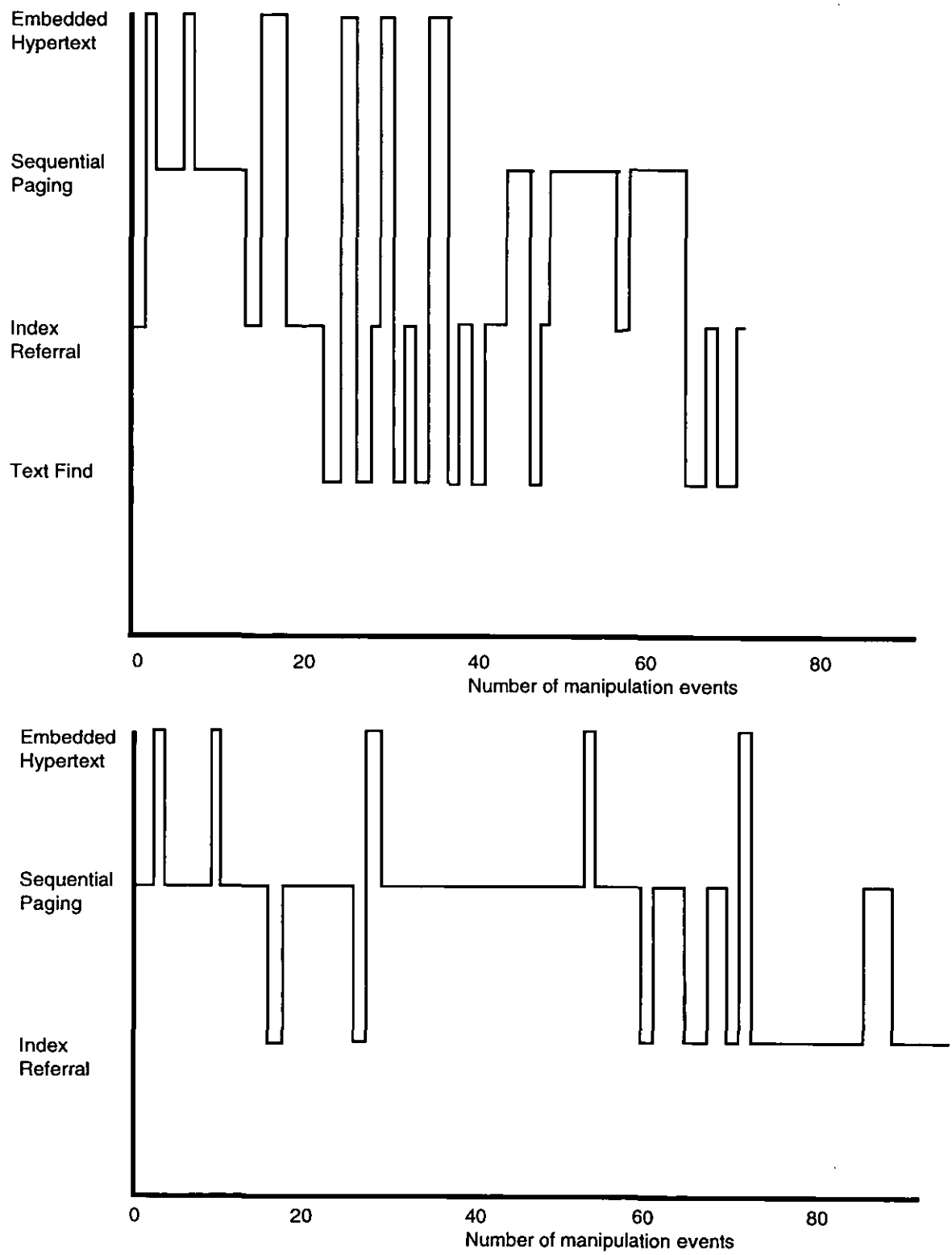

Figure 7.3: Top — Record of navigation of events for subject with text find permitted. Bottom — Record of subject with text find denied.

The three types of hypertext link that were tested against each other by no means cover all alternatives, but the comparison of some different techniques was considered useful to the study. The lack of difference between those mechanisms tested was exacerbated by the fact that once subjects realised they could bypass the pre-jump explanation by option-clicking on the Macintosh system, they tended to avoid the explanation completely. This can be explained by the observation that the number of manipulations required to (a) view the explanation then follow the link; and (b) follow the link anyway and if it is not what was expected click on the *previous* icon; are both the same. Perhaps in a larger hypertext system, where the probability of getting lost may be greater, pre-jump explanations might be more usefully employed.

A depressing possibility relating to the hypertext facility is that it may have been even more unpopular than the results suggest. The usage of hypertext linking was most popular for browsing techniques. However, as browsing was the first activity to be undertaken by the subjects, and given that familiarisation with the application was taking place during this period, it is apparent that the subjects could have been merely *trying out* the alternative manipulation strategies, only to ultimately reject hypertext (for whatever reasons) when moving further into the session, and towards the goal-directed activities.

The results of the debriefing session were largely positive, especially the final conjecture put to the subjects: "The package would be more useful in a learning environment than a paper-based text book". The high average score (4.45) is underlined by the fact that no subject gave less than 4 (agree). In other words, every student without exception regarded this method of learning as more useful than a standard textbook. Whilst this result is encouraging for advocates of hypertext systems, it must be regarded with some caution, as other factors must be taken into consideration. For example, as the subjects were novices and had consequently no prior experience of such technology, there may have been an overall attitude of novelty towards the package.

7.6. Conclusion and implications for further research

It was regarded as important to consider the implications that document navigation and manipulation may have on the design of an environment to support essay and dissertation development. This is highlighted by the number of issues which this chapter has considered from the framework for HCI in educational hypermedia (i.e. interaction, users, evaluation, educational domain and tasks). However, it is also apparent that it is difficult to investigate conclusively these issues. Indeed, given that there are a number of surprising results from the reported experiment, it would be over-ambitious to draw any specific conclusions from the subsequent analysis. What is apparent however, is that even for relatively small electronic documents, design decisions that are based on intuitive approaches are potentially dangerous. For example, hypertext *seems like a good idea*, and its many advocates have presented very credible arguments as to its usefulness in educational software. However, even a simple empirical study such as this brings those arguments into question. Indeed, the influence of hypertext on contemporary developments in computer assisted education appears to be distinctly marginal, as suggested recently (Whalley, 1993):

> The adoption of such a conceptually simple technology as hypertext is unlikely to have as much pedagogic impact as was originally claimed.
>
> *Whalley, 1993 (16)*

Chapter 8
Reading music from screens versus paper

8.1. Introduction

Undergraduate music students are regularly invited to write essays and dissertations of a biographical nature. This type of work requires a great deal of interaction between the two activities of reading music and listening to music. This is intuitively obvious in the context of biographical study. Nevertheless, the observation raises the question of identifying appropriate artefacts to support these parallel activities in a computer-based environment. It is possible that a computer may harness such parallel activities in an interactive multimedia representation.

Traditionally, music students will listen to a piece of music with the manuscript in front of them (if they can get it — otherwise, a transcription exercise is necessary). Whilst the music is playing, notes can be taken to remind them of important points in the score, such as typical motifs, unusual chord structures and so forth. The best sight-readers will have no difficulty in following even the most complex of scores. They will read ahead, look away to make notes, close their eyes even, and still manage to locate easily the current place in the score. However, not all musicians are so gifted — they get lost occasionally. The potential for computer-based score trackers in this context is clear. If a student does need briefly to look away from the score during their study, perhaps a score tracking device could help. At another level, students with basic reading skills may benefit from such an approach.

This chapter considers the issues relating to the cognitive psychology of reading from screens in general. The use of computer-based animation in education is also briefly reviewed. A specific study which compares a number of computer-based presentation styles to assist reading and listening to music is then described. The results of the study are considered in the context of the future for computer-based music reading tools.

The reading of music text from a computer screen was compared to paper in a laboratory controlled study. Computer-based animated score tracking devices of three types were tested, as well as a static screen representation of the music text and its paper-based counterpart. A proof-reading exercise was given to subjects, which involved them listening to pieces of music and identifying intentional errors in the score. Their subjective views were also recorded. No significant difference between the five presentation styles were apparent in the proof-reading study, although observational evidence suggests that

animation improved performance. Subjects showed a significant preference for animation over paper and static representation. The most popular style of animation was where each note on the score was marked in time to the music. Paper performed better overall than the static screen representation.

8.2. Reading from paper versus reading from screens

Comparisons between the effectiveness of reading text from paper and computer screen have been an issue of psychological enquiry for a number of years. Most research was undertaken in the 1980s, as much interest abounded with the rapid evolution of screen display technology. Most of this research has tended to regard reading from paper to be faster than from screens (Muter et al., 1982; Wright and Lickorish, 1983; Gould and Grischowsky, 1984), although some studies have found no significant difference between the two (Switchenko, 1984; Askwall, 1985; Cushman, 1986; Muter and Maurutto, 1991). In terms of accuracy (in a proof-reading scenario for example) the results of research are also unclear. Wright and Lickorish (1983) and Gould and Grischowsky (1984) have reported no significant differences, whereas Creed, Dennis and Newstead (1987) and Wilkinson and Robinshaw (1987) found screens to be significantly poorer. The whole issue is still one of debate, as consideration for factors such as fatigue, personal preference and comprehension are often overlooked in preference to quantitative measures such as speed and accuracy. A complete discussion of the issues is beyond the scope of this paper. For the interested reader, Dillon (1992) provides a comprehensive and balanced critique, and concludes in his review of the issues:

> Although reading from screens may be slower and occasionally less accurate than reading from paper, no one variable is likely to be responsible.
>
> *Dillon, 1992 (1314)*

As display technology continues to improve in presentation quality and portability, one could argue that any differences between screens and paper may one day be eradicated. More recently, a number of researchers have advocated screen-based media, choosing to concentrate on the conceptual differences between paper and screens (as opposed to the visual) and the opportunities for improved text manipulation (e.g. Reinking, 1992; Landow, 1992; Cunningham et al., 1993).

8.3. Computer-based animation

Computer animation is used widely in the film, advertising and computer games industries. Its ability to recreate realistic environments has also led to applications in simulation and modelling, not least in the currently topical domain of virtual reality.

Whilst animation has been used extensively in computer-based educational applications, most of this has only provided a novelty value (Rieber and Kini, 1989). The difficulties encountered by researchers in this area are exacerbated by such effects over studies of short duration (Clark, 1983). One must be conscious of novelty effects in any study relating to educational research, whilst also being aware of the ethical implications of longitudinal studies.

Most serious research into computer-based animation for learning was undertaken in the late 1980s, when the technology for production and presentation became widely available. Application areas have largely concentrated on drill and practice instruction, for example, Rieber, Boyce and Assad (1990) and Palmiter and Elkerton (1991).

Some researchers have specifically investigated the combination of text and animation. Chen, Chan and Tsoi (1988) and Chen and Chan (1990) tested a number of methods of displaying animated text on a computer screen. Speed of reading and comprehension were both considered. Results suggested that animation may help to increase both of these factors, although no control group was used. Their study attempted to find the best form of animation, as opposed to whether animation *per se* is more effective than more traditional presentation styles. Another novel study considered whether reading performance could be improved by varying the presentation rate of text on screen (Tombaugh, Arkin and Dillon, 1985). Reading material was presented to subjects at 15 characters per second (cps), 30, 120, 960 and instantaneously. They found that comprehension was highest under the 30 cps and the instantaneous conditions. They also found that task completion time was slow for the slower presentation of 15 cps. Whilst this may seem intuitively obvious, previous recommendations (Bevan, 1981) had suggested slow rates for novice users. As with early studies regarding reading text from screens, much seems to have depended on the technology of the day.

8.4. Experiment overview

Whilst much research effort has concentrated on the effect of reading standard text in a computer-based domain, as yet no empirical study has considered the effect of reading music text from a display screen. Nevertheless, by implication one might expect there to be some differences between paper and computer presentation, as this seems to be a relatively repeatable phenomenon. The usefulness of animation is intuitively more domain specific, and given the lack of research in the area of reading music from screens, it is certainly worth ascertaining what, if any, effect it might have.

An experiment was undertaken to establish some indication of users' performance and attitude to this phenomenon. The opportunity to compare various animated reading aids was also taken.

A number of presentation styles were considered for this study. The most obvious ones are the simple paper-based medium, as well as its screen-based counterpart (i.e. a static representation of the music text on screen). A review of MIDI music publishing software and the various reading support tools they offer was carried out to identify computer-supported presentation styles. This revealed three commonly used animated music tracking techniques: a smooth tracking device, which moves along or above the music stave (henceforth referred to as a *Tracker*), a bar marker, usually situated above the music stave at the beginning of the currently playing bar (henceforth referred to as a *Stepper*), and a note marker, often called a *bouncing ball*, which indicates which note is currently being played (henceforth referred to as a *Jumper*).

One other novel technique was piloted. This involved animating the stave itself, as opposed to an animated music tracker. A single line stave smoothly moved from the right to left of the display screen in time to its music. It transpired however, that such a presentation technique was unfeasible, as the pilot subjects found it impossible to follow the music. This can be explained by the fact that a stave related to anything but slow music moved faster than the fixation threshold of the human eye. For example a semi-quaver at 120 beats per minute would remain still for 125 milliseconds — approximately half the duration of a typical eye fixation. Unless the reader can read ahead of a moving target (as opposed to reading ahead of static music text), such demands are beyond expectation. The technique was abandoned. Consequently, only five presentation styles were selected: *Paper*, *Frozen* (static screen display), *Tracker*, *Stepper* and *Jumper*.

In accordance with earlier accuracy-orientated text reading studies, a proof-reading exercise was decided upon. Reader preference was also considered. Arguments of ecological validity against such an approach are well-documented (e.g. Dillon, 1992), but as this is essentially an investigative study with an aim to provide indicators of performance and preference, the experimental design is deemed sufficient.

The null hypothesis H_0 for this study was: there is no difference between the presentation styles, either on paper or on a computer display monitor, whether animation is or is not employed in the latter medium.

8.5. Method

Three pieces of music of varying difficulty were selected for the study. The pieces of music were all short extracts (about thirty seconds each) from the opening melody of established jazz melodies — *Embraceable You,* by George Gershwin; *Yardbird Suite*, by Charlie Parker; and *Giant Steps*, by John Coltrane. The author consulted with experienced musicians to confirm the relative difficulty of each piece of music. *Embraceable You* is a very simple, slow ballad; *Yardbird Suite* is a medium speed be-bop tune based on a simple chord progression; and *Giant Steps* is a racing, complex tune, with unusual and unexpected chord changes.

Each piece of music was transcribed into a computerised form using the music publishing package Encore, on the Apple Macintosh platform. The short duration of the pieces meant that each one could be displayed on one screen alone. The proof-reading exercise was accommodated by the inclusion of intentional errors in each piece of the written music. The subjects' task was to record the errors by repeatedly listening to the accompanying music. Various errors were considered at the piloting stage of the study such as pitch errors, rhythmical errors and misplaced notes. However, it was decided that pitch errors alone would suffice, as more complex errors might result in knock-on effects subsequent to the error (e.g. a subject could lose place after the confusion of a rhythmical error).

An accompanying digital soundtrack for each piece was used from *Jazz: A Multimedia History*, published on CD-ROM by Compton New Media. HyperCard stacks were used to display static music text, whilst sound and animation were overlaid onto each stack using the Macromedia Director suite of software. To minimise any confounding variables with the bit-mapped resolution of the HyperCard stack, a printout of the stack itself was used as the paper copy (figure 8.1).

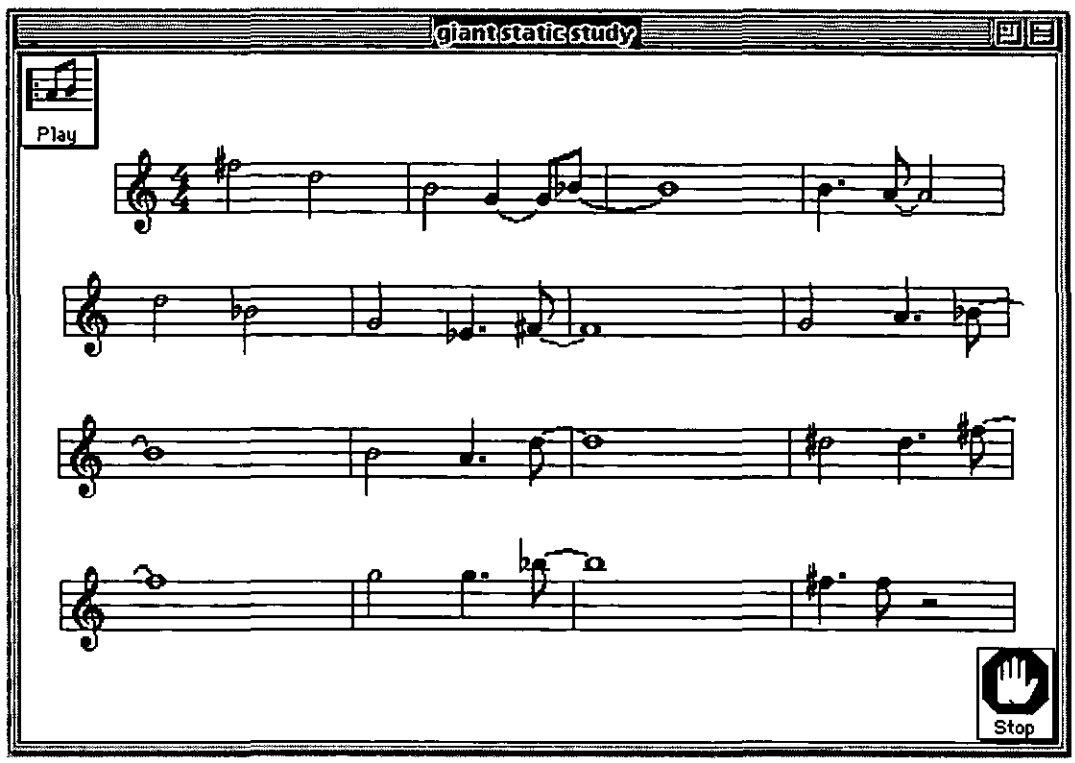

Figure 8.1: Example of HyperCard stack. This piece has three intentional pitch errors in bars 8, 12 and 14 respectively.

8.5.1. Subjects

Nineteen subjects took part in two sessions at the computer music studios of the City of Leeds College of Music. The studios incorporate a laboratory containing fifteen workstations. Each workstation comprises an Apple Macintosh LCII, a MIDI keyboard, interfacing hardware, and high-fidelity Sennheisser headphones. Thirty subjects in total were expected, but adverse weather conditions affected attendance.

A range of music reading abilities was exhibited by the subjects — two were Music BA (Hons) students, sixteen were BTEC students on the Music Technology programme and one was an Engineering student from Leeds Metropolitan University familiar with music composition techniques. Seventeen students were male and two were female.

8.5.2. Procedure

Subjects were asked to make themselves comfortable at one of the workstations. The author, who was present throughout the experiment, explained the nature of the study and

its potential relevance to computer-based music reading tools. Subjects were told the procedure of the experiment, and what was expected of them. An accompanying set of instructions was handed out. All subjects were advised that if they had trouble at any time during the experiment, they should ask for help immediately.

Three HyperCard stacks were displayed on the computer screen. They were labelled *1*, *2* and *3* respectively. Each icon referred to a different piece of music. Each workstation had a different configuration of both music and presentation styles, such that any interaction between order of play, music and style would be randomised. Therefore, a subject would listen to all three pieces of music, but only see three presentation styles, providing a total sample of 57 tests. Those subjects who would be reading music from paper were given a paper copy at the beginning of the experiment, but were told not to look at it until the software gave them an indication to do so. This instruction was provided after opening the relevant HyperCard stack.

Each piece of music contained three errors. The subjects were told that there were up to three pitch errors in the music (i.e. 0, 1, 2 or 3). The instruction sheet contained small forms for the subjects to record their perceived errors. They were asked to indicate in which bar the error occurred, as well as writing down a short explanation (e.g. the G should be higher).

The instruction sheet guided the procedure closely throughout. Once a subject had double-clicked on icon *1*, they would see the piece of music displayed on the screen, along with an icon named *Play*. Once this was clicked, the music would play three times, with a gap of approximately fifteen seconds between each rendition. Subjects were advised to try to spot one error on each listening. This procedure was decided on at the piloting stage, as potential short-term memory overload was identified. After finishing the first piece of music, subjects could look at the music text one last time before clicking on the *Stop* icon. When this was done, HyperCard was closed down in preparation for the user double-clicking icon *2*. The same procedure was carried out for icon *3*.

Once the subjects had finished the proof-reading exercise, their familiarity with the music, their subjective preferences and their music reading abilities were recorded. This information was acquired via a short questionnaire, and related to each piece of music as well as the style in which it was presented. Questions enquired as to the students' familiarity with the music, the degree to which the presentation style annoyed them, the

degree to which the presentation style helped them to follow the music and their perceived complexity of the music. For clarity, further reference to the questions will be referred to as *Familiarity*, *Annoying*, *Helpful* and *Complicated* respectively. A five-level Likert scale was employed to record subject responses (Likert, 1932). Subjects were asked finally to add any comments of their own which they felt might be helpful.

8.6. Results

Statistical analysis comprised largely of ANOVA comparisons, primarily to test the null hypothesis that there was no significant difference between presentation styles. The dependent variable in this experiment was the subject score i.e. success in identifying the errors in the music text. The questionnaire results were also analysed, mainly in the context of subject preferences (descriptive analysis suggested a normal distribution). The independent variable was the presentation style, although analysis was also carried out on the music itself to identify if any interaction or bias resulted from perceived musical complexity (or even taste).

8.6.1. Proof reading study results

No significant difference was found between styles of presentation when subject score was used as the dependent variable [$F(4,52) = 0.421$, $p = 0.7927$]. An interaction bar plot (figure 8.2) however, provides some observational evidence that the animated music scores have performed better than their static counterparts.

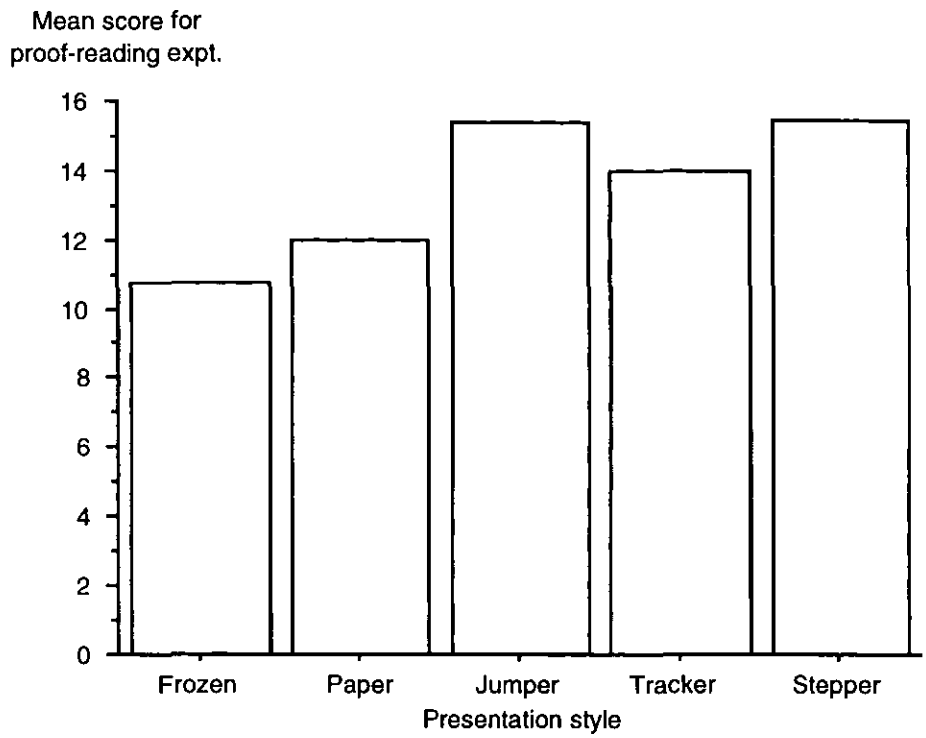

Figure 8.2: Histogram for presentation style against proof-reading score. The vertical axis is the mean value for the proof-reading score. Ten points were awarded for each correct observation, providing a range of 0-30 for each subject.

8.6.2. Subjective study results

For the purposes of the statistical analysis, all responses were converted to an interval scale with a range from one to five. When subjective data were considered, significant differences between some styles were observed. Firstly, for the assertion "The presentation style for this piece of music annoyed me", a significant difference was observed [$F(2,54) = 2.738$, $p = 0.0384$]. Post-hoc analysis revealed that *Jumper* was perceived to be less annoying than *Frozen* and *Paper*, and *Tracker* was perceived to be less annoying than *Frozen*.

No overall significant difference was evident regarding the assertion "The presentation style for this piece of music helped me to follow the music" [$F(2,54) = 2.539$, $p = 0.0654$]. This figure is very close to the 5% boundary however, and post-hoc analysis suggests significant differences between *Frozen* and *Jumper* and *Frozen* and *Tracker*.

Although these figures appear to be interesting, it is important to consider possible interaction effects due to the three music pieces. No significant difference was observed across the pieces of music [$F(2,54) = 2.614$, $p = 0.0825$], although again, as the level is close to 5%, post-hoc analysis reveals *Embraceable You* to be perceived as less complicated than *Yardbird Suite*.

An analysis was carried out to establish whether the music itself had an effect on the subjects' preferred styles of presentation. Although there was no significant effect on the *Annoying?* scale, a significant result was generated on the *Helpful?* scale [$F(2,54) = 3.497$, $p = 0.0373$].

The concern here is that results have been affected not by presentation style, but by the music itself. Another ANOVA was carried out, this time considering the interaction between music and presentation style. No significant effect was identified [$F(8,42) = 0.868$, $p = 0.5507$].

Observational analysis illustrates this, as shown in figure 8.3. It can be seen that whilst *Embraceable You* scores highly across the presentation styles, *Frozen* performs badly for all three pieces of music.

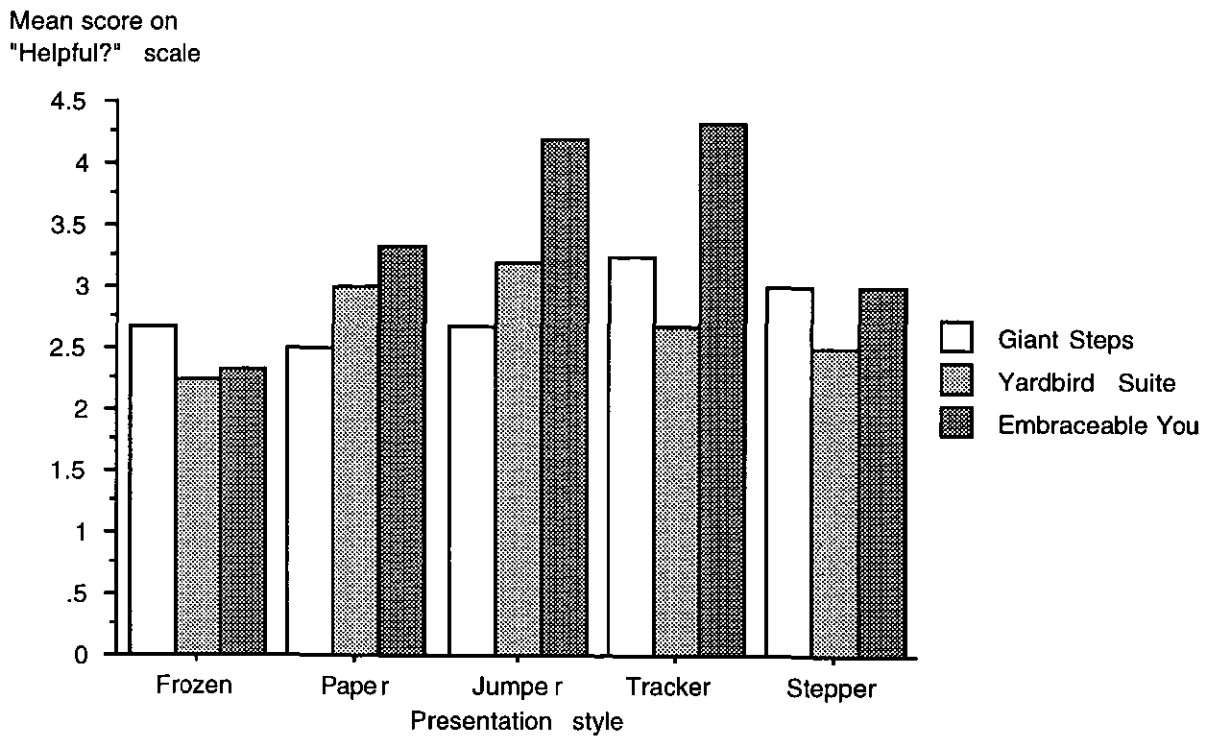

Figure 8.3: Interaction bar plot for the *Helpful?* variable, showing each piece of music by presentation style.

A similar outcome applies to the *Annoying?* scale, although the *Paper* medium is perceived to be only slightly better than *Frozen* (figure 8.4).

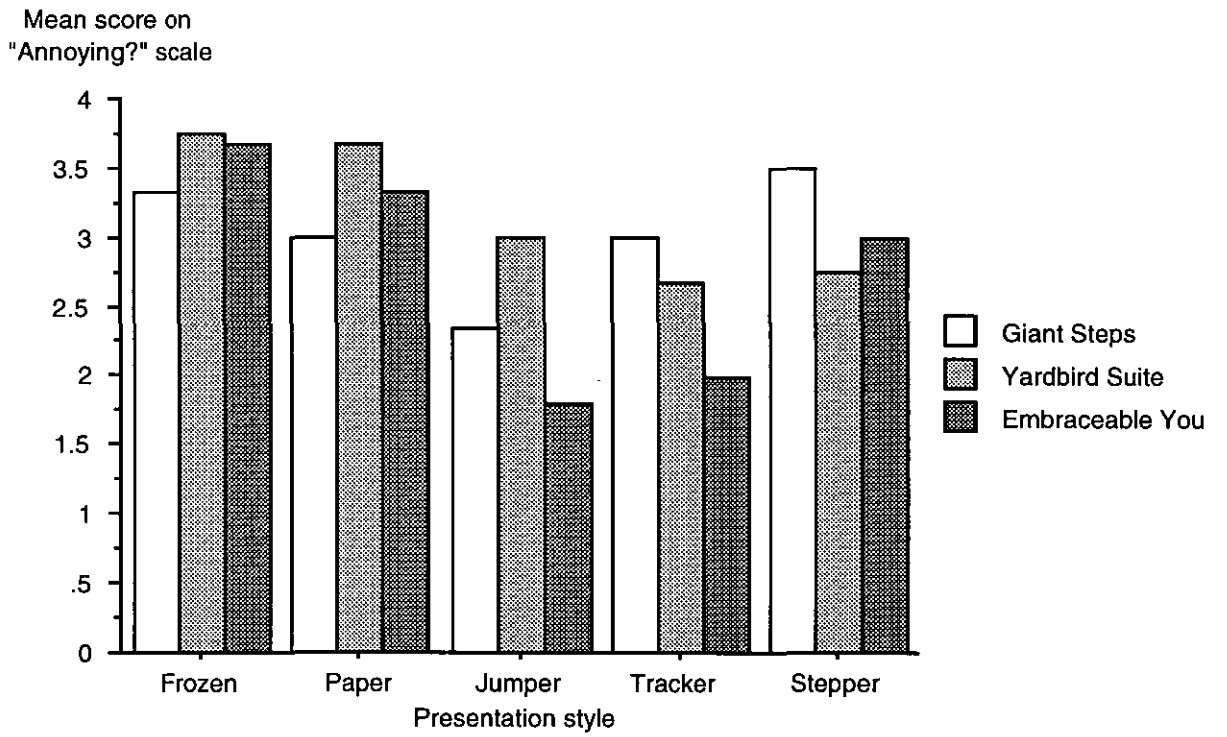

Figure 8.4: Interaction bar plot for the *Annoying?* variable, showing each piece of music by presentation style.

Helpful? and *Annoying?* did in fact correlate to some extent with each other, as might be expected [$r = -0.585$, $p < 0.0001$]. A similar relationship was also evident between *Score* and *Complicated?* [$r = -0.591$, $p < 0.0001$].

8.7. Discussion of results

8.7.1. Simple screen display of music (Frozen)

The *Frozen* presentation style performed worst of all in both the proof-reading exercise and the subjects' personal preference ratings. Although there was no significant difference according to the analysis of variance, *Paper* showed a 10% improvement in proof-reading score in comparison to *Frozen*. However, this presentation was optimised for screen. Properly printed scores may have produced even bigger differences, as the paper-based score was a based on a bit-map of the HyperCard display. This concurs with many of the early studies which compared reading text from paper and from computer screens.

With respect to subjective data, it should be noted here that there is arguably a narrower distribution of results in this study due to the duration of the music extracts. A longer rendition (perhaps several minutes) might reveal wider differences between subjects in terms of the perceived helpfulness of or annoyance caused by the presentation styles. There would be further implications for computer displays in terms of pagination and/or scrolling, but these issues are beyond the scope of this study. Certainly, one might expect some advantages for performers (as opposed to readers) of music if page turning could be controlled by the performer in a more automated fashion. For example, a violinist may eliminate the danger of interrupting the delivery of the music by using a foot switch to turn a page.

8.7.2. Paper-based display

The paper-based display performed better than the *Frozen* display, but worse than the animated techniques. This result suggests that the computer display itself may cause readers problems in the ergonomic sense, but that visual aids may cancel out that problem. Paper has obvious advantages in this context. It is easier to manipulate, it is easier to annotate (although at least one subject marked the display screen with a felt-tip pen!) and can be scrutinised with less fatigue over a long period of time. In a relaxed environment, where music students might be studying music recordings in the comfort of their own home, the additional advantages of paper cannot be questioned. However, a library environment might benefit significantly from the computerised display — not just in terms of the observed improvements offered by animated reading aids, but also in terms of media security and durability.

8.7.3. Screen display with bar tracker (Stepper)

Of the three animated reading aids, the *Stepper* was least popular, although it performed well in the proof-reading exercise. It is the *least* animated of the three, as the pointer only moves at the end of each bar. The advantage in accuracy of this presentation style may lie in the possibility that position in the score is maintained without distracting the reader's attention away from the notes on the stave. However, *Stepper* was only regarded as marginally more helpful than *Frozen*, and less helpful than *Paper*. From the point of view of the animation, it was certainly the most easy to produce.

8.7.4. Screen display with continuous tracker (Tracker)

The *Tracker* performed relatively well in terms of both accuracy (proof-reading exercise) and preference. It tended to be liked by the more able readers, judging by the positive comments offered. The production of the animation was relatively straightforward, especially with the *in-betweening* features offered by most computer animation packages. There are, however, two problems with this technique — where the music is not in regular time, and where notes are not laid out in proportion to the time they take to play. In the former case, most music speeds up or slows down during a performance, either by accident or by design. The exception to this is where rhythms are computer generated. In the latter case, music with several notes in one bar may not easily fit into a standardised bar width. Indeed, most written music is presented in a much more complicated manner on the stave. Timing may be the main factor involved in score layout, but it is certainly not the only one. Complexity, tempo, note congestion, use of accidentals, mood and emphasis are just a few other factors which must be taken into account. As a generic solution therefore, this approach may be problematic. With simple, introductory music, the *Tracker* may be more feasible.

8.7.5. Screen display with note tracker (Jumper)

The *Jumper* provided the best results in terms of both accuracy and preference. It was liked particularly by the less able readers. Timing problems experienced by the *Tracker* are eradicated, as the emphasis is on following the note, as opposed to the stave (although there are further implications for a multiple-part score). The unfortunate drawback of this approach however, is that the production of animation is extremely cumbersome and time-consuming. If digitised music (e.g. MIDI) alone is used, the problem disappears, as programs can be written to directly follow the MIDI score. This approach is common in music publishing software. For *Jumper* to be feasible for prerecorded music, perhaps a more novel form of animation production is required. Perhaps MIDI could be used in the generation of animation via an experienced musician mirroring changes in notes as played by the original performer.

8.8. Conclusions and implications for further research

Just as in the reading and manipulation of textual documents discussed in chapter seven, this chapter has considered similar issues from the framework for HCI in educational hypermedia relating to the reading and manipulation of music text. In a computerised environment, there may be techniques to support such tasks. For example, the reported study has shown that there is a strong indication that animation can offer very powerful reading assistance, especially to less able readers of music. For more able readers, there is certainly an argument to support animated reading aids in a biographical study environment, where context switching may be prevalent.

User preferences and skill levels do vary, so there may be support for providing more than one animated presentation style. Although the static presentation (*Frozen*) performed badly, the overhead of providing a switch in software to disable any animation would be minimal — there is bound to be someone who would prefer this style. The aim of the study was not to find a *best* solution, as individual preferences should be honoured. However, the study has provided evidence to justify the extra effort of incorporating animated support tools in this domain.

Research is needed to produce rapid animation development tools for such applications. Even this relatively trivial animation exercise was very difficult to produce. There were problems with synchronisation across computer platforms, a lengthy production time, as well as constraints on the proportional spacing of the music notation (especially for the *Tracker*).

Chapter 9
A hypermedia environment to support essay and dissertation development for music students

9.1. Introduction

This chapter describes a hypermedia system prototype, which was designed according to the framework for human-computer interaction in educational hypermedia proposed in chapter two, as well as a consequence of the findings of the studies presented in other areas of this thesis. Each aspect of the system will be justified in the course of this chapter with respect to prior work.

The hypermedia system prototype has been named HECTOR, an acronym for ***Hypermedia from Essay Conception TO Realisation.*** This name was also chosen in recognition of Auden's poem *Moon Landing*, quoted in the introduction to this thesis. HECTOR is a system which contains a number of original tools as well as some off-the-shelf products. It provides an integrating environment for these artefacts, and a structure which reflects the model of essay and dissertation development, as proposed in chapter five. Consequently, HECTOR's artefacts support research (type I), planning (type II) and writing (type III) activities. For the prototype environment, the observations of the survey reported in chapter six also helped to provide a minimal subset of artefacts. The artefacts supported by the early prototype of HECTOR are summarised below:

Type I	**Type II**	**Type III**
Netscape browser	*Overview*	Word processor
CD player	*Bibliography*	
Music reader	*Concept mapper*	
Jazz encyclopaedia		

Table 9.1: Artefacts supported by HECTOR (those in italics have been specially developed).

There is a range of interaction between the artefacts, which will be discussed further when each one is presented in detail. This interaction is summarised overleaf (figure 9.1).

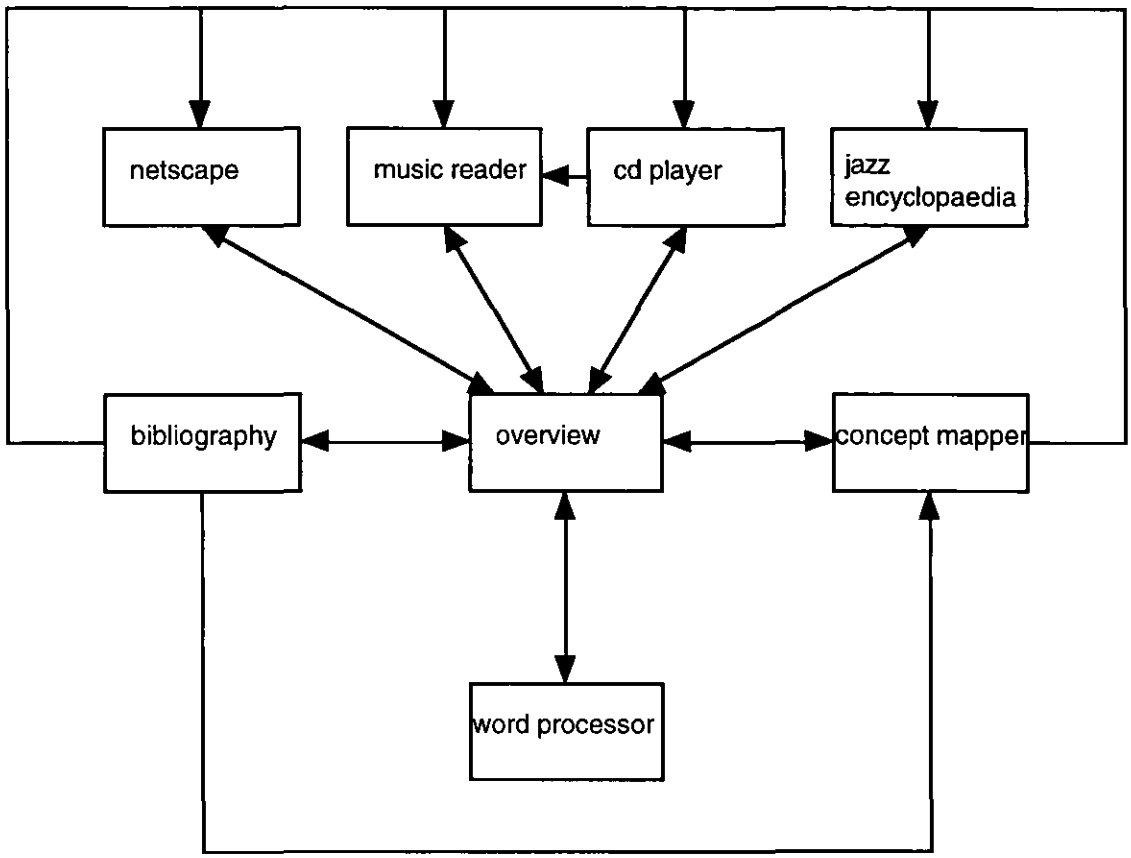

Figure 9.1: Schematic diagram of HECTOR software environment, showing software artefacts and possible transitions.

HECTOR runs on Apple hardware, and requires at least one CD-ROM drive, a two-page grey-scale display monitor and a high quality laser printer as a minimum configuration. Figure 9.2 shows a schematic overview of the hardware platform.

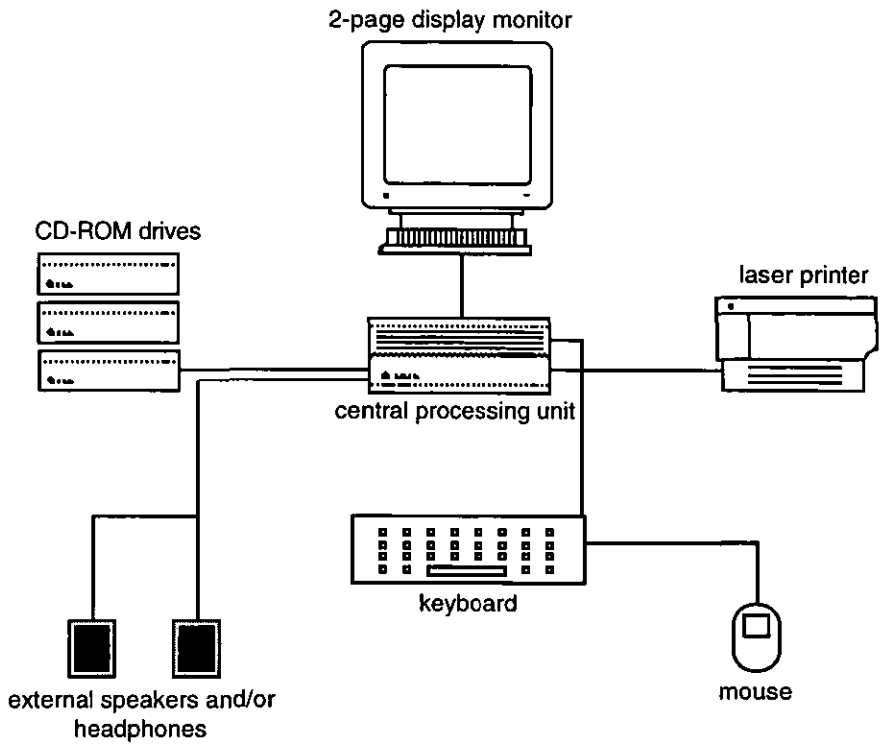

Figure 9.2: Schematic diagram of HECTOR hardware.

A large screen was chosen because of the probability of a large number of windows being open at once, as well as with regard to research recommendations (Reisel and Shneiderman, 1987; Hansen and Haas, 1988). Grey-scale was selected, as most photographic and video media in the jazz music domain are in a monochrome form. Specially developed software was written in HyperCard 2.2, Symantec Think C and AppleScript. Figure 9.3 shows a typical screen from a session with HECTOR. The following sections will describe each artefact, how they interact with one another, how users would interact with them, and how they relate to earlier work in this thesis.

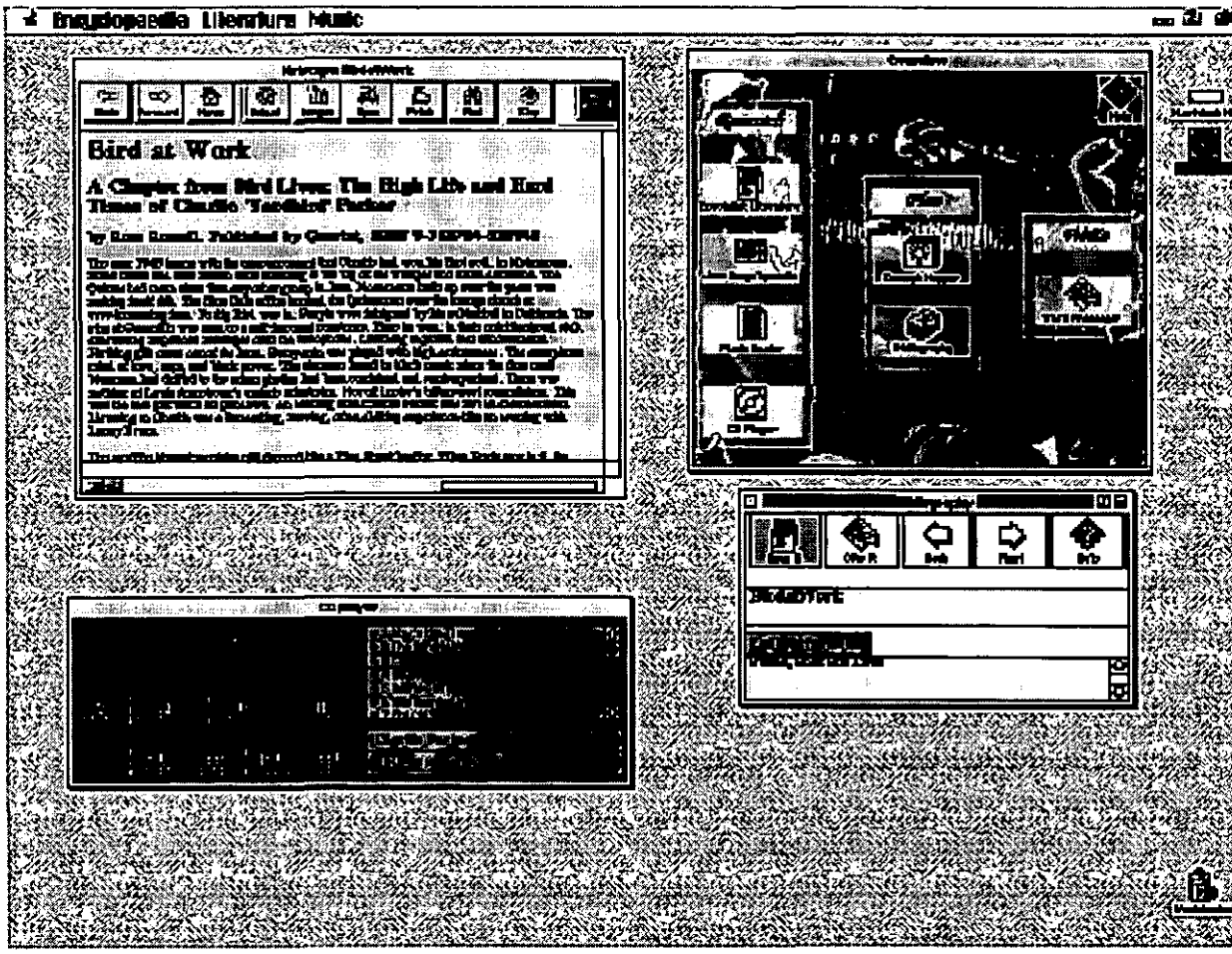

Figure 9.3: Typical screen from HECTOR, showing the artefacts
Netscape, Overview, Bibliography and CD player.

Each user of HECTOR must be initially registered, so that subsequent personalisation (hypertext authoring, for example) can be maintained.

9.2. Type II artefacts

Type II artefacts are the most central, integrating artefacts in HECTOR. They are the focus for the organisation, planning and scheduling activities of essay and dissertation development. There is significant interaction between these artefacts, as well as between others in the system. Consequently, it is considered more sensible to present type II artefacts here before those of type I, as an understanding of the former will aid in describing the latter.

9.2.1. Overview

The Overview provides the gateway to all other artefacts. It is a graphical representation of the research-plan-write typology, and indicates the artefacts available to support those activities. A screen shot of the Overview is shown in figure 9.4.

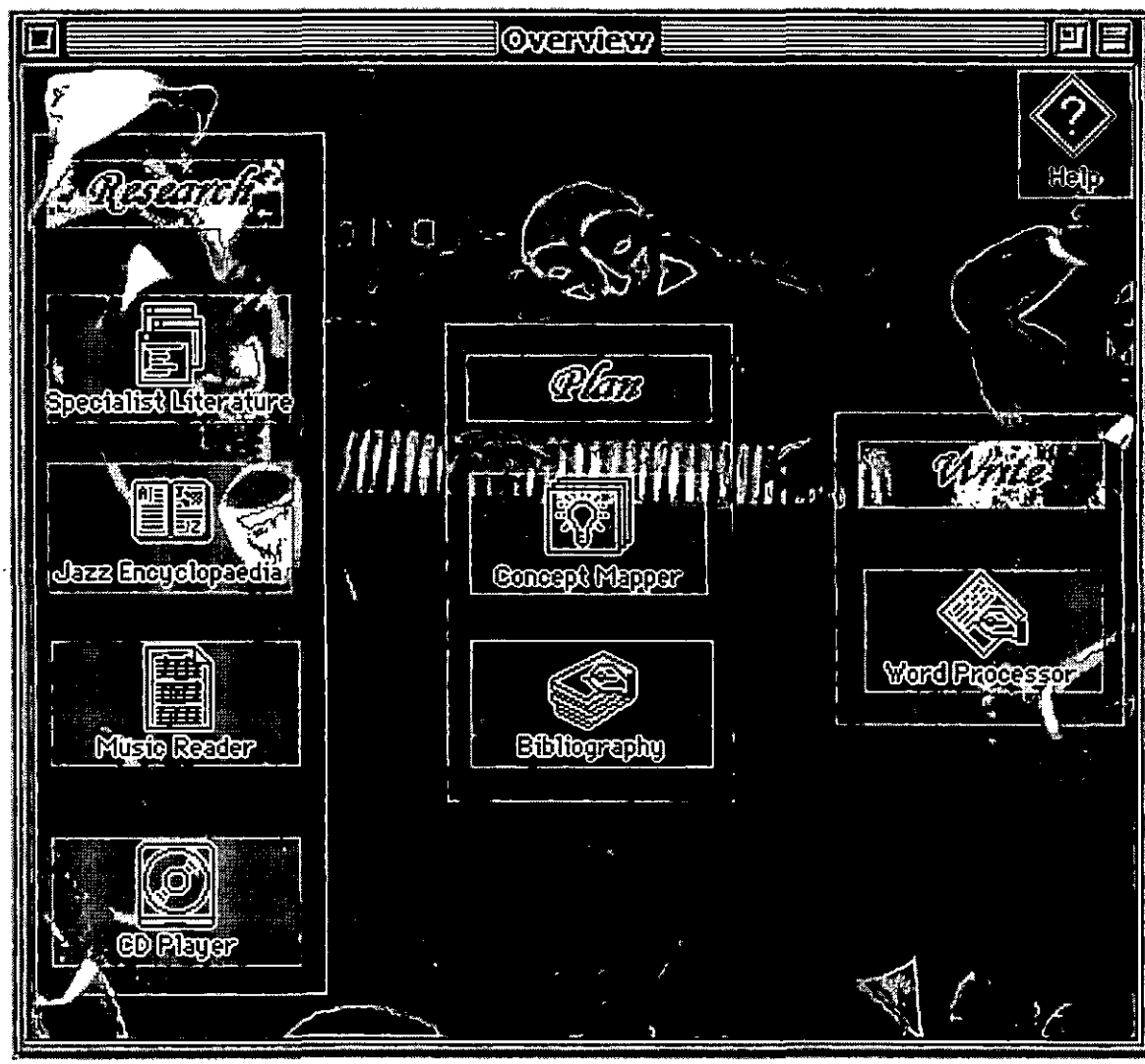

Figure 9.4: Screen shot of the Overview.

Each graphic in the Overview represents an icon. When the user clicks on any of these icons, the appropriate artefact will be opened in a new window. As many artefacts as are required by the user can be opened at once. The Overview window will be open throughout a HECTOR session. It represents a landmark for users to return to in situations of disorientation, or alternatively, if they need to access an unopened artefact. Where a number of artefacts are simultaneously open, users can navigate from one to another by clicking the mouse pointer anywhere within the window of that artefact, as typified by the current Apple Macintosh environment.

9.2.2. Bibliography

The Bibliography incorporates a database where references to media of interest to the user are stored. This media is essentially anything which is accessed by type I artefacts. For example, a bibliography reference might be a page from the Jazz encyclopaedia, or it could be a reference to a piece of music, a page on the World Wide Web, and so forth. The Bibliography is able to automatically update its references by consulting the bookmarks databases for each of the type I artefacts. All type I artefacts have a bookmark facility. Therefore, whenever a user decides that an article or other media artefact is of interest and may be used in a future citation, an *add bookmark* menu option is activated from within that type I artefact. A new record is then created to accommodate the new item in the Bibliography database. Figure 9.5 displays a typical window from the Bibliography.

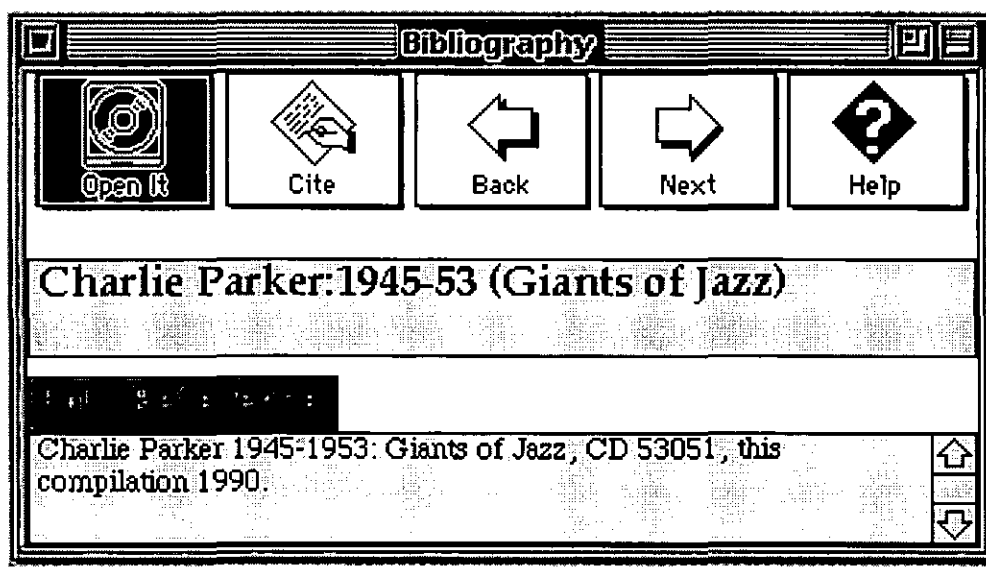

Figure 9.5: Typical window from the Bibliography artefact of HECTOR.

The Bibliography provides a pull-down menu for each type I artefact. A new option is created under the appropriate menu title for each reference. Reference records can then be accessed directly from the menu structure. The Bibliography can also be browsed, by using the left and right arrow buttons. The *Open it* button, when clicked by the user, will open the document relevant to the currently displayed Bibliography record. The *Cite it* button will cause a citation to be written directly into the reference list of the Concept mapper artefact. The citation will be copied from the *Full description* field. This may be typed in by the user in a standard reference form. This is optional however, as a user can edit the reference list in the Concept mapper anyway.

9.2.3. Concept mapper

The Concept mapper is very much an essay planning and note-taking tool. It may be used as a concept mapper, as a hierarchical planner, a mind-mapping tool, or even as an argumentation tool. This artefact also comprises the central hypertext resource of HECTOR. Any references cited from the Bibliography can be embedded in the text fields of each concept, and can be automatically accessed via hypertext linking mechanisms. A concept map may also be accessed in this way, providing the possibility of a network of concept maps to assist student research and planning. For example, a lecturer may provide a set of student notes in the form of a concept map, with the reading list embedded as hypertext links. Another potential use of this recursive concept mapping idea may be provided by students themselves, in collaborative working situations. Figure 9.6 shows a typical window from the Concept mapper artefact.

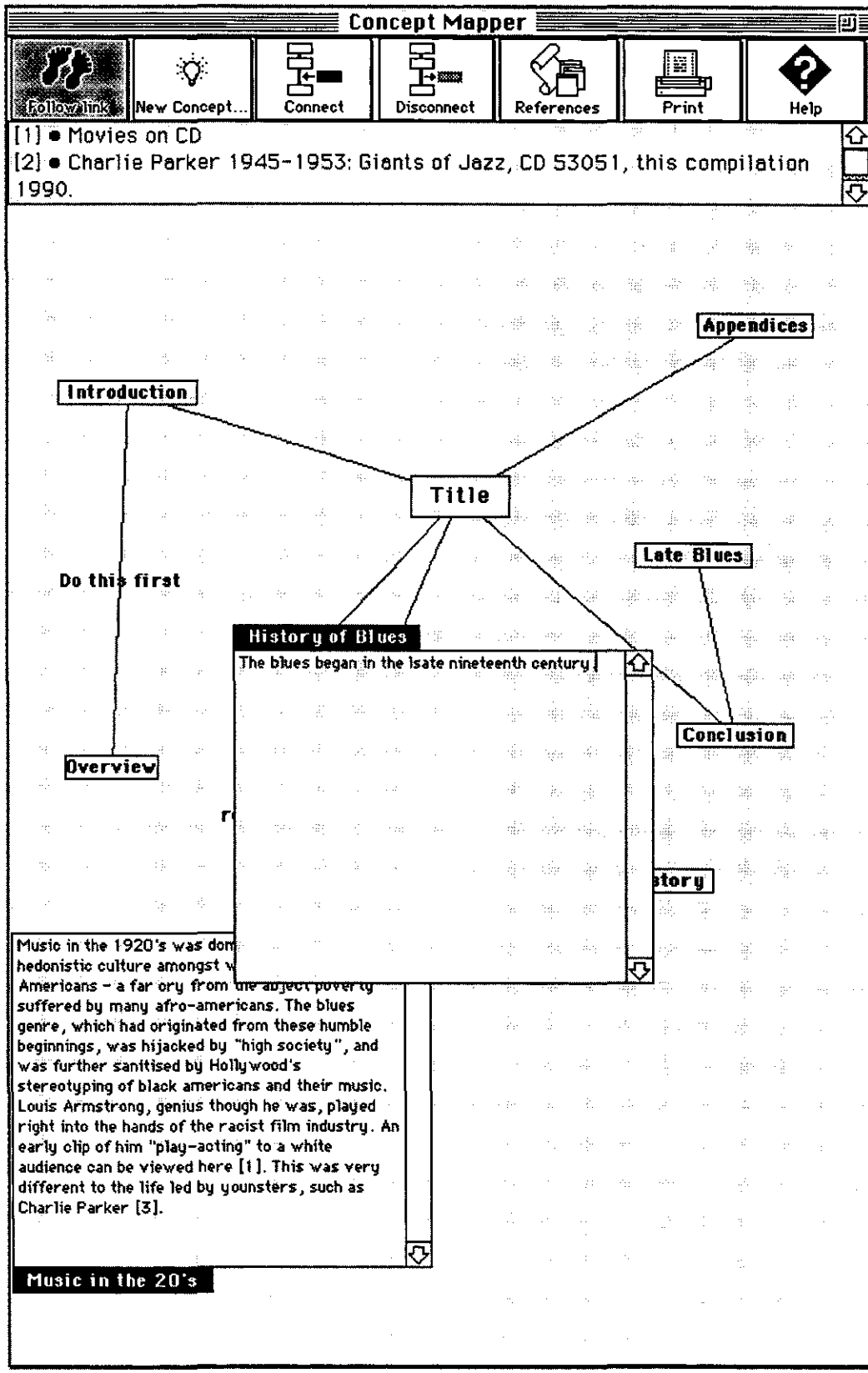

Figure 9.6: Typical window from the Concept mapper artefact of HECTOR.

The user is provided with the necessary features to create a structure diagram (concept map) within the Concept mapper window. Buttons to enable this are provided at the top of the Concept mapper window.

New concept will create a new node (concept box) for the concept map. A dialogue box appears and requests the user to enter a name for the new concept. The concept box can then be placed anywhere on the concept map by holding down the option key on the Apple keyboard in combination with established drag and drop techniques. When the user clicks on a concept box, a scrollable text field pops up to allow the user to write any relevant notes. References can be made to the reference list by typing in the number of the reference from the reference list. The reference list can be viewed by clicking on the *References* button. Whenever a number is double-clicked within a concept box pop-up text, it can be opened automatically by clicking the *Follow link* button. This provides a simple hypertext facility to enable users to navigate their research material. Concept boxes can be renamed or deleted by option-clicking on them. A dialogue box will then appear with these options, as well as the facility to cancel the change mode.

Connect will enable the user to connect two concepts together. After this button is clicked, the user marks the relevant concept boxes. Once this is done, a dialogue box requests the user to name the connection. The connection may be a semantic link, an argumentation clause, or it may be left blank for simpler structural links. Subsequent dragging of concept boxes will still maintain the connection, providing a kind of *rubber-banding* characteristic to the connecting arc.

Disconnect works in exactly the same way as Connect. Concept boxes are not deleted as a result of the disconnection.

9.2.4. Justification for design and selection of type II artefacts

The design of the three type II artefacts was undertaken according to a number of guidelines proposed in the human-computer interaction for educational hypermedia framework from chapter two. Also, the results of original studies have produced principles for good design in this scenario. This section will discuss these issues with respect to the Overview, Bibliography and Concept mapper artefacts. Evaluation will be considered later in chapter ten.

9.2.4.1. Users, tasks and information

The users are provide with a flexible structure, although the Overview implies an element of task modelling via its indicated relationships between artefacts. The Bibliography provides a repository of information, which also acts as a summary of media of interest to the users. The preference of music students for browsing and non-sequential reading established in chapter three is catered for here.

The individual approach to task structuring in the domain of essay and dissertation development, as observed in chapters four and five, is supported by the flexible approach to the Concept mapper design. This artefact allows multiple strategies for the planning and drafting of essays.

Access to detailed information is provided from the Bibliography, as well as the Concept mapper. This design decision was taken, as it is considered that planning activities overlap, or at least are performed in parallel, with writing, drafting and research activities, as observed in chapter five. In fact, the type II artefacts support a range of the activities identified in earlier studies and interviews, including **plan essay**, **analyse essay titles**, **make notes**, **plan research** and **write draft/rough copy of essay**. According to the proposed model of essay and dissertation development, these activities involve a high degree of planning, and take place throughout the chronological range, certainly until the final activity of **write up essay**. Also, as the model suggests, these activities involve a combination of communication strategies.

9.2.4.2. Interaction

The interaction exhibited by type II artefacts is direct, consistent and flexible. Most articulation is mouse driven through pointing and clicking. The presentation clearly reflects this articulation through consistent and structured screen designs. The restrictions of the prototyping language limit the speed of performance, although the observation phase caters for delays by informing the user of any delay. The hypertext facility provided by the Concept mapper is not ideal, as the limitations of HyperCard forced this prototype of HECTOR to require a *Follow link* button, thereby creating unnecessary work for users.

In isolation, there is little screen clutter exhibited by the type II artefacts. However, once type I and II are open on screen, the user may experience cognitive overload. In anticipation of this, a minimalist approach was taken to the sizing of type II artefact windows. Both the Bibliography and the Overview are very small. As the Overview is always open however,

users should still be able to reorientate themselves to this without trouble. The Concept mapper must be large enough to enable users to view structure within the concept map, so it was decided to set this window size at initially half the screen area. Unfortunately, HyperCard does not provide window resizing options, as this would have been much more ideal. In a fully developed system, this facility would be provided.

9.2.4.3. Pedagogy

The pedagogy of the type II artefacts reflects the constructivist approach to educational hypermedia. It is based very much on the premise that students learn more effectively when they are actively involved in creating, rather than absorbing. The Concept mapper provides the best example of this, as students are able to author their own simple hypertexts and subsequently share these creations with their peers. This approach reflects the philosophy of approach adopted by other successful educational hypermedia projects, such as Context32 (Landow, 1989) and the Dickens Web (Landow and Kahn, 1992).

9.2.4.4. Educational domain

Another advantage of HECTOR's constructivist approach may be that in this educational domain, it is much more practicable. Music students are reluctant writers, so perhaps a novel and empowering approach will make the whole process more enjoyable. Also, the problems of creating a hypermedia database in an educational environment which is often running to stand still, make this approach distinctly more attractive.

9.3. Type I artefacts

9.3.1. Netscape

A World Wide Web browser was chosen to enable readers of hypermedia documents to research music-related documents. Students are able to access music servers from around the world, and cite various media in their essays and dissertations.

The bookmark facility is of particular importance to HECTOR, as students can create their own links to documents in their bookmark list. Netscape produces a separate HTML document for a user's bookmarks list, and stores it in the Apple Macintosh system folder. Type II artefacts, such as the Concept mapper and the Bibliography can parse this document to maintain their knowledge of the user's marked information. To accommodate multiple users, Apple scripts were developed to make temporary copies of bookmarks lists

from students' personal folders. Orientation and Home pages were constructed to provide the users of Netscape with starting points and landmarks for their musical and biographical research.

9.3.2. CD player

Although a number of proprietary CD player emulators are available for the Apple environment, it was necessary to develop a special artefact for HECTOR. This is due to the requirement for providing integration within the hypermedia framework. The CD player performs more functions than a typical emulator, which includes interaction with the Music reader and Bibliography artefacts. For example, if a user requires to read the music currently playing, an icon can be selected to open the Music reader. Should a user choose to make a reference to a recorded piece of music, a bookmark can be placed in the track list, which is subsequently referenced in the Bibliography. Anything which is referenced in the Bibliography artefact can be subsequently automatically opened from within the Bibliography, or from the Concept Mapper. This applies to each of the type I artefacts which support bookmarking (i.e. Netscape, CD player and the Jazz encyclopaedia).

A database of compact disc music stores all of the information relating to titles, tracks and music scores. When a CD is selected by the user, HECTOR consults its CD database and updates the on-screen track list.

The interface design of the CD player represents a typical hi-fidelity system fascia. The buttons on the panel adopt the same iconic standard used by virtually all systems of this type. The additional functionality of this system necessitated some deviation from the everyday artefact, however. Other buttons were required to allow the consultation of the track list, and the opening of the Music reader artefact. Tracks can be selected for play individually from the track list simply by clicking on the title text.

A pull down menu system provides the user with the facility to add and delete bookmarks, as well as a fast way to access CDs in the existing bookmarks list. As many CD-ROM drives as possible should be daisy chained together to allow a number of CDs to be simultaneously accessible. However, from a practical point of view, it is unfeasible to resource such hardware, especially in a prototype. Consequently, the CD player exhibits a form of *half-dead* hypertext linking (Bederson and Druin, 1995; Nielsen, 1995). This means that users must perform a physical activity before a hypertext link can be completed — in this case, the CD must be ejected and replaced with the one requested by HECTOR.

Users are always prompted to place the appropriate CD in the CD drive tray. Figure 9.7 shows example screens from the CD player artefact.

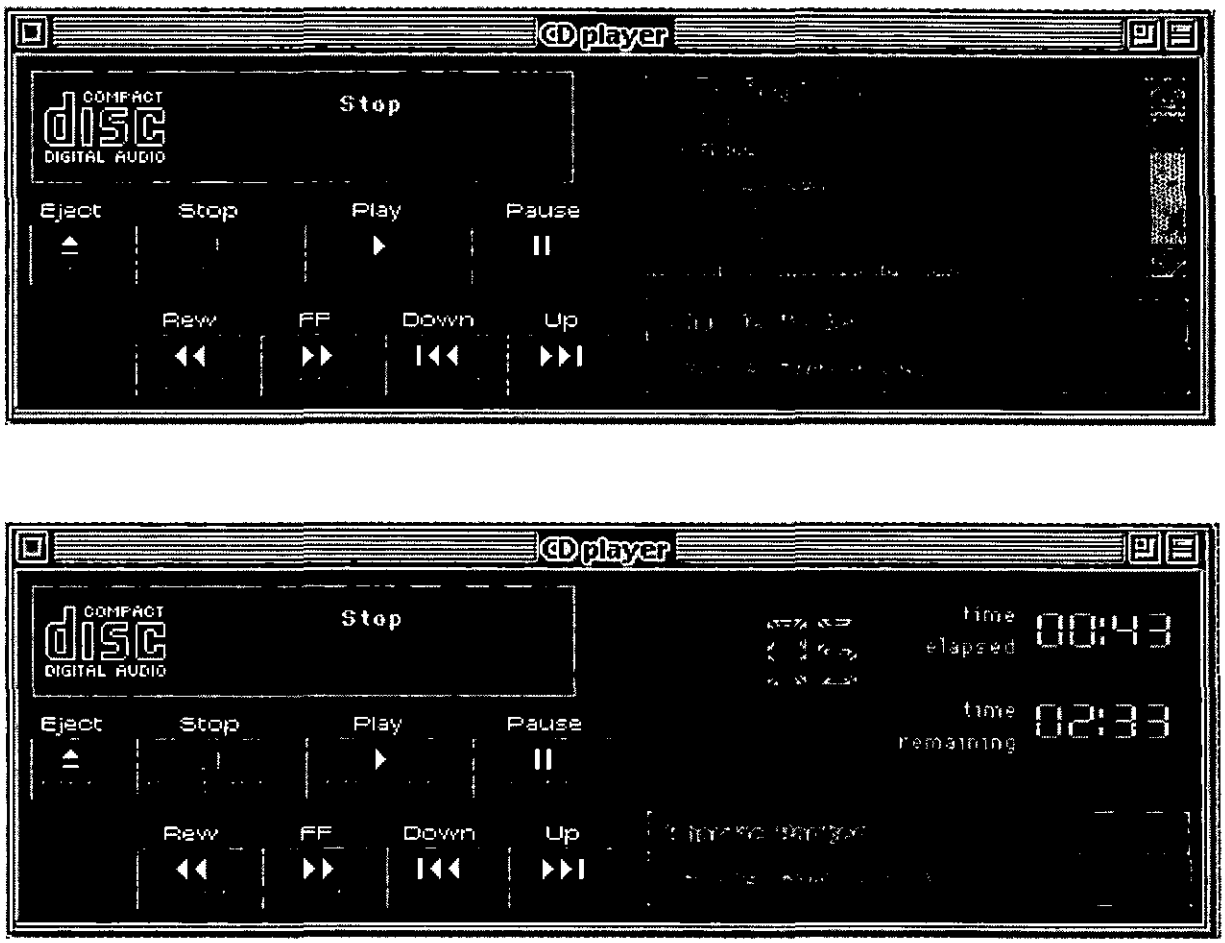

Figure 9.7: Example screens from the CD player artefact.
Top: Displaying track list. Bottom: Displaying track statistics.

9.3.3. Music reader

The Music reader enables users to consult the scores of the music stored in the CD database. Users can read music scores independently of listening to it, but if they do wish to listen and read, an animated score aid may be optionally selected. The preferred method for animation is the *Jumper*, as it performed better for less able music readers, and subjective comments from experienced musicians indicated that they did not need such reading aids. The ability to print paper copies of scores is also a desirable option, but copyright restrictions make this currently unfeasible.

9.3.4. Jazz encyclopaedia

The Jazz encyclopaedia is an off-the-shelf interactive multimedia CD-ROM. It was evaluated during the early stages of HECTOR's development, and was considered to be a suitable background research resource, as long as some enhancements could be made to its interface.

The full title of this CD-ROM is *Jazz: A Multimedia History*, and it is produced by Compton Press. Extra functionality, such as a bookmark feature, could be added to the product, as its source code was easily accessible. A new user interface was also added to provide users with a consistent look and feel to HECTOR's interaction. As with other type I artefacts, users can mark pages in the encyclopaedia, and then create hypertext links for their subsequent access from the type II artefacts. An example of a screen from the enhanced Jazz encyclopaedia is shown overleaf.

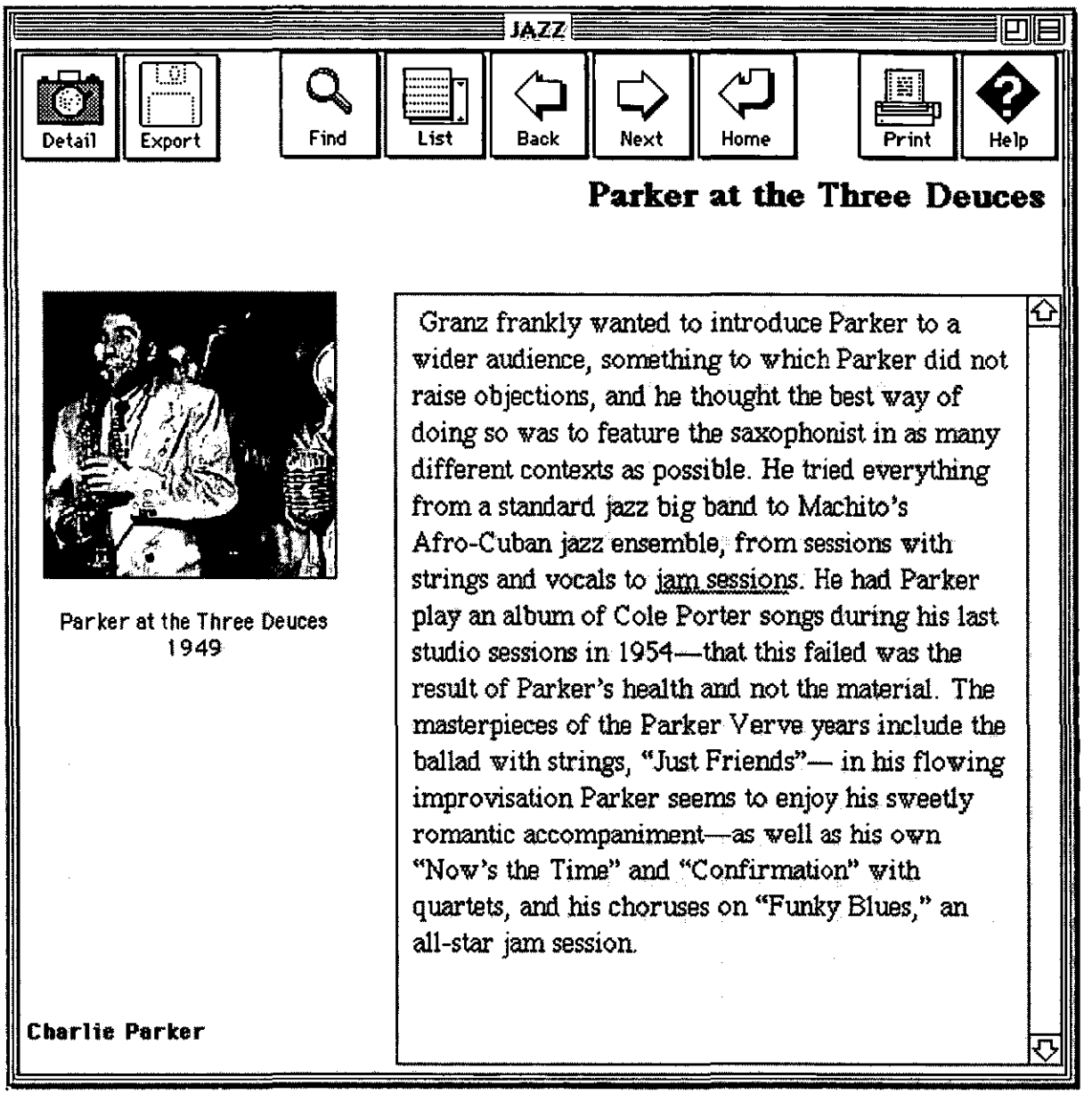

Figure 9.8: Example screen from enhanced Jazz encyclopaedia artefact.

9.3.5. Justification for design and selection of type I artefacts

As with type II artefacts, the design and incorporation of the type I artefacts was undertaken according to guidelines proposed in the human-computer interaction for educational hypermedia framework from chapter two, as well as from the principles for good design recommended in the original work. This section will discuss these issues with respect to the selection of Netscape, the Jazz encyclopaedia and the design of the CD player and the Music reader.

9.3.5.1. Users, tasks and information

In the proposed model of essay and dissertation development, music students expressed a significant preference for the activities involving research (i.e. type I activities). Not surprisingly, they liked the listening to and reading of music most. However, this should not detract from the need to adhere to good design principles. Indeed, if HECTOR can help the reading of text to be as interesting as of other media, perhaps the reluctant readers of chapter three can be converted.

The type I activity of **read books/articles** is supported by the type I artefacts Netscape and Jazz encyclopaedia. Although Netscape's hypermedia facilities are somewhat limited, it is considered adequate for the reading of books and articles in this scenario. The same consideration applies to the Jazz encyclopaedia. Reading is not an intensive activity for these students. They tend to use texts for reference purposes (browsing and searching), the New Grove Dictionary of Jazz being the prime example. A multimedia version of this extensive source of reference would be ideal, but for the sake of the prototype, the Jazz Multimedia History will suffice. The Internet represents an excellent source of information for music students, as there is a large number of music education related sites around the world. Netscape is at the time of writing the most established World Wide Web browser, as it is fast, usable and flexible.

The Music reader and CD player artefacts support the other type I activities of **study music text** and **listen to music**. These activities are the most closely matched in the model of essay and dissertation development, and this relationship is recognised by the close level of interdependence between the two artefacts.

The method of animated support offered by the Music reader reflects the findings of the study in chapter eight. However, a fully developed system would require more research into automatic animation generation and synchronisation with prerecorded music.

9.3.5.2. Interaction

Direct manipulation again underpins the central interaction style. After all, consistency across the whole system is important. The enhancement to screen designs in the Jazz encyclopaedia was necessary to maintain this consistency at the presentation phase of the interaction framework.

Navigation and document manipulation are of importance with respect to the interaction design of type I artefacts. Chapter seven provided a number of observations with respect to these issues. However, some navigation aids, such as the pre-jump link anchor definition and pre-jump link target definition, did not prove to be significantly helpful. The text finding facility was more popular for searching activities, and actually had an inverse effect on the usage of hypertext. Such evidence for not providing sophisticated navigation facilities is supported by earlier work, for example Landow (1990) and Dillon, McKnight and Richardson (1990). These observations add weight to the argument that simple hypertext browsers, such as Netscape, are adequate for this scenario.

9.3.5.3. Pedagogy

Pedagogical consideration for the type I artefacts is perhaps not so important as for the type II artefacts. Planning, analysis and design of media have much more scope for pedagogical enquiry than those relating to raw research. Probably the most important pedagogical aspect of this component of HECTOR is the need to support comprehensively the constructivist process adopted by the type II artefacts, whilst maintaining a flexible, personal approach to individual research techniques. The wider separation of artefacts of type I provides flexibility and supports individuality, as users can access information in a variety of ways. The straightforward menu-based technique of constructing references via the bookmarks lists supports the constructivist organisation and building process.

9.3.5.4. Educational domain

The multimedia support offered by the type I artefacts is representative of the media required by students in this educational domain. Readers can access a range of media, including text, music, pictures, music scores and film. All of these media play some role in the development of essays and dissertations by music students.

The mix of media in this domain is also of importance. As has already been mentioned, the Music reader and CD player present different media, but the mix offered by them is highly interdependent. The Jazz encyclopaedia and Netscape also provide a mix of media which reflect both the educational domain and the model of essay and dissertation development proposed in chapter five.

9.4. Type III artefact — a word processor

Only one type III artefact was deemed appropriate for the prototype environment. This was decided upon as currently available proprietary word processors offer an array of powerful writing features. It could be argued that advanced word processors suffer from an over-provision of functionality — indeed, even early text processors were accused of this (Rosson, 1983). However, already a number of artefacts are supported by HECTOR, and to incorporate more might lead to users experiencing even more cognitive overload. Consequently, a sophisticated word processor, supporting not only text processing, but also drawing, outlining and tabulating functionality was selected as the one type III artefact.

Microsoft Word (version 5.0) offered a reasonable combination of usability and utility, and was selected as a suitable artefact for HECTOR's prototype implementation. Its applicability with respect to the framework for HCI in educational hypermedia and to the original work in this thesis will now be considered.

9.4.1. Users, tasks and information

As the users of HECTOR will be essentially novice computer users, it was important to identify a word processor which supports fairly intuitive use. Microsoft Word is based on the now familiar typewriter metaphor, so even users with no experience of computer technology should be able to relate to this presentation. A simple training wheels facility (Carroll and Carrithers, 1984) can be self-selected, by activation of Microsoft Word's *short menus* feature.

The activities of **write draft/rough** and **write up essay** are both supported by Microsoft Word. Features such as cut and paste, outline views and contents page creation can all assist the user in the process of essay and dissertation development, although it is not clear to what extent these features are typically used. Compatibility across applications is also important, as users will need to copy notes made in the Concept mapper over to the word processor environment.

9.4.2. Interaction

Like most modern word processing environments, Microsoft Word is developed for the WIMP (windows, icons, menus and pointers) environment. Articulation is therefore performed by keyboard and pointer input. Again, this is consistent across the HECTOR system.

One helpful aspect of presentation this software supports is the option of *page display*, which makes the text area appear at the same size as the paper it will be eventually printed on. Combined with the two-page display monitor, this provides a representative WYSIWYG (what you see is what you get) view of a sheet of A4 text.

An iconic menu bar at the top of the word processor window provides the user with observational cues as to the current text mode. For example, if the user has selected the bold text mode, this can be clearly observed by the *bold* icon becoming highlighted. The same principle applies to other important modes which are often invisible in a WYSIWYG environment, such as line spacing, font and text size.

9.4.3. Pedagogy

Pedagogical considerations at this stage are perhaps of little concern, as most learning will have been carried out by the time the student reaches the writing up phase. This observation is supported by the model of essay and dissertation development proposed in chapter five. The writing activities are undertaken late in the development process, and there is little or no inward communication involved. Planning does feature however, during the **write draft/rough** activity, so it is important to support interaction between type II and type III activities. This interaction is supported through the HECTOR's flexible approach to information interchange across its environment.

9.4.4. Educational domain

Ultimately, one would hope that HECTOR could support the electronic production of essays and dissertation. The paperless realisation of student submission of this type offers much more than purely environmental benefits. Multimedia essays and dissertations could enable music students to present musical pieces to their assessors, to enhance their explanation of concepts and arguments. Whilst this is a future consideration, Microsoft Word for the Apple environment does support the embedding of digital sound and film images. This makes this type of advanced word processor highly desirable for the educational domain of music.

9.5. Conclusions and implications for further research

Now that a prototype version of HECTOR has been described, it needs to be evaluated. The justification for HECTOR's design may seem tenuous in some areas, but this will always be the case for interactive system design before significant evaluation has taken place. Afterall, the best way to justify a product is to test it in the field. The final piece of original work of this thesis will perform exactly this.

HECTOR carries the baggage of the bulk of the thesis so far. It forms the amalgamation of the literature search, surveys and experimental studies. This amalgamation is manifested in the framework for HCI in educational hypermedia proposed in chapter two. Whether HECTOR is accepted by music students in a college environment will be the ultimate determinant of the reliability of this work. However, to incorporate the hypermedia system directly into the educational domain is both practically and ethically problematic. A longitudinal evaluation would have to take place for accurate assessments to be made. This is beyond the scope of this thesis, and would involve students depending upon an unproven product.

Consequently, a small scale field study will be carried out, where HECTOR will be placed in the library at CLCM. Volunteer students will be able to evaluate the product and record their opinions for later analysis.

Chapter 10
An evaluation of HECTOR

10.1. Introduction

An evaluation of HECTOR was carried out in a field study setting at CLCM. The study took place over a period of three days. The author was involved with discussions, demonstrations and evaluations, and also assisted students who felt they could use the system for their ongoing work. Quantitative data were collected via an evaluation form (see appendix D) which was based loosely on the Questionnaire for User Interface Satisfaction (QUIS) (Shneiderman, 1992), whilst qualitative aspects were recorded during semi-structured interviews and from written comments on the evaluation forms. The overall reaction to HECTOR was very positive, although some problem areas relating to its usability were identified. The willingness of HECTOR's evaluators to be critical of aspects of the system was regarded as a positive indication of their ability to overcome the novelty of new technology, a factor which could have otherwise biased the results.

This chapter presents what is essentially a *closure* study. All that has gone before in this thesis is in some way contained within the prototype system. It began with a research hypothesis, proposed a framework for educational hypermedia design through the literature search and expanded into a series of original studies. HECTOR represents the collation and integration of the findings of this work, and its evaluation is the test of the research hypothesis.

The structure of this chapter is, to all intents and purposes, a chronological account of the events of the three day evaluative field study. Discussion of both qualitative and quantitative data is embedded within this account.

10.2. Setting and configuration

The prototype HECTOR system was placed in the library study area of CLCM. The configuration was similar to that described in figure 9.2, except that a laser printer was not available, two CD-ROM drives were chained together, and headphones were provided for audio output to minimise any inconvenience to others working in the study area. Although HECTOR uses the Internet as a source of reference, this feature was disabled for the field study, as CLCM has no provision for computer networking. Instead, a number of local HTML documents were made available on the system's hard disk to simulate World Wide Web functionality.

The setting of the library was chosen as it is expected that such a system will be ultimately a library resource. The choice of a realistic environment was intended to improve the ecological validity of the study.

Posters were placed within the library and adjacent to the system. The intention was to attract students who were actually using the library at the time. The posters invited students to attend demonstrations of the system, and those who were further interested were then asked to evaluate it. A demonstration lasted about twenty minutes, with subsequent evaluation taking up to another three quarters of an hour. During evaluations, users were encouraged to browse the system, and to consider how they might use it for essays and dissertations they had previously written, or were in the process of developing.

10.3. Discussion with dissertation students

On arrival at CLCM, the author was asked to address the cohort of final year undergraduate students specialising in dissertations, of which there were seven. Also in attendance were the dissertations tutor and the chief librarian. The prototype system was explained to them, and the audience was invited to take part in an open discussion. Students appeared to be enthusiastic about the prospects of using interactive hypermedia environments, and particularly expressed interest in the Internet. They all volunteered to evaluate the system, and booked various times over the three day period. The discussion lasted approximately half an hour.

10.4. Demonstration to library staff

Prior to any student evaluations, HECTOR was demonstrated to the chief librarian and his assistant. Both were impressed with the system, and the assistant librarian offered to perform a more detailed evaluation.

Her overall reaction was positive. She indicated scores of seven out of nine on three of the five scales, although she perceived the system to be slightly more difficult to use (6/9). Nevertheless, her score of nine on the *dull ... stimulating* scale was encouraging. Most other scores were high, although she thought the screen was somewhat cluttered (5/9). Her only other score outside the range seven to nine was for the final question: *Would you prefer to use a multimedia environment over your current approach to developing essays and dissertations?* For this, she gave 5/9 and added the comment: *would prefer to develop skills in both this type of approach and more traditional methods.* A pragmatic outlook

towards the incorporation of multimedia into library environments is one of the principles upon which HECTOR is based, and the observation by an evaluator that such an approach should be supported is of particular note.

10.5. Student demonstrations and evaluation

Over the period of the field study, approximately twenty to thirty students viewed the system to some degree. Some gathered around for group demonstrations, whilst others watched as evaluations took place. Of this number, a total of ten students offered to perform a more detailed evaluation. It was considered that students should volunteer themselves for this, as any coercion from tutors or payment from the author might serve to bias the results. Students were each provided with an envelope in which to seal their answers to preserve their anonymity. Again, the author was conscious of the possibility of user bias, this time due to students seeking to please the researcher. The Hawthorne Effect was an obvious danger for this study, and it was considered that evaluators may be more objective if it was made clear they could not be cross-referenced to their evaluation forms.

The first demonstration and evaluation of the system was provided by one of the final year dissertation students. Unfortunately, he had to cut short his evaluation to about twenty minutes as he had a prior engagement. Consequently, he felt unable to provide a comprehensive evaluation. The evaluation scores he did give tended to support the usefulness of HECTOR, apart from the very low score of 1/9, indicating that he thought the system was not at all useful for planning essays and dissertations. This result was very much the exception, and is probably explained by the fact that he did not have time to use the concept mapping tool. The student offered his identity on the evaluation form, and indicated why his responses were incomplete.

During the first afternoon, another four students evaluated the system. One was a Music Technology (HND) student, one was another dissertation student, whilst the other two were both second year BA Music students. Spoken comments were generally positive, although some students did offer personal recommendations for improving their perceived usability of the system.

On the second day, a total of five students provided evaluations of the system. Two were the previously arranged final year dissertation students, one was a Music Technology student, one was studying on the second year BA in Music course, and the final student was on one of the college's preliminary courses. In all cases, the author ensured that

students regularly wrote essays as part of their studies. Again, the reaction of evaluators was very positive. The Music Technology student later returned to use the system more extensively, as he found it so interesting. In all, this student spent approximately ninety minutes with the system.

One of the final year dissertation students, whose studies involved researching Charlie Parker and Charlie Christian, asked whether he could return the following morning to use the system for his research. He spent a total of ninety minutes searching for information on the Jazz CD-ROM and on the local WWW pages. He expressed the view that he found the system extremely useful for research and planning activities, but was hesitant about whether he would like to use it for writing.

10.6. Demonstration to Head of Jazz Studies

The Head of Jazz Studies had expressed interest in a demonstration of the system, and on the final day of the field study he found time to view a demonstration of the system. He had wide experience of designing music publishing software and also of other uses of computers in music, having studied electro-acoustic music for his doctoral research. He was familiar with the concept of hypermedia and had experience of a number of related products. His view of HECTOR was that it could be a very useful resource for students of Jazz Studies at CLCM. He was particularly impressed with HECTOR's approach, stating that a virtue of the system is that, unlike other hypermedia systems, it is open to the integration of other resources.

10.7. Analysis and discussion of results

A total of eleven (ten students and one librarian) completed evaluation forms. These were subsequently collated and the overall results were analysed. This section reports the analysed aggregated results, and discusses their implications.

10.7.1. Past experience

All evaluators had some knowledge of at least one type of computer system. The majority (eight) indicated their experience to be in the range from two to four different systems. Predictably, all had used a keyboard, although one student had never used a mouse. The majority (nine) had used word processing software, although only three had experience of drawing packages. Seven students had used compact disc drives.

No statistics currently exist regarding people's experience of computer systems in the mid-nineties, so it is impossible to identify whether the subject group from CLCM is typical. However, it is encouraging to observe that experience of computers is not alien to most music students. Indeed, computers are playing an increasingly important part in music composition and publishing, as well as in library environments at CLCM. At the time of writing this thesis, one can assume that the majority of music students have at least some experience of personal computer systems, and that the trend towards increasing knowledge, experience and frequency of use will continue.

10.7.2. Overall reactions

Overall reactions to HECTOR were consistently good, varying from a mean of 6.3 for the *difficult ... easy* scale to 7.7 for the *dull ... stimulating* scale. Although, the mean values suggest a consensus of positive reaction, some evaluators regarded the system to be rather difficult to use. There was no significant relationship however, between the past experience of different computer systems and the perceived difficulty of the system [$F(2,6) = 0.130$, $p = 0.8801$]. This may be a shortcoming of the QUIS questionnaire design, as although the evaluator had used three to four different computer systems before, the following written comment was provided:

I'm still quite new to computer technology — so what I have seen seems exciting, but I know from experience that it will take me quite a while to use it. I would need to get used to the layout — I'm unfamiliar with Apple.

Consequently, comparison between the indicators of past experience and other ratings must be considered to be fairly tenuous.

10.7.3. Screen

The range of mean values for the evaluation of screen layout and design was similar to that for the *Overall Reaction* section (6.3 for density of screen *cluttered ... clearly presented* to 7.6 for windows on screen *confusing ... clear*). One evaluator offered suggestions for improving the interface design, citing use of colour and more explanations of window and icon functionality. Certainly, colour coding might be useful to help users relate windows to the overview map, and there are facilities in the Apple Macintosh system to design *bubble help* messages, which pop up in the style of speech bubbles whenever the mouse pointer is

moved over windows and icons. Whilst not all suggestions from evaluators are sensible or even feasible, such constructive feedback serves to reinforce the usefulness of field-based evaluation exercises.

10.7.4. Learning

This aspect of the evaluation proved to be very difficult for users to evaluate. To gain a clear insight into the learnability of a system which is designed for longitudinal use requires a much more extensive trial. The ethical and practical problems of such a study have been mentioned already in this thesis, so the ratings provided by the evaluators can only act as an approximation to the system's actual learnability.

Two evaluators felt unable to provide any response to the learning related questions, and one gave very low scores, commenting that there was no real opportunity to learn how to use the system. Nevertheless, the mean values for this section ranged from 6.2 for exploration of features by trial and error *discouraging ... encouraging* to 7.2 for learning to use the system *difficult ... easy.*

10.7.5. Usefulness

The question of perceived usefulness suffers from similar evaluative judgements mentioned for aspects of learnability. All evaluators felt however, that they had gained enough insight into the system to form an opinion of its value as an essay and dissertation development tool. The questions in this section were regarded by the author as the most crucial evaluation criteria, especially the last one, which asks the evaluator to compare the approach provided by HECTOR with their current methods. The results for each question are discussed separately.

10.7.5.1. Useful for researching?

Figure 10.1 shows a histogram of the results of question 5.1.

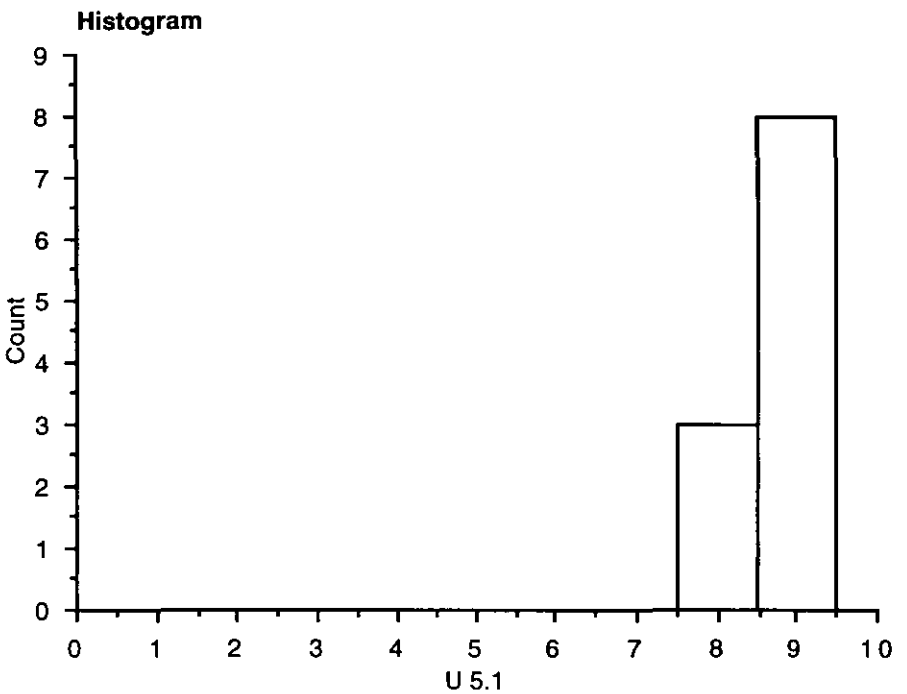

Figure 10.1. Histogram for evaluation ratings for question 5.1.
Useful for researching essays and dissertations *not at all ... very much.*

The mean value for this question was 8.7, with a standard deviation of 0.47. As can be seen from the graph, all evaluators considered HECTOR to be an extremely useful research tool. Considering students at CLCM have access to extensive research facilities both at the College and the nearby University, this result is particularly satisfying.

10.7.5.2. Useful for planning?

Figure 10.2 shows a histogram of the results of question 5.2.

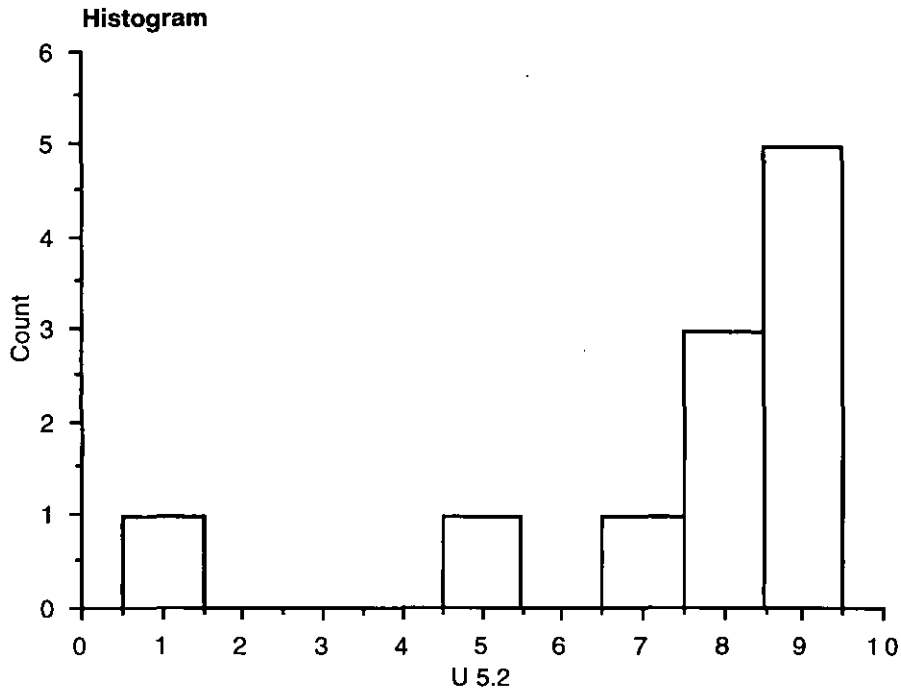

Figure 10.2. Histogram for evaluation ratings for question 5.2.
Useful for planning essays and dissertations *not at all ... very much.*

The results for this question were more spread out (mean = 7.5, s.d. = 2.47). However, the lower value of 1/9 was given by the student who did not have time to properly evaluate the planning tools. Again therefore, the perception was that HECTOR would be very useful for planning essays and dissertations.

10.7.5.3. Useful for writing?

Figure 10.3 shows a histogram of the results of question 5.3.

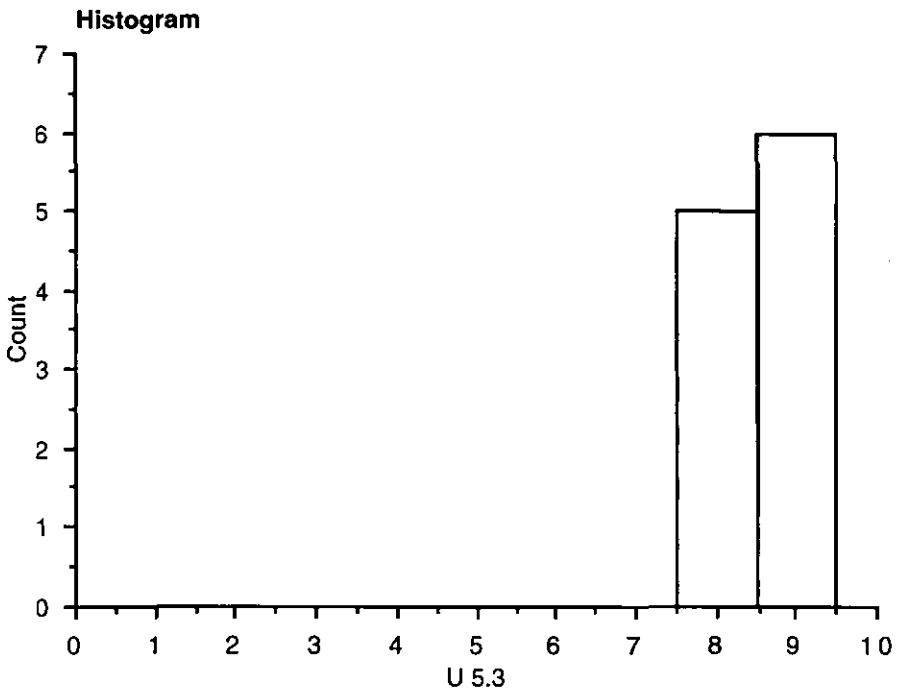

Figure 10.3. Histogram for evaluation ratings for question 5.3.
Useful for writing essays and dissertations *not at all ... very much.*

The graph suggests a similar pattern to the evaluation of HECTOR's usefulness for researching, with ratings given exclusively in the range from eight to nine. The mean (8.5) and standard deviation (0.52) reinforce this similarity. The slightly tentative verbal reservations suggested by one or two students regarding their motivation to write using this system are perhaps reflected in the results, as research activities score highest across the three types of activities.

10.7.5.4. Would you prefer to use a multimedia environment?

Figure 10.4 shows a histogram of the results of question 5.4.

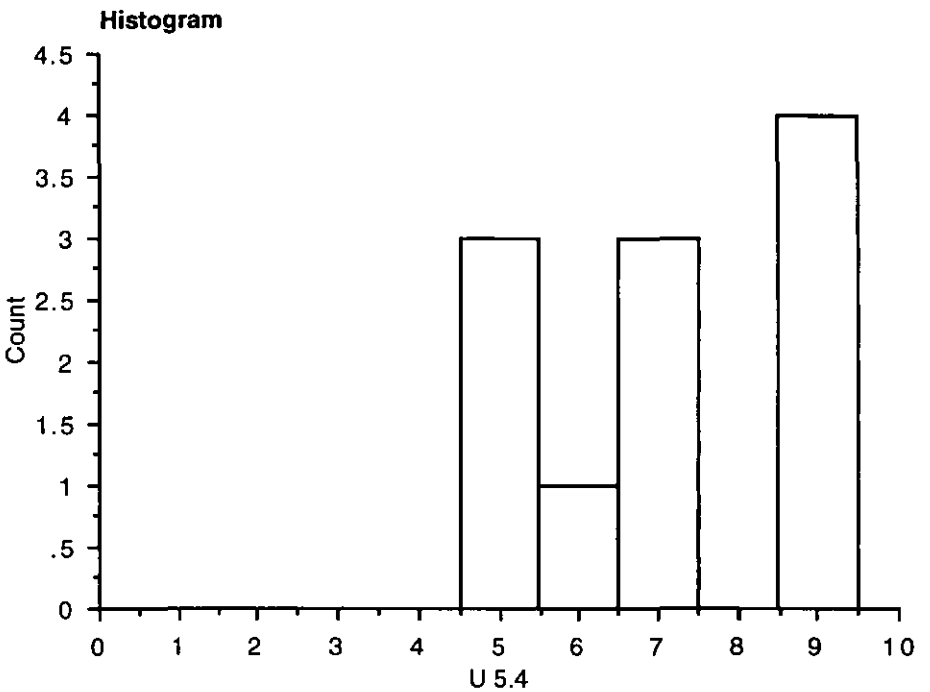

Figure 10.4. Histogram for evaluation ratings for question 5.4.
Would you prefer to use a multimedia environment over your current approach to developing essays and dissertations *no way ... definitely*.

This final question on the evaluation form reflects the central issue of the hypothesis of this thesis: can hypermedia be useful in music education? Evaluators were asked to consider whether they would prefer a computer-based multimedia approach to developing essays and dissertations over their current approach. None of the responses favoured the current approach (mean = 7.1, s.d. = 1.7), although four of the eleven evaluators expressed the view that the computer-based system would best complement their current approach. This result adds further weight to their suggestions that HECTOR's advantage lies in supporting research and planning activities, as opposed to over the complete cycle of essay and dissertation development.

10.8. Conclusion

The evaluation of HECTOR has demonstrated that a number of music students at CLCM are keen to embrace information technology, if it can assist or improve their current working practices. The question as to whether HECTOR can do this has been answered to some extent by the student evaluations. However, one must err on the side of caution in drawing any major conclusions from a study of relatively short duration. The study was essentially an interface evaluation, as it was based on the Questionnaire for User Interface Satisfaction (QUIS) (Shneiderman, 1992). However, questions relating to the perceived usefulness of HECTOR, positive comments given during interviews, as well as the question comparing it to other, more traditional approaches did serve to provide confidence in its potential. Nevertheless, a thorough, longitudinal analysis of the issues and outcomes of introducing a system into an educational environment needs to be undertaken, before such confidence can be assured.

Chapter 11
Conclusions and further research

O Thou! whose glory fills the ethereal throne,
And all ye deathless powers! protect my son:
Grant him, like me, to purchase just renown,
To guard the Trojans, to defend the crown,
Against his country's foes the war to rage,
And rise the Hector of the future age!

from Hector's prayer, Book VI, The Iliad of Homer

11.1 Introduction

This thesis began with hype. It concludes with hope. One could propose that the research conducted in this work has demonstrated the effectiveness of hypermedia in music education. One might also evince the success of the framework for human-computer interaction for educational hypermedia. Such statements cannot yet fully be determined however, due to the necessarily limited scope of the thesis.

Instead, it is suggested that this research has provided a further step towards establishing hypermedia as a complementary agent in education. Any research with complex, qualitative attributes cannot prove a hypothesis beyond all refutation; it can only serve to convince beyond reasonable doubt.

Reasonable doubt is itself a qualitative measure, and where the outcomes of this thesis are placed on such a scale is a matter for argument. This chapter will assess the results of the reported research, and present the case for their acceptance. The future of educational hypermedia will then be considered, and work will be proposed to develop further the notion of ***Hypermedia, from Essay Conception TO Realisation.***

11.2 Summary of work

The hypothesis of this thesis concerned the proposition that hypermedia can be employed effectively in higher education. More specifically, the question of its use by undergraduate music students for writing essays and dissertations was considered.

The hypothesis prompted a review into issues relating to educational hypermedia: its history, application, design and architecture; and the ensuing discussion resulted in the identification of a framework for human-computer interaction for educational hypermedia. A case study environment was chosen to facilitate the undertaking of research, as were other subject groups to carry out more generic research.

Both reading strategies and writing strategies were investigated, and the results from these studies prompted a repertory grid analysis of students' approaches to and perceptions of essay and dissertation development. The outcome of this experiment concluded with a proposal for a model of essay and dissertation development.

Analysis of the model suggested the need for further survey analysis of task-artefact usage, and experimental studies into electronic document manipulation and the reading of music from computer screens.

The implications of all this research assisted in and helped to justify the design of the prototype system HECTOR, which aims to support students in their research, planning and writing of essays and dissertations. HECTOR was evaluated in the field, and the results of this study go some way to supporting the hypothesis of this thesis.

11.3 Critique of the framework for HCI for educational hypermedia

The Shorter Oxford English Dictionary defines the word framework as:

> A structure composed of parts framed together.
>
> *Shorter Oxford English Dictionary, Third edition*

The proposed framework consists of several parts, but it could be argued that there is little evidence of their being framed together. However, this is not so. It is suggested in fact that all parts impact upon each other. This makes for a very complicated framework if it is applied properly. If it is not, the framework becomes essentially a checklist. It is important though, to recognise that any decision or guideline identified in one part of the framework, may have a positive or negative effect on another. The evaluation of such effects is the key issue, and in this respect the evaluation part of the framework is its nucleus, providing a similarity between this framework and the star life cycle proposed by Hix and Hartson (1993).

No specific method or procedure for application of the framework is proposed, although this could be a matter for further research. It is expected however, that in a user-centred methodology, participative analysis and design, prototyping and formative evaluation are fundamental. At each stage of the development process, it is suggested that careful consideration should be given to the framework. It is accepted however, that the framework has not been evaluated thoroughly, and that further empirical study should be carried out to evaluate its true validity.

11.4 Critique of research methods employed and outcomes of the work

This thesis employed a number of research methods, including surveys, interviews, repertory grid analysis, task analysis, experimental studies and fieldwork. Each application of these methods is summarised here, and a short critique is presented.

11.4.1 Survey techniques

Survey techniques were used in two studies. The first was a cross-sectional survey which aimed to ascertain the differences between reading strategies of biographical material used by students of literature and students of music. The two samples demonstrated a number of problems and issues typical of survey-based research. Whilst both samples were primarily equal in size, the number of returned forms was significantly different. The author suggested that the small number of responses provided by the CLCM students may indicate their reluctance to read such material. This may well be the case. However, there could be other reasons relating to conceivable differences in culture and student attitude between UCE and CLCM, for example. As the survey was a postal one, the author was unable to follow up such possible explanations. A criticism of the application of this survey would be that subsequent detailed interviewing should have taken place. This approach would certainly have been feasible in an environment where the author was able to dedicate significant blocks of time to the research. Another problem due to the low response rate was the validity of the subsequent comparative analysis. A sample size of thirteen for this type of study is problematic. Nevertheless, its intention was to form the basis for further study, and to justify the suggestion that individual environments have unique requirements. Even if the author's causal analysis was flawed, the recognition that there are indeed differences between the two samples satisfied the aim of the study.

The second survey was conducted in a more controlled environment. All forms were returned, as the survey was conducted in the classroom setting. The aim was to compare student usage of computer-based and non-computer based essay and dissertation

development artefacts. Students of computing were selected as the most appropriate subjects for the study, as they were assumed to have extensive experience of computer-based artefacts. The author made the additional assumption that undergraduate music students would be likely firstly, not yet to have such experience and secondly, to have it eventually. This was based on the observed trend that computers are becoming increasingly used in society. As the survey aimed to consider the future application of computer technology, what we currently call *knowledgeable* computer users were selected. Any decision of this type which relies on a prediction of the future, no matter how well justified by credible forecasting, is open to some criticism. However, in this case the author was able to follow up the survey results with an evaluation of the prototype system. This survey helped to provide a basis for the design of HECTOR, and in this sense it was successful.

11.4.2 Interviews

Interviews were conducted using both unstructured and structured techniques. Structured interviewing took place during repertory grid sessions. Unstructured interviewing was employed as a preliminary to the repertory grid sessions. It was felt that this approach would be better than that of structured interviews, as the participants might provide a more honest and open account of their approaches to writing essays and dissertations in an informal, conversational setting. A comfortable and familiar environment was also chosen (the college bar). It should be emphasised that the whole point of this investigation was not to train students to write better essays, but to provide them with a facility to support more effectively the way they want to work.

11.4.3 Repertory grid analysis

Significant discussion has already been presented to justify the use of repertory grid analysis for analysing and classifying the tasks involved in essay and dissertation development. Whilst a detailed model was not proposed as a result, it did serve to help structure the prototype system. Consequently, the repertory grid study provided the lynchpin between the formative research and the summative work, as manifested by HECTOR. This work was regarded by the author as very successful. The sessions were well-conceived and well-executed, and feedback from the subjects was positive. The limitations of the computer analysis program were disappointing, but this did not affect the results in an adverse way.

11.4.4 Task analysis

The evaluation of a traditional task analysis technique's applicability to investigating essay and dissertation development was considered by a number of experienced essay writers. The subject group was familiar with Hierarchical Task Analysis (HTA), but ironically (and typically) was not extensively trained in writing skills. In this respect, they were particularly suited to this exercise. The study emphasised the uniqueness of writing styles, and questioned the appropriateness of task analysis for what might be considered *ethereal* activities. HTA was not well-suited to the study however, as it adopts very much a procedural approach. A more complex, knowledge-based technique would have been more appropriate, but the skills-base to develop analyses in this form was not available. In order to redress some of the problems of this shortcoming, HTA was adapted by the author to provide the generification supported by these more modern approaches.

11.4.5 Experimental studies

The behavioural studies undertaken in this thesis followed well-established models of experimentation. The author gained significant insight into the design of experiments, and was successful in the management and execution of both studies. Limitations of behavioural studies for educational research are well-documented, although the outcomes of the studies reported here are intended to be formative. We do need to be aware of the ethical problems involved, but there has to be a point when one must decide to introduce new ideas to an educational environment. Experimental studies may help to justify when and how to do this, although researchers should be aware that some results in the laboratory may prove to be orthogonal to those in the field. Hence the need for fieldwork to reinforce them.

11.4.6 Fieldwork

It was considered imperative that the formative research involved in this thesis should be evaluated through a summative prototype in a realistic setting. As HECTOR aims to facilitate music students' development of written work, a music college library was regarded to be a typical environment where such a product might eventually be situated.

Although it was impossible to simulate perfectly the longitudinal use that HECTOR would be required to support, it was rewarding to observe some students actually using the system to help them research and plan their ongoing, real work. The Jazz CD-ROM and the World Wide Web artefacts were of particular interest to the students, and one might argue that the environment provided by HECTOR had a purely arbitrary effect on the artefacts'

usability. Indeed, advanced computer users might find such a structure constraining in some situations. However, HECTOR's intention is to provide that structure for those who need it, and to enable writers to maintain control and orientation within the research, planning and writing activities. As they are required to be *constructors* of written work, it is important to provide them with the necessary resources, as well as the means to organise and plan the usage of those resources. It should be noted here again, that most music students (perhaps most students even) are reluctant writers. They do understand though, that they have to do it. HECTOR provides an environment which, by integrating the things they like doing, such as research, and the things they don't like doing, such as writing, aims to improve the lot of the reluctant writer.

The results of the fieldwork were positive. Most students indicated that they expected they would prefer the approach supported by HECTOR rather than their current one. Even students with very little experience of computers demonstrated enthusiasm for it. Bearing in mind the limitations and the short duration of the field study, one should not herald the achievements of the system. Rather, the evaluation of HECTOR should be regarded to be of reasonable, if guarded success.

11.5 Critique of prototype system

The prototype system was by no means fully functional. Enough was implemented however, to demonstrate the principles of HECTOR's computerised approach to essay and dissertation development. Perhaps the most valid criticism of the implemented prototype was its slow performance. HECTOR pushed both HyperCard and the Apple Macintosh platform to their limits, and this was markedly demonstrated by the speed of interaction.

In terms of Abowd and Beale's (1991) other arcs of their interaction framework (articulation, presentation and evaluation), HECTOR was greeted with largely positive feedback from its users. A number of comments regarding the system's usability were provided during HECTOR's evaluation, such as the employment of colour coding. It is still believed though, that a system which relies on multiple windowing and context switching benefits more from a larger, grey-scale monitor than a smaller, colour option.

HyperCard was chosen as the prototype environment because of its support for rapid and flexible application development. More complex requirements were implemented in a third generation programming language (Symantec Think C), and it was known that HyperCard could support the integration of such functionality. At the beginning of development,

HyperCard could only effectively support monochrome presentation, although this was not a problem, as colour was not required anyway. When HyperCard 2.2 was released, which does support colour, grey-scale backgrounds and icons were incorporated into the design to improve its aesthetic appeal, and to provide some form of realism and affordance for the screen designs. Unfortunately, this enhancement significantly increased the run-time memory requirements of HECTOR (to about 12MB of RAM) and further slowed down the screen refresh time. Due to the limitations of the prototype, any full implementation of HECTOR would involve a completely new development, and at the time of writing, the construction of a more sophisticated system is ongoing.

11.6 Evaluation of research hypothesis

The introduction to this thesis stated the research hypothesis that hypermedia can be useful in music education. It also indicated the cautious consideration of results, considering the difficulty of applying general recommendations in such a highly complex working environment. Throughout this work, a reasonable amount of scepticism has been adopted, and consequently, one cannot state categorically whether this thesis has shown hypermedia to be truly useful in music education. Whether such statements can ever be made is a matter for argument. Education is by definition a highly complex field, and any innovation will be met with resistance from some parties, even if it demonstrably improves learning experiences and outcomes. However, considering the results of the evaluation of HECTOR and the methodical approach to its developmental research, the author feels able to defend its record of achievement, and to promote its potential for further research.

11.7 Further research

Just as the original Hector played out his part in the history of Troy, this HECTOR has played just one role in the ongoing history of hypermedia. Whether *Son of HECTOR* will have an impact in the wider field is a matter for future investigation. The prospects for the framework for HCI for educational hypermedia also requires wider analysis through further application and empirical analysis. It may be feasible for example, to incorporate the framework into a broader methodology. A tentative basis for methodological investigation might begin with the processes adopted in this thesis. That is, in the development of an educational hypermedia product, the following guidelines should be considered:

1. Take careful account of these interdependent issues throughout the development cycle
   - the educational domain
   - the pedagogy
   - the users, tasks and information
   - the evaluation of work.

2. Employ a range of qualitative and quantitative methods to describe and model the inevitable uniqueness of the chosen domain.

3. Build a prototype based on outcomes from the previous work.

4. Evaluate the prototype in a field setting with real users performing real tasks.

5. Use the results of the evaluation to improve the product, repeating previous stages as necessary.

The work reported in this thesis has described one pass through the cycle. Future work will support a more generic application of the underlying philosophy of HECTOR. It is proposed that a library of multimedia artefacts will be developed which may be used to facilitate a number of individual educational domains. For example, students of photography might benefit from visual artefacts such as virtual cameras, CD-ROMs of famous photographers and photographs, virtual photographic development laboratories and so forth. Medical students could use animated anatomical diagrams, animated demonstrations of surgical procedures and virtual operating environments. Such facilities would require a redesign of HECTOR's architecture to make it a true open hypermedia system.

Another necessary extension of the prototype system will be the support of more extensive collaborative work. Currently, HECTOR only supports this on a post-hoc basis. That is, users can share work, but only after it has been completed. In other words, they can share only their results. Students regularly communicate with one another as well as with teachers during their ongoing work (as exemplified by some of the constructs generated

during the repertory grid sessions), and this is regarded by most modern educationalists to be a healthy approach. Harri-Augstein and Thomas (1991) go even further:

> It is our contention that networks of Learning Conversations generated within many of the formal and informal groupings in our society could enable us quietly but irreversibly to reconstruct ourselves into more fully functioning people, and transform our environment into a better place to be.
>
> *Harri-Augstein and Thomas, 1991 (338)*

The provision of a collaborative work environment within or in parallel to the HECTOR system will become a priority once a wider, multi-user networked implementation is made possible. Indeed, computer-mediated conversation is already being used in music education at Glasgow University to facilitate seminars (Duffy, Arnold and Henderson, 1995).

The research described in this thesis has suggested promising implications for further work, but to assess the real usefulness of any future work developed from this thesis will require a thorough and in-depth evaluation. This must be longitudinal by definition, and all of the baggage that such a study carries with it will have to be borne.

11.8 Final comments

In his seminal survey of hypertext, Conklin wrote:

> ... hypertext, far from being an end in itself, is just a first crude step toward the time when the computer is a direct and powerful extension of the human mind, just as Vannevar Bush envisioned when he introduced his Memex four decades ago.
>
> *Conklin, 1987 (40)*

Another decade on from this statement, and hypertext is perhaps as problematic as ever. This is not necessarily because research into the relevant issues has been lacking, but more likely the *accessibilty* of hypertext has become so open that no recourse to good authoring practice is required. That is not to say that further development of open hypermedia systems is not a good idea. Indeed, quite the opposite has been proposed in this thesis. Open hypermedia is regarded here as an imperative for future systems. What is required however, is good and responsible practice within such liberalised environments.

We might provide readers and writers of hypertext applications with advice, methods, guidelines and so forth, but can never guarantee that we will be heeded. This thesis has attempted to provide such users with the opportunity to create original hypermedia documents in a simulated open environment, whilst preserving context and structure through activity-based artefacts. However, many authors might regard the very ethos of hypertext to be ultimately at odds with any structural form. The repost to such a stance is to remind hypermedia writers that they are the readers too, and in the words of Samuel Johnson:

> The only end of writing is to enable the readers better to enjoy life or better to endure it.
>
> *Dr. Johnson*
> *Review of Soame Jenyns' The Enquiry into the Nature and Origin of Evil*

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Appendix A

Survey of Readers of Biography

Please take a few minutes to answer some questions about a biography that you have read or are currently reading.

---

1. How old are you?
   - ☐ younger than 20
   - ☒ 20-29
   - ☐ 30-39
   - ☐ 40-49
   - ☐ 50-59
   - ☐ 60+

2. Please state your occupation ...STUDENT (CLCH)...

---

3. What is the title of the biography? ...BIRD LIVES...

   .....

4. Who is the author? ...ROSS RUSSELL...

5. Who is the subject of the biography? ...CHARLIE PARKER...

6. Please tick a box beside the statement which most accurately describes your reason for selecting this particular biograpy:

   - ☐ I read biographies for a hobby.
   - ☐ I don't normally read biographies, but this particular subject interests me (e.g. someone who is interested in art might want to read a biography about Leonardo da Vinci).
   - ☒ Other (please specify) ...INFORMATION FOR ESSAY...

Please answer question 1 only if the book has a table of contents.

1. Did you use the table of contents to help you to refer to sections or chapters that interested you in the book?

☐ Yes ☒ No

Please answer question 2 only if the book has a subject index

2. Did you use the subject index to help you refer to items that interested you in the book?

☐ Yes ☒ No

Please answer questions 3 to 5 only if the book contains photographs and/or illustrations.

3. Please indicate how the photographs or illustrations are organised within the book:

☒ The photographs/illustrations are grouped together in one or more blocks

☐ Photographs/illustrations are presented at points in the book where they relate to the narrative

☐ Most photographs/illustrations are grouped together, but there are some at other points in the book.

☐ Other (please specify) .....

4. Please indicate when you studied the photographs or illustrations in relation to reading the book's narrative text (tick more than one box if necessary):

☒ Before reading the book

☒ After reading the book

☒ Whilst reading the book

☐ Not at all

5. Did the book have a table of photographs or illustrations, and if so, did you use it to help you to refer to the photos/illustrations in the book?

☐ Yes and I did use the table

☐ Yes but I didn't feel that it was useful to me

☒ No, there was no table of photographs or illustrations

---

6. Please indicate any of the following types of media which you feel would help you in appreciating or learning more about the subject of the biography.
For example, if your biography is about a musician, maybe you feel it would help to be able to listen to the music which is referred to in the narrative text
(tick more than one box if necessary):

- [x] Film (e.g. TV documentary or dramatisation)
- [x] Music (e.g. record, tape or compact disc)
- [x] High quality pictures/graphics (e.g. for artist's prints)
- [ ] Other (please specify) .....

.....

7. Please tick a box beside the statement which most accurately describes the manner in which you read the biography:

- [ ] I read the whole thing from cover to cover - just as if I was reading a novel. Once I'd got to the end, I put it down and didn't bother looking at it again.
- [x] I read the whole book, but I spent some time browsing through sections in advance of and even after reading them.
- [ ] I did read all of the book, but I didn't necessarily start at the beginning and finish at the end. Some chapters/sections in the book particularly interested me so I read them first.
- [ ] I didn't finish the book (please specify the reason why in the space provided below)

.....

.....

- [ ] Other (please specify) .....

.....

8. Did reading the biography encourage you to seek further information concerning the life story of its subject?

☐ Yes ☒ No

---

9. Have you completed this questionnaire for one or more other biographies?

☐ Yes ☒ No

End of Survey - thank you for your time and patience.

Appendix B

Transcript of conversation with students at Leeds College of Music

Date: 29/4/93
Time: 1200-1230
Place: College Bar
Interviewer: RP - Richard Picking
Present: A - second year honours undergraduate
B - second year honours undergraduate

C - third year honours undergraduate (arrived later)

RP I'm looking into ways in which people like yourselves might use computers for essay and dissertation writing. I'd like to start by asking you how many essays you have to write each year.

B Four a year, and that's only if you do the honours course. If you're not on the honours course, it's only two a year. In the third year on the honours course you have to do a ten thousand word dissertation.

RP What kind of subjects are you asked to write about?

A Varied

RP Are they general, such as "Write about the history of be-bop", or are the topics more specific, say about specific people in jazz history?

A and B joke about the last "awful" essay they had to write

B "The East/West coast controversy of the 1950's caused much heated debate. If at all, was it justified. Discuss."

A It required quite a bit of research. I've got a list here of titles for the next essay.

RP So, you have four choices:
Reading list
"The Career of Duke Ellington to 1956"
"The Mid 50's Miles Davies Quintets"
"Avant-Garde jazz and the influence of John Coltrane, Ornette Coleman and Cecil Taylor"
"Contrasting styles of the Miles Davies Quintet mid 50's, Max Roach Orchestra mid 50's, Art Blakey's Jazz Messengers mid 50's"

How would you go about writing one of these essays?

no response

What would be the first thing you'd do?

B Listen to the music

RP And would you go to the library for this?

A The library's OK. It's got copies of magazines, articles...

B Yeah, that was useful for the last essay 'cause it was a controversial debate, and we had to find out where the debate came from. The debate was actually in Britain mainly.

RP Is the archive of material in the library stored on microfiche?

A No, it's the original material.

RP Do you get a booklist or a list of references for each essay?

A It's pretty much up to you to find your own sources.

RP I see - so once you've found your sources, what's the next stage?

B Read your books, listen to your music, make your notes ... put it together ... that's about it. It's hard to say really - how to write an essay.

RP Let's assume that you're in the middle of writing an essay - would you use source material at this stage, or would you have put it to one side by now?

A I'd have taken photocopies, made notes from books and articles - sometimes it's difficult because 20 or 30 students are all after one book - the library won't let you borrow some books, so you have to make photocopies there and then.

RP Would you actually refer to source material in your essay text?

A A bibliography...

RP Would you reference directly within the body of the text?

A Yeah, if we want to quote something, we'd do that. Lots of lecturers do these essays every year, so they know the books like the backs of their hands and they'd know if you've copied text as your own work.

RP Are you taught how to reference properly?

B We were given a leaflet by John Brown *Head of course* . You just put your quote down, then you number it, and then specifically list them at the back before the bibliography. If it's music you refer to the discography. I take quotes from the backs of record covers. It's a good place to find out about the music really.

RP So you've effectively got three different kinds of reference listings at the back of your essay.

A/B Yeah, that's right.

RP Do you ever use video at all to aid your work?

B Yes, there's a Duke Ellington video actually, and also a Coltrane video. In the jazz history lessons we use them, and we write down who said what.

A The thing with videos is - they're informal y'know. It's hard to get any specific information from them. Video gives a general background really. For more detailed information, you need to look at magazines and things...

B The last essay I did which was discussing the unity of Benjamin Britten's "Nocturne", I just used the record and the score and quoted that in the bibliography. If you know the work and you know the music - that's all you need to know really - for that type of essay.

RP Maybe I should at this point explain a little more about my research. What I am looking into is whether students like yourselves could write an essay - have a reference to say, a record, and the reader or assessor could actually listen to the record (stored on the computer) that you've referred to. Do you think that would be a good idea?

B Brilliant. That would make essays so much easier. Rather than try to explain how Parker's style made you feel or whatever, you could just say, well - "listen to it".

RP Do you think it would change the way in which you write the essay?

B Definitely.

RP For the good?

B For the good. I think what we should actually do is rather than do an essay, is prepare a little lecture on it, and have tapes that we play and say blah blah blah and here's an example of the music, and not talk about philosophy or literature or ... *(turning to A)* . It's true though isn't it, it's hard to write about music.

RP *(To A)* Do you think differently?

A No, no - I think he's right, but I think the essay is about acquiring a skill in writing as well as the musical side. I mean, you might be a brilliant musician, but you might be hopeless at writing an essay. And in real life, you've got to write as well as play, so perhaps it's worth developing that skill as well.

RP As far as writing is concerned, do you type up your work?

A I type my own work because I did a Business and Finance course before I came here and we were taught typing skills.

RP *(To B)* How about you?

Student C arrives and sits down. B informs him he's "on tape"

RP *Introduces himself and research topic*

B Here's the man you should talk to - he's just done a ten thousand word dissertation.

C Fifteen

RP What was the subject?

C Multi-cultural music in Brazil.

RP How long did it take you?

C I've been doing it all year, but I've had a lot of other things to do as well.

RP OK, just to be really boring, I'll ask you a couple of questions I asked earlier when you weren't here. What was the first thing you did when you began the dissertation?

C I read a lot of books.

RP Did you listen to the music?

C Oh yeah.

RP And have you referred to the music in your dissertation?

C Yeah, yeah. I've actually got manuscript examples and also verbal references.

RP And is all that referred to at the back of the text?

C The actual score examples are printed in the text, and the references are separate at the end of each chapter.

RP Did you get hold of any videos or photographs?

C No, I couldn't. They're not available. There are some videos, but you can only get them from Brazil.

RP If they were available, do you think you'd find them useful?

C Yeah, I expect I would - in a kind of indirect way. I'm not sure they'd give anything more than the sound recordings though.

RP So the material you did get hold of, was it available in the library?

C No - I got in touch with the National Sound Archive, and I used the University a lot.

RP Do you know how your dissertation is going to be assesed? Will you be given a grade - A,B,C,...

C Yeah.

RP Will you get comments back?

C I dunno actually. I think you get some comments, and they might call you to a viva ... *(to RP)* What exactly are you looking into?

RP *Explains more about computer essay wriiting project*

C What I'd like to see is a word processor with musicnotation on it.

B *Explains to C idea of referring to sound references*

C I've been thinking about putting a tape in my dissertation.

RP Do you know anyone else who's done that?

C I dunno, but there's three years of past dissertations in the library archive.

Noise increases as band tunes up for performance

RP Well you've all been a great help. I'd like to thank you for your time.

End of Recording.

Appendix C

This survey seeks to establish the resources you used to help you research and develop your **major project report**. The resources are split into two types: **computer based** on this page and **non-computer based** overleaf.

Please indicate the course you studied at the University ....BCA.....

For each resource listed below, please tick a box which best describes your usage of it. Any comments which clarify your selection would be appreciated. There is space for a couple more resources which you may wish to add to the list.

Which Computer based resources did you use?	Yes, a useful resource	Yes, but not essential	No, no need for it	No, no access to it	Other explanation	Comment
Word Processing Software	☑	☐	☐	☐		I use the one available at home, not there at the uni.
Drawing Package	☐	☑	☐	☐		
DTP Package combining text and graphics (e.g. Pagemaker)	☐	☐	☑	☐		
A Scanner	☑	☐	☐	☐		Useful for a multimedia/ HCI intensive kind of project
Electronic Mail	☑	☐	☐	☐		Good for research->"rich" especially from the Internet
CD-ROM Abstracts databases	☐	☐	☑	☐		
GEAC (Library Resource Search System)	☑	☐	☐	☐		Very helpful as an online index/retrieval system for my books
External Network (e.g. Internet/Janet)	☐	☐	☑	☐		
Electronic Diary/Organiser	☐	☐	☑	☐		
	☐	☐	☐	☐		
	☐	☐	☐	☐		

....Please circle any of these resources whose function you feel would be more beneficial in a non-computer based domain.
For example: You might consider a typewriter to be more useful to you than a word processing system.

PTO

Which Non-Computer based resources did you use?	Yes, a useful resource	Yes, but not essential	No, no need for it	No, no access to it	Other explanation	Comment
Diary	☐	☐	☐	☐		
Project Timetable/Plan	☐	☐	☐	☐		
The Royal Mail	☐	☐	☐	☐		
Hand-delivered mail	☐	☐	☐	☐		
Telephone	☐	☐	☐	☐		
Hand-written notes	☐	☐	☐	☐		
Academic Journals/Books	☐	☐	☐	☐		
Photocopying facilities	☐	☐	☐	☐		
Newspaper/Magazine Articles	☐	☐	☐	☐		
	☐	☐	☐	☐		
	☐	☐	☐	☐		

....Please circle any of these resources whose function you feel would be more beneficial in a computer based domain.
For example: You might consider computerised academic books/journals to be more useful than their paper based equivalent.

THANK YOU FOR YOUR TIME AND PATIENCE. PLEASE RETURN YOUR FORM TO RICHARD PICKING (room K332)

Appendix D

Evaluation Form

Part 1: Past experience

1.1. How many different types of computer systems (e.g. Atari ST, Apple Macintosh, IBM PC) have you worked with?

none	☐	3 - 4	☑
one	☐	5 - 6	☐
two	☐	more	☐

1.2. Of the following devices, software and systems, which ones have you personally used and are familiar with?

keyboard	☑	word processor	☑	compact disk drive	☐
mouse	☑	drawing package	☐		

Part 2: Overall user reactions

Please circle the numbers which most appropriately reflect your impressions about using this computer system.

2.1. Overall reactions to the system

terrible — wonderful
1 2 3 4 5 6 (7) 8 9

frustrating — satisfying
1 2 3 4 5 6 (7) 8 9

dull — stimulating
1 2 3 4 5 6 (7) 8 9

difficult — easy
1 2 3 4 5 6 (7) 8 9

rigid — flexible
1 2 3 4 5 6 (7) 8 9

2.2. Please write any other general comments you have about the system below, and over the page if necessary.

The system will be extremely useful for research especially when linked up to the internet. However the time it takes to search for material may make it quicker to use the music college libary at first - until more "connections" are established. It would be interesting to see if it could be linked to other programme in

Part 3: Screen

3.1. Characters on the computer screen — hard to read / easy to read
1 2 3 4 5 6 7 8 (9)

3.2. Were the screen layouts helpful? — not at all / very much
1 2 3 4 5 6 (7) 8 9

3.3. Windows on the screen — confusing / clear
1 2 3 4 5 6 (7) 8 9

3.4. Density of screen — cluttered / clearly presented
1 2 3 4 (5) 6 7 8 9

Part 4: Learning

4.1. Learning to use the system — difficult / easy
1 2 3 4 5 6 7 (8) 9

4.2. Exploration of features by trial and error — discouraging / encouraging
1 2 3 4 5 6 7 (8) 9

4.3. Remembering names and commands — difficult / easy
1 2 3 4 5 6 7 (8) 9

4.4. Can tasks be performed in a straightforward manner? — never / always
1 2 3 4 5 6 7 (8) 9

Part 5: Usefulness

5.1. Useful for researching essays and dissertations — not at all / very much
1 2 3 4 5 6 7 8 (9)

5.2. Useful for planning essays and dissertations — not at all / very much
1 2 3 4 5 6 7 8 (9)

5.3. Useful for writing essays and dissertations — not at all / very much
1 2 3 4 5 6 7 8 (9)

5.4. Would you prefer to use a multimedia environment over your current approach to developing essays and dissertations? — no way / definitely
1 2 3 4 (5) 6 7 8 9

(because of time involved - at present)