An Evaluation of Structured Navigation for Subject Searching in Online Catalogues

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CONTENTS

List of Tables 5
List of Figures 8
Acknowledgements 11
Abstract 12

1. Research Context of Online Catalogue Study, Part One 13
1.1 Introduction: Research Problem Context, Questions and Objectives 13
1.1.1 Research Problem Identification 13
1.1.2 Problem Refinement: Multidimensional Efforts to Improve Subject Searching 14
1.1.3 Online Catalogue Study Research Questions and Objectives 16
1.1.4 Design of the Experiment 17
1.1.5 Research Questions of the Study 17
1.1.6 Research Objectives of the Study 18
1.2 Second Generation Online Catalogues: Subject Searching Features and Problems 19
1.2.1 Two Approaches to Searching in Online Catalogues 22
1.2.1.1 Query Searching 23
1.2.1.2 Browse Searching 24
1.2.2 Easier Subject Searching 26
1.2.3 Conventional, Second-Generation OPAC Subject Searching Summarized 29
1.2.4 Problems and Shortcomings of Today's OPACs 31
1.2.5 LCSH-Based Subject Searching 33
1.3 Subject Searching in the Expanded Online Library Catalogue 37
1.3.1 The Phenomenon of the Expanding Online Catalogue 37
1.3.2 Pursuing the Vision of the E-3-OPAC 38
1.3.2.1 Ways of Enhancing, Expanding and Extending the OPAC 39
1.3.3 Enhancing the Functionality of the OPAC 41
1.3.4 Expanding the OPAC 43
1.3.5 The Extended, Networked OPAC 44
1.3.5.1 Searching Interconnected OPACs - Problems, Challenges, and Needed Standards 46
1.3.5.2 Barriers to Effective Access and Use 47
1.3.5.3 OPAC User Interface Standards 50
1.3.6 Today's Online Catalogue: New Perpectives and Escalating Demands 52
1.3.7 The Scholar's Workstation 54
1.4 Research Context Summarized 57
1.4.1 End-user Searching of Bibliographic Retrieval Systems 57

2. Research Context, Part Two: Searching and Browsing in Information Retrieval Systems 62
2.1 The Conventional Information Retrieval Model 62
2.1.1 Functional Objective of an Information Retrieval System 62
2.1.2 The Information Retrieval Situation 63

2.1.3 A Classification of Retrieval Techniques 65
2.1.4 The Exact Match Search Paradigm 66
2.1.5 Explicit and Implicit Online Catalogues 67
2.1.6 Browsing in Exact Match Systems 70
2.1.7 Summary: Browsing as an Information Seeking Method 71
2.2 The Nature and Types of Browsing 72
2.2.1 The Concept of Browsing 72
2.2.2 Types of Browsing 76
2.2.3 Browsing Aids 77
2.2.4 Searching or Browsing? 78
2.3 Limitations and Problems of the Conventional Model of Information Retrieval 80
2.3.1 Performance and System Use Problems: A Reappraisal of Boolean Retrieval Methods 81
2.4 Information Retrieval Research and the Probabilistic Model of Information Retrieval 86
2.4.1 The Information Retrieval Situation 86
2.4.2 Information Retrieval as an Inference Process: From Matching to Relevance 90
2.4.3 Summary of Contributions From Information Research and Experimentation 94
2.5 A New Paradigm: Browsing as a Primary Search Strategy 95
2.5.1 New Models of Information Seeking 97
2.5.1.1 As We Often Seek 100
2.5.2 Conclusion: Information Seeking, Retrieval Systems and Browsing 102

3. Methodology, Part I: Design and Development of Experimental Online Catalogue 104
3.1 Chapter Overview 104
3.2 A Design Rationale for Browsing Systems: Alternative Viewpoints 104
3.3 Experimental Online Catalogue Design Aims and Objectives 115
3.4 Software and Hardware Selected for the Research Project 116
3.5 Test Database Contents and Structure 123
3.5.1 Bibliographic Records Used in the Experiment 123
3.5.2 Subject Augmentation of Bibliographic Records in the Test Database 125
3.5.3 Thesaural Relationships in the Library of Congress Classification Schedules 128
3.6 Catalogue Database Search Access Options 133
3.7 Three Test Online Catalogues 135
3.8 Design of the User Interface 142
3.9 Summary 150

4. Methodology, Part II: Testing and Experimenting with the Online Catalogues 151
4.1 Chapter Overview 151
4.2 Design of the Retrieval Test 151
4.2.1 Structure of the Experiment 151

4.2.2 Search Performance Measures Used 153
4.3 Setting and Participants in the Experiment 156
4.3.1 Setting and Conditions 156
4.3.2 Recruitment and Scheduling of Participants in the Experiment 158
4.4 Test Procedures and Data Collection Methods 159
4.4.1 Overview of Procedures and Data Collection Methods 159
4.4.2 Personal Data Collection: Pre-Search Questionnaire 161
4.4.3 Hands-on Training in System Use 161
4.4.4 First Search Task 163
4.4.5 Second Search Task 164
4.4.6 User Responses to the Experimental Online Catalogue: Post-Search Questionnaire 165
4.5 Summary 166

5 Data Analysis and Test Results 167
5.1 Chapter Overview 167
5.2 Analysis of Search Results 168
5.2.1 Preliminary Analysis of Results 168
5.2.2 Secondary Relevance Judgements of SELECTS 170
5.2.3 Overall Search Results: Overlap Analysis 172
5.3 Creation of the Database for Statistical Analysis 177
5.4 Characteristics of Searchers and Groups 180
5.4.1 Personal and Catalogue Use Data 180
5.4.2 Characteristics of Groups and Tests for Homogeneity 183
5.5 Search Performanced Analysis 190
5.5.1 Summary Statistics of Performance Scores By Group 190
5.5.2 Results of Group Performance Score Comparisons 200
5.5.3 The Correlation Between Recall and Performance 204
5.6 User Responses to the Experimental Online Catalogue 208

6 Discussion and Conclusion 213
6.1 Key Findings of the Study 213
6.2 Conclusion 217

References 221

Appendix - A 232
Appendix - B 233
Appendix - C 234
Appendix - D 235
Appendix - E 236
Appendix - F 237
Appendix - G 238
Appendix - H 239
Appendix - I 240
Appendix - J 241

List of Tables

Table 5.1 Total Number of Subjects By Group 169

Table 5.2 Task-A Topic Selection Totals By Group 170

Table 5.3 Task-A, Topic 3 SELECTS 172

Table 5.4 Task-A, Topic 5 SELECTS 172

Table 5.5 Task-B SELECTS 173

Table 5.6 Mean No. of Selectors of Relevant Documents, Topic-3 174

Table 5.7 Mean No. of Selectors of Relevant Documents, Topic-5 174

Table 5.8 Mean No. of Selectors of Relevant Documents, Task-B 174

Table 5.9 Topic-3 Overlap By Group 176

Table 5.10 Topic-5 Overlap By Group 176

Table 5.11 Task-B Overlap By Group 176

Table 5.12 Task-B Top-7 Document Selection Analysis By Group 177

Table 5.13 Task-B Top-17 Document Selection Analysis By Group 177

Table 5.14 Independent and Dependent Variables Examined in the Study 179

Table 5.15 Frequencies: Sex 180

Table 5.16 Frequencies: Age 181

Table 5.17 Frequencies: University Level 181

Table 5.18 Frequencies: Major Area of Study 181

Table 5.19 Frequencies: Level of Economic Knowledge 181

Table 5.20 Frequencies: Number of OPACs Used 182

Table 5.21 Frequencies: OPAC Use Frequency 182

Table 5.22 Frequencies: Known-item vs. Subject Search 182

Table 5.23 Frequencies: Prior Book Knowledge 182

Table 5.24 Frequencies: Found Term in Browse Lists 183

Table 5.25 Frequencies: Experienced Difficulties or Confusion 183

Table 5.26 Frequencies: Used BOOKSHELF BROWSING option 183

Table 5.27 Frequencies by Group: Sex 184

Table 5.28 Frequencies by Group: Age 185

Table 5.29 Frequencies by Group: University Level 185

Table 5.30 Frequencies by Group: Major Area of Study 186

Table 5.31 Frequencies by Group: Level of Economic Knowledge 186

Table 5.32 Frequencies by Group: Number of OPACs Used 187

Table 5.33 Frequencies by Group: OPAC Use Frequency 187

Table 5.34 Frequencies by Group: Known-item vs. Subject Search 188

Table 5.35 Frequencies by Group: Prior Book Knowledge 188

Table 5.36 Frequencies by Group: Used BOOKSHELF BROWSING option 189

Table 5.37 Frequencies by Group: Found Term in Browse Lists 189

Table 5.38 Frequencies by Group: Experienced Difficulties or Confusion 190

Table 5.39 Task-A Summary Group Performance Scores 191

Table 5.40 Task-B Summary Group Performance Scores 191

Table 5.41 Average E Scores by Group, Task-A and Task-B 196

Table 5.42 Summary Statistics for Browsers and Non-Browsers, Task-A 198

Table 5.43 Summary Statistics for Browsers and Non-Browsers, Task-B 199

Table 5.44 Avg. E values for browsers and non-browsers, Task-A 199

Table 5.45 Avg. E values for browsers and non-browsers, Task-B 199

Table 5.46 Results of ANOVA on Group ZSCORE_A's 202

Table 5.47 Results of T-test on ZSCORE_A's of Groups 2 and 3 202

Table 5.48 Results of Mann-Whitney Tests on Group-2 and Group-3 Task-A ZSCORES 203

Table 5.49 Results of Mann-Whitney Tests on Group-1 and Group-3 Task-A Q-SCORES 204

List of Figures

Figure 1.1 Second Generation Online Catalogue Advances 20

Figure 1.2 Models of Online Catalogues 21

Figure 1.3 Two Online Catalogue Search/Access Options 23

Figure 1.4 The Extended OPAC - Eight ways 40

Figure 1.5 Third-Generation OPACs 42

Figure 1.6 Microcomputer-Based Distributed Access Via LANs, Gateways, and Wide-Area Networks 55

Figure 2.1. The Retrieval Technique Situation 64

Figure 2.2. The Classic Information Retrieval Model 64

Figure 2.3. A Classification of Retrieval Techniques 65

Figure 3.1 An Online Catalogue Database Model 119

Figure 3.2 Experimental Online Catalogue Levels of Access 121

Figure 3.3 Economics Area Sub-Classes Included in Test Database 125

Figure 3.4 Page From Library of Congress Classification Schedules 127

Figure 3.5 Full citation display with added LCC-derived subject heading 130

Figure 3.6 Experimental online catalogue "thesaurus" display 130

Figure 3.7 Alphabetical Subject Heading Index Display 132

Figure 3.8 Experimental Catalogue Main Menu 133

Figure 3.9 Experimental Online Catalogue "Author" Search Menu 134

Figure 3.10 Experimental Online Catalogue Conference Name Browse List 134

Figure 3.11 Group-1 Search Display Sequence (Figs. 3.11 - 3.18) 135

Figure 3.12 Group-1 Search Display Sequence (Continued) 136

Figure 3.13 Group-1 Search Display Sequence (Continued) 136

Figure 3.14 Group-1 Search Display Sequence (Continued) 136

Figure 3.15 Group-1 Search Display Sequence (Continued) 137

Figure 3.16 Group-1 Search Display Sequence (Continued) 137

Figure 3.17 Group-1 Search Display Sequence (Continued) 137

Figure 3.18 Group-1 Search Display Sequence (End) 138

Figure 3.19 Group-2 OPAC Full Citation Display 138

Figure 3.20 Group-2 Navigation Results Screen Display 139

Figure 3.21 Group-3 OPAC Full Citation Display 139

Figure 3.22 Bookshelf Browsing Search Display Sequence (Figs. 3.22 - 3.28) 140

Figure 3.23 Bookshelf Browsing Search Display Sequence (Continued) 140

Figure 3.24 Bookshelf Browsing Search Display Sequence (Continued) 140

Figure 3.25 Bookshelf Browsing Search Display Sequence (Continued) 141

Figure 3.26 Bookshelf Browsing Search Display Sequence (Continued) 141

Figure 3.27 Bookshelf Browsing Search Display Sequence (Continued) 141

Figure 3.28 Bookshelf Browsing Search Display Sequence (End) 142

Figure 4.1 Outline of Test Procedures 160

Figure 5.1 Mean ZSCORES, Task-A SELECTS by Group 193

Figure 5.2 Mean Task-B SELECTS by Group 194

Figure 5.3 Mean Recall Scores by Group and Task 194

Figure 5.4 Mean Precision Scores by Group and Task 194

Figure 5.5 Mean Q-SCORES by Group and Task 194

Figure 5.6 Mean Task-B Fallout Scores by Group 195

Figure 5.7 ESCORES by Group and Task 196

Figure 5.8 Precision-Preference ESCORES by Task 197

Figure 5.9 Recall-Preference ESCORES by Task 197

Figure 5.10 Mean Browser and Non-Browser ESCORES for Task-A 200

Figure 5.11 Mean Browser and Non-Browser Q-SCORES for Task-A and Task-B 200

Figure 5.12 Plot for Precision and Recall for All Task-A, Topic 3 and 5 Searches (n=22) 205

Figure 5.13 Plot for Precision and Recall for All Task-B Searches (n=54 205

Figure 5.14 Plot of Group-1, Task-B Precision and Recall Scores 207

Figure 5.15 Plot of Group-2, Task-B Precision and Recall Scores 207

Figure 5.16 Plot of Group-3, Task-B Precision and Recall Scores 208

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Abstract

Understanding and improving subject searching in online library catalogues is the focus of this study. Against the backdrop of current research and developments in online catalogues an analysis of the problems and prospects for subject access in the expanding online catalogue is presented. Developments in recent information retrieval theory and practice are reviewed, and a case is made for a new model of information seeking and retrieval that more closely describes much of the subject searching and browsing activity actually conducted by library users.

The center piece of this study is the experiment that was conducted using an experimental online catalogue developed to investigate and evaluate the effect of alternative browse and navigate search methods on overall retrieval effectiveness and subject searching performance.

The objectives, methodology, and findings of this online catalogue search experiment are discussed. The primary aim of the experimental study was to evaluate the usability and retrieval performance of a pre-structured "navigation" approach to subject searching and browsing in library catalogues. The main hypothesis tested was that the provision and use of a navigation search and browse function would significantly improve overall OPAC retrieval effectiveness and the subject searching performance of OPAC users.

The OPAC used in the study was designed and implemented by this author using the database management and retrieval software known as "TINMAN", provided by Information Management & Engineering, Ltd. TINMAN employs an entity-relational database structure which permits the linking of any field in the stored bibliographic record to any other field. These linkages establish browse and navigation pathways among data fields ("entities") and citations to support guided but flexible searching and browsing through the collection by users. Thus, a rudimentary form of hypertext is provided for the users of the OPAC. The test database consisted of 30,000 Library of Congress MARC bibliographic records selected at random from all LC catalog records for publications through 1988 in the English language in the LC classes HB-HJ (Economics, Business, etc.). For each record, the verbal description of the assigned LC class number found in the printed schedules was added as a subject descriptor to augment the subject cataloging provided by the Library of Congress.

Three different OPACs were tested for comparison purposes. The control OPAC lacked the navigation feature. The other two OPACs supported related-record navigation, one on title words only, the other on subject headings only. Searchers were encouraged to use the OPAC's features and search options in whatever manner they wished. Subjects in Group-1 were permitted to navigate only on the subject headings from the controlled subject vocabulary assigned to the work cited (augmented by the verbal meanings of the Library of Congress class number). Subjects in Group-2 were permitted to navigate, but only from title words of the work cited and displayed. Navigating from one of these title words would result in the retrieval of all works whose titles had at least one occurrence of the selected word. Subjects in the control group were not permitted to navigate; that is, it was not possible for them to point to a selected data element in a displayed citation to move on to related terms or citations associated with that data element.

The positive value of related-record navigation in improving subject searching in OPACs was not clearly determined. The navigation groups performed significantly better than the control group on the first search task, but all three groups performed nearly equally well on the second search task. Navigation on subject headings or title keywords resulted in higher recall scores, especially among first time, novice users of the system, but precision suffered significantly in title-word navigation. In fact, the control group achieved higher precision scores on both search tasks. Navigation did not seem to aid subject searching performance after greater familiarity with the system was achieved, except perhaps to increase recall in persistent searches without much decrease in precision. Online bookshelf browsing seems to improve recall without a significant decrease in precision, and may be a more positive factor than navigation on either subject headings or title words.

Chapter 1

Research Context of Online Catalogue Study, Part One

1.1 Introduction: Research Problem Context, Questions and Objectives

This study is an investigation of subject searching in online library catalogues. Understanding and improving subject searching in online library catalogues is the motivation for this study. Against the backdrop of current research and developments in online catalogues an analysis of the problems and prospects for subject access in the expanding online catalogue is presented in chapter 1. In chapter 2, developments in recent information retrieval theory and practice are reviewed, and a case is made for a new model of information seeking and retrieval that more closely describes much of the subject searching and browsing activity actually conducted by library users.

1.1.1 Research Problem Identification

Online catalogues, in their present-day expanded, extended form, are being transformed into radically new instruments for access to library collections. This access includes the traditional catalogue of books (but with subject-augmented records), additional bibliographic databases, non-bibliographic information files, and even full-text document files as they become available in electronic form.

The problem context addressed by the research reported here will be discussed in considerable detail in this chapter and chapter 2. In short, it is a context where the use of expanded, extended online catalogues to meet a growing variety of subject information needs is increasing, and the pervasive problems and difficulties associated with subject searching in operational online catalogues are still largely unresolved. These problems remain and are commonly encountered even in the retrieval systems that have been "fronted" with easy-to-use interfaces, interfaces that have greatly reduced the "mechanical" barriers to end-user searching. The challenge to researchers and system designers is to propose and evaluate alternative approaches to online subject searching and new methods for improving the performance of subject searchers and the overall effectiveness of information retrieval systems.

1.1.2 Problem Refinement: Multidimensional Efforts to Improve Subject Searching

Most of the searching conducted in online catalogues involves searching for information or materials on a specific subject, topic of interest, or exploration of an area of interest. Reflection on the reported numerous and different difficulties associated with subject searching leads to the inescapable conclusion that subject searching in online retrieval systems is a complex, multidimensional problem.

This realization should come as no surprise. Research into online catalogue use and end-user searching behavior is no longer in its infancy and is passing into a more mature phase. As a scientific discipline typically matures, early issues, problems, and questions do not so much get resolved or answered as they get restated or refined. The pressing or interesting problems undergo reductive analysis or restatement from new perspectives. This process yields new and different questions, questions usually more specific than the earlier ones. We get more manageable research topics to chew on, so to speak, but we are also able to address aspects of a complex issue in greater depth.

In recent years some information retrieval (IR) system and online catalogue researchers have been refining the earlier research questions, "What is subject searching?", and "How much of it takes place in the library catalogue?", and have replaced them with a set of related questions:

* How do searchers actually go about seeking information on a topic in the larger context of the library, or elsewhere?

* What are the varieties of search behavior undertaken by subject searchers in our bibliographic retrieval systems?

* What are the various search aims or objectives of subject searchers?

* What sort of search and display interactions are satisfying to different subject searchers?

* What are the interactive search and display requirements for a

variety of kinds of subject searching?

* What are the difficulties faced by inexperienced users of multiple-database systems?

* What search assistance or retrieval methods will lead to a reduction in subject search failures?

Early online catalogue research focused on catalogue use, characteristics and reactions of users, and the search approaches and features of operational online catalogues (Hildreth, 1985). Use and user studies continue as online catalogues evolve and expand. The application of several research methods, for example, surveys, questionnaires, transaction logging and analysis, focus groups, and controlled experiments, have sharpened our understanding of the problems encountered by end-users of our online bibliographic retrieval systems (Mischo & Lee, 1987; Drabenstott, 1991; Hancock-Beaulieu, 1989; Larson, 1991).

These problems are being addressed by researchers, developers, and librarians on several fronts. The areas of concentration include:

- Augmenting and enhancing the bibliographic record itself with additional subject access points and contents information

- Evaluating training, instructional, and online assistance needs of users

- User-system interface enhancements

- Improved, alternative retrieval techniques

- Intelligent, expert system "client" front-ends to distributed database servers

The major thrust of recent research and development in online catalogues has been to propose, test, and assess solutions to the system performance and use problems identified in the more than ten years of concentrated research on operational systems and their use and users. In her review of research methods used in the studies of online catalogues, Hancock-Beaulieu identifies three different directions this research has taken in recent years (1989a):

> - Firstly there are those studies which further explore the potential of transaction log analysis as a means of extracting more information about usage of actual operational systems which could feedback to systems design.
>
> - Secondly we have some projects which concentrate on the system design features, developing prototype experimental systems with new or improved features whose retrieval effectiveness could then be tested on real users.
>
> - Thirdly several dissertations, using controlled experiments and test searches, explore the more cognitive aspects of searching behaviour and user interaction.

The research reported here fits primarily into Hancock-Beaulieu's second category, and contains some elements of her third category.

1.1.3 Online Catalogue Study: Research Questions and Objectives

The centerpiece of this research study is an experiment that was conducted using an experimental online catalogue developed to investigate and evaluate the effect of alternative browse and navigation search methods on overall retrieval effectiveness and subject searching performance. A full discussion of the objectives, methodology, and findings of this online catalogue research project will be presented in the chapters 3 - 6. The primary aim of the experimental study was to evaluate the usability and retrieval performance of a pre-structured "navigation" approach to subject searching and browsing in library catalogues. One of the secondary aims was to investigate users' responses to, and the impact on search performance of, an online emulation of bookshelf browsing as it typically takes place in libraries. The main hypothesis tested was that the provision and use of a navigation search and browse function would significantly improve overall online catalogue retrieval effectiveness and the subject searching performance of online catalogue users.

1.1.4 Design of the Experiment

In design, the experiment may be characterized as a multi-factor, multi-level comparison of three independent groups, with pair-wise comparisons intended. Human subjects were recruited to conduct subject searches on the test online catalogues in a controlled environment. Each subject used only one of the three different online catalogues tested for comparison purposes. The subject searching performance of three separate groups of searchers, each group using a different online catalogue, was measured and evaluated.

Group-1 and Group-2 (as they will be referred to in the following text and on data graphs) searched the online catalogues which featured navigation as a search method. The Group-1 online catalogue allowed navigation only on the subject headings displayed with a document's citation. The Group-2 online catalogue also allowed navigation, but only on key words from the title of a displayed document reference. Group-3 served as the control group and searched the online catalogue lacking the navigation search capability. The control online catalogue featured a conventional full-record display format. Thus, subjects in Group-3 were not permitted to navigate (and they were not told about this "missing" feature); that is, it was not possible for Group-3 searchers to point to a selected data element in a displayed citation to move on to related terms or citations linked to that data element.

Navigation, then, is the primary "treatment factor" or experimental variable of interest in this study. Three "levels" of this system factor were investigated: no navigation; navigation only on subject headings; and navigation only on title keywords.

1.1.5 Research Questions of the Study

1. What is the role of unconventional, nonlinear, hypertext-like methods of subject searching and browsing in online catalogues, and for which type of user and search task are they the most appropriate?

2. Does the use of an unconventional browse and navigational approach to subject searching in an online catalogue lead to improvements in search performance, specifically,

a. When navigation is permitted only via the subject headings of a controlled vocabulary?
b. When navigation is permitted only via significant title words?

3. What is the effectiveness of a classified approach to subject searching, namely, navigation via call numbers and online "Bookshelf Browsing", in the online catalogue?

4. What qualitative factors influence searchers' retrieval performance?

5. What difficulties are encountered in their use and how do users assess these alternative subject searching approaches:

a. Alphabetical term browsing?
b. Navigation?
c. Bookshelf Browsing?

1.1.6 Research Objectives of the Study

1. To build an online catalogue retrieval system, including the design of the database, that could support a variety of subject browsing and display approaches to be used as an experimental tool and demonstration system to address these and related research questions.

2. To evaluate the usability and effectiveness of the linked-term, cross-document navigational approach to subject searching and browsing.

3. To examine the acceptance and use of bookshelf-like browsing at the online catalogue.

4. To employ a variety of quantitative performance measures to assess the retrieval performance of the different search approaches tested.

5. To explore which qualitative factors, if any, have an effect on subject searching performance (e.g., sex, subject knowledge, educational level, online catalogue experience, etc.).

1.2 Second Generation Online Catalogues: Subject Searching Features and Problems

The most recent stage in the development and evolution of automated library functions is the provision of online, interactive library catalogues for direct use by the "public" (as we shall see, both "resident" in-library users and non-resident library users). This development is historic and monumental. The online catalogue, unlike earlier forms of the catalogue, has the practical potential to become a microscope for deep exploration of the library's collection, and it holds the promise of providing the user an open window to the entire universe of bibliographic and recorded information.

Today's interactive Online Public Access Catalogues (OPACs) and CD-ROM catalogues tend to resist definition or functional description, because, unlike automated library cataloguing, circulation, and interlibrary loan systems, they are ever-changing in content, functionality, range, and usability. At birth, online catalogues were little more than mechanized replications of the card catalogues, and at this early stage they provided less access and content than their traditional predecessors in card, book, or microfilm forms.

Most of today's operational online catalogues, both university-based systems and the online catalogues supplied by the commercial vendors, can be characterized as second-generation online catalogues (See Figure 1.1). Functionally speaking, these second-generation online catalogues with their databases of library catalogue records can be viewed as special purpose online reference retrieval systems.

Second-generation online catalogues represent a qualitative leap of progress over first-generation online catalogues, the target of much criticism in the professional literature. These are some of the reasons. In first-generation online catalogues searching was initiated by derived-key input or by exact word or phrase-matching on at least the first part (left-most) of the word or phrase (as with heading searches in the card catalogue). In addition to lacking full bibliographic records and subject access, including any keyword access to titles or subject headings, first-generation online catalogues provided only a single display format, a single unforgiving mode of interaction with the system, and little or nothing in the way of online user assistance. Refining and improving a search in progress, based on an evaluation of intermediate results, was out of the question. Without full records, subject access, authority-based searching with cross references, and meaningful browsing facilities, first-generation online catalogues were understandably criticized as inferior to traditional, non-automated library catalogues.

Subject Access via Library of Congress Headings
Keyword Access to a Variety of Fields
Browsing Index or Thesaurus Terms (With Cross References)
Interactive Search Refinement (Boolean Logic, Limiting, Etc.)
Search Term Approximate Matching (Truncation, Wildcards)
Shelf List Scanning

Two or More Dialogue Modes (Menu, Command, Conversational)
Informative Error Messages
Directory-Based Help Facility
Automatic Search/Display Option Suggestions

Full Bibliographic Records Accessible
Multiple Display Format Options (Inc. Non-MARC Labels)
Search Results Output Options (Save, Printing, Sorting)

Figure 1.1 Second Generation Online Catalogue Advances

Today's second-generation online catalogues represent a marriage of the library catalogue and conventional online information retrieval (IR) systems familiar to librarians who search online abstracting and indexing databases via DIALOG, BRS, DATASTAR, MEDLINE, etc. (See Figure 1.2) Improved card catalogue-like "main entry" searching and browsing-by-heading capabilities have been joined with the conventional IR keyword and Boolean searching approaches. Much of the power and flexibility familiar to online database search specialists which enables the "post-coordinating" of search concepts and terminology has been brought to the online catalogue searcher. Many online catalogues support the ability to restrict searches to specified record fields, to perform character-masking and/or right-hand truncation, and to limit the results by date, language, place of publication, etc. Also, bibliographic records may be viewed and printed in a number of different display formats.

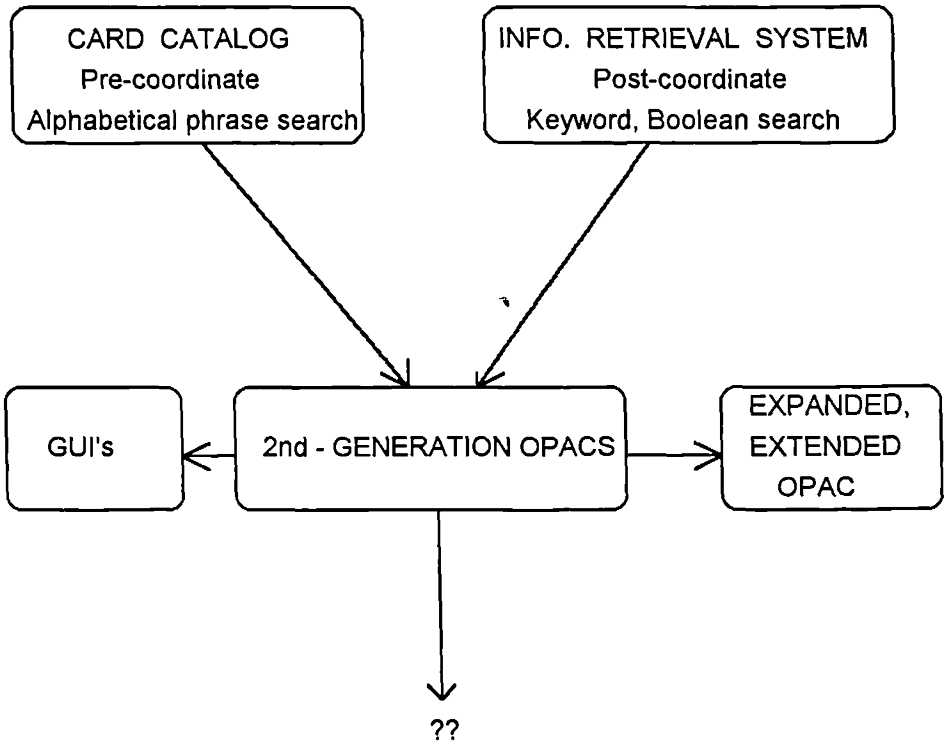


Figure 1.2 Models of Online Catalogues

Second-generation online catalogues should be viewed as online bibliographic information retrieval systems. But when compared to conventional keyword, Boolean commercial database search and retrieval systems, these key differences should be kept in mind:

* the online public access catalogue must be usable directly by untrained and inexperienced users (online assistance is usually provided to help with the mechanics of searching),

* records in the catalogue database lack abstracts, the subject indexing is sparse and the vocabulary is often not representative of current terminology, and

* the catalogue database, in covering a library's collection, includes information on a wide variety of disciplines and subject areas.

Designers of second-generation online catalogues have addressed these differences in two ways:

(a) by providing card catalogue-like pre-coordinated phrase searching and browsing options (along with keyword/Boolean capabilities), and

(b) by providing more and more online user assistance in the form of menus, help displays, suggestive prompts, and informative error messages.

Post-coordinated keyword searching on subject-rich fields (e.g., titles, corporate names, series entries, notes, and subject headings) supported in most of today's online catalogues can be used to alleviate the twin problems associated with the sparse subject indexing of most library materials and the users' unfamiliarity with the controlled subject indexing vocabularies (e.g., PRECIS - PREserved Context Indexing System - and LCSH - Library of Congress Subject Headings).

1.2.1 Two Approaches to Searching in Online Catalogues

Two fundamentally different search approaches can be found in second-generation online catalogues (See Figure 1.3). It is commonly recognized that keyword, Boolean post-coordinate searching is different than pre-coordinated phrase searching, but the difference I am addressing now cuts deeper across the online catalogue interface territory. It is the difference between exact match querying and browsing. These different search approaches are best understood by considering differences that may exist in 1) users' search objectives, 2) system requirements for query specification and input, and 3) system output displayed and subsequent interaction (if any) with the searcher.

I. QUERYING
   A. Phrase Matching
      (Text strings or controlled vocabulary)
   B. Keyword Matching
      (Discrete words, with Boolean or proximity formulations)

**Query search requirements: Search aim/criteria known and can be expressed with relative precision and completeness

II. BROWSING
   A. Pre-sequenced, linear, inflexible
      (Typically, lists of index terms, headings, descriptors, or brief titles)
   B. Non-linear, multi-directional, flexible
      ("navigation", "chain", "bridge", "relational", "serendipitous" browsing)

**Browse search requirements: Search aim/criteria not specific, not known, and/or cannot be expressed in appropriate query/indexing language

Figure 1.3 Two Online Catalogue Search/Access Options

1.2.1.1 Query Searching

There are two kinds of query searching: phrase matching and keyword matching. A query consists of a term or terms (e.g., a character, number, word or words, or a phrase) and the specification, sometimes called the query "formulation," which defines how the component term(s) of the query are to be interpreted or related for matching purposes (e.g., word truncation, Boolean combinations, word adjacency). The matching function of an online catalogue is the mechanism through which the retrieval software makes a comparison between index terms which represent documents and query terms to effect retrieval. The matching criteria are specified through the query by the user or applied automatically by the system. Query searching of either kind (often called just "searching," to distinguish it from an online catalogue's Browse mode) utilizes an exact matching function on the part of the system, regardless of the manner in which the matching criteria are specified.

In this all or nothing approach, documents (bibliographic records in online catalogues) will be retrieved in response to a search only if an exact match of the query is found. The query may consist of a pre-coordinated phrase (with or without truncation) or a post-coordinated Boolean expression of keywords. In either case the Query search matching requirements are precise and rigid. The process is purely mechanistic. The burden is on the searcher to enter terms that will match the entry (index) terms in the database and to specify appropriate proximity or term relationship logic. Bates criticizes this predominant approach to subject searching for requiring a "perfect pinpoint match on the one best term." (1986) No match means no retrieval, as viewers of silent online catalogue screens witness too often. The search may fail (i.e., not identify relevant documents that are in the collection) unless the searcher knows or guesses the exact way the term (word or phrase) appears in the subject index.

In keyword, Boolean queries, the system's matching mechanism makes a binary (yes/no) split of the database into bibliographic records that conform exactly to the requirements of the query, and all the rest. Only the former are retrieved as "hits." Partial or "closest" matching operations are generally not supported in second-generation online catalogues and conventional retrieval systems.

Query searching is an appropriate, useful search option when the aim of the search is specific, when the searcher knows precisely what he wants, and when this request can be expressed in the language of the database. Even in subject searching for books or articles on a topic the searcher may know his topic exactly and may be able to express it in the language of the system (e.g., the assigned subject headings or descriptors).

1.2.1.2 Browse Searching

Browsing in online catalogues can take many forms. Typically, the system displays ordered lists of terms, descriptors, or brief bibliographic records for scanning by the searcher. Lists of index terms are usually presented in alphabetical order. The arrangement of brief citation records may be according to date, and some systems support short record browsing in shelf-list order. Usually the only "navigation" option for browsers is to go backward or forward through the list in a constrained, linear manner. Cross references, if included, represent a way of jumping out of the sequence and over to related areas of the database. Hypertext operations, which permit navigation throughout the database's network of related terms and records, and the dynamic definition of "related areas and interests", have not been implemented in second-generation online catalogues. Conventional browsing assumes a vocabulary aim on the part of the searcher. It assists in identifying the correct form of a term and any related terms. Other forms of browsing, rare in today's online catalogues, support related record or document discovery through non-linear explorations of the database. They will be illustrated further along in this report.

Browse searching is the most useful and preferred approach when the search aim is not specific (regarding, for example, discipline or topic, type of publication, level of treatment, perspective, etc.), the desired results are not precisely known in advance, or the correct terms for representing the user's query (which may be vague) are not known at the outset. One or more of these circumstances may be present in most subject searching activities.

Some designers of online catalogues have recognized the difference in these search requirements and have provided some rudimentary browsing facilities such as scanning index terms in the same alphabetical neighborhood. This feature is not intrinsically tied to either phrase matching or keyword matching search facilities. Phrase matching often incorporates index term browsing automatically in the search dialogue, whether or not an initial match occurs, but there are exceptions to this. Most keyword match online catalogues now offer the searcher an option to browse alphabetical term and descriptor indexes.

Most of today's online catalogues support both phrase matching and keyword matching query searching. However, these are hybrid systems that do not integrate or link these separate approaches in any useful way during a search. It is usually up to the searcher to choose, through commands or menu selection, one query type or the other. If the system assumes (defaults to) a particular search operation, the user is not informed which specific operation is being carried out on the search terms. Phrase searching, of course, generally assumes a word adjacency, same word order, matching specification. Keyword searching on two or more words requires the specification of a Boolean operator either by the searcher or by the system. Most online catalogues supply the Boolean AND as a default operator between words. When a search term like "economic indicators and business cycles" is entered into an online catalogue, if not explicitly instructed by the user the system automatically will decide precisely how to interpret the statement for matching purposes. The primary decisions to be made include the indexes to be searched and the logic to be applied to specify the word relationships.

Each type of query search has its advantages, but each may produce very different results even when the same search statement is being processed. This can be a source of confusion for the untrained user who may not understand the relative value of each approach. Such a user may not even know that both ways of searching are supported in a given online catalogue, or how to invoke one or the other. Within a given catalogue database, one search choice on the same term can produce poor results, another choice, good results. Given these dual, unintegrated search approaches in many online catalogues, it is a new responsibility of many librarians to understand their differences and to interpret these differences in a meaningful way for the users of these online catalogues.

1.2.2 Easier Subject Searching

Recent improvements to user interface software have made subject searching in online catalogues easier, if not more effective. However, these improvements are independent of, and have had no impact on, the query matching requirements and retrieval methods previously described. Yet, online catalogue design is clearly moving in the right direction: namely, to a greater recognition of the needs and difficulties of untrained or casual users of online catalogues. New interface design features are making it easier to select and enter a subject search in online catalogues. Difficult to learn command languages with their complex syntax requirements have largely disappeared from the online catalogue interface. They have been replaced by straightforward menu selections, prompted search term entry, and newer approaches such as graphic entry devices (window search logic boxes and on-screen search worksheets), and query-by-example or query-by-form. With query-by-example a retrieved record can serve as a model template to initiate, through editing, a new or modified subject search. A query-by-form template is a prompted, preformatted search entry, citation-like, form just needing data in chosen fields to initiate a search. The fields and field labels can be customized by the library staff. Its value lies in the intuitive association it triggers between query expressions and document representations (citations) in the catalogue database.

In her landmark study of subject access problems and opportunities in online catalogues, Markey (1984) pleads for a "forgiving and simple implementation of Boolean search capabilities." This is now being achieved through simplified query interfaces which do not require explicit entry of commands or Boolean operators. When a phrase search results in no hits, the online catalogue might prompt the searcher to enter a keyword, Boolean search to achieve broader results. Another online catalogue might require the user to type the desired command word, but the command is spelled out on the screen in the list of options. The Boolean AND is normally assumed between search words when no operator is entered by the searcher. Most of these online catalogues permit the logical operator assigned by the system to be replaced with another operator explicitly entered by the searcher.

Subject term or heading browsing in online catalogues has improved somewhat through the provision of clearer, better labeled displays and the addition of postings data (number of citations which match each term). Some online catalogues are incorporating "see" and "see also" cross references in these term browsing lists, and shelf list browsing is becoming a common feature although it is not usually prompted by or linked to term or citation browsing activities.

The implicit or automatic specification and post-coordination of search statements into formal queries is becoming both more flexible and "smarter." Markey's research indicated that "post-coordination features of online catalogues need to automatically or explicitly assist searchers in the selection of searching vocabulary and the combination of terms" (1984). More and more the scope of subject keyword or "topic" searches is being automatically extended to include matches in the title index as well as the subject headings index. Some online catalogues also search the notes and corporate name field indexes when executing a subject search. This multi-field subject searching does not have to be specified in advance by the searcher through a complex query syntax. Analysis of online catalogue transaction logs has shown that this widening of the subject search target and the implicit choice of the AND logic rather than adjacency to connect search words improves recall (number of relevant documents retrieved), with little or no decrease in search precision (absence of unwanted documents in the retrieval results), when MARC bibliographic records are the target of online catalogue subject searching. Perhaps most satisfying to searchers, far fewer "0-hit" ("No matches found") search results occur.

The online catalogue subject searching process in all its varieties has been improved through better displays of retrieved citations. From the use of natural language field labels to the highlighting of matched terms, citation displays have been made more comprehensible and more informative. Matched query terms appearing in retrieved bibliographic records can be highlighted through reverse video or lightbar techniques, or through the use of special character or graphic markers. This feature shows the conceptual context of a search term, and promotes an understanding of catalogue record structure and system matching principles. On a negative note, the improved labeling of subject headings and call numbers in displayed citations does not yet include indications of their special collection role or suggestions that additional potentially relevant documents are linked to (collocated by) these subject descriptors.

Online user assistance displays and messages designed to help users conduct subject searches and to post-coordinate search terms have improved dramatically in online catalogues. In this area, online catalogue design leads commercial retrieval system design. Searchers may be asked to add a word (usually for a Boolean AND operation) or to enter limiting information such as a range of dates.

Online catalogue error messages are usually specific, helpful, and informative, for example:

> "Your BROWSE command does not contain a browsable index name. Please type HELP for more information." (MELVYL)

Help is frequently context-sensitive, requiring no more than the simple request by the user to bring specific, point-of-need assistance. Specific, addressable help displays are available to assist with the mechanics of searching and operation of the local online catalogue. Explicit messages and menus embedded in the routine search interaction displays explain things like what the system is doing, what to do next, what options are available at any stage of the search process, and, in some cases, what may be done to improve the search process to produce better results.

1.2.3 Conventional, Second-Generation Online Catalogue Subject Searching Summarized

Subject searching in today's largely MARC-based online catalogues is supported by a variety of exact match query methods and browsing facilities. Exact match query searches are basically of two types: 1) phrase searching on pre-coordinated subject headings, and 2) keyword searches on cataloguing or indexing data in the bibliographic record (e.g., titles, notes, subject headings and their subdivisions). Keyword subject searches may be formulated as Boolean expressions to indicate the desired relationship between search terms, and some online catalogues also permit explicit proximity designations in the formulation of the query. The trend is clear: most online catalogues support both types of exact match searching.

The syntax and mechanics of entering subject searches have been simplified, and the task of precise search statement/query formulation has been delegated to the system software. Choice of subject query type is selected from a menu, or invoked by a pressed function key or simple typed command. Phrase searches are automatically processed as straightforward character string matches or word adjacency, same order matches. In most cases the match must begin with the leftmost significant word or character of the indexed entry. Keyword searches with more than one word are automatically processed as Boolean AND queries in most online catalogues. Keyword searches may be targeted by the user or the system to one or more field indexes (e.g., title, notes, series statement, subject headings). Some flexibility is permitted in most keyword search online catalogues. When searchers choose not to identify in their queries fields for subject keyword searching (or are not permitted by the system to do so), the trend is toward automatically searching both subject and title. ANDed keywords do not have to appear together in either the title field or the subject field to cause a match. Matching records would include those having one word in the title and another word in the subject heading.

Successful subject phrase searching in most online catalogues still requires an exact match on at least the initial, main portion of the subject heading in the catalogue record. In the U.S., this usually requires a perfect match on a Library of

Congress Subject Heading (LCSH). However, if a LCSH heading is entered as a search term and the heading has been modified or replaced in the local catalogue record no match will occur. In some online catalogues, when no match occurs on the user's search term, the system displays headings in the alphabetical neighborhood of the term. This may or may not help the searcher find a heading which expresses his search interest.

In today's online catalogues browsing is even less developed and is generally provided as an intermediate or secondary stage in the subject search process. Some keyword online catalogues offer the searcher an unpublished (on the screen) option to browse (scan) alphabetical lists of index terms or headings. Phrase search online catalogues typically display these lists after a search is constructed and entered, even when an exact match occurs. Research has not shown whether, in the latter case, this helps or confuses the searcher. A few online catalogues are beginning to include cross references and related terms in these browsing displays. This will make them more useful browsing tools for certain kinds of subject searching.

More informative, flexible, and intelligent browsing facilities can be provided in the online environment. It is time for librarians and online catalogue designers to recognize that subject browsing may be a primary search activity in the user's quest to discover materials on a topic, or to discover unknown items of potential interest. This kind of search activity requires more than term selection browsing facilities, or even thesaurus-based automatic switching among related terms. Related document browsing and discovery can be facilitated in online catalogues through richer pre-coordination in the database of multiple subject/topic clues found in bibliographic records (e.g., linking title terms with subject headings with call numbers, etc.), and by providing more search navigation options between retrieved and unretrieved (but linked) records, that is, record to record "jumping" at the discretion of the searcher (e.g., "Show me more books from this publisher." "What other titles are in this series?" "What documents cite this work?")

Most of today's online catalogues also fail to provide the more traditional subject search aids. For example, they do not support browsing in displays of classification outlines or schedules. Neither do they permit related term lookups in online subject thesauri or lists of subject headings. Markey's research (1986a) has shown the first of these to be useful in online catalogue subject searching. Classification schedule terminology and systematic subject information can lead the searcher to relevant records not likely to be retrieved by the traditional phrase and keyword subject search methods. It is seldom recognized that even Cutter favored this approach. Immediately following the famous passage where he lists the "objects" of the library catalogue, Cutter proposes the means for achieving them. To enable finding books on a subject, the catalogue needs the subject entry, cross references, and a "classified subject table" (1904).

1.2.4 Problems and Shortcomings of Today's Online Catalogues

Good retrieval performance in second-generation online catalogues can be achieved only by library staff and by library patrons trained to use and understand their particular indexing and search idiosyncrasies. Most of these online catalogues are not yet effective, usable "self-service" information retrieval systems for a wide variety of untrained, occasional users.

Bates (1986b) poses the central question about subject access in today's online catalogues: "With all the power of online subject searching of catalogs - Boolean logic, keyword match, truncation, etc. - have we, perhaps, already given the user all the search capability that is practically necessary?"

Online catalogue research studies have uncovered a number of common problems experienced by users of second-generation online catalogues. In general terms the major problems include:

* too many failed searches (search attempts that are aborted, that result in no matches, or that result in unmanageably large numbers of items retrieved), (Markey, 1984;1986; Peters, 1991; Hunter, 1991; Larson, 1991)

* navigational confusion and frustration for the user during the search process ("Where am I?", "What can I do now?", "How can I start over?"), (Knipe, 1987; Hunter, 1991)

* unfamiliarity with subject indexing policy and vocabulary, leading too often to the failure to match search terms with the system's subject vocabulary, (Markey, 1984; Carlyle, 1989; Zink, 1991; Allen, 1991; Johnson and Carey, 1992)

* misunderstanding and confusion about the fundamentally different approaches to retrieval and search methods employed in today's online catalogs (e.g., pre-coordinate phrase searching and browsing, and post-coordinate keyword/Boolean searching), (Kranich et al, 1986; Peters, 1991) and,

* partially implemented search strategies and missed opportunities to retrieve relevant materials (e.g., searches in which large retrieval sets are not scanned or narrowed in size, and title keyword searches that are not followed by searches on the call numbers or subject headings of the found records). (Tolle, 1983; Wiberley et al, 1990)

Chan points out that online searching is a process of extracting a subfile of useful documents from a large file, a process where "in most cases, a sequence of search statements is required for even minimally satisfactory retrieval" (1986). To optimize retrieval results in subject searching, more than one search approach may have to be employed in the overall search strategy: "Through combination, keywords and the [controlled] vocabularies of DDC, LCC, and LCSH should offer far greater possibilities in search strategies than any one of them can provide alone" (Chan, 1986; also, Croft, 1981). Markey (1986b) has demonstrated, for example, that different records on a particular subject would be retrieved by using a classified approach from those retrieved using keyword or alphabetical subject heading browsing approaches.

Conventional information retrieval systems require the user to reformulate and modify or reenter queries until satisfactory results are obtained. This is typically the case with second-generation online catalogues, as well, but mechanisms for modifying queries interactively are minimal or not provided at all. Also, this approach assumes that the user knows what he wants and can describe it in the language of the catalogue database being searched.

Even the best second-generation catalogues do little to help the user transform an information need to explicit expressions of the need acceptable by the system. Nor do these catalogues lead the user from "found" information to related, linked information that has not yet been discovered. Research has shown that it is unrealistic to expect our catalogue users to know in advance the structure and language of our library databases (Zink, 1991; Allen, 1991; Peters, 1991). It is equally unrealistic to expect online catalogue users to be proficient in the various search approaches and techniques before they engage an interactive system in the retrieval process. Humans find it easier to recognize things than to generate formal descriptions. Online catalogues could take advantage of this human facility by permitting requests such as, "Give me more like this!"

1.2.5 LCSH-Based Subject Searching

Markey's (1984) research has shown that online searchers are not very successful in matching their subject terms with the catalogue's controlled subject vocabulary. The assigned subject headings in the catalogues she investigated were derived from the list of Library of Congress Subject Headings (LCSH), the subject vocabulary used in most library catalogues. In one study of subject searching on a university online catalogue (SULIRS, Syracuse University), a total of 859 search statements entered in 188 subject searches were analyzed. 45% of these search statements resulted in no retrievals. "We were concerned about, and subsequently sought an explanation for, the surprisingly large percentage of subject searches resulting in no or very few retrievals." In comparing the subject statements with LCSH headings, only 29% of searchers' terms matched or closely matched LCSH. Yet only 7% of these LCSH searches resulted in no matches. This is not surprising since online catalogue subject headings are extracted from actual bibliographic records in the collection. More often than not searchers used whatever terms popped into their minds; this produced no retrievals 65% of the time. These depressing findings have been corroborated in studies of other university online catalogues (Carlyle, 1989; Peters, 1991; Hunter, 1991).

Another finding in Markey's SULIRS study raises questions about the effectiveness of LCSH subject searches for retrieving only the most relevant documents for a query. 29% of the LCSH searches retrieved 100 or more citations. When this occurred, searchers either aborted their searching or looked individually at all the results. Very few searchers entered valid LCSH cross references. A good guess is that they usually entered and matched LCSH terms broader than their topic of interest. Markey concludes that the study "drives home the need for online vocabulary assistance. Alphabetically arranged or rotated lists of subject headings only scratch the surface."

Based on a variety of online catalogue subject searching research studies, Markey lists the major problems subject searchers face, with little or no assistance from online catalogues:

* matching their terms with those indexed in the catalogue,

* identifying terms that are broader or narrower than their topic of interest,

* improving search results when little or nothing is retrieved,

* reducing search results when too much is retrieved,

* grasping LCSH indexing policies and idiosyncrasies.

In one case study, Pritchard (1986) underscores the "conceptual problems" facing users of the Library of Congress' online subject access systems (LOCIS): "To choose the best [subject] headings, readers may need to understand concepts of indexing depth and specificity since the Library of Congress only catalogues for the general subject of the entire work and does not assign books to both broad and narrow categories. This causes difficulty both in topical headings and geographical ones. LOCIS searchers intuitively seek to post-coordinate numerous terms, whereas MARC records contain two or three (at best) pre-coordinated, subdivided, inverted, and parenthetically qualified headings" (1986).

Bates' research also indicates that there is more to good subject searching than matching an LCSH heading. One study "tested whether people would actually hit upon specific relevant material in a search rather than just whether their term would match with any heading in the catalogue, whether or not that heading indexed material relevant to their query" (1986b). Participants in the study were asked to state what word or phrase they would use to search in the subject catalogue for a specific book described to them by its title and an abstract. The degree of match between their terms and the subject headings used in the library catalogue to index the books was calculated. The initial set of contributed terms matched headings in the catalogue record only slightly more than 20% of the cases.

Thus, there are two (at least) major online subject access problems associated with the official subject vocabulary (LCSH): 1) initially matching the assigned headings (the "entry" or "lead-in" vocabulary problem), and 2) once into the system's vocabulary, identifying terms and term relationships that will help direct a search to the precise topic or most relevant materials (the subject focusing/discriminating problem). Mandel and Herschman (1983) point out that online catalogue subject browsing displays that list only subject terms from catalogue records in the system do not show conceptual relationships among terms or lead the searcher to the most relevant term. A linear alphabetical arrangement of terms scatters related terms. The authors recommend including a hierarchical subject thesaurus online - a restructured LCSH - to help searchers overcome this problem.

With regard to the entry term, LCSH matching problem, Mandel and Herschman explain: "Displaying the existing LCSH headings and references will not, in itself, solve the problem of an entry vocabulary that matches only half of users' first tries. Even without making a single change in an LC subject term, access to the terms could be improved enormously by adding to the entry vocabulary (i.e., adding "see" references) (1983).

Bates (1986b) describes this as the problem of low vocabulary "redundancy" (i.e., lack of quantity and variety of synonyms and related terms) in subject catalogue records stemming directly from LC's subject indexing policies and practices. These book indexing/subject cataloguing policies - pre-coordinate, whole book indexing; single, uniform heading indexing; specific heading only indexing - result in a very small amount of subject terminology in catalogue records (on average, two or fewer headings per record). Indexing a particular book under broader or narrower terms is rarely done. As Bates says, "the searcher is only directed to terms at the same or more specific levels. Usually, there are not very many of even these latter references anyway."

Research has shown that subject searchers frequently enter terms broader or narrower than the subject in which they were actually interested (Markey, 1984; Smith, 1989; Johnson and Carey, 1992). LCSH offers little assistance here in its present form, confirmed by the low LCSH term match ratio in online catalogue subject searching.

The LCSH cross reference structure is limited and weak. Cochrane (1986) believes that following its "see also" references usually leads the searcher out of his topic, rather than to various aspects or levels of the topic. Bates distills an expression of the dilemmas experienced by subject searchers in this poignant passage: "In both manual and online catalogues the user must launch the search with a subject term. For the search to be successful, the term must not only match with some term in the system, but must match, either directly or through cross references, with a term describing relevant material. As I have argued earlier, LCSH uses so few terms for indexing each document and provides so little assistance to the searcher that the latter is hard to do" (1986).

In summary, second-generation online catalogues are deficient in subject-searching because they:

** do not sufficiently assist with the translation of entered query terms into the vocabulary used in the catalogue,

** do not provide online thesaurus aids useful for subject focusing and topic/treatment discrimination,

** do not automatically assist the user with alternative formulations of the search statement or execute alternative search methods when the initial approach fails,

** do not lead the searcher from successful free-text search terms (e.g., title words) to the corresponding subject headings or class numbers assigned to a broader range of related materials,

** do not provide sufficient information in the retrieved bibliographic records (such as tables of contents, abstracts, and book reviews) to enable the user to judge the usefulness of the documents,

** do not rank the citations in large retrieval sets in decreasing order of probable relevance or "closeness" to the user's search criteria,

** do not facilitate open-ended, exploratory browsing through following pre-established trails and linkages between records in the database, in order to retrieve materials related to those already found.

1.3 Subject Searching in the Expanded Online Library Catalogue

1.3.1 The Phenomenon of the Expanding Online Catalogue

It will be useful to begin with an overview of what might be referred to conservatively as the "phenomenon of the expanding online library catalogue." The expansion of interest here is not the widespread adoption in only a few years of online catalogues by most university and research libraries, and medium to large public libraries, though this development is remarkable enough itself.

Since online public access catalogues were introduced in the late 1970s as replacements or supplements of a library's traditional catalogue, a remarkable evolution in their functionality and scope has taken place. Recent enhancements in online catalogues are both the cause and the effect of rising expectations and new demands of librarians and information specialists. Online catalogues have been the subject of extensive research and discussion over the last twelve years. Still referred to by some writers as the "card catalogue online," most librarians and online catalogue users view the online catalogue as something more than the traditional card catalogue transferred over to a computer database and viewable at a computer terminal or VDU.

Traditional library catalogues consisted primarily of catalogue records for books and periodical titles. In machine-readable form, these bibliographic data records were the first constituents of early online catalogues. These data records generally contained no more subject information than that imprinted on the catalogue cards of the traditional medium. However, the notions of what an online catalogue should include - and very recently, what additional data records have been loaded - have changed as files of other bibliographic records, such as periodical article citations and abstracts, have become readily available to libraries. As Potter (1989) has noted, librarians and system developers have acquired a new perspective on the online catalogue. They view the online catalogue as an *expanded* or *extended* library catalogue that will provide both broader and deeper access to library collections by including periodical article index databases, other bibliographic databases, and even the full text of documents as they become available in electronic form.

1.3.2 Pursuing the Vision of the E-3-OPAC

There has been some confusion in the literature of late as to whether the emerging online catalogue is the "expanded" or the "extended" online catalogue. Some writers view these terms as synonymous and use them interchangeably; but often there is a lack of clarity or consistency in their use to explain related but different developments. For example, Potter identifies three complementary "expansion" paths along which online library systems will proceed: 1) more indexes to more sets of collections and more online reference databases, 2) the gradual inclusion of more full text of journal articles, and possibly, books, and 3) "greater connectivity from online library systems to other systems, including other library systems, commercial services, bibliographic utilities, local networks, CD-ROM servers, and other information providers in the community" (1989). Mischo puts it this way: "Recently the idea of the 'extended' online catalogue has been introduced to describe online catalogues containing specific functional or data extensions. Extended third generation catalogues typically provide value-added access beyond the conventional online catalogue by providing expanded entry points, augmented information resources, access to locally mounted and/or remote periodical index databases, and gateway functions to local, regional and national telecommunication networks" (1991).

This author has introduced the notion of the E-3-OPAC as a vehicle for elucidating these concepts:

The E^3OPAC

<u>Enhanced</u>
Functionality and Usability

<u>Expanded</u>
Indexing, data records, collection coverage;
i.e., a "full-collection" access tool

<u>Extended</u>
Through linkages, networks, and gateways to additional
library collections, information systems and resources

The E^3OPAC would have *enhanced* functionality and usability; its indexing, record data content, and collection coverage would be *expanded* to make it a "full-collection" access tool; and its access would be *extended* to include the collections and resources of other libraries and information centers.

1.3.2.1 Ways of Enhancing, Expanding and Extending the OPAC

Figure 1.4 lists eight ways the conventional library catalogue is being extended in a variety of online manifestations in our libraries. Most of these extensions involve adding data to the MARC catalogue records, integrating related data files such as customized periodical indexes into the monograph catalogue, or adding reference information files to the overall online catalogue database or aggregate of databases searchable through the online catalogue. However, functional and transactional performance extensions are also being made to today's second-generation online catalogues. This is all to the good, because research and experience have provided us sufficient reason not to be satisfied with the performance of today's online catalogues. Reflecting on all this creative, expansive activity by online catalogue designers and librarians, it is clear that in practice no pre-defined "theoretical" boundaries for the proper library catalogue (regarding its form, function, or content) are being respected or observed. We are witnessing a shift in emphasis from our usual concern for bibliographic control to expanding access to all the materials and information in our collections. The promise is that the library's primary access instrument, the "catalogue", will become its most used and most effective access and discovery tool.

1. Functional Search and Retrieval Enhancements
(e.g., closest-match retrieval and enhanced
subject searching)

2. MARC-PLUS Augmented Catalogue Records
(subject descriptors, headings from tables
of contents, classification vocabulary, etc.)

3. Integration of Local Non-MARC and Pseudo-MARC
Bibliographic Records
(non-standard records, subject pathfinders,
abstracts, book reviews, and research guides)

4. Advanced Relational Database Syndetic Structure
(pre-defining customized sub-catalogues and
subject-based linkages, trails and pathways)

5. Additional Self-Service Convenience Functions
(self-charging, online ILL or reference service
requests, etc.)

6. Locally Created and Mounted Information and
Referral Files

7. Remotely Published, Locally Mounted and
Accessible Information Databases

8. Gateway Access to External Bibliographic or
Information Networks and Databases
(online reference databases, other OPACs,
electronic union catalogues, and research
networks, etc.)

Figure 1.4 The Extended OPAC - Eight ways

1.3.3 Enhancing the functionality of the OPAC

Hildreth has outlined a general framework for classifying online catalogues into first, second, or third generation systems, each generation having its distinguishing features and functions (Hildreth, 1982; 1989). Today's second-generation online catalogues represent a qualitative leap of progress over first-generation online catalogues, the target of much criticism in the professional literature.

Innovative design work on the user-system interface has made many of the second-generation online catalogues far easier to use than the conventional, dial-up commercial database search systems after which they were modeled.

Third-generation online catalogues are not yet generally available in the mainstream library system marketplace. Only a few of these more advanced catalogues have been developed, primarily as prototype or demonstration systems. The major functional improvements that will define the next generation of online catalogues are included in Figure 1.5. These systems incorporate some or all of the listed search, matching, and interactive display techniques developed and tested over the past twenty-five years by information retrieval system researchers.

There are many ways of describing and classifying these features, and progress will almost certainly occur in incremental steps, but the third-generation online catalogue will be a wholly new kind of retrieval system because it will be based on much more representative models of actual user information seeking behaviors.

2ND GENERATION FUNCTIONALITY, PLUS:

NATURAL LANGUAGE QUERY EXPRESSIONS
(In your own language, what it is you are looking for)

AUTOMATIC TERM CONVERSION/MATCHING AIDS
(Spelling correction, Soundex, Intelligent stemming, Synonym tables, etc.)

CLOSEST, BEST-MATCH RETRIEVAL
(Unlike Boolean queries, doesn't require exact match to be retrieved as possibly relevant)

RANKED RETRIEVAL OUTPUT
(Many ranking criteria: most likely to be relevant first, most recent, most cited, most circulated, etc.)

RELEVANCE FEEDBACK METHODS
("Give me more like this one." "What else do you have on this topic?" "This book is not at all what I want!")

HYPERTEXT, RELATED-RECORD SEARCHING & BROWSING

INTEGRATION OF KEYWORD, CONTROLLED VOCABULARY,
AND CLASSIFICATION-BASED SEARCH APPROACHES

EXPANDED COVERAGE AND SCOPE
(THE "FULL-COLLECTION ACCESS TOOL")

Figure 1.5 Third-Generation OPACs

1.3.4 Expanding the OPAC

The enabling technology of the online catalogue makes it possible to *expand* the scope of the library catalogue, and, joined with telecommunications technologies, to *extend* its range. With the online catalogue, it is again feasible to expand the catalogue's coverage over, and to deepen access to, all the information materials in the library's collection. As Potter (1989) reminds us, this is not a new ideal:

> *At one time, a library's catalog was designed to index every intellectual work in the collection - not just books, but also articles in periodicals held by the library, pamphlets, maps, government publications, the whole range of materials acquired by a library. By 1900, all but a few highly specialized libraries found this was an impossible task, and today most catalogs provide access only to the books and the set titles of serials. Readers interested in the other types of materials are compelled to consult indexes that are separate from the catalog such as printed indexes, CD-ROM databases, or commercial online services. While these tools are usually of high quality, they are scattered throughout a library. The reader has lost the unifying function of the catalog, the ability to locate any item from a single source.*

It is possible to exceed the ideal of yesterday by providing comprehensive access to the local collection, as well as access to resources beyond the local library's collection. Potter reviews library cases where expanded access to materials and information both within and beyond the library has been "performed in conjunction with an online catalogue so that the reader is provided with a single source, a common interface, a unified environment in which to retrieve information." He identifies three trends in current online catalogue development and practice: 1) the unification of local collections, 2) providing access to outside resources, and 3) the inclusion of machine-readable reference works and full text (1989).

Access to and knowledge of a work's location and availability status is deepened when the holding library has automated its bibliographic management, circulation, and public catalogue functions in an integrated manner of one sort or another. If one views the online catalogue as no more than the card catalogue replicated online, then it is easy to see how integrating or linking the data records of the circulation and acquisitions systems with the corresponding bibliographic records represents the first stage in the development of the "extended online catalogue." One might say, "the extended online catalogue begins at home." When the online catalogue is interfaced with the local circulation and acquisitions systems, more precise answers can be given online to the user's primary questions: "Does this library have what I want?" and "Can I have it now?" or "When will it be available?" In the locally-extended online catalogue on order, in process, or availability information is immediately at hand, along with the bibliographic record.

Two additional developments are leading to an expansion of the local online catalogue's full-collection access potential: 1) inclusion in the bibliographic record and the indexing of contents notes opens access doorways to specific authors and titles of essays or short stories published in collections or anthologies, and 2) the mounting (loading, indexing and storing) of commercial indexes and abstracts for periodical journal articles and government publications. Some libraries are also loading locally-created indexes to specialized collections and reference materials. A few are adding headings from the tables of contents of newly acquired books and journal issues to the corresponding bibliographic records. An available 'Notes' field in the standard bibliographic record format can easily be used to accommodate this additional book or serials content-rich data. As a result, additional access points to the material are provided to the online catalogue user, and when displayed, the table of contents can show the user more accurately than one or two subject headings what is inside a book or periodical issue.

1.3.5 The Extended, Networked OPAC

What is perhaps more revolutionary in Potter's vision is the notion of extending the local online catalogue to become a gateway to other library collections, and/or to become a full-text *delivery* system. An automated library system offers a library the opportunity to access the systems and databases of other libraries through the terminals on its own system. Using a vendor's proprietary network linkages to other libraries using the same vendor's system, or customized software gateways, or dial access public networks, a user at the terminal of one system can access the database of another system. In doing so, the user can search that database to discover if that library owns a desired item, check on the availability of the item, and submit an electronic request for the delivery of the item via interlibrary loan procedures. The advantage of this situation over the "traditional" electronic union catalogues joined with ILL messaging capabilities (e.g., OCLC) should be obvious. The local status, precise location, and availability of specific copies of the item can be determined quickly, and the holding library can be notified instantly that a loan request has been placed on an item that is available. This can lead to major reductions in staff time (and reductions in the associated costs), and dramatically reduces the user's "wait time" to have the requested item in hand.

The value of extending the online catalogue to include the collections of several libraries in a district or region seems to have been proven. Experience to date shows that resource sharing increases significantly when library online catalogue users can view the holdings of other libraries in their metropolitan area or nearby region. Interlibrary loan and reciprocal borrowing (one library's patrons are permitted to borrow directly from another library by special administrative arrangement) have doubled and tripled in some cases. There are, of course, different methods of extending the local online catalogue to include the holdings of other libraries: for example, by joining an online union catalogue, by loading the catalogues of other libraries into the local database, and through gateway linkages or interfaces to the other libraries' local systems.

Looking back on the past twenty years of library automation and networking developments in North America, one can recognize three overlapping stages of activity: 1) the birth and rapid growth of the bibliographic utilities (OCLC, RLIN, WLN, UTLAS) and the introduction of online database search services (DIALOG, BRS, etc.), 2) the widespread adoption of stand-alone, multi-function "local" automated systems in libraries and the era of the online catalogue, and 3) the most recent stage, the interconnection of library systems, library networks, and both with institutional/regional/national computing networks , resulting in a plethora of new networking and access arrangements.

The bibliographic utilities provided the function of shared cataloguing in a networked environment, developed enormous union catalogues and research databases, and established efficient electronic interlending systems for their members/clients. The widespread introduction of local automated systems in libraries in the 1970s and 1980s addressed the need to streamline the internal operational functions of libraries (e.g. acquisitions, serials management, local cataloguing, and circulation of library materials). A parallel path of development led to the emergence of public access systems. During the 1980s, emphasis shifted from automating library operations to providing users computer-based access to library collections.

The popularity of the library online catalogue has raised user expectations in regard to improved access to information, and these expectations have spurred new developments and extensions to the online catalogue. One of these new expectations is now developing into an expressed need or demand from the users, namely, access to the library's databases from outside the library. Thus, the role of computer communications networks becomes central. Emphasis has shifted once again to networked public access to library and information resources, increasing the need to interconnect separate, even remote, library systems and networks.

Lynch (1990) summarizes these developments in this succinct passage:

> *As a result of progress in library automation in the last decade, great changes have occurred in access to information within institutions. Emphasis has shifted from automating library operations to providing computer-based access to library collections. This transition has raised user expectations, and as a result, libraries face challenges in the coming decade that will be tremendously costly and technically difficult to meet.*
>
> *Libraries have traditionally cooperated in operational activities such as cataloging through the national utilities like the Online Computer Library Center (OCLC) and Research Libraries Information Network (RLIN), and the formation of consortia for resource sharing through interlibrary loan. Only now are libraries becoming involved in movement toward national end-user resource sharing that is represented by the development of the national research network. They are just beginning to explore the ways in which national networks interact with interinstitutional resource sharing to support public access to information resources.*

1.3.5.1 Searching Interconnected OPACs - Problems, Challenges, and Needed Standards

Online library catalogues and advanced telecommunication technologies together provide the opportunity to distribute and dramatically expand public access to information resources. Early online catalogues may initially only automate the existing manual catalogues they replace and provide interactive access to little more than monographs in libraries' collections. However, as we have seen, online catalogues are likely to be expanded -- partly in response to user demand -- to include indexes for the periodical literature and many other kinds of information.

Developments in telecommunications have led to new technologies and standards that make it easier and more reliable to connect computers, networks, and both to users at terminals or microcomputer workstations. High-speed and high-capacity communication networks are now in place serving the education, scientific, and research communities. Many of these national networks are or soon will be interconnected and will support expanded international access and communications. As these networks continue to evolve, attention is shifting from the network technologies and capacities to the resources available now and those that could be made available in the near future through the networks. Scientists and scholars have used these networks to share resources needed for their work -- resources such as computer software and factual databanks -- and to communicate about research findings or research in progress, using the networks' E-mail function. New resources finding their way onto the networks include numerical databanks, electronic document text, images, and, quite recently, online library public access catalogues (OPACs) and additional library-maintained specialized information files. There is every reason to believe that we will witness a proliferation of information databases, including more online catalogues, as network resources.

1.3.5.2 Barriers to Effective Access and Use

Provision of remote access to library computer information systems via dial-access, local area networks, or the wide area research networks is still a very new phenomenon. Many barriers and technical problems exist which stand in the way of easy and effective use of these online library systems. A few of the major problems are described here.

For the short term, access to remote online catalogue systems via networks will be by remote log on using established protocols like TELNET. The end-user appears to the remote system as a terminal that system recognizes and "speaks" with. Users may have any of a variety of terminals, of course, or even microcomputers or advanced workstations, and any of these may ordinarily function within a local system or local network. It is not important for this discussion where the terminal emulation software and communications equipment (e.g., modems) and software required for remote access and login reside in the local configuration. Two typical scenarios would be 1) a user at the public access terminal of a local library system online catalogue, and 2) a user at home or in the office with a personal computer equipped with a modem and modem software which includes some terminal emulators. In the first case, the modem and communications software would probably reside in the library system's host computer or one of its telecommunications processors. In the latter case, the connection to the remote online catalogue system would be through the user's modem and the public-switched telephone network or a PSDN.

This mode of access currently has serious shortcomings, not the least of which is the fact that many remote systems do not offer any way to log off? Remote log on must be made as easy and transparent as possible. Many remote library systems now require the user to struggle and stumble through complex login and database/function selection sequences. Remote systems often assume or require specific types of terminals without informing the remote user and/or presenting a selection list of acceptable terminal types.

The problems associated with terminal incompatibilities must be resolved. Some systems use cursor addressing specific to a single type of terminal, and assume all connected users have such a terminal (or terminal emulation software for the specific brand and model of terminal). The host computer may incorrectly assume that the user has a DEC VT100 terminal, for example, and will fill the user's screen with VT100 cursor addressing sequences. Other systems will not work at all unless the user has a specific type of terminal; others will rapidly scroll all the transmitted data off the user's screen in an unstoppable and non-retrievable manner. The host may assume a terminal type with special- purpose function keys defined by the online catalogue software. Keyboard sequences on the common ASCII terminals may be able to match these special-use function keys, but the user may have to guess the correct key combination or sequence that will send the equivalent of the pre-programmed function key to the remote system. The remote system should at least display helpful messages to aid with this problem.

The problem caused by the use of different character sets in the languages of bibliographic descriptions employed in various countries is an extension of this problem. Perhaps a standard character set definition should be adopted for bibliographic purposes, at least for Roman languages, then developers of online catalogue systems and manufacturers of terminals and software could be urged to support this standard character set at a minimum. Non-Roman character sets present a greater difficulty and will require the development of special software to permit the display and transmission of these characters on the network. The development and use of well-defined, standard character sets for these languages will aid in the resolution of this problem.

These technical problems can be solved by redesign and reprogramming of existing library and online catalogue systems. However, the solutions would require a great deal of work and investment by the many commercial suppliers of library systems. They will have to be convinced that it is in their interests to make these improvements. Developers of "in-house" systems will have to be educated on the requirements of network access to and remote use of their systems.

A further difficulty is the speed at which personal computing and workstation technology is developing and becoming available to ordinary individuals as well as scientists and designers. Today's network log on and database search interaction are based on line-by-line, character-oriented terminals. This approach does not exploit the capabilities of today's graphics, bit-mapped high resolution workstations. Sadly, much of the good work being done on graphical displays of thesauri to enhance online subject searching cannot be incorporated into today's network access environment. A step in this direction would be for the library and information systems on the current remote login networks to implement the X Windows protocols. Commercial vendors of library systems have shown little interest in this technology to date.

It is best to be optimistic about the resolution of these technical problems, and both vendors and system designers must be made aware of user requirements for feasible access in a network environment. But additional problems exist. Users should not be expected to learn a new interface for each online catalogue they wish to use on the network. The need to accommodate full-text and non-textual information formats (e.g., images, video, etc.) on the network has been mentioned. Turning the search workstation into a multi-functional, productive business or scholar's tool is a major challenge. At the very least, users should be provided assistance with the task of online database/resource selection, and have the tools to consolidate and manipulate information retrieved from many different systems and databases.

1.3.5.3 OPAC User Interface Standards

Standards are needed to bring a degree of uniformity to the user interfaces of online catalogues. Users are confronted by different interfaces in almost every online catalogue they access, while at base every online catalogue performs a common set of functions as a library catalogue. A greater degree of consistency must be provided to searchers in the fundamental use and manipulation of these systems. Three areas in need of greater uniformity are the command language semantics and syntax, the indexing policies of each online catalogue, and online assistance.

Efforts during the 1980s to develop a standard "common command language" for information retrieval are coming to fruition. Both the North American and International (ISO) efforts have reached the penultimate "draft" standard stage. Many library system vendors have installed the draft version "common command language" (CCL) in their online catalogue interfaces or are planning to do so when it is finally adopted. These developments are encouraging, but they take us only part of the way to the desired and needed uniformity and consistency in the online catalogue interface.

Some online catalogues may not employ a command-line type of interface, preferring, perhaps, to offer a menu or "point and click" type of interface. However, all online catalogues conduct searches through indexes, and many display portions of their indexes for browsing or scanning by the user. Currently, there is no consistency from online catalogue to online catalogue in indexing practices, the mapping of search commands or selections to the searchable indexes, or the display of index listings and individual bibliographic citations. Even the use of a common command syntax, for example, "FIND TITLE oil and energy", will yield very different results in many online catalogues. The data content of the title indexes varies from online catalogue to online catalogue, as does the method of indexing (e.g., phrase, keyword, etc.).

Standardization of term matching and retrieval algorithms is probably not desirable at this time, as a great deal of innovation is underway in these areas, including intelligent processing of natural language queries and post- Boolean retrieval methods. As a next step, it would be useful if a set of general guidelines could be established for defining a minimum set of data elements to be indexed and the associations of these basic indexes with the most common types of searches conducted in online catalogues. Of course, agreements on the data contents and a uniform format for bibliographic records for most types of materials would aid in this effort to provide more consistency for the user of multiple online catalogues.

Greater consistency will be provided for a singular search approach among networked online catalogues when the development of the "Search and Retrieval" standard protocol is completed and adopted. This work is taking place within ISO and is divided into two standards: ISO 10162 (Search and Retrieval Service), and ISO 10163 (Search and Retrieval Protocol). These specifications have recently achieved draft international standard (DIS) status. The search and retrieval protocol is designed to function as an application-level (layer 7) protocol within the Open Systems Interconnection (OSI) protocol suite for the connection and interfunctioning of different computer systems. Among other things, the ISO search and retrieval protocol specifies a canonical search format through which searches can be transmitted from one computer (the "client") to another (the "server"). This format consists of a series of predicates linked by Boolean operators such as OR and AND; the predicates are composed of field names, relational attributes, and values (for example, AUTHOR - lastname value; or TITLE - keyword-of value). Both the field names and relational attributes are selected from a predefined and registered (i.e., officially sanctioned) attribute set that forms part of the context of a connection between a "client" computer and a "server" computer. The current "working set" of attributes represent fields in MARC or MARC-like bibliographic records.

Although some uniformity will be introduced in the searching of networked online catalogues when the ISO Search and Retrieval protocols are available for use (conforming software must be developed and installed on hosts and/or network servers), limited search and browse functionality will be supported by the standard approach, and no assistance to the user having search problems during a session will be provided by the new protocol-based search interaction. For example, this approach will not inform the user why a search resulted in no matches. The search can be repeated with new attributes and/or values, but it will be transmitted and processed in the same pre-defined and rigid manner. The assistance of a friendly local user interface will be excluded from this process.

Another set of problems appears when users wish to exploit multiple online catalogues and other databases on a network to solve specific problems. As Lynch (1990) describes the situation, the user typically wants to:

> *- search a series of databases that may be located anywhere on the network (preferably without having to reformulate the query for each system);*
>
> *- move the results to some convenient local workstation or timesharing system;*
>
> *- consolidate the results and eliminate duplicates based on some precedence scheme (for example, when searching for books, if the same book is found in multiple catalogues, keep the citation from the library most easily accessible to the user); and*
>
> *- store the consolidated search result. print it, incorporate it in the bibliography of a paper, or place it in a personal database.*

This description partially reflects the vision of a "scholar's workstation". There is a great deal of work and cooperation to be accomplished in order to achieve this goal. Today, the user can merely save the output of search sessions on different remote systems. Afterwards, the results must be consolidated and edited, a process which is made more difficult due to the differing output formats of the online systems.

1.3.6 Today's Online Catalogue: New Perspectives and Escalating Demands

At about the time second-generation functionality was becoming the operational standard for installed online catalogues in the mid-1980s, librarians and system planners had already begun to expand and extend the traditional access boundaries of these library catalogues. These developments have enriched and enlivened the debate about the proper role, content, and functions of the online catalogue. In this continuing debate, several perspectives on this evolving library access system can be identified.

The online catalogue may be viewed as:

* The expanded bibliographic database

* A sophisticated computerized search and retrieval system

* A "gateway" to other online catalogues and electronic resources

* An integrated component of a multi-function "scholar's workstation"

These new perspectives on the library catalogue represent the nature and extent of the rising expectations for expanded online catalogue data content, access, and functionality. Apparently, these expectations have already been translated into demands and requirements by many librarians. The evidence comes from a look at how online catalogues are being defined and requested by librarians via the formal "Request for Proposal" (RFP) document tendered to potential automated system suppliers as part of the planning and procurement process . (The online catalogue is usually one system specified as part of a desired multi-function automated library system.)

The online catalogue that is desired today by librarians and users, even required, is indeed <u>expanding</u> in scope and functionality. Boss and Harrison (1989) produce a stunning list of "Functional Requirements of online catalogues" culled from the recent RFPs of several academic, public, and special libraries. Only requirements appearing in more than 25 percent of the RFPs were selected for this list. This list, subdivided into sections on Searching (54 requirements), Prompts and Help Messages, Authority Files, Printing, Statistics, *Gateway, Journal Citation Access*, Information and Referral File, *Other Bibliographic and Data Files*, Conformity to Standards and Interfacing, and System Performance, totals 187 separate requirements! (My emphasis) The section headings are an indication of the broad scope of the requirements and the degree to which the online catalogue is truly expanding. These requirements have been specified by experienced, practicing librarians, many of whom are in the process of choosing their second or third automated system. The list is not a "wish-list" created by researchers. Furthermore, after a survey of 23 system vendors, the authors report that several vendors' systems can satisfy 80 percent or more of these requirements.

Installed online catalogues typically stand alone or are integrated or linked to other system components that manage and perform the library's internal housekeeping functions. The latter linkage expands the data content of the online catalogue beyond that of the card catalogue, as it provides "on order" and availability status information. It is becoming more and more common to provide access to the periodical literature through the local mounting of indexing and abstract databases. These locally mounted periodical index databases provide users with access to the periodical literature from the same terminals used to access the online catalogue, and, and in many cases, the online catalogue's search protocols and interface may be used to search these added databases. Gateways that reside in the host computers may be provided to facilitate access to other library systems or communications networks, thereby extending access to information resources beyond the local source.

1.3.7 The Scholar's Workstation

This functional model is being extended - some might say, replaced - by the recent development of microcomputer-based personal or "scholar's" information workstations at several universities and research centers. The emergence of several important information technologies has provided researchers and system developers the tools needed to support not only the expanded, extended online catalogue, but also this further development of powerful, multi-purpose, information workstations. These technologies include powerful microcomputer workstations, optical and advanced magnetic disk storage media, computer graphics and imaging technologies, sophisticated document retrieval and management software, and widespread national and institutional high-speed computer communication networks, gateway and linking facilities.

The early applications of these technologies center around the development of personal information systems or "scholar's workstations" linked via local networks to both nearby and remote computing and information resources. The workstation is typically implemented on a microcomputer platform which employs a variety of special-purpose software modules to enhance user access to the online catalogue and other local and remote information resources. The workstation may be viewed as the center of a client-server access system model that includes a distributed retrieval network of databases on local and remote file servers, with the user interface, gateway, and other "client" software residing on the microcomputer workstation. The University of Illinois's implementation of this model is illustrated in Figure 1.6 (adapted from Mischo, 1989). In this architecture the information databases may be contained in a variety of storage media and may reside at various locations. Search interface software is used to provide a unified access environment for the end-user.

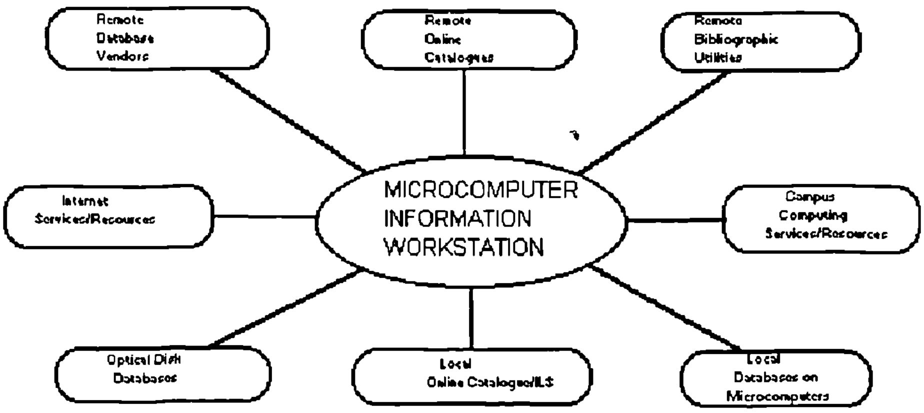


Figure 1.6 Microcomputer-Based Distributed Access Via LANs, Gateways, and Wide-Area Networks

The University of Illinois "Library Information Workstation" project has the aim of developing and testing microcomputer software and hardware technologies in an operational environment to: 1) enhance the user-system interface: 2) provide expert system search technologies and guidance in user searching; 3) employ multimedia technologies for providing online instruction and assistance; 4) provide extended access to networked resources; 5) investigate document and image transmission technologies; and 6) provide improved access to the periodical literature through an alternative search engine and retrieval methods.

Some have described this scenario as the "one-stop, self-service information station." Others call it the "electronic library without walls." Mischo (1989) points out that

> *From a single workstation, a user will be able to 1) perform a literature search using the major periodical index databases; 2) identify retrieve and read the full text of journal articles, book chapters, etc.; 3) send results to electronic mailboxes and personal databases as desired; 4)*

use scholarly software residing on the workstation or provide a gateway to a remote computing facility (such as a supercomputer) for data analysis or preparation; and 5) capture and display the results of the work using the multimedia capabilities of the workstation to prepare presentation materials for the classroom or publication.

With the proper communications software installed these workstations can provide access to the expanded, extended catalogue from within libraries, as well as other locations such as work offices and homes. Some predict that most online catalogue searches in the future will be performed on non-library workstations.

From a very practical, utilitarian perspective, the perspective of the actual user of library and other information sources, any ordinary user -- student, teacher, researcher, worker, professional, or manager -- should be able to use the local library system or a personal microcomputer to access via a network remote, online library catalogues, citation databases, and even full text of the library's holdings; to place a request via e-mail for delivery of a document; and in some cases, to immediately receive the desired information file at the user's workstation through the use of standard "downloading" methods and protocols.

New computer and telecommunication technologies have lessened or removed constraints to both the scope and effective delivery of library and information network services. At the same time, users' expectations for new and expanded network services have risen and new demands will surely be placed on library systems and networks. It is important "to make the distinctions between the use of these technologies for facilitating the transfer and exchange of 'information about information' -- i.e., bibliographic citation exchange -- and the transfer and exchange of information" (Stone, 1990). This, of course, is the well-known distinction between bibliographic and reference databases on one hand, and actual document or "full-text" databases, on the other. After brief experience with the expanded and extended online catalogue, scholars and professionals typically ask, "How can I get the document or information now ?"

1.4 Research Context Summarized

1.4.1 End-user Searching of Bibliographic Retrieval Systems

Search access to online bibliographic databases is not new to libraries. The benefits of access via the commercial database search services have been provided to library users and clients since the late 1960s. However, until recently, direct and regular use of these systems has been almost the sole province of trained, professional search specialists. It is only in the last few years that library patrons and other "end-users" have been provided the opportunities for direct interaction with online or CD-ROM database retrieval systems.

There is reason to believe that many users of today's varied end-user interactive retrieval systems, including CD-ROM-based systems, gained their first experiences with computer database searching via a local online catalogue. Now, with the explosion and popularity of CD-ROM database retrieval systems, end-user, menu-based "front-ends" to the dial-up commercial search services, and the rapid growth of expanded, extended online catalogues, it may well be that most searching and retrieval from bibliographic databases is conducted directly by end-users.

The opportunity to search these databases from a single online catalogue terminal or workstation is becoming more common. In addition to the trend toward mounting publisher's index and abstracting, and other reference databases on the local online catalogue system, the nearby end-user CD-ROM search stations may already be networked to the online catalogue system, and thus be searchable at the online catalogue terminal.

In these early developmental stages of extended online catalogue use and mixed-environment searching (some universities report providing access to 8-10 different database search products, in addition to the online catalogue), users, system managers, and system designers face formidable difficulties and challenges. Users may have to grapple with different search interfaces, and suffer the consequences of not knowing a given database's structure, indexing policies, or the controlled subject vocabularies used. Designers of online catalogues and information workstations are working on user interface or "front-end" technologies and methods to alleviate the problems end-users face in searching these large databases, and to improve the retrieval performance of existing systems. The state of interactive retrieval system interface design may no longer be in its infancy, but interface design knowledge is still rather fluid, and there is no complete set of standards or guidelines to direct it.

Innovations in interface design have made online catalogues and other end-user systems much easier to use than their commercial online search system progenitors. This includes online catalogues that provide sophisticated post-coordinated search capabilities. Unlike their command line-based interface predecessors, these "friendlier" systems employ WIMP (windows, icons, menus, and pointers) interface techniques to facilitate user-system interaction, rather than a formal command language. The trend in interface design is toward the use of fully graphical user interfaces (GUIs) which include descriptive icons that serve as decision/action buttons to be pointed to and depressed.

The growing number of online catalogue and CD-ROM end-users - untrained and occasional users for the most part - have benefited from the significant contributions made by researchers and designers of interface software and "front-ends". These retrieval systems have become much easier to learn and to use. Users of these retrieval systems generally express enthusiasm for them and are usually very satisfied with their performance. Whether or not today's "friendly" retrieval systems actually perform more effectively than earlier versions is a matter of considerable debate. One line of thought holds that a degree of retrieval power and flexibility must sacrificed to provide users with simpler, easy-to-use systems. An a priori case could be made that users' search performance is better in today's online catalogues simply because it is easier to enter a search and complete it through to the display of some results. Research on early online catalogues using transaction logging and analysis methods showed that a significant percentage of searchers simply stopped searching before any documents were retrieved and reviewed, presumably because they could not get past the hurdles of the interface (Tolle, 1983).

With very few exceptions, the large number of online catalogues and CD-ROM systems currently installed in libraries are second-generation systems, with regard to search and retrieval functionality. The journey to the E-3-OPAC is not finished. Major progress has been made in expanding and extending online catalogues. (Understandably, many librarians now prefer to call them "Library Information Systems" rather than the somewhat outdated "OPAC".) On the other hand, development of *enhanced* search, browse, and retrieval functionality has remained essentially stagnant, at least in the camps of the major commercial suppliers of library systems and software. The designers of many CD-ROM online catalogue and reference database retrieval systems have produced innovative user-system interfaces that improve the "look and feel" of interaction with the system. These advances have had a "pulling" effect on traditional online catalogue designers, many of whom have upgraded the user-system interfaces of their products to look competitive. Still, the majority of operational online catalogues and CD-ROM retrieval systems embody the traditional, conventional model of information retrieval. This model is reflected in query-oriented, exact match retrieval systems that typically feature keyword, Boolean searching or string or "phrase" searching.

As more and more databases are added to the expanded online catalogue, more subject searching at the online catalogue will take place than ever before. Studies of online catalogue use continue to report the predominance of subject searching in online catalogues. With the addition of contents information to the bibliographic records and expanded access to the periodical literature, there is every reason to believe that most of the searching conducted in the online catalogue will be subject searching, that is, searching for information or materials on a topic or topics. In its early stages, this expanded information environment will also be a more complex search environment for the online catalogue user, with its variety of sources and search capabilities.

There is a growing body of research-based evidence which demonstrates that present-day, second-generation online catalogues are not very effective instruments in meeting the information access needs of library users. This research continues to reveal that there are pervasive problems with subject searching on online catalogues, and, as Larson (1991) notes, "the major problems pointed out by users of online catalog systems were symptomatic of a lack of effective subject access to the contents of the collection."

As Larson and others point out (e.g., Hancock-Beaulieu, 1989a), many of the reported problems with subject access have a long history, and may be inherent in the complex processes of document content analysis and indexing, or associated with limitations in the media and functionality that have been provided for subject searching and retrieval in the past. There seems little doubt, however, that the extent and impact of the difficulties associated with subject access and the deficiencies in subject searching performance will increase as end-user searching in the expanded, extended online catalogue increases.

The problems with subject access experienced by users of today's online catalogues have been described earlier in this chapter. Some key findings are summarized here. Studies of end-user searching of automated bibliographic retrieval systems and online catalogues show that: 1) users experience difficulties in conducting effective searches in the "friendlier" but conventional Boolean retrieval systems now offered by the online search service and CD-ROM vendors; and 2) online catalogue users experience the most difficulties with subject searching. Formulating good search strategies and using the Boolean operators correctly pose difficulties for users. Studies of search outcomes reveal seemingly high rates of search failure: for example, nothing is retrieved by many searches, or the retrieval sets are very large and often remain unscanned by the user. Indications are that between one-third and one-half of all searches result in no items retrieved; and user-entered subject search terms seldom match the indexing subject vocabulary of the catalogue. Not surprisingly, when surveyed, online catalogue users rank improvements to subject searching a high priority among various system enhancements. In addition, online catalogue users have expressed a strong desire for access to the periodical literature.

Nonetheless, many research studies report high levels of user enthusiasm and satisfaction with the use and performance of these retrieval systems, even though there is considerable evidence that search success rates are far from optimal (Ankeny, 1991; Kenny and Schroeder, 1992). The areas that present the most difficulties to searchers of today's online catalogues and CD-ROM retrieval systems are the following: implementing good, appropriate search strategies for the task at hand; expressing accurate and complete queries in a form acceptable by the system; and matching search terms to the system's indexing language. That these conceptual and "entry" requirements for good searching represent formidable challenges even for highly-trained database search specialists indicates that fundamentally new and different approaches may need to be applied in the design of end-user search interfaces and retrieval methods. In their research on users of conventional online database search services, both Vigil and Bellardo point out that formulating accurate, clear search queries is a complex cognitive activity that requires a very high cognitive load; and further, according to Vigil, often results in "a cognitive strain that limits the mental resource and energy which can be devoted to the primary task of judging relevancy" (Vigil, 1983, and Bellardo, 1985).

In the next chapter, the recent theoretical and experimental contributions of information retrieval researchers are reviewed, and it is argued that a new model of information seeking and retrieval is needed, a model that more closely describes much of the subject searching and browsing activity actually conducted by library users. It is suggested that a new non-query-oriented search paradigm may be appropriate for guiding the design of subject access mechanisms in future online catalogues.

Chapter 2

Research Context, Part Two: Searching and Browsing in Information Retrieval Systems

2.1 The Conventional Information Retrieval Model

2.1.1 Functional Objective of an Information Retrieval System

A tool should do well what it has been designed and built to do. That is, a tool, no matter how sophisticated, is a means of performing some or all of the tasks and operations needed to achieve the functional objectives intended by its designers. What, then, is the primary purpose or functional objective of an information retrieval system? If it makes sense for form to follow function in the design of tools, the answer to this question should not only provide the basis for system design and implementation, but also serve as the central normative criterion in evaluations of information retrieval systems.

There seems to be a consensus in the profession as to the primary function of an information retrieval system, particularly, a conventional document retrieval system. Van Rijsbergen reminds us that "When we search a document collection, we attempt to retrieve relevant documents without retrieving non-relevant ones" (Van Rijsbergen, 1979). Restated in functional terms from the user's point of view, "the objective of an information retrieval system is to find all the relevant items and only the relevant items in a database that satisfy his or her information needs" (Cox, 1992). Cooper suggested much earlier that additionally, the system should accomplish this function *efficiently*, again, from the user's point of view: "The primary function of a retrieval system is conceived to be that of saving its users to as great an extent as is possible, the labour of perusing and discarding irrelevant documents, in their search for relevant ones" (Cooper, 1969). Cooper proposes that a time-labour saving measure be used to evaluate the performance quality of an IR system.

While agreeing that the purpose of a retrieval system is the retrieval of relevant documents, Robertson (1988) adds: "More accurately, we may say that a system should retrieve, in response to a request based on an ASK, those documents which the user will find relevant to the resolution of the ASK." (Author's note:

"ASK" stands for, "anomalous states of knowledge.") In their recent review of research and development in information retrieval systems, Belkin and Croft state that information retrieval systems provide "the means for identifying, retrieving, and/or ranking texts (or text surrogates or portions of texts), in a collection of texts, that might be relevant to a given query (or useful for resolving a particular problem)" (Belkin & Croft, 1987). To do this, according to the authors, IR systems employ various retrieval techniques to compare a representation of a query with representations of texts. Writing specifically about online catalogues, Larson states: "Ideally, an information retrieval system such as an online catalog should retrieve *all*, and *only*, the documents that the user would judge to be relevant in response to a given query" (Larson, 1991). Such an ideal system would achieve perfect, 100-percent recall (percentage of all relevant documents retrieved) and precision (percentage of retrieved documents that are relevant) in its response to a given query; that is, it would retrieve all and nothing but the relevant items in the database.

This prevailing view of the primary function of an IR system is essentially *query-oriented*. It assumes, and some say it requires, that the user is able to express his information need with some degree of clarity and specificity. "In conventional information retrieval systems, the user is required to formulate a query on which to search, necessitating her/him to be familiar with special terms and keywords that appear in a text" (Cove & Walsh, 1988). Furthermore, most conventional IR systems in operation require the searcher to express the information need in a form and manner that can be acted upon by the system. This is the process called by information scientists, "query construction" or "query formulation." The specific procedural rules and requirements for formulating a proper query are dictated by a particular system's software. Making the transition from an information need or interest to a statement of that need or interest in the query language of a particular system has been characterized as an arduous and "complex cognitive activity" (Bellardo, 1985).

2.1.2 The Information Retrieval Situation

This query-oriented model has been described by many writers and is variably referred to as the "traditional," "conventional," or "classic" model of information retrieval. Belkin and Croft provide a sketch of what they call the "Retrieval technique situation" (1987):

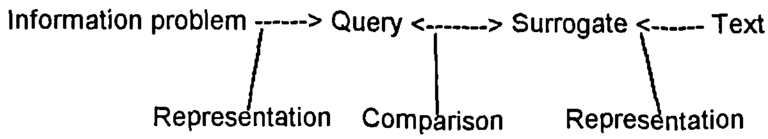


Figure 2.1. The Retrieval Technique Situation

"Retrieval techniques," say the authors, "address the issue of comparing a representation of a query with representations of texts," and further, this depiction of the situation "shows that different representations allow different retrieval techniques without necessarily specifying them." The comparison factor at the heart of this "situation" model is usually referred to in the literature as the "matching" function. "Remember that the basic instrument we have for trying to separate the relevant from the non-relevant documents is a matching function" (Van Rijsbergen, 1979).

The information retrieval situation described by Belkin and Croft is represented in Bates' graphical depiction of the "classic" model of information retrieval: (Bates, 1989)

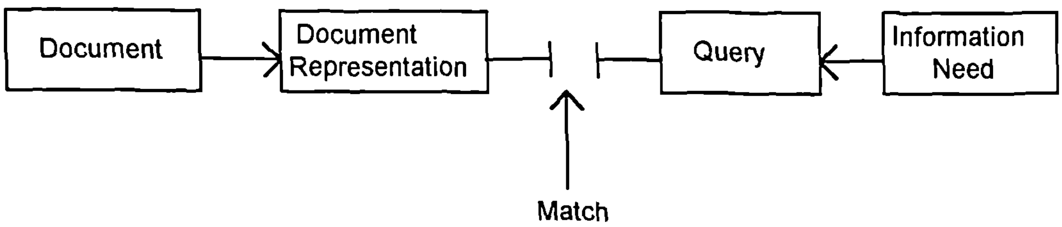


Figure 2.2. The Classic Information Retrieval Model

While Bates recognizes that this classic model has been useful and productive in information science research, she questions whether the model is adequate for representing most of the kinds of searching and information seeking behavior of users in real situations. Pointing out that the focus of the classic model is the match between the query and document representations, Bates explains: "Fundamental to it is the idea of a single query presented by the user, matched to the database contents, yielding a single output set" (Bates, 1989). The classic model assumes, according to Bates, that the user's information need does not change during the search process, and is expressed in a single query that is the original, one-time representation of the information need.

2.1.3 A Classification of Retrieval Techniques

This somewhat narrow interpretation of the information retrieval model contrasts with the expansive views of Belkin and Croft. In their review of research on IR systems, they present an all-inclusive framework and classification of retrieval techniques employed in IR systems. They believe this classification scheme remains representative of the real-life retrieval situation, and will prove useful for comparisons and discussions of the many different retrieval techniques. The scheme is illustrated in the following diagram.

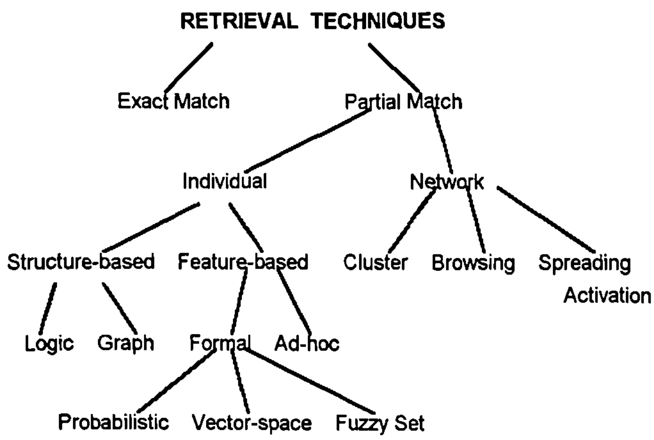


Figure 2.3. A Classification of Retrieval Techniques

Each retrieval technique in the scheme involves the comparison of a query with the document representations. There are a variety of ways this comparison or "match" may be carried out. Other criteria used for delineating and classifying techniques involve the characteristics of the retrieval set of documents and the representations of queries and documents. The primary distinction made among all these retrieval techniques is whether the retrieved documents exactly match or partially match the query specifications. It should be noted that partial match techniques are usually more inclusive than exact match techniques; in fact, in a partial match, the set of retrieved documents will include those that would be retrieved in an exact match of the query. A better name for this category might be, "full match" or "best match."

As the diagram illustrates, all techniques other than exact match techniques are classified under "partial match." Note that browsing techniques are included as a subcategory under partial match techniques. Thus, Belkin and Croft imply that even browsing involves at base a query-document comparison or match of some sort. This assumption will be questioned later in this chapter.

2.1.4 The Exact Match Search Paradigm

Most of today's operational information retrieval systems and second-generation online catalogues use exact match retrieval techniques, featuring keyword, Boolean, proximity, and string searching. Search field specification, truncation and/or wildcard searching is usually supported as well. These exact match techniques require that the specifications of the query (e.g., the search terms and their specified logical or textual relationships) be satisfied precisely by any and all document representations that would make up the retrieval set.

Although the object of widescale criticism by researchers and many librarians, exact match searching remains the paradigm for operational online information retrieval, CD-ROM, and online catalogue systems. There is much discussion and debate in the research literature regarding the reasons for this situation and why it continues. A full review of this discussion is beyond the scope of this study report. Two explanatory factors should be mentioned in brief: 1) some techniques have been employed by system designers that relax the constraints of exact match searching, for example, stemming of query or index terms, and the provision of "wild card" searching; and 2) "The traditional Boolean, analytical search strategy is widely used by professional searchers of online bibliographic databases because of its potential for expressing an information need accurately" (Marchionini, 1988). In other words, it can be plausibly argued that Boolean propositions provide the flexibility and finesse to represent fine aspects of a user's information with great precision. Researchers and designers have given database searchers post-coordinate searching tools that are both powerful and flexible for constructing expressions of users' information needs.

Designers of second-generation online catalogues implemented this model in the 1980s largely because it was the model incorporated by the major commercial online search services, and because it was preferred by the librarians who had become the trained, experienced users of those services. Willett points to the inertia factor: "Boolean systems have been with us for many years now and there is a natural disinclination on the part of both users and system providers to develop new techniques" (1988).

After end-users' difficulties with Boolean query systems began to be widely reported and discussed, some online catalogue designers implemented various techniques aimed at reducing the difficulties associated with formulating and entering complex queries. For example, menus were provided for command selection, and users of these system interfaces had only to enter search terms and optionally specify a type of search or field to be the target of the search. The online catalogue software then "constructed" the query and supplied the Boolean or proximity operator to coordinate the terms entered by the user. The default or "implicit" operator used to specify the relationship between the search terms could, in many cases, be changed by system managers if they felt it was necessary to change the logic of the relationship between search terms. For example, changing the system-supplied implicit operator "between" search terms from adjacency to the Boolean "AND" would likely broaden the search and usually yield a larger results set or reduce the number of no match, "no hit" search failures. This change was found to be necessary when users began to complain of not being able to find titles of books they knew were in the collection, and consultation with transaction logs confirmed the problem. Searchers typically remember and enter two or three significant words in a title, rather than the complete title or precise order of words in the title.

2.1.5 Explicit and Implicit Online Catalogues

With or without these "user friendly" techniques, most online catalogues in operation are still Boolean query or string-matching, exact match retrieval systems. One might refer to these two kinds of second-generation online catalogues as "explicit" and "implicit" exact match systems. In implicit online catalogues, the query formulation requirements placed upon the user are greatly reduced or removed altogether. In the former case, the searcher is required to enter a term or terms that represent his information need, and, perhaps, specify a type of search or search field by selecting it from a menu or by using a simplified command language (e.g., FIND TITLE medieval art). The system then supplies the combinatorial logic which specifies a relationship between the terms to be assumed and acted upon in the matching operation. Implicit truncation, for example, might also be applied to the terms such that a match could occur on both "medieval" and "medievalist", or "art" and "artists".

Such implicit online catalogues leave the user entirely in the dark about the term combinatorial logic, truncation (if any) and matching functions they automatically employ. As a consequence, most searchers will not have a clue as to why some searches fail to retrieve any documents, or why other searches retrieve large numbers of non-relevant documents. Thus, they have no information feedback to aid in the modification or reformulation of their search queries for a second or third try. Even if they guess that the online catalogue they are using searches on "medieval art" as a unitary string of contiguous characters, these implicit online catalogues generally do not provide the means for a searcher to re-specify the request as "medieval AND art", for example.

Another category of implicit online catalogues includes those that remove the requirement to formulate and enter a query altogether. Using these online catalogues, the searcher may optionally select a type of search from a menu (e.g., author, title, subject, etc.) or proceed directly to a display of index terms or brief document titles usually presented in an alphabetically ordered list. (some online catalogues display title lists in class number order.) Markey calls this approach, "alphabetical searching" (Markey, 1989). This approach closely mimics the way searchers access and scan document records in the earlier manual, card catalogues. Searchers choose a location in the displayed alphabetical list (or drawer of cards) of "headings" terms as an entry point to the database, then scan nearby terms or the bibliographic records filed under them. In the online catalogue, a selection of a single term from the list (terms can be keywords extracted from text or pre-coordinated phrases from a controlled subject vocabulary) will typically call up a display of all bibliographic records associated with the selected term. These usually abbreviated document "title" records may, in turn, be scanned for further selection, fuller display, and assessment.

This list scanning and selection approach to searching, found in many online catalogues, is often named the "BROWSE" mode or searching option. The only search approach offered in a few online catalogues, in most second-generation online catalogues this approach is offered as a search option, along with a keyword, Boolean search option (explicit in some, implicit in others). Thus it is that we have identified three types of operational online catalogues: 1) explicit, exact match systems (usually Boolean and string searching systems); 2) implicit Boolean exact match systems (in which the system software defines the term relationships); and 3) "browse" online catalogues that feature alphabetical searching of index term or citation lists.

The "browse" online catalogues make the least demands on the searcher with regard to the process of query formulation and entry. The searcher merely scans a list, selects a term from the list (rather than entering one of his own), then sees what document records are retrieved. The searcher may have a term or terms in mind, of course,then consults the system's lists to find it or one like it in some sense and thus suitable for searching. When a term has been selected, the system carries out the "built-in" matching and retrieval operations. Such browse online catalogues may still be classified in the category of exact match systems.

In all three types of operational online catalogues - and most are mixed, hybrid systems - effective subject searching requires the user to express his need for information in a form or terminology acceptable to the system. This means that users must not only specify their need in advance, but think about what sort of documents will satisfy their need, and <u>also</u> translate these concepts into the terms used in the indexing vocabulary of the system. These terms may then be used in a formal query, if the particular system requires one, or sought for in an alphabetical list displayed for this purpose. The system then takes the query or selected term and applies a matching function to determine which records are to be retrieved for display and evaluation by the user.

Larson explains that the process of query formulation or term selection from lists required in conventional information retrieval systems and online catalogues "involves <u>predicting</u> which terms in the indexing language of the system have been used to index the documents that the user would want to retrieve" (Larson, 1991). He goes on to state that evidence indicates that online catalogue users do not conceive of subject searching in this way, and that when required to, they usually do not do a very good job of predicting or guessing the terms used to index the desired or potentially useful documents. Some of the guessing required may be reduced in systems that permit or require searchers to scan lists of index or thesaurus terms to identify search terms. However, in large online databases, the length of these lists, or the complex structure of lists such as thesauri, may place an unreasonable burden on the untrained, infrequent user.

2.1.6 Browsing in Exact Match Systems

Browsing in conventional database search systems and online catalogues presents problems for Belkin and Croft's retrieval technique classification scheme. Browsing of a sort surely takes place in these exact match systems. As Bates notes, "In discussions of 'browsing' in online databases, the term usually refers to reading short lists of alphabetically arranged subject terms or reading citations and their associated abstracts" (Bates, 1989). Thus, even this form of browsing includes more than the visual scanning of lists, and this form of browsing may be an intermediate step in an iterative process of searching, even in exact match systems.

To state that this sort of browsing does not constitute a retrieval technique, but is, rather, a method "for enhancing the query or request model" (Belkin & Croft, 1987), begs the question of the proper use of the term, "browsing". Presumably, the authors would label this activity, "scanning", "relevance feedback", "query enhancement", or something similar. They reserve the term "browsing" to mean searching through "documents, terms, and other bibliographic information... represented in the system as a network of nodes and connections," and classify this retrieval technique as a subcategory under partial match systems. Surely it is possible, however, to characterize browsing in conventional, exact-match online catalogue databases in this manner, that is, searching a network of nodes and connections. The traditional catalogue database can be conceived as a network of subject terms, related terms and their referenced citations, and these citations linked to others by the class mark they share, and so on.

There are other reasons to question the placement of browsing in the Belkin-Croft classification under network-based, partial match retrieval techniques. Recall that the authors define a retrieval technique as "a technique for comparing the query with the document representations." As we shall see, in some forms of browsing as an information seeking behavior, one may reasonably ask, "Where is the query?" Belkin and Croft recognize that browsing "places less emphasis on query formulation than do other techniques," but fail to consider cases of browsing in which a query is *never* generated, or cases where the "query" is not just modified but discarded altogether and replaced by an entirely new query, or discarded and replaced by a recognition-based search activity.

In placing browsing under partial match techniques, they commit themselves to the odd assertion that browsing produces ranked sets of retrieved documents, "since partial match techniques automatically produce retrieved text rankings." The browsing conducted in conventional information retrieval systems and online catalogues does not yield ranked sets of search results.

Lastly, Belkin and Croft make the apparently sensible observation that "Whatever retrieval technique is used, the quality of the results depends almost entirely on the <u>accuracy</u> of the information in the request model." (Emphasis mine) This seems to imply that "quality results" cannot be achieved in many kinds of browsing, or that the likelihood of attaining good results from browsing decreases in proportion to the lack of clarity in the browser's mind about his information need or interest. Experienced browsers might say, on the other hand, that quality browsing depends equally or more so on the structure and organization of the database, effective navigation methods, and a helpful search interface that assists the user in understanding the structure of the database and in the use of the browse and navigation techniques.

2.1.7 Summary: Browsing as an Information Seeking Method

To summarize the discussion to this point, browsing is not one but many kinds of activities, any one of which may be observed in actual searching behavior. All information retrieval systems including online catalogues support some form of browsing. In traditional, query-oriented systems, browsing plays a subordinate, supporting role in assisting with the formulation or modification of a query that is to be matched exactly or partially with document representations. This probably explains why some people view browsing as a secondary activity, and not real searching. Some forms of browsing are quite different than this and may serve as the <u>primary</u> information seeking method used by most people in real-life searching situations. In light of this, some researchers have suggested that a browsing paradigm for searching replace the query-matching paradigm in the design of information retrieval systems. Before commenting further on this point of view, it will be well to examine more closely the concept and types of browsing.

2.2 The Nature and Types of Browsing

2.2.1 The Concept of Browsing

A browse is an edible in the eyes of a young animal. It may be a tender twig, leaf or shoot of a plant that is fit and easy to eat. These delicacies must be sought for and are the object of selective review, that is, browsing. Browsing takes place in a patch of interest and is characterized as tentative nibbling, at least at the start. Human browsing activity has many connotations. In the context of information seeking and library use activities, probably the most visible and commonly understood browsing activity is the behavior of roaming among the shelves of a library or bookstore to scan materials of potential interest or utility. Books and other materials are casually perused in order to decide what we want to buy or borrow, if anything at all. Librarians have long recognized that users who come into the library enjoy browsing among the shelves, and thus they make special efforts to display groups of related books of potential interest in noticeable, easy to browse ways. Research studies of library users confirm this experience and show further that many library browsers prefer to browse the organized materials on the shelves than search and browse in the library catalogue (Hyman, 1971, 1982; Hancock-Beaulieu, 1989a).

From our ordinary experiences, we recognize that both the focus of our browsing interests and the strength of our motivation to discover relevant items vary from time to time. When browsing we may employ a variety of techniques ranging from the casual and undirected to the planned and systematic. As Marchionini explains, "These techniques are dependent on the object sought, individual searcher characteristics, the purpose of the search, and the setting and context for conducting the search. The objective of browsing may be well-defined (e.g., a particular antique chair to match a desk), or ill-defined (e.g., an interesting wall hanging for a favorite room)" (Marchionini, 1987). In the latter category, I prefer the example of a tourist on the last day of an island holiday searching about for a souvenir suitable as a memento of the trip.

In his discussion of types of browsing, Apted labels this activity. "general purposive browsing." He describes this activity in the following way:

> *General purposive browsing ... may be defined as planned or unplanned examination of sources, journals, books or other media, in the*

hope of discovering unspecified new, but useful information. In a library the user perhaps wanders along some section of the collection and, from time to time, picks up items for casual or more detailed examination. He may look at works in his own field, or he may examine material in quite unrelated areas (Apted, 1971).

Contrasted with the aimless, haphazard scanning of publications in a physician's waiting room, browsing is frequently a purposeful activity occasioned by a felt information need or interest. The need may be ill-defined but nonetheless very real. Oddy reminds us that, "It is important to try to come to grips with the problem of serving a library user who is not able to formulate a precise query, and yet will recognize what he has been looking for when he sees it. A man, left to his own devices among the bookshelves, accomplishes searches of this sort by browsing" (Oddy, 1977). Aided by various structural and navigation devices provided by the library, he can well be expected to browse even more efficiently and effectively. A mix of science and art and good fortune might be involved in all successful browsing searches. Cove and Walsh have described browsing as "the art of not knowing what one wants until one finds it" (Cove & Walsh, 1988).

Past studies of browsing as a library use activity have assumed that browsing in the stacks, the direct shelf approach to searching, is the essential form of browsing to locate items of interest or need. In his study of how faculty learned about books they borrowed from the Georgia Tech University Library, Green's "discovery" categories were 1) references in a publication, 2) browsing in the library, 3) from a colleague, 4) from the library catalogues, 5) from memory, and 6) from some other source (Greene, 1977). His findings indicated that browsing in the stacks was the most used method of finding out about new books. Hancock-Beaulieu's recent research confirms that users have shown a preference for the direct shelf approach over use of the library's catalogue and other bibliographic tools (Hancock-Beaulieu, 1989a). She warns us, however, that, "The behavioural aspect of browsing as part of the information seeking activity is far from understood." Her review of shelf browsing studies reveal that users handle a limited number of items from the shelves, and select only a small number. Hancock points out that the searcher who browses only at the shelves may miss other related items scattered elsewhere in the collection. In large university libraries, these related items may be located in different buildings or on different campuses. "Shelf consultation seems to produce not only low recall but also low precision." For these reasons, believes Hancock-Beaulieu, shelf browsing should not be considered as an alternative to catalogue use. Browsing support at the catalogue can lead to improved searching at the shelves by providing direction and linkage clues.

In his attempt to apply the theories of successful submarine search operations developed during wartime, Morse (1973) explains the behavior of the library browser in this manner:

> *The browser usually is not seeking a specific book; he is looking through the shelves to see 'what catches his eye.' Nevertheless he does not allocate his search effort purely at random; he goes to that section of the library that he estimates has the highest probability of containing a book or books his immediate interests would find to be worth borrowing.*

Morse's early work may be the first attempt to apply the probability model of information theory to shelf browsing.

Lancaster (1968) describes another form of browsing found in the behavior patterns of individuals who conduct literature searches in a variety of bibliographic tools and retrieval systems:

> *Personal searches tend to be browsing searches. The seeker of information in a card index, a printed bibliography, or an abstracting publication, normally does not prepare a formal search strategy before beginning his search. Indeed, he may not have a clear statement, even in his own mind, of the exact subject matter that will be of use to him. The search, thus, tends to be heuristic. He begins by consulting the most likely subject headings, subsequently allowing his search to be guided by the cross-reference structure and arrangement of the various tools he is employing.*
>
> *Having found some promising references, he locates the documents cited, and, from the text and bibliographies of these, may be led to other sources or made aware of additional subject labels that might usefully be consulted in the tools with which he began the search. During this whole process, the information need tends to be modified, to a greater or lesser extent, by what is found during the search, and the final set of documents, accepted by the searcher as useful in relation to his requirements, may be*

somewhat different in character from the kinds of documents he visualized as useful when the commenced.

This sort of "personal searching" is what is now popularly known as direct, "end-user" searching, and is contrasted by Lancaster with the searching patterns of trained search intermediaries. Recent studies have shown that much of Lancaster's characterization holds, but end-users of online catalogues seldom guess and consult the "most likely subject headings."

Fox and Palay offer this definition of browsing: "Access to related information is the essence of browsing" (Fox & Palay, 1980). They encourage retrieval system designers to provide systems that allow quick and easy access to related records for the inexperienced or untrained user. Purely random browsing in unorganized, unfamiliar territory makes little sense, and is probably beyond the bounds of normal browsing of any sort. The authors describe the process of browsing as "a heuristic search in a well-connected space of records." They state that browsing in bibliographic retrieval systems should consist of the following iterative, five-step process:

1. Choose a browsing attribute, such as a category, author, keyword, etc.

2. Access and peruse entries via the chosen attribute

3. Narrow perusal (search) to a small subset

4. Examine a small subset of entries to confirm interest and find new information

5. If an entry suggests a new attribute, then go to step 1 or else go to step 2.

Fox and Palay believe these steps are better supported in a well-designed online retrieval system than in traditional manual systems.

2.2.2 Types of Browsing

A review of the literature on browsing revealed several attempts to delineate and classify types or forms of browsing behavior. These can be reduced to three broad categories, using the different but corresponding labels of the researchers:

Category 1	Category 2	Category 3
undirected browsing (Herner, 1970)	semi-directed browsing	directed browsing
general browsing (Apted, 1971)	general purposive browsing	specific browsing
serendipity browsing (Cove & Walsh, 1988)	general purpose browsing	search browsing

General or serendipity browsing is largely random, unstructured, and undirected activity. The browser may be just passing time, looking over items near to hand while occupied with another activity or aim. Apted includes in this category the perusal of documents in the desire to find anything of interest for informal, recreational reading.

In general purpose browsing, the browser does not know in advance where relevant information may turn up, but selects and scans a specific publication or set of publications on a regular basis in the hope of improving his chance of success, or to insure that nothing of likely interest goes unnoticed. Herner adds that this type of browsing is usually guided by habit, and that the personal scanning of a specific document type follows a predictable pattern.

The search activities described by Lancaster would probably be characterized as "specific browsing" by Apted. Herner calls these activities "directed browsing." The searcher has a specific end in mind, but does not approach the catalogue with a well-formulated search strategy. The activity is initially directed toward that end and proceeds in a structured manner. The searcher is deliberate in purpose, but specifically assumes a state of mind that is open to clues and suggestions. The searcher expects guidance from the bibliographic tool he chooses to use and often follows the clues and pointers to items or areas of information relevant to his interests or needs.

Browsing can thus be viewed as a family of information seeking activities. As Herner (1970) concludes, browsing is not one but many things:

> *It is sometimes a purely random, unstructured and undirected activity. Other times it is closely directed and structured, where, although the final sources or media may not be known, the desired product or goal is clear. Then again, specified media and sources may be browsed or consulted on a regular basis, not necessarily to produce answers to concrete queries, but because it is highly probable they contain items of interest.*

2.2.3 Browsing Aids

This classification of browsing activities is useful because it invites us to expand our traditional, pre-examined understanding of browsing. Browsing may be more or less planned and directed, or proceed from an information need or interest that is more or less well-defined at the start. In addition, browsing may be carried out in a variety of information media, packages, and bibliographic tools, both manual and online. Many of these media and tools have been systematically designed and structured to facilitate browsing. They employ structural, semantic, and navigational aids for this purpose. The library itself can be such a tool if its collection of materials is stored and maintained in any than a random manner. When direct access to the shelves is permitted, the arrangement of books on the shelves according to a subject scheme or some other classification (e.g., author, genre) facilitates browsing by library users.

A book or periodical journal is typically organized and structured to promote browsing. Such devices as the tables of contents, indexes, prefaces or introductions, and lists of references both encourage and enhance browsing. Whatever the user's level, specificity, or area of interest, such devices permit the easy and convenient gathering and perusal of information needed to make preliminary decisions about the relevance or potential usefulness of the documents.

Various forms of library catalogues, and indexing and abstracting publications or services, manual or online, incorporate devices and features that permit browsing of one kind or another. These sources utilize structure, recognition, and navigation devices to assist and guide the user looking about for items of interest or pointers to such items. Browsing is essentially visual and depends more on recognition than on recall or a priori formulations of need. A good browsing tool, source, or system, exploits the human ability to recognize items of interest, a cognitive ability that is faster and easier than juggling concepts to specify a need and describing relevant items in advance (Card, Moran and Newell, 1983).

As Liebscher and Marchionini (1988) remind us, filters are also useful devices for browsing. In large information systems they may be an absolute necessity. Recognition is easier than recall or query formulation, but many, many items of potential interest may be presented to the browser in large systems. Thus greater effort may be required to filter out truly useful items from the large set of items discovered during browsing. "The effectiveness of such a browsing strategy depends largely on the system's ability to facilitate the searcher's filtering activity during browsing" (Liebscher & Marchionini, 1988).

2.2.4 Searching or Browsing?

Marchionini (1987) discusses three primary reasons why people browse:

First, they browse because they cannot or have not defined their search objective; they have what Belkin, Oddy and Brooks have called anomalous states of knowledge (1982).

Second, people browse because it takes less cognitive load to browse than it does to plan and conduct an analytical, optimized search.

Third, people browse because the information system supports and encourages browsing.... Particular information sources like encyclopedias invite browsing by supplying indexes, outlines, section headings, tables and graphs, which help users quickly filter information.

Searchers often have difficulty defining and expressing their information needs. The database structure and vocabulary requirements of the search system may be unknown to the searcher. For such searchers, looking is more inviting then formulating. Browsing is inherently active and engaging, and many users seem to prefer action and encounter to reflection and analysis. It could be said that good browsing systems and sources attract such users, but there are not enough good online browsing systems in operation to justify this claim at this time. However, Hancock-Beaulieu's research provides some evidence that the "tool tailors the task" (1989a). Expanded access points and search options in the online catalogue probably account for the variety of subject search strategies used by searchers in this medium as compared to the card catalogue.

Reflection on the reasons and circumstances in which people browse should yield a new understanding of the importance of this activity. These insights should inform the design of information retrieval systems and lead to improved browsing capabilities in these systems. In the past browsing has often been viewed as a secondary or supplemental search strategy or technique to primary, query-oriented, directed, structured searching. Bates suggests that there may still be a "lingering tendency in information science to see browsing *in contrast* to directed searching, to see it as a casual, don't-know-what-I-want behavior that one engages in separately from 'regular' searching" (Bates, 1989).

Searching by browsing is a natural, preferred searching technique for many people, especially when they are engaged in "general purposive" information seeking. Ellis' research on the information seeking behavior of social scientists shows that various forms of browsing are a standard component of their research and "keeping aware" activities. He recommends that browsing of a variety of types of information that supplement the standard bibliographic record be provided in online retrieval systems (Ellis, 1989). Liebscher and Marchionini's research has demonstrated that browsing can be as effective in its results as structured, query-oriented Boolean searching, for novice searchers of full-text documents. Marchionini argues that because of the massive amounts of poorly organized information available in electronic form, browsing is even more important in electronic environments than in traditional environments like those presented by open-access libraries (Marchionini, 1987).

Designers of information retrieval systems and online catalogues must expand their knowledge of the browsing requirements of searchers, and provide capabilities and search options in their systems that will support these requirements. Most IR systems support some aspects of browsing, but still implement the paradigm of direct, query-matching retrieval. Browsing also provides a suitable paradigm for information system design, and, perhaps, an even more representative one, given the many varieties of information needs and searching behavior.

2.3 Limitations and Problems of the Conventional Model of Information Retrieval

As explained. most operational information retrieval systems and online catalogues embody in their design and implementation the query-oriented, exact match retrieval paradigm central to the conventional model of information retrieval. These systems typically feature Boolean, full text (e.g., word proximity), or string searching. Salton and McGill (1983) provide a useful overview of this design approach:

> *Conventional retrieval systems are based for the most part on a common set of principles and methodologies. The documents are normally indexed manually by subject experts or professional indexers using a prespecified, controlled vocabulary; alternatively, some systems use the words included in document texts or text excerpts as index terms. Users or search intermediaries formulate search statements using terms from the accepted vocabulary together with appropriate Boolean operators between terms. The main file search device is an auxiliary, so-called inverted directory which contains for each accepted content identifier and for some of the objective terms a list of the document references, or markers, to which that term has been assigned. In a free text search system, the inverted directory contains the text words from the documents and the references to all documents containing each given word. The documents to be retrieved in response to a given search request are then identified by obtaining from the inverted directory the document reference lists corresponding to each query term, and performing appropriate list comparison and merging operations in accordance with the logical search term associations contained in the query statements. An <u>exact match</u> retrieval strategy is used which consists of retrieving all items whose content description contains the term combination specified in the search requests. Furthermore, all retrieved items are considered by the system to be equally relevant to the user's needs, and normally no special methods*

are provided for ranking the output items in presumed order of goodness for the user (Salton and McGill, 1983).

Conventional information retrieval systems and the model they embody have been under heavy attack by information scientists for more than twenty years. Objections have been issued on both theoretical and empirical grounds. Much of the early criticism of conventional systems was theoretical in nature, and focused on the relative poor performance and ineffectiveness of these systems in various document retrieval tasks. Controlled experiments were often conducted in artificial test environments (e.g., no human searchers were used) to confirm the hypotheses regarding the poor performance of conventional systems and/or the superior performance of alternative models and techniques. The flood of evidence produced by more recent studies of online catalogue use and end-user searching demonstrating major performance and use problems has provided additional ammunition for the critics of conventional retrieval systems and online catalogues.

There have been a number of complaints and objections to conventional, Boolean retrieval systems voiced by researchers who specialize in information retrieval theory and design. Upon review, these criticisms fall naturally into two broad categories: 1) performance problems or deficiencies, which includes the subcategories of system use difficulties and retrieval deficiencies; and 2) questions about the adequacy of the model itself to represent the "retrieval situation" and the varieties of subject searching behavior.

2.3.1 Performance and System Use Problems: A Reappraisal of Boolean Retrieval Methods

In the early 1980s many librarians and online catalogue researchers urged vendors and system designers to upgrade their online catalogues to keyword, Boolean retrieval systems. Many thought that the provision of Boolean search formulation and retrieval methods in online catalogues would provide more search flexibility and subject access points than first-generation online catalogues, and, by offering term/query post-coordinated searching, would give subject searchers an effective alternative to exact matches on unknown LC subject headings. Some librarians welcomed keyword/Boolean online catalogues as the panacea for the problems of subject searching in early online catalogues.

This enthusiastic anticipation of the arrival of Boolean online catalogues in libraries is easy to explain. First-generation online catalogues were not very good retrieval systems. Many of them are still in place alongside the new interactive CD-ROM reference retrieval systems and the online search terminals being used to access the commercial database search services. Boolean retrieval is the predominant mode of access in the world of commercial online reference searching, and has acquired over the years an immense prestige in the eyes of librarians. The commercial database search services have steadily grown in the number and size of their databases, and the number of libraries and librarians using one or more of them has increased greatly in the 1980s. Doszkocs (1983) comments on this phenomenon:

> *The impressive growth and acceptance of these systems is partly due to the search efficiencies inherent in the inverted list file structures and Boolean set operations commonly employed. The prime advantages of the inverted file, Boolean logic design paradigm are speed and iterative search flexibility. These advantages, however, are invariably offset by limitations in query and document analysis and the restrictive nature of the user interface. The file inversion process inevitably results in a certain loss or increased ambiguity of meaning in searching document content, regardless of whether manual or automatic indexing procedures are utilized. Similarly, the Boolean coordination of search terms imposes semantic loss and a yes-no rigidity on matching queries to document titles, abstracts, full text or subject descriptors.*

Reflecting on the popularity of Boolean retrieval, Porter and Galpin remark, "This is unfortunate, since it has a number of inherent weaknesses" (1988). What is behind this prevalent anti-Boolean opinion which seems to pervade the IR research community? In a nutshell it is this: much research and experience with Boolean retrieval systems (including online catalogues) indicates clearly and repeatedly that Boolean search formulation syntax and retrieval techniques are not very effective in search performance and not very usable or efficient search methods for end users. The accumulating evidence clearly supports this summary critique of Boolean retrieval by Porter and Galpin (1988):

> *The number of documents retrieved is usually too large or too small, and a certain amount of juggling with terms is necessary to get a retrieved set of*

manageable size. Users frequently cannot compose boolean expressions, and require an expert to do it for them. The retrieved set of documents is usually not ranked in any way, so it is necessary to inspect the entire list in the search for relevance.

In their recent review of the literature on end-user searching of online bibliographic databases, Mischo and Lee (1987) report: "There is also much anecdotal evidence and observation showing that end users have particular difficulties with search strategy formulation and the use of Boolean logic." Mischo and Lee discovered that numerous authors tell of the significant difficulties end users are experiencing with the proper use of Boolean logic: "Several evaluation studies indicate that the use of Boolean operators is viewed as the most difficult aspect of retrieval" (1987). Apparently, the solution is not more and better training programs. (How do you force training on public library patrons and dial-up online catalogue users?) In one study reviewed by Mischo and Lee, the experimental end-user group was required to attend several training sessions and have their search strategy approved prior to searching online (BRS). The investigators found that end users had major problems with the choice of terminology, the use of Boolean operators, and search strategy modification. Even after this training and supervision, each subject who returned to attempt new searches needed to meet with expert search specialists beforehand to review system commands and Boolean logic. These findings have been corroborated by a number of similar studies.

In explaining their motives in designing an alternative, non-Boolean, natural language retrieval system for their users ("STATUS with IQ"), Pape and Jones (1988) refer to the "basic problem" with Boolean logic systems: "namely that high precision and high recall seem incompatible in this environment." And they go on: "There is also the important issue of allowing queries to be entered in natural language and saving users from the horrors of a typical Boolean based query syntax." Salton, et al (1983), describe the high recall/high precision compatibility problems in this way:

> *The basic problem in Boolean query formulation consists in first choosing an appropriate set of query terms, and in then using the Boolean operators to generate a formulation which is not so broad as to retrieve an unreasonable amount of extraneous matter thereby causing a loss in search precision, nor so narrow as to reject*

a large number of relevant items thereby causing a loss in search recall.

Noreault, et al (1977), the founders of SIRE, an experimental prototype bibliographic retrieval system developed at the University of Syracuse, focus their criticism of traditional Boolean retrieval on a major problem associated with the output (results) of Boolean systems. The problem is especially felt by users when their searches produce large results sets:

In a normal Boolean search output one expects a random distribution of relevant documents. That is, Boolean searching of a data base usually results in a list of references with no indication as to which of those documents are more likely to be relevant to the user's request. Ranked output [on the other hand] attempts to provide the user with information indicating that the closer a document is to the beginning of the output list, the more likely it is to be relevant to his query.

Automatic ranked output based on probable relevance requires the calculation of a similarity measure which does more than make a binary decision on whether there is any matching of terms between the query and the document.

A near-consensus exists among information retrieval theorists and investigators regarding the shortcomings of IR systems that rely solely on Boolean-logic query formulation and matching. Salton (1984) gives us the best overall summary of criticisms of Boolean retrieval systems voiced or shared by most researchers and experimenters in the information science community:

1. *The formulation of good Boolean queries is an art rather than a science; most untrained users are unable to generate effective query statements without assistance from trained searchers.*

2. *The standard Boolean retrieval methodology does not provide any direct control over the size of the output; some query statements may provide no output at all, whereas other statements provide an unmanageably large number of retrieved items.*

3. *The Boolean methodology does not provide a ranking of the*

retrieved items in any order of presumed usefulness, thus all retrieved items are presumed to be equally good, or equally poor, for the user.

4. *The Boolean system does not provide for the assignment of weights to the terms attached to documents or queries; thus each assigned term is assumed to be as important as each other assigned term, the only distinction actually made is between terms that are assigned (with an implied weight equal to 1), and terms that are not assigned (with an implied weight equal to 0).*

5. *The standard retrieval methodology may produce results which appear to be counter-intuitive:*

   a. *in response to an or-query (A or B or ... or Z) a record or document with only one query term is assumed to be as important as a document containing all query terms;*

   b. *in response to an and-query (A and B and ... and Z) a document containing all but one of the query terms is considered as useless as a document with no query term at all.*

Recent online catalogue design efforts have centered on making post-coordinate, exact match, Boolean logic, library retrieval systems easier to learn and easier to use than the commercial models used by trained intermediaries. However, too little attention has been given to the performance limitations of Boolean online catalogues, and no commercially available online catalogue uses any of the advanced post-Boolean retrieval methods which have been tested with some success in the retrieval labs by the probabilistic and fuzzy-set retrieval theorists.

The shortcomings of second-generation online catalogues and Boolean retrieval systems are now well known. There is no doubt that a vigorous dialogue between IR researchers and online catalogue designers could lead to improvements in online catalogues and other IR systems intended primarily for use by the "everyman" end user rather than trained search specialists. Much is to be gained by a sharing of their separate insights and theoretical or design advances.

2.4 Information Retrieval Research and the Probabilistic Model of Information Retrieval

Over the past fifteen to twenty years researchers in automated information retrieval have contributed a large body of experimental findings, theory, and published literature (See, for example, Van Risjbergen, 1979; Belkin and Vickery, 1985; Salton and McGill, 1983; Cleverdon, 1984; Bookstein, 1985; Gerrie, 1983; Belkin and Croft, 1987; Willett, 1988). There have been many advances in the field, and the work of the IR researchers has produced a great many successful experiments and enlightening results. The primary accomplishment of this group of researchers and scholars has been the transformation of traditional indexing and retrieval analysis, opinion, and design activities into an empirical science resting on sound theoretical bases. Major outcomes of this scientific work include: 1) the development of a deeper understanding of the inherent complexities in the information retrieval process and surrounding situation, 2) new theoretical models of the IR environment, models which have more explanatory and predictive power, 3) widely applicable evaluation methods and performance measures, and 4) tested, more effective retrieval techniques and more usable user-system interfaces.

2.4.1 The Information Retrieval Situation

Eastman (1988) provides a useful description of the information retrieval function and its constituent processes as understood by information scientists:

> *Although the information retrieval architecture has been used in a variety of contexts, the archetypical system is one designed to handle document retrieval. In response to user queries, the system retrieves documents relevant to those queries. So the queries correspond to problem instances, and the documents correspond to possible solutions. A common representation for both queries and documents is as sets of keywords, or index terms. A query is abstracted into a set of keywords to be used as search terms. It is then matched against document representations to choose documents that appear likely to be relevant. Most current commercial systems handle queries that are represented as Boolean*

combinations of keywords. A number of experimental systems are based upon alternative representations, including vector space representations, and use different matching algorithms.

Heuristic searching is almost always present, but may be shared in a variety of ways between the system and the searcher, who is frequently an intermediary between the user and the system. The search query may be expanded by considering broader terms (super classes), narrower terms (subclasses), or related terms (synonyms or siblings). This expansion may be done by using a thesaurus or by examining intermediate output. The search is generally performed interactively and modified on the basis of intermediate results. In commercial systems, the searcher is responsible for most of the heuristic searching. However, ways to handle it automatically are being investigated.

There is wide agreement among information scientists that the Boolean retrieval model is theoretically flawed because it does not reflect or account for all the inherent subtleties and complexities which comprise the real world information retrieval situation. Researchers have proposed alternative models of the IR function and situation which they believe more accurately identify critical aspects of the problem area under study. As Bookstein (1983) explains, "One of the most important functions of a model, mathematical or otherwise, is that it helps us focus our attention on features of a problem area that may have been overlooked when simpler models are considered. It gives us a way of thinking about the problem."

If theory is to lead to improvements in practice (i.e., IR system design and use), theoretical models must take into account both the simple and the complex characteristics of the activity being modeled. Much of the complexity of the IR situation can be attributed to the large degree of indeterminacy, uncertainty, and variability inherent to various levels of the whole domain (Bates, 1986).

Researchers have shown that the IR situation is loaded with variability at all sides and, as a result, uncertainty must be accepted as intrinsic to the retrieval process. From document description and subject analysis of texts to IR system design, efforts to improve matters must confront the inherently probabilistic nature of the entire retrieval environment.

Doszkocs (1986) describes the challenges facing IR researchers and system designers: "Investigators have been confronted with the variability of ways in which the same ideas and topics can be expressed by different authors, abstractors, indexers, and searchers, the inevitable limitations of the query-matching procedures and the contextual subjectivity of users' relevance judgements concerning retrieved items." Doszkocs characterizes the common goal of most IR researchers: "to transcend the limitations of the basic keyword/subject heading/inverted file/Boolean logic search paradigm characteristic of the mechanized systems of the 1960's and 1970's." In the process, "IR researchers have come to recognize the inherently uncertain and probabilistic nature of the information retrieval process."

Maron (1983) describes this situation in the following passage:

When a patron approaches a retrieval system seeking documents for some purpose, neither he nor the system knows for certain which ones will be relevant. That information simply does not exist. Whether or not any document will be judged relevant by that patron is a complex affair because relevance can be influenced by so many different factors ... because the presence or absence of properties of documents and properties of patrons can (and do) influence the probability that a document will be judged relevant, we see that the document retrieval problem can be approached probabilistically. What is needed is a retrieval system that can accept and combine "relevance clues" and then use them to compute for each document the probability that it would be judged relevant by the inquiring patron. The system then uses those computed probabilities of relevance to rank the documents and thus provide that patron with an optimal search strategy.

This probability ranking principle was also enunciated by Robertson (1977), who elucidated its solid theoretical grounding. In brief, the principle states that optimal performance is achieved by that retrieval system which ranks retrieved documents in decreasing order of their probability of relevance to the query which has been submitted.

Bookstein (1983) further clarifies the impact of this pervasive variability and uncertainty on the fundamental task of information retrieval, namely, how to decide, on the basis of a variety of imperfect indicators ("clues") of document relevance, which documents to retrieve and the order in which to display them. The task is seen as a problem amenable to statistical decision theory solutions:

> *Uncertainty seems to be a characteristic intrinsic to the information retrieval (IR) process. When retrieving a set of documents in response to a request, an Information Retrieval System (IRS) must somehow make decisions about document relevance on the basis of items of evidence, each of which only imperfectly indicates the appropriate action to take. A range of data is currently recognized as being valuable for this purpose; these include such variables as author's name and institution, journal, age of paper, cited or citing papers, and, of course, indicators of subject content. However, even in situations in which only some or even none of these data alone provide strong evidence, collectively they may produce a rather strong case for retrieving or not retrieving a document. The problem, then, is how to bring together a range of evidence to make a retrieval decision in the face of uncertainty.*

The challenge facing system designers is to exploit the science and technology of automated information retrieval to achieve the "best" retrieval for a given user query in an inherently imprecise and uncertain situation. Compounding the variabilities and complexities of subject cataloguing/indexing, file structure, and matching and retrieval algorithms, the user may not know or be able to adequately express his need, or may simply change his mind during the retrieval process about what he wants or is interested in. In addressing the topic, "What is intelligent information retrieval?", Croft acknowledges the many advances made in the field of information retrieval since the arrival of the computer, but points to several basic issues remaining to be resolved. "To put it simply, we do not know the best way of representing the content of text documents and the user's information needs so that they can be compared and the relevant documents retrieved" (1987). Croft points to the small but significant improvements to the retrieval process where statistical approaches to the analysis of text and collections of documents have been applied.

2.4.2 Information Retrieval as an Inference Process: From Matching to Relevance

Subject access researchers like Bates and Markey have identified the major shortcomings of systems which do no more than execute exact matches of phrases or queries expressed as Boolean combinations of keywords and retrieve documents that contain exactly the phrase or combination of keywords entered. Simply put, such systems do not go far enough. The aim of any retrieval process is to bring relevant documents to the searcher, arranged in some useful manner so that they can be assessed. Conventional retrieval system matching mechanisms which exploit the inverted file structures of their databases may be internally efficient, but they too often produce large, unordered results sets that turn users off and away. Few end-users display the desire or ability to use existing system query syntax to modify their queries to achieve better, more manageable results.

For these and related reasons researchers argue that information retrieval should be viewed as much more than an efficient, fast document matching and gathering operation. The IR situation requires that we view information retrieval as an iterative, truly interactive, inductive process, a process which engages the user throughout the process to gain relevance feedback that can be used by the system to correct its assumptions or to modify its automatically applied, heuristics-based matching and document ranking procedures. In other words, information retrieval, especially document retrieval, should be viewed as an interactive, cooperative process of mutually supportive inference.

Croft and Thompson (1987) draw a useful contrast between document or bibliographic retrieval systems and the database management systems now so popular in microcomputer software business applications. The retrieval facilities are similar, the authors point out, but document retrieval should not be viewed as a special case of data retrieval from such database systems. To do so "obscures the features of document retrieval that make it a challenging and difficult research area."

What are these unique and troublesome characteristics of the document retrieval situation which force upon us the informed view that this sort of information retrieval is a process of inference? Users have a wide range of both predictable and unpredictable information needs. Most bibliographic, document searching appears not to be for previously known, specific items. Only in a small proportion of searches are users able to provide a query that accurately expresses their information needs.

Croft and Thompson (1987) explain that there is a big difference between a database query such as:

> Find all employees with age >30 and salary <20000

and a bibliographic retrieval query such as:

> Find all documents about controlling inflation through monetary policy

Far from providing an exact specification of the desired citations, the bibliographic retrieval query provides "only an indication of the content of the desired document. The actual content of the documents identified as relevant by the user may vary considerably from the phrases provided in the query."(Croft and Thompson, 1987)

The aim of a bibliographic retrieval system is to retrieve documents likely to be relevant to a particular user's query, or, more precisely, documents relevant in the eyes of the user. Thus, relevance is a function of user assessment and cannot be established by the simple, mechanistic query-document matching procedures employed in conventional retrieval systems. We do not know enough about how and on what basis users make relevancy or utility judgments about retrieved bibliographic citations. Such reasoning activity may consist of a careful process of inference after examination of all the pertinent data in a citation. On the other hand it may consist of simple "flash" recognition, a drawing on a quick analogy to other known items, or just playing a hunch. The first case seems to be ruled out in present-day online catalogue subject searching: every study of transaction logs indicates online catalogue searchers seldom if ever look at a display of the full citation, which is the only way to find any explicit relevancy assessment data other than that contained in the title. The less subject data there is in the citation, the less likely a systematic process of inference will be undertaken to decide the matter. The user's knowledge of the subject field and any prior knowledge of the contents of the database would no doubt be significant variables in this assessment/selection activity.

An information retrieval system is effective to the degree that it supports and facilitates these document-relevancy assessment, selection or rejection activities. Since this human reasoning/recognition activity is not singular, one-dimensional, or usually predictable in a mechanistic way, it is unlikely a matching mechanism that does not interactively seek clues and rank its output will get the job done.

A number of methods have been tested for supporting this inference process, including automatic indexing techniques and retrieval techniques that employ statistical criteria and procedures. Statistical properties of text or terms in a database of citations are used to assign special values or weights to words, phrases, groups of related words, or clusters of citations. These techniques are in turn used in probabilistic or extended Boolean retrieval methods.

Willett (1988) describes the concept of "best match" or "nearest neighbor" searching:

> *A best match search matches the set of query stems against the sets of stems corresponding to each of the documents in the database, calculates a measure of similarity between the query and each document, and then sorts the documents into order of decreasing similarity with the query. ... The output from the search is a ranked list, in which those documents which the system judges to be most similar to the query are at the top of the list, and are thus displayed first to the user. Accordingly, if a sensible measure of similarity has been used, the first documents inspected will be those which have the greatest probability of being relevant to the query which has been submitted.*

A probabilistic retrieval system, simply understood, retrieves all documents that match a query in any degree, even if the match occurs on only one word or word root (stem), infers (computes) the probability of relevance of these documents to that specific query and ranks them accordingly. The ranking algorithm orders the set of retrieved documents according to their decreasing similarity to the query. The probability of relevance may be calculated from the frequencies of occurrence of query/index terms in the entire database and/or the retrieved documents, or on the basis of a variety of other query-document similarity measures. As an example of term weighting, a query term that occurs with very low frequency in the entire database but has a high occurrence count in particular documents would be considered to have special (high) value, and the documents it indexes would be considered to have a high probability of relevance.

Relevance feedback from the searcher is now considered essential to the effective performance of probabilistic retrieval systems. The searcher may explicitly change the values (system calculated weights) assigned to search terms or may respond to the first-listed, top-ranked documents. Relevance feedback may lead to a refinement or expansion of the user's query and "fuel" the system for even better performance (Robertson and Sparck Jones, 1976; Oddy, 1977; Harper, 1980; Hendry, et al, 1986).

Probabilistic retrieval with relevance feedback is especially useful and effective in searching bibliographic databases because the user, on his own, cannot possibly know or specify all the possible linkages, associations, and relevancy ties among documents in a large multidisciplinary database. Probabilistic retrieval techniques, automatic search heuristics, and relevance feedback can exploit pre-coordinated conceptual structures and statistical associations to improve retrieval in such a universe.

Croft and Thompson (1987) summarize the advantages of probabilistic, statistical retrieval techniques:

* They are efficient to implement,

* They are more effective in terms of finding relevant documents than searches based on Boolean queries/exact matching,

* They have a sound theoretical basis,

* They are independent of any particular domain. That is, different types of documents (journal articles, office memos) from different domains (medicine, law) can be handled using the same techniques. (1987. See also Bookstein, 1985, for a list of strengths and weaknesses of probabilistic retrieval)

Probabilistic, combinatoric, retrieval methods, and rule-based search strategy selection (if one retrieval strategy fails, automatically attempt another) can supplement the human tasks of relevancy assessment, inference, and selection better than Boolean methods, but neither can replace the human factor entirely. Human judgment is not only richer, it is the human who wants the documents or the information they contain. An intelligent retrieval system may never have the proper motivation to do a perfect job, that is, retrieve all relevant documents (assuming a comprehensive search is desired) and no non-relevant documents and rank order the retrieved documents according to degree of relevance. Croft and Thompson (1987) remind us that the other source of imperfection in any machine retrieval environment is the system's inability to achieve in its interpretation of a query anything more than a close approximation to the actual information need. He concludes that the two best ways to improve retrieval performance are "to enhance the inference process used by the system and to acquire better descriptions of the information need."

2.4.3 Summary of Contributions From Information Research and Experimentation

IR research has resulted in a significant gain in our knowledge of the information retrieval process and environment, more effective and feasible retrieval methods, and useful performance evaluation measures and methods. One of the strengths of the IR research tradition is the community's emphasis on testing and evaluation. New techniques and hunches have been put to the test, and have often produced negative results. Theories and new models are not accepted until there is a large body of confirming evidence. The two most common measures used to evaluate retrieval system effectiveness and performance are recall and precision. They are used to assess the results of specific retrieval operations. Recall is the proportion of relevant documents in the database retrieved; precision is the proportion of retrieved documents that are relevant.

These measures have been subject to some criticism that is often beside the point. Clearly there is an element of subjectivity in the relevancy judgments they measure. But once those judgments are made, recall and precision are quantitative measures that can be objectively applied in a given case. They are standard measures used to compare automated indexing techniques, retrieval methods, or systems in test or evaluation scenarios. They are not intended to replace or assume human judgment in real world retrieval environments. When applied consistently, especially to evaluate different retrieval strategies or methods in the same test document database, they are solid indicators of performance levels and they can support sound judgments regarding the relative effectiveness of one approach over another. They can also be used to measure incremental improvements resulting from refinements in a single technique or approach.

Doszkocs (1986) cites the following advanced information retrieval functions and features as being among the paramount achievements of the IR research and experimentation community: "the notion of accepting unrestricted natural-language user queries, flexible matching functions, ranking of retrieval output according to potential relevance to the query, and dynamic utilization of user feedback in automatic search strategy modification."

Some newer IR systems and online catalogues and demonstration prototypes have established the operational feasibility of implementing one or more of these functions and capabilities. Today's state-of-the-art computer technology provides means not available in the 1970s to implement intelligent retrieval systems. New distributed system architectures, processing equipment and configurations (including intelligent, microcomputer-based user workstations), and software languages and techniques are supporting the implementation of natural language query input and linguistic analysis of that input, graphic aids to browsing, closest-match, probabilistic retrieval methods (weighted term/logic and ranked output), and sophisticated user interface dialog/display techniques to engage the searcher intelligently for purposes of acquiring relevance feedback and search strategy modification.

2.5 A New Paradigm: Browsing as a Primary Search Strategy

The design principles and retrieval methods contributed by probabilistic retrieval theorists and researchers have successfully addressed many of the major limitations and documented problems of conventional information retrieval systems. When employed, these methods - weighted-term, best match searching, relevance feedback, and ranking of retrieved documents - generally lead to significantly better search performance than that obtainable with exact match, Boolean retrieval techniques. By not requiring their use, probabilistic retrieval resolves the problems users have with understanding and correctly using Boolean logic operators. Document ranking largely solves the problem of coping with large retrieval sets, the problem Maron calls "output overload." This problem occurs when the patron is "swamped by records which match his query. ... Simply narrowing his query by use of the logical AND causes serious deterioration of recall" (1983). Online catalogue research shows that most users say they do not wish to look at more than 15 records in a large unranked results set. In their study of user persistence in scanning displays of search results, Wiberley, et al, analyzed data from transaction logs and learned that many searchers will persist in looking beyond 15 records, but that "Users' persistence falls off significantly when the number of postings retrieved exceeds 30" (1990). Furthermore, when searches retrieve more than 30 records, a majority of users display and look at no records at all. Document ranking addresses this problem by placing the documents most likely to be relevant at the top of the output list.

Other subject searches fail when nothing is retrieved. In large, heterogeneous online catalogue databases, expanded or not, it cannot be assumed that there is nothing in the database that might be relevant to the user's information need or interest. It is theoretically possible, of course, that this case could occur; that is, there simply is not any information or material represented in the database potentially relevant to the user's request. However, this should not be an operational assumption, primarily because the user may want the opportunity, *interactively*, to refine or change his subject query. The relaxation of "exact" matching in probabilistic retrieval techniques greatly reduces the number of subject searches that result in no items retrieved. Searchers are almost always provided some retrieved items to assess and to which they may respond. This makes relevance feedback, the process of obtaining relevance information from the user and using it in a further search, possible in almost all searches. IR researchers have come to accept the view that relevance feedback from real searchers is a major factor in improving the performance of retrieval systems. Relevance feedback techniques can provide the system useful information not contained in, nor derivable from, the original query, or not available at all from a user who begins to search and browse without a specific, clear expression of his information need. To reiterate, Croft and Thompson (1987) state that one key way to improve retrieval performance is to obtain better descriptions of the user's information need.

Another line of criticism directed at both conventional and probabilistic retrieval models has to do with their lack of expressive power in representing the wide variety of actual retrieval situations, search aims and behaviours. The probabilistic model is thought to be more expressive than the traditional model because it recognizes, explains, and incorporates the element of uncertainty intrinsic to the retrieval process. But that process is assumed by both models to be an essentially query-based process. Neither model adequately takes into account information seeking that is not query-based or centered, for example, many kinds of browsing. It will not do to extend the meaning of "query" to include all information seeking behaviour, then say that the model represents them all. This would simply blur important distinctions found in actual information seeking behaviour. The probabilistic model has helped us better understand and cope with a common retrieval situation and a related set of search aims and activities. With its assumptions about unchanging information needs and the query-centeredness of all information seeking, the probabilistic model is not able to represent the majority of actual retrieval situations and information seeking activities of people.

2.5.1 New Models of Information Seeking

Unfortunately, most present-day operational and experimental retrieval systems, including most online catalogues and CD-ROMs, reflect in their design and operation a partial, inadequate conceptual model of information retrieval activity. This model describes the exact or best-match, output-oriented approach of most IR systems. The model assumes the presence of a known, specifiable information need (or subject topic) to start with. Materials that are relevant to that need or topic are represented by index terms such as keywords or subject descriptors, and the need is represented in a well-specified query. These representations are then "best-matched" by the retrieval system (set in motion by the search specialist) to produce the best output set of retrieved materials or information.

This "known-subject need, best-match, end product-oriented" information retrieval paradigm accounts for only part of the subject searching story. It is conceptually inadequate for explaining a variety of information seeking situations or for describing different actual subject searching behaviors. For these reasons, a number of researchers, among them Cochrane, Bates, Belkin, Hjerppe, Oddy, Marcus, Markey, Tague, Hancock-Beaulieu, Marchionini, Cox, and Cove and Walsh have proposed other retrieval paradigms or conceptual models equally well-suited to guide the design of information retrieval systems. Bates (1986a) has proposed the "exploratory paradigm" to describe unfocused information seeking and other forms of browsing. The insight and assumption shared by these researchers is that browsing, a complex activity in itself, is a primary, frequent or preferred mode of subject searching for many individuals (Hildreth, 1982).

Bates (1989) thinks the classic, traditional model of information retrieval should no longer occupy center-stage in our thinking about retrieval problems, and improving retrieval performance and system design: "It represents some searches, but not all, perhaps not even the majority, and that with respect to those it does represent, it frequently does so inadequately." As an alternative Bates proposes the "berrypicking" model of searching, a model she states is much closer to the actual behaviour of information searchers than the "classic" model.

The strength and soundness of Bates' interpretation derives from the fact that she bases it on a consideration of a variety of information seeking activities in which different sources, tools, and retrieval systems, both manual and automated, are used. Close examination of "real life searches" and the literature on the information seeking behaviour of scholars, scientists, and other end-users leads to the realization that a frequent, common pattern of searching can be characterized by the berrypicking/evolving search model she describes:

> *In real life searches in manual sources, end users may begin with just one feature of a broader topic, or just one relevant reference, and move through a variety of sources. Each new piece of information they encounter gives them new ideas and directions to follow and, consequently, a new conception of the query. At each stage they are not just modifying the search terms used in order to get a better match for a single query. Rather the query itself (as well as the search terms used) is continually shifting, in part or whole. This type of search is here called an evolving search.*
>
> *Furthermore, at each stage, with each different conception of the query, the user may identify useful information and references. In other words, the query is satisfied not by a single final retrieved set, but by a series of selections of individual references and bits of information at each stage of the ever-modifying search. A bit-at-a-time retrieval of this sort is here called berrypicking* (Bates, 1989).

Users employ a number of strategies and techniques when searching in this way, among them various kinds of browsing, in both manual and online sources, as well as at the bookshelves. In fact, a searcher may choose to conduct a formal query/best match search in an online bibliographic database as one step in the evolving, berrypicking process: "It is part of the nature of berrypicking that people adapt the strategy to the particular need at the moment; as the need shifts in part or whole, the strategy often shifts as well - at least for effective searchers" (Bates, 1989). In an evolving/berrypicking search, the search techniques typically change throughout the search (and may or may not include traditional information retrieval techniques), and the sources consulted may include many different in form or content.

Peters (1991) points out that in most information retrieval research, the basic unit of a search or a "search session" is defined very narrowly for purposes of measurement. The search unit may range from a single query input to the system and the system's output, to the period from the time the user approaches the system's search entry device to the moment the user departs this device. End users view the situation quite differently:

> *The user, however, usually is visualizing the search session in much broader terms - probably most often in terms that extend far beyond the online catalog. Users often are thinking in terms of a large project, and use of a library's online catalog is just one small phase in the project."*

A model having the expressive power to represent this variety of strategies, techniques, and sources will better guide our thinking about desirable design features for information retrieval systems. In her eloquent plea for alternative design models that reflect the demonstrated need for a variety of searching capabilities to match various information-seeking needs and users' search objectives, Pejtersen states that "design [of future online catalogues] is to be based on the concept of an adequate 'resource envelope' around the search space instead of support of a particular normative procedure for retrieval interactions" (1992).

Bates concludes her case for an alternative design model with these words:

> *This model of searching differs from the traditional one not only in that it reflects evolving, berrypicking searches, but also searches in a much wider variety of sources, and using a much wider variety of search techniques than has been typically represented in information retrieval models to date. With this broader picture of information retrieval in mind, many new design possibilities open up* (Bates, 1989)

For these reasons, I think we must recognize that information retrieval theory and methods developed over the past twenty years will play an important but limited role in advancing online catalogue development into the third generation of systems. There are at least two reasons for this. First, the extended-Boolean, vector-space, probabilistic, and fuzzy-set retrieval models tested in artificial laboratory conditions (generally excluding the human variable) have led to significant but not large improvements in system performance (using recall and precision measures), and as Salton and others have recently concluded, these advanced retrieval models "may be too complex for practical use" (1986). Secondly, the information retrieval paradigm assumed in most IR research, even when embellished with relevance feedback methods, may be the wrong model for representing the information seeking and search process situation and behaviour of both scholars and general library and information system users.

The information system requirements of online catalogue and IR system end-users differ considerably from those of trained search intermediaries. The behavior of trained search specialists is product/output-oriented. Their aim usually is to produce a high quality list of citations or other references for the end user. The "quality" of the output product is measured by such variables as recall, precision, and search efficiency (minimizing the costs to the user of the retrieval process). The search topic or need is usually well-understood (a "known-subject") and well-expressed in advance of the search, and the search is typically processed in a highly-structured, subject-specific domain.

2.5.1.1 As We Often Seek

The search situation is fundamentally different in the case of scholars and many others who use online catalogues for their own purposes. These searchers, an expanding heterogeneous community, have a variety of information-seeking needs and behaviors. Furthermore, the document collections available to them for online searching are multi-disciplinary in coverage and, at present, are poorly structured and indexed. Evidence indicates that the *process* of searching and discovery is more central to end-user searching objectives and satisfaction than the delivery of any pre-defined product. Most end users are not going after a specific "known item", nor do they have a well-defined output product in mind at the outset of their interaction with the online system. Researchers may wish to branch out into new disciplines or unfamiliar approaches to a problem. Typically, end users wish to discover materials on a topic of interest, and they seldom have or wish to present a precise expression of that interest. Both the expression of the topical interest and the interest itself may change dynamically during the search and browsing activity.

At the beginning of the age of mechanized storage and retrieval, Vannevar Bush (1945) criticized the prevailing linear, rule-constrained retrieval ("selection") paradigm described by the conventional model of retrieval:

> *When data of any sort are placed in storage, they are filed alphabetically or numerically, and information is found (when it is) by tracing it down from subclass to subclass. It can be in only one place, unless duplicates are used; one has to have rules as to which path will locate it, and the rules are cumbersome. Having found one item, moreover, one has to emerge from the system and re-enter on a new path.*
>
> *The human mind does not work that way. It operates by association. With one item in its grasp, it snaps instantly to the next that is suggested by the association of thoughts, in accordance with some intricate web of trails carried by the cells of the brain.*

As a solution, Bush proposed his legendary Memex personal storage and retrieval system, perhaps the first hypertext system envisioned.

Unlike the linear, highly structured, logical search strategy approach pursued by the efficient search intermediary (human or machine), much end-user searching can best be described as exploratory, circuitous, and, yes, fully interactive. The search process is likely to be largely a trial-and-error process, having no particular pre-determined end or outcome. In trial-and-error exploratory searching, both the experience of the search process and its initial results can lead the user to new or altered information needs and may lead to additional materials or information of value.

Miller and Tegler correctly point out that the "traditional methods of evaluating information searches -- recall and precision -- have completely overlooked this generative, creative aspect of a search. By evaluating the product and not the process, recall and precision limit our understanding of information searches and fail to measure them effectively" (1986).

While it is clear that measures other than recall and precision are needed to evaluate the performance and effectiveness of interactive, end-user retrieval systems (e.g., measures of usability, browsing effectiveness, and exploratory power, etc.), recall and precision have been the measures of "success" most often applied in evaluations of new indexing or retrieval approaches tested in information retrieval experiments. The aim of much of this research has been to develop automatic retrieval methods that, given a particular document collection and a specific query (an expressed information need), would increase either the recall or precision value of the document set retrieved. This approach is of limited value in the online catalogue/IR end-user searching situation where "illogically relevant" information encountered during the search process may be more valuable to the searcher than logically relevant materials (Harter, 1984).

2.5.2 Conclusion: Information Seeking, Retrieval Systems and Browsing

Information retrieval research has pursued two directions in recent years in looking for solutions to problems presented by conventional Boolean IR systems. Two schools of thought can be delineated. The first school I prefer to call the "automatic" school. It has a strong grounding in statistical decision theory and probability theory. This school relies heavily on statistics-based computational or algorithmic approaches which, when they are implemented in retrieval system software, are largely invisible to the searcher. The work of these scientists is reviewed by Bookstein (1985) and Belkin and Croft (1987).

The second school of investigation I call the "interactive" school. The approach of this group relies heavily on constructive, on-going interaction with the system user to find means of improving both search results and the search process. Major theorists of this school include Belkin, Oddy, and Brooks (1982), Doszkocs (1983), and Marcus (1986).

The work of the "interactive" school of IR investigators holds more promise for the improvement of online and CD-ROM catalogues. This school's understanding of the nature of end-user searching and its associated problems in uncontrolled environments, and the need to constantly engage the user in the search process, more closely reflects the reality of many online catalogue use situations.

Some of the automatic retrieval aids tested by the first school (e.g., stemming routines, term weighting, relevance feedback mechanisms, query expansion, document ranking) may prove to be useful in a supporting role, but I agree with Marcus' assumption that in most end-user searching it is "vital to bring human intelligence into play in an interactive, mixed initiative environment and that the human input is best induced when the human can easily perceive the nature of the (system's) matching algorithm" (1986). Moreover, the user should not be viewed merely as the best judge of good query interpretations and processing by the system (i.e., the source of relevance feedback), but as one who enjoys engaging the system and who can be both creative and productive in using it, whatever the searching and browsing aims may be or become.

Online library catalogues and their users may indeed be viewed as "messy" or, at best, "fuzzy" indeterminate variables which present numerous problems for researchers and system designers. Yet, if progress is to be made, these variables must be understood as they exist in all their varieties . We need better descriptions of user search behaviour in a variety of online catalogue environments, and we need a more complete typology of search tasks and objectives from the perspective of the user. What do they do and why do they do it? What would they like to do if they had more flexible search and browse systems? With answers to these questions, we can more productively manipulate other variables (such as database structure, retrieval methods, and dialogue styles and techniques) in experiments aimed at improving the overall search and discovery process.

Chapter 3

Methodology, Part I: Design and Development of Experimental Online Catalogue

3.1 Chapter Overview

The online catalogue research study described and discussed in this thesis had two major purposes associated with the development and evaluation of particular browse and navigation subject searching features in an online catalogue. The first was to design and develop a prototype experimental online catalogue with these subject searching features, and the second was to test and evaluate these features using real human searchers. This chapter discusses the first of these, namely, the design and implementation of the experimental online catalogue used in the tests. After a general discussion of the design rationale which guided this implementation, key system design decisions are discussed, and the system is described in full. User-system interaction, search and browse options tested, and system displays are illustrated.

3.2 A Design Rationale for Browsing Systems: Alternative Viewpoints

There are a variety of information seeking needs, aims, and strategies that would seem to require searching by semi-directed exploration, recognition, and discovery, in a word browsing, rather than searching by explicit query formulation-matching operations, whether aided or not by relevance feedback, query expansion techniques. Thus, it seems self-evident that users would greatly benefit from the development of computer-based information systems that support and encourage searching and exploration of electronic information resources via browsing or "berrypicking." Interested researchers and system designers might reasonably ask, "What sort of information system would this be?" or, "What are its essential design features?" These questions may be expressed as a formal request for principles or guidelines for the design of browsable information systems.

Models, in whatever language or form they are described, serve a number of useful functions. They help us better understand a phenomenon of interest which may be under investigation or evaluation, and, if they are well-grounded, they can inform our thinking about innovative design features and underpin recommendations or tentative guidelines for the design of improved information retrieval systems.

The broadened perspective on information seeking behaviour promoted in the preceding chapter, and specifically, a deeper understanding of the needs, motivation, and behaviour of individuals who engage in browsing activities, has led some researchers and system designers to 1) propose - put forward - general strategies or frameworks for the design of browsable information retrieval systems, and others to 2) put forward lists of specific enhancements to be made to operational information retrieval systems. The second approach may be characterized as piecemeal, incremental, and inductive. This is the approach taken by Ellis (1989), Hancock-Beaulieu (1989), and Bates (1989). The first approach is more theoretical, top-down, and, by contrast, largely deductive. This more systematic approach attempts to discover general insights or principles, or broad guidelines for the design of browsable information systems from an analysis of the cognitive, motivational, and behavioural aspects of information seeking by browsing.

The deductionists typically begin with a statement of "first principles" or general observations about what <u>any</u> browser system should do, then proceed to intellectually derive the major design features or parameters of such a system. These features may target database design, retrieval techniques, user interface design, or all three of these areas. A review of the sparse literature on browsing systems suggests that the deductionists may be further grouped into those who define a general framework for system design or prescribe the principle features a system should have (Marchionini, 1987; Cove and Walsh, 1988), and those who describe a prototype browser system (Cox, 1992; Noerr and Bivins-Noerr, 1985; Fox and Palay, 1980).

In a formal study, Ellis (1989) investigated the information seeking activities of a group of social scientists, because, as he states, "there appeared to be no study which attempted to systematically derive recommendations for information retrieval system design from analysis of actual information-seeking behaviour." From an analysis of the information-seeking patterns of these social scientists manifest in their use of a variety of information resources, Ellis derives a behavioural model that he believes can "underpin recommendations for information retrieval system design."

Ellis (1989) identifies six major categories of characteristic patterns of information-seeking behaviour:

1. Starting: initial search activities
2. Chaining: following citation chains or other referential connections
3. Browsing: semi-directed searching in an area of potential interest
4. Differentiating: using differences between sources as a quality filter
5. Monitoring: current awareness monitoring of selected sources
6. Extracting: systematically reviewing a source to identify information

Each of these behavioural patterns ("features of the model") are then discussed in detail by Ellis to derive, as he says, "a set of general recommendations for information retrieval system design and to consider the issues involved in implementing the features of the behavioural model on an experimental system." (1989) Ellis suggests that a hypertext retrieval system would be needed to support the wide variety of searching activities carried-out by scholars and scientists.

As we have seen, Bates believes her inductively-arrived-at berrypicking model can serve to inform our thinking about key design features for IR systems (1989). She identifies six search strategies or techniques that information seekers commonly employ in a variety of sources, and, for each of them, suggests a specific equivalent or comparable capability that should be implemented in an online berrypicking search interface. Emphasizing the need for variety and flexibility at the search interface, Bates makes a plea for the adoption of new techniques that do not reflect narrow, rigid assumptions about users' search aims and search styles.

One danger lurking in the behavioural, inductive approach to IR system design is the very real possibility that one or more of the methods customarily used by actual information seekers may be inefficient or only partially effective. Other methods in use may simply have become outdated. The card catalogue is an example of the latter case. In recent years, online catalogue design has broken free of the limits of that outdated model. Actual bookshelf browsing in libraries is a common information-seeking strategy, and it is a strategy that holds the potential for great improvement in the online environment. Reasoned analysis must follow-on the collection of behavioural data, "to assess which aspects of user behaviour could provide feedback to the future design of online interactive catalogues" (Hancock-Beaulieu, 1989).

Cove and Walsh (1988) review the literature on browsing to support their analysis of the nature and types of browsing. This analysis then provides the basis for their thinking about the design of an intelligent browsing computer system. Contrasting it with conventional IR systems, the authors make a number of general observations about what any browser system should do for the user:

> *Browsing should give a priori details about the information under investigation. The ultimate aim of work in this area is to develop an intelligent system that will complement and enhance human browsing but will not replace it. An intelligent system will be able to route to the user some of the difficult problems. This is not an undesirable feature, for a browsing system is a tool, leaving the user to think about and understand the material being processed. Browser systems should not develop to mimic some of a human browser's functions. Their intelligent function is that of setting out the material to be browsed over in an easily accessible form. This includes preparation of the material and guidance during browsing.*

Based on reflection and personal insight (e.g., "Browsing is essentially visual and, therefore, has a strong 'direct access' feature"), Cove and Walsh propose three principal design features that are required for effective browsing online: structure, semantics, and navigation. When considered in detail, these broad features lead to specific browser functionality that has been incorporated in a prototype system developed by the authors for the purposes of testing and evaluation.

One finding to date is that users will employ different browsing strategies, with these differences determined by such factors as the aim of the search task and the nature of the source being examined. The authors call for more research on database or document structure-revealing aids, and navigational aids for assisting users in moving within and among information sources presented online.

Marchionini (1987) presents a "framework" for the design of browsable information systems which he states is based on his research with novice users of electronic encyclopedias. Marchionini reports that these users generally performed in a satisfactory manner, but the research revealed difficulties encountered by the searchers, including disorientation, distraction, and cognitive overload. He outlines the requirements for improved electronic browser systems, "systems that invite and guide browsing," consistent with his research findings.

Marchionini suggests the design framework for browsable information systems includes these five interdependent factors:

STRUCTURAL	- information units (nodes)
	- relational links between nodes
FUNCTIONAL	- display - navigation - help/learning

Marchionini notes that electronic documents provide few physical cues when displayed, and that the user can benefit from specialized structural or organizational schemes suited to this medium. The author seems to envisage a network-type database of linked nodes, but does not draw a specific representation of a particular organizational scheme. He recommends that the system support both 'coarse' (i.e., broad) information unit nodes and 'finer' nodes to enable the user to focus in on specific information or concepts. A useful suggestion is that of node 'filters'. Broad topics that are linked to large amounts of information could be trimmed and focused through the use of topic-class filters. Marchionini suggests that users could apply such filters optionally to focus their browsing in wide information or document spaces.

Links express the relationships between information unit nodes. Links have both conceptual and physical aspects. They define a relationship between information nodes, and they also impose a physical order on the nodes in the database and thereby enable users to actually navigate among the nodes. If the links have been "activated", the user may traverse them at will, seeking to discover new or related items of interest. The nature of the relationship between nodes (e.g., "is cited by," "is on the related topic") is typically expressed in a particular kind of linkage. It is a challenge for designers to present the meanings of these links in a way easy for a user to grasp and exploit.

Moving through the links, links perhaps best thought of as various kinds of pre-built pathways, enables a user to browse and navigate through an information source to find and display related information. Navigation consists of the ability to traverse the meaningful links or pathways that have been established between particular information nodes (also called information units or entities) by the database designer(s). Thus, navigation can be seen as both a physical, mechanical activity, and as a cognitive, intellectual activity. Examples of mechanical aids include menu-locator or selection devices, on-screen pointers, and "hot" action activator buttons.

Designers are especially challenged to uniquely represent each of a variety of pre-established conceptual linkages and present each to the user as an intuitively meaningful pathway that might be navigated as the user's need, problem, or interest dictates. Marchionini (1987) recommends that navigation for browsing capabilities include support for moving backward and forward (or up and down) between coarse and fine nodes (e.g., broader and narrower term relationships in a thesaurus), and an ample amount of displayed prompts and feedback so that, "In any given state, the user must know what is possible as a next move and what she/he did to arrive in the current state."

In his paper, "Information retrieval by browsing," Cox (1992) describes a prototype browsing system under development. His description of the system includes the data structures required, the user interface, and search operations performed for or by the user. Like other researchers, Cox initially defines his browse system in terms of what it is <u>not</u>, namely, a conventional query-formulation/evaluation, matching-operation IR system. Rather, "In this paper, traditional queries are never formulated in the machine and it is suggested they are unnecessary for efficient information retrieval." Instead, states Cox,

> *When browsing the user never expresses his or her query explicitly, but looks through the database to find items of interest. When an item is seen then it is selected. The system only provides appropriate support to the user for this browsing activity. ... The information retrieval system gives the user a set of tools with which to investigate the database. Its primary function is to allow the user to see and understand the data and to browse more efficiently.*

According to Cox, the user best searches through browsing, recognition and discovery, rather than by a formal process of explicit query formulation, entry and modification. He recognizes that this search approach requires careful structuring of the database and requires the user to understand this structure to browse effectively. Cox does not entirely rule out a role for traditional query-document matching techniques, but states that, "the mechanism for the system to formulate and evaluate queries is a peripheral activity to the browsing and user discovery. It can be done as a way to support such activities." Such techniques as Boolean searches and query expansion methods are not excluded from the interface, but, under the user's control, would play a supporting role to the "main structure of the interface."

Searching by recognition and discovery in a well-structured space is only the first stage of browsing in Cox's system. When an item of interest has been recognized, then the user should be presented an array of similarity operations that might be performed by the system to find those items similar or closely related to the item already found. Viewing information retrieval primarily as a gathering function, Cox points out that the user only has to know what each type of similarity means to the system that effects it, and then to choose one appropriate to his need at the moment. The user's ability to choose from among several similarity measures, clustering or classing criteria that may be used in the gathering function is key to Cox's approach: "Any system would implement appropriate similarity measures according to the user's browsing needs."

Cox believes it is easier for users to learn types of relatedness or similarity between items, many of which can be carried across databases, than to learn a complex query logic, syntax and language for each information system or database encountered. Searching is more readily accomplished through browsing, scanning, recognizing, selecting (items of interest), then choosing and invoking a similarity operation that will identify and retrieve additional related items for display and further assessment. Providing users several similarity or related-item gathering operations from which to choose would appear to be something novel in end-user system design. Recent research that shows different search strategies or techniques may perform comparably in terms of recall while retrieving different sets of documents would seem to lend some support to this design approach (Croft, 1981 and 1987).

Hypertext as a concept is burdened by its current popularity and overuse. If it means non-linear composition or reading of text, or the non-linear conveyance of information through text and other graphic means, then the phenomenon has been in existence much longer than the popular term. To the casual reader the notion of "non-linear" which invariably shows up in definitions of hypertext or hypermedia may convey a sense of freedom to move about text or other media in unparalleled, unrestricted and flexible ways. Being pointed and permitted to proceed only in a single, straight-line direction as we read, peruse or search in informational materials is thought to be the constrained situation from which the hypertext approach frees us.

Is hypertext with its non-linear dimension something fundamentally new or an old idea applied in new ways with the aid of new technologies? Traditional printed works are thought by some to be pre-hypertext informational materials. Though most printed works display a front-to-end or top-down structure, they may be viewed or read in a non-linear manner, however eccentric this may seem. The organization of the printed work may indeed encourage a linear approach on the part of the reader, and this may well have been intended by the author of the work. But the work's organization, signposts, and auxiliary material (e.g., indexes, tables, illustrations, citations, etc.) may actually support a variety of ways of approaching and moving about the work. Rather than an alternative to traditional textual presentation, hypertext may best be viewed as a matter of degree and purpose in the presentation of text and other informational materials to be intelligently "handled", that is, viewed, read, searched, browsed, assessed, etc.

Conventional automated information retrieval systems are typically more "linear," restrictive and deterministic than printed information sources. Early IR systems and online catalogues allowed little or no flexibility in searching and browsing once the user had "entered" and begun using the system. The search interface permitted only one or two search strategies to be carried-out in a precise, pre-determined step-by-step manner. Not only tree-structured searching but also the post-coordinate searching was designed to be performed in an inflexible, pre-defined manner: enter query, review results set, limit results set, modify query, or start a new search, and so on. With minor variations, these continue to be the basic search steps the user is forced or encouraged to follow in the prescribed "routine" manner. No wonder then that some online catalogue users complain that they have less freedom to browse about than they did in the card catalogue.

Conventional IR systems provide little flexibility in searching or browsing at will in the information databases they contain. Those that do generally exact a large cost in learning time and effort from the user. But as a look back to earlier information systems should suggest, characteristic factors such as structure, organization and other reading or access devices are not the limiting, restricting factors. There are few options available at the conventional computer system search interface because the designers have put few there. Lack of interface flexibility and search options is imposed neither by today's technology nor by highly-structured databases. In fact, organization, structure, pre-established linkages between information entities or nodes and navigational search methods are the means by which system designers can provide retrieval systems that offer users not only a variety of search options but also increased flexibility in the way they may wish to browse and move about the information source. Hypertext is one way of characterizing this increased, "non-linear" flexibility.

Noerr and Bivins-Noerr (1985) have addressed the challenge of providing new search and flexible browsing capabilities in IR systems at the level of database design. They describe an unconventional "entity-relational" database design for information retrieval systems that supports new forms of browse searching and navigation among related items in the information database. The authors view these new forms of searching as complementing existing keyword, Boolean search strategies.

Browsing or scanning ordered lists of informational items or records is not new, of course, but the Noerr database design permits the easy typing and sequencing of any number of such lists as deemed necessary by the database designer to support varied and highly targeted browse searching in lists of items. In addition, the database design, or rather, its data modeling and mapping support features, permit the designer to define desired relationships between information entities or nodes in the database and to establish links between these entities or nodes that enable the user to navigate between items and from node to node in the database in search of related information.

This unique database design has been described as "entity-relational" and "multi-linked." At a minimum, any database design describes a way of identifying its constituent elements (e.g., files, records, key fields, etc.) and how they are organized for one or more data management purposes like storage, updating or access. The Noerr database design (actually a meta-design facility, since a database "owner" may design a specific database and how it is to be accessed and navigated) provides powerful data modeling and search definition facilities. In the multi-linked database, each record represents an information entity which may have associated attributes or properties. These items, entity descriptions and their properties are contained in the fields of the record. Thus records contain data fields as identified and typed by the designer, but also contain link-to fields. Records of the same type or different types are linked by placing the prime key of the "linked-to" record in a linking field. This underlying linking mechanism supports navigation from record to record and is as "flexible" as the specific database designer wants it to be and builds links to support. All individual records of the same type are sequenced within the set of those records by their prime key, for example, author's name, or class mark.

The application designer, consider the online catalogue, for example, has great freedom and flexibility in modeling the catalogue database, from defining the basic types of records, to defining search path access, browsing lists, and the links between records and record types that support navigation at the user interface. The cost of this flexibility is the intellectual effort and planning required to create an online catalogue from the ground up, so to speak. Since bibliographic records may be uniquely identified and typed at the time of database design and construction, with each type to be considered as an independent entity to be linked or not linked to other entities, the catalogue designer need not accept the standard "full" catalogue record as the basic information unit to be stored in the database, a unit to be indexed by special-purpose partial or subordinate data entities. To the contrary, any particular part of the catalogue record, for example, author's name, publisher, subject descriptor, etc., may be selected as an independent entity or record type to be included in the database, and any record item may be considered an index to any other items to which it is linked.

At the user interface, this database design allows some non-traditional ways of searching. In addition to the browse scanning of alphabetical or otherwise ordered lists of item keys (e.g., title keywords, names, subject descriptors, class marks, etc.) not uncommon in today's online catalogues, it is possible to provide the user with a pre-structured,multi-level, "tree" searches that require only the same simple search mechanics as scrolling/scanning lists and selecting of the desired item from a displayed list. For example, a browse tree search could be pre-defined by this structure and sequence: subject; language of publication; title. This would permit the user to select a subject entry from a displayed list, and then select the language of the titles indexed by that subject descriptor to be retrieved for display and assessment/selection. The number and depth of tree searches that can be provided is limited only by the number of unique record sets that have been identified by the designer at the initial data modeling stage. Any available data from these records can be pre-coordinated to produce the tree to be searched, and any number of trees can be created, all converging on the same citations if this is desired.

The tree searching made possible by the Noerr database system is in reality pre-coordinated searching that requires only browse-select operations on the part of the user. As Noerr and Bivins-Noerr explain, "The levels of search allow the refinement of producing a final result set without explicit combining, as the combination is performed by the tree structure. Thus, a single method browse-select enables extremely complex combined searches, so long as they are pre-defined" (1985). As these pre-structured levels are traversed by the user, a filtering or sifting takes place, narrowing the outcome possibilities, and at each level a more focused context is set for subsequent search selections. While the catalogue designer has great flexibility in selecting and structuring these search trees, once they are built-in and made operational they impose restrictions on the search options and search paths available to the user. Little research has been done on the optimal number of either search trees or levels of search trees for a given database access system such as an online library catalogue.

In the pre-structured tree search user actions consisted of a series of browse-select operations, each select being limited to the set of items created by a select at the former level. Freedom from this structure is made possible by the Noerr database system's multi-linking capability. Any number of pre-defined links between records in the database can be established to allow navigation along these linked pathways from record-to-record by the user.

Navigational links between record types established at the time of the design of a specific database access application provide flexible and optional search paths for the user. Used together with browse-select searching each "link to" or navigation path selected by the user will lead to a new set of records to browse or select from or to use as the "jumping-off" link to another set of records. This allows long paths to be traversed, and, if the design includes many linked-to record types, provides the user great flexibility in deciding the "related-record" search paths to pursue. It should be noted that the use of the navigation feature is not tied to or dependent on the browse-select method of searching the database. Regardless of how the searcher arrives at a record that has been linked to others, including the retrieval of that record by the use of Boolean techniques, the navigation option -

moving on directly from that record to related records - may then be chosen by the searcher.

The mechanics of browsing and navigating in this manner are extremely simple and easy to learn and to use. They require only list-scrolling, pointing, and selecting devices and skills on the part of the user, as will be illustrated in the next chapter. However, as with all "hypertext" database applications, "Systems like this need specially structured databases and a degree of forethought on the part of the designers of the catalogues" (Noerr and Bivins-Noerr, 1985). This is something of an understatement because great care must be exercised during the planning and modeling stages to ensure that the needed and desired search, browse, and navigation functionality is available to a variety of searchers who will bring different search needs and tasks to the retrieval system.

3.3 Experimental Online Catalogue Design Aims and Objectives

The primary design aim of this project was to develop an operational online catalogue retrieval system that could serve as a flexible experimental tool and demonstration system, a system complete in itself and capable of supporting a variety of subject browsing, navigation, and bibliographic display options. It was hoped that the system could serve as a vehicle or "testbed" for a variety of experiments that would address not only the research questions posed in this study, but others as well. To achieve the "demonstration" aim, it would be necessary to build a system that could easily be moved out of the "laboratory", so to speak, and set up in places like the classroom or lecture hall for real-time use and illustration.

Thus, such a system had to contain a rich set of search and display features, and be easily modified to present different test online catalogues to users, such modifications being under the control of the researchers and not requiring further software development. Corollary design objectives included a large degree of researcher autonomy and control over the design, maintenance, and use of the system, and system portability. In short, it was desired to design a system that would give the researcher the ability to define several different online catalogues and select any one at will, to carry out tests and demonstrations in a variety of locations.

Key options in this online catalogue definition or customization process were to include test database content, search indexes, search trees or pathways.

active record-to-record navigation links, and displays of bibliographic information. Thus, it was desired that not only the original design and development of the system be under control of the researcher, but also the particular selectable and testable search/browse functionality and user interface features, such as search assistance prompts and citation display formats.

Much online catalogue and information retrieval system research and experimentation has not benefited from such freedom and flexibility in system design, manipulation and testing, what would be, in short, considerable researcher autonomy and control over most experimental variables. Generally, researchers have had to conduct tests either on operational systems over which they had no design influence or control, or on prototype systems lacking the flexibility to permit manipulation of a variety of design features for testing purposes. These limitations have had the effect of restricting the number and kind of research aims and objectives that might be pursued, and the design variables that could be selected and manipulated for test purposes. Fortunately, developments in software and hardware technologies in recent years are enabling information retrieval researchers to overcome these limitations and achieve a large degree of autonomy and control over their research activities.

3.4 Software and Hardware Selected for the Research Project

The system portability requirement dictated that the experimental online catalogue be a microcomputer-based, stand-alone information retrieval system. Such a system would also enhance the researcher's autonomy and control of the experimental tool. At the time this research was being planned, most available information retrieval and online catalogue systems ran on either mainframe or minicomputer hardware. There were a small number of "generic" retrieval software products that could run on microcomputers, but microcomputer-based, special-purpose online catalogue software was just beginning to appear, and these products were generally limited in functionality. In addition, these online catalogue software products permitted little or no design flexibility or customization.

The well-known Okapi online catalogue and retrieval system software was available (Walker, 1989), but this prototype demonstration system did not support the multi-linked database structure required to allow the selection of a variety of record-to-linked record navigation search options for testing purposes.

When one is unable for lack of time or sufficient skills to design and program (i.e., write computer code) an entire retrieval system from scratch, there is no choice but to select from existing software. Of course, this usually involves some compromise and adaptation on the part of the researcher. In this case, the software selection was strongly influenced by the initial research interests, and the contraction of research objectives was influenced by the actual software selected and the design flexibility it allowed.

The software selected for the design and development of the experimental online catalogue used in this study is known as "TINman" (Noerr and Noerr, 1987). The TINman software is the property of IME, Ltd. The owners of the firm generously provided this software at no cost to support the online catalogue development and research reported in this thesis. The TINman software utilized in this project includes the database management and modelling software, the retrieval and display software, and various supporting modules needed for data record import and editing.

A TINman-based online catalogue or information retrieval system can be implemented on a stand-alone microcomputer (it can be networked also), operating under either the PC/MS-DOS or UNIX operating systems. The microcomputer used in this research was an IBM-compatible, AT-80286 machine using the MS-DOS operating system. Peripheral equipment included an 80-megabyte hard disk on which was stored the online catalogue program modules and the catalogue database, a standard '101' keyboard, and a VGA monchrome display monitor that permitted the display of black text on a white background. TINman applications can be imaginatively designed to take advantage of color display monitors, but this capability was not used in this project. Reverse video highlighting and blinking video features were incorporated in the design of the user interface.

TINman is best thought of as a database management system with associated search and retrieval software. Although particular applications, both bibliographic and non-bibliographic, have been developed by IME as commercial products and are sold in the marketplace (e.g., TINlib, TINterm, Information Navigator), TINman consists of a set of system development tools centered around its entity-relational, multi-linked database management software. The strength of any database management system derives from its ability to model data in a variety of ways. TINman supports virtually unrestricted data modelling, by which is meant, the "typing" or categorization of source data entities such as records and fields, and the definition and establishment of relational linkages between these fields and records. In fact, TINman encourages creative, deliberate data modelling on the part of the retrieval system applications designer. TINman comes with no built-in "default" data model or pre-structured database organization. The TINman-based retrieval system must be built upward from the database model, but any initial database model or organization produced by the designer can easily be changed to accomodate new or modified relationships among data types or entities.

In computer systems, information is typically organized in *fields* of data, which make up *records*, which are stored in *files*. These data components make up the database of information that must be stored in such a way that meaningful units of that information can be retrieved. Each data field is uniquely defined and "tagged" (given a field name such as author, title, series, call number); one or more related data fields make up a record (that is, a record can consist of a single field of data). Records having one or more attributes in common are gathered together to form a file or "set" as it is termed in TINman. These fields, records and sets that make up a TINman database may be thought of as data entities (or nodes in a network structure). Typically, then, there are levels of data entities, many types of entities, and a variety of relationships among these entities. Thus, the concept of an "entity-relational" database structure is incorporated in this type of database management system.

Data modelling involves defining or "typing" unique record sets and specifying the data field or fields which make up each type of record. In a multi-linked database structure, it also involves defining the logical links within and/or between record sets. Figure 3.1 shows a model of an online catalogue. In the center of the figure is the primary set of document records. Each of the boxes represent a set of like records. The boxes or sets may also be thought of as separate inverted files or indexes. Each record in each set consists of a "key" field which uniquely identifies it (e.g., the title of a monograph or series, a person's name, a subject heading, etc.) and serves as its retrieval "handle", so to speak; optionally additional data fields; and a "link-to" field. The link-to field in a record is used to store the key field of a record to which it shall be linked.

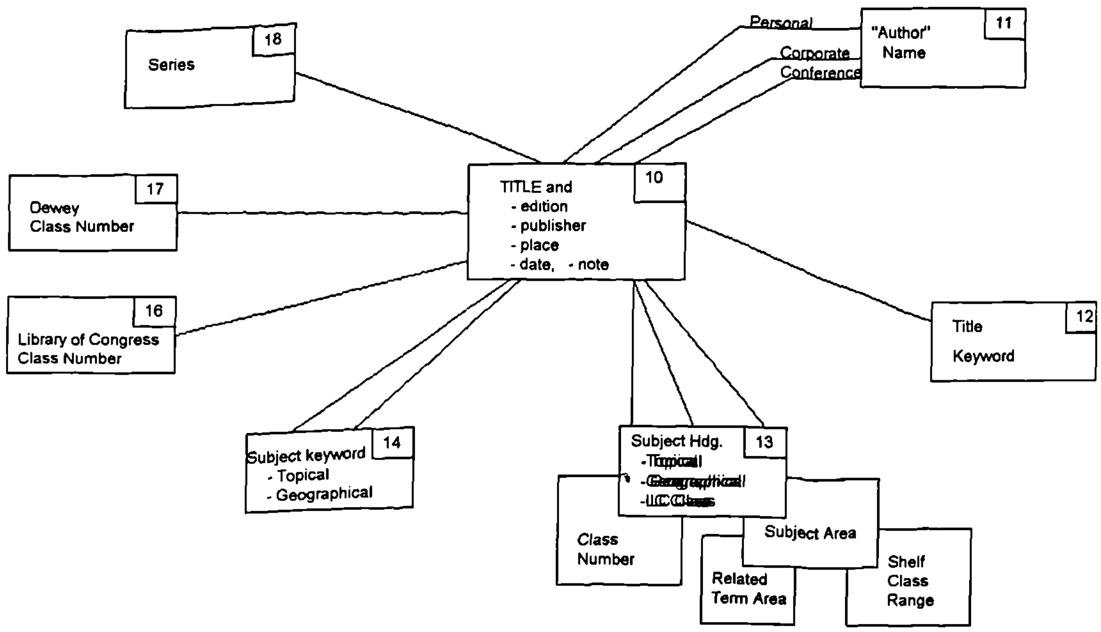


Figure 3.1 An Online Catalogue Database Model

The numbers in the upper right of the boxes are simply numeric tags for identifying unique record sets in the design and implementation of an application. The lines between boxes and around a box represent logical links or relationships established by the application designer. There may be more than one type of link between sets, or between records or fields within a set. These links support, of course, possible browse and navigate pathways that may be activated by the system designer for use by system users. TINman supports any number of links, and one-way, two-way, and recursive links. Recursive links are useful, for example, when a database has a data set representing authors who not only have preferred names, but also aliases that need to be linked to the preferred names. In this example model, the set of "Authors" is subdivided into personal, corporate, and conference authors, each having its own link pathway to the title record. In other applications, persons may be grouped into different sets as authors, editors, compilers, illustrators, composers, and so on.

The importance of well-thought-out, careful data modelling cannot be overemphasized. At this fundamental level of design, the designer defines the indexes that will serve as the primary search and browse database access options, structures any tree searches, and establishes the links which permit navigation from a found item to related items.

Primary search access to information stored in a structured TINman bibliographic database is through selection menus which allow the searcher to choose a pre-defined search approach (e.g., browsing a list of title keywords, browsing the shelflist, or direct entry of a query search) or a particular record set to browse (e.g., titles, subject headings, etc.). After this catalogue "entry" selection, the searcher typically browses one or more ordered lists of terms or document titles to make a further selection of a single document of interest. This selection then yields a "full citation" display of all fields of that document record. Thus, the searcher usually proceeds through four levels of access screen displays (see Figure 3.2). At each level the searcher selects an option from a list of items. A list may consist of a choice of search approaches (some writers prefer to call this "search strategies") or searchable record sets, ordered index entries, associated terms (as in a thesaurus set), brief document titles, or the display of all fields that make up a single document record. In the last case, if one selects an active "link-to" field in a displayed document record, one navigates to all the related records linked to that field.

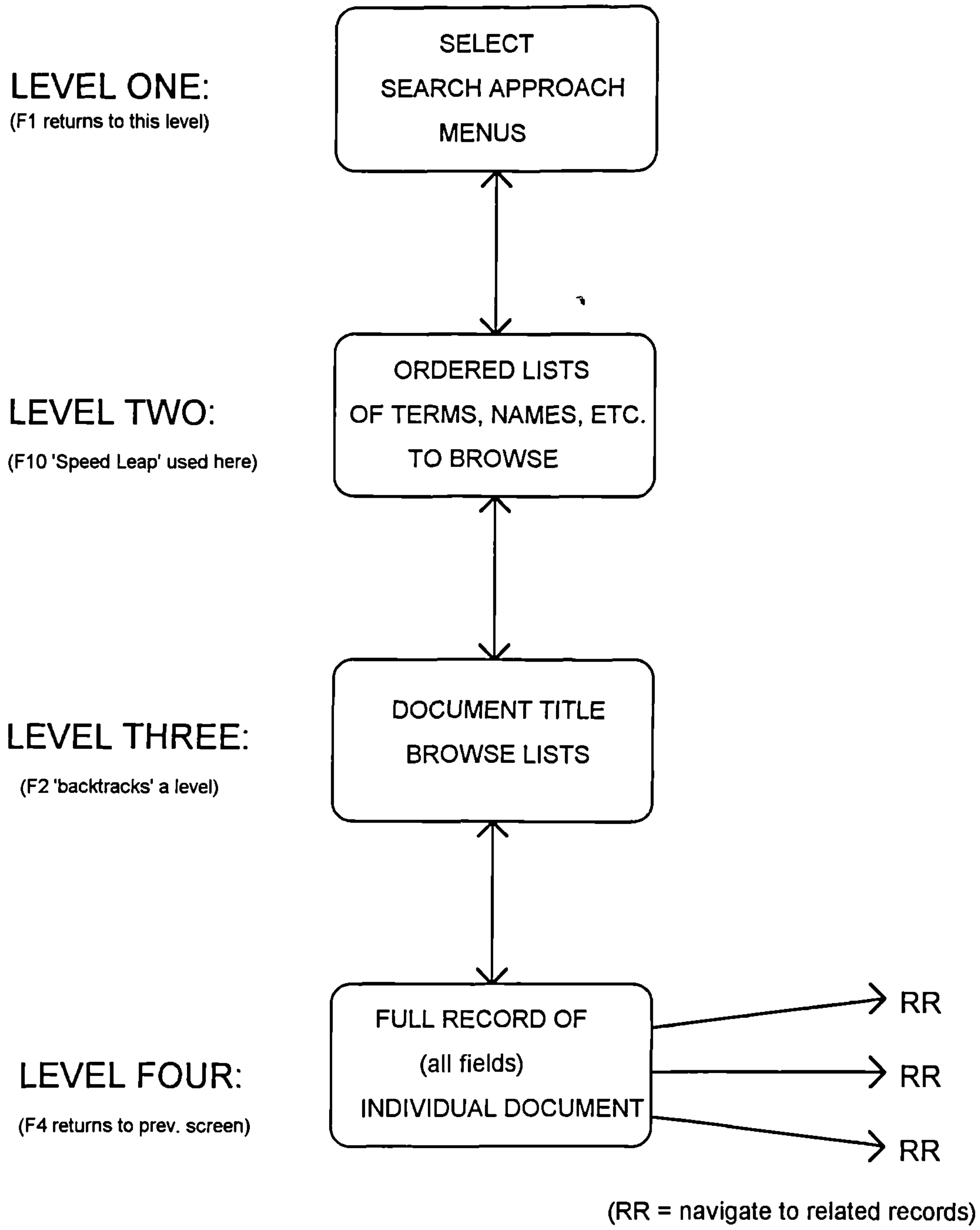


Figure 3.2 Experimental Online Catalogue Levels of Access

This browse, select, and related-item retrieval navigation mode of searching is central to the TINman-based experimental online catalogue. The mechanics of searching in this way are very simple. A selection pointer arrow is always displayed on the screen alongside a menu list or a list of selectable data items (from record sets or individual records). The up and down arrow keys on the keyboard move the selection arrow up and down through the displayed list. The entire length of the list can be scrolled in either direction. The Page Up and Page Down keys permit this scrolling to be done in page-size chunks. Any item the selection arrow points to is selectable. Simply pressing the Enter key selects the item pointed at. Any display on the screen is a list of items that may be browsed and from which an item may be selected. Items that cannot be selected (so determined by the database designer or system administrator) cannot be pointed at with the selection arrow. This sort of "point and click" style of interaction is an example of what interface designers have come to call, a "direct manipulation" interface. System actions can be evoked without the need to use a command language. Data items can be selected directly from the screen display to serve as triggers or input to further actions or requests.

Once a full record of a thesaurus term or document has been identified and displayed, any active linking field in that record may be selected (using the same keyboard mechanisms) to connect to and retrieve related records. This search technique is referred to as "navigation" in this study. Again, the selection arrow will only point at those fields in a displayed record that have active links from the record to related records. Navigation allows movement to related records within a set, as well as "jumps" from one set to another set.

In addition to list browsing, tree searching, and navigation, the TINman software supports several other conventional search techniques that were not investigated in this study. Among these, only the "DIRECT SEARCH", a query-by-form search technique in which Boolean operators and term truncation can be used, was included on the main search options menu. However, test subjects were not told of it or instructed in its use, and there is no evidence any subject used this search technique. When made available to the user as search options, any of these techniques can be combined with the browse and navigate techniques for searching the database.

3.5 Test Database Contents and Structure

3.5.1 Bibliographic Records Used in the Experiment

By the late 1980s, the bibliographic databases of most second-generation online catalogues consisted primarily of standard MARC (machine-readable cataloguing) catalogue records. The MARC standard defines a uniform record format and structure for creating, storing, and communicationg in machine-readable form library catalogue records for books, periodicals, and many other types of documents and materials libraries collect and/or provide access to. The MARC record format defines a variety of data fields for bibliographic information, the organization of those fields within a record, and supplies standard content identifiers for its data components such as field tags and subfield codes.

The primary sources for MARC catalogue records for published works are the national library agencies and the online bibliographic utilities. Libraries acquire these standard catalogue records for loading into their online catalogues through magnetic tape or CD-ROM subscription services, or download them for a fee from online vendors. A small number of commercial firms repackage these MARC records, typically add retrieval and editing software, and distribute them to libraries on magnetic or optical media. The decreasing amount of cataloguing performed at the local library is either "copy" cataloguing (modification of a pre-existing catalogue record to describe a document being added to the local collection) or "original" cataloguing. Cataloguers are increasingly trained to create catalogue records in accordance with national and international standards, and to register those newly-created records in the MARC format. The online bibliographic utilities require their users to enter and edit bibliographic records in the MARC format.

Although the MARC catalogue record includes a lot of encoded data needed for the inter-institutional exchange and sharing of these records and for local processing of these records for inclusion in the libraries' automated systems, the core bibliographic data contained in a MARC record is essentially that printed on the traditional and familiar library catalogue card. Two kinds of data make up a typical catalogue record: *descriptive* data and *subject analysis* data. Descriptive data includes such things as a document's title, author or source (especially the correct form of these names), edition, publisher, date, and the physical characteristics of the work being catalogued. Until quite recently, Library of Congress subject cataloguing practices resulted in only 1-3 subject headings assigned to a work (on average less than 2 headings per work catalogued); and most works are assigned two class numbers (class marks extended with book numbers). In the USMARC records used in this experiment, these call numbers are taken from the Dewey Decimal System and the Library of Congress Classification System.

MARC records generally do not contain abstracts or summary data about the contents of a work (children's literature is an exception), and only in the 1990s has a field been defined for entering data from a document's table of contents. On their own initiative, some libraries have added these kinds of document "aboutness" or contents data to their catalogue records to enhance local online bibliographic access and displays, but this data has not been included to date in the MARC records distributed by the national library agencies and the major bibliographic utilities. Thus, the standard MARC source bibliographic record that has been incorporated into most operational online catalogues contains very little "subject-rich" or document "aboutness" information. Three types of subject information are found in a typical MARC record: 1) "free-text" information, as in the document title, a conference name or proceedings title, and occasionally in a "notes" field; 2) subject descriptors or headings assigned to the work by subject cataloguers; and 3) the implicit information (the verbal meaning) that lies behind the coded call number assigned to the work.

To evaluate the usability and retrieval effectiveness of particular online catalogue design features in this study it was decided to use standard MARC bibliographic records to build the test database. Another decision was to confine the test database to one broad subject area. This would simplify the selection of test searches and the comparison of search results by three groups of subjects, each using a different test online catalogue. This researcher was predisposed toward the social sciences, somewhat under-represented in information retrieval tests. After a review of the Library of Congress Classification Schedules which cover the social sciences, the "Economics" sub-classes prefixed HB-HJ were chosen as the classed areas of documents to be included in the test database. As outlined in Figure 3.3, these sub-classes include topics ranging from economic theory and history, to current economic conditions around the globe, to all aspects of commerce, business, labor, and both public and private finance.

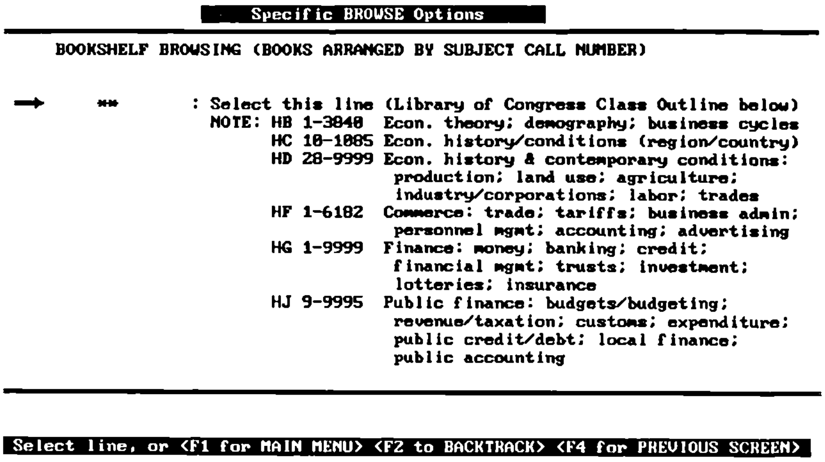


Figure 3.3 Economics Area Sub-Classes Included in Test Database

To support this research, the U.S. Library of Congress donated more than 155,000 MARC catalogue records on magnetic tape. These records represented almost all Library of Congress catalogue records for works published through 1988 in the English language and classed in the LCC sub-classes HB-HJ (sub-class HE, transportation and communications was omitted).

MARC records are of variable length, with the average record size being about 550 bytes. Since the rich indexing overhead needed to support a variety of planned tests would increase that figure by 2-3 times, it was not possible to load all 155,000 records into a database that would not exceed the capacity of an 80-megabyte hard disk. For this reason, a sample of 30,000 records was randomly selected from the larger set and loaded into the test database. Most of the represented works were published between 1968 and 1988, and all sub-class areas previously selected were represented in the sample. A database of 30,000 bibliographic records is considerably larger than most databases that have been used for information retrieval experiments since Cranfield 2 (Cleverdon, Mills, and Keen, 1966; Spark Jones and Van Rijsbergen, 1976).

3.5.2 Subject Augmentation of Bibliographic Records in the Test Database

During the initial loading and indexing of the MARC records, non-bibliographic fields and fields not essential for test purposes were stripped from each incoming record. Before data strings were included in various search indexes, they were run against lists of "stop words" to exclude non-significant or likely-to-be highly posted words from these indexes.

After the test database was loaded and indexed, the decision to add an additional subject heading to each bibliographic record was implemented through a manual editing process. The source of these headings is the captions that accompany the classification notations in the printed Library of Congress Classification (LCC) Schedule H. This was done to increase the likelihood of the searcher finding a suitable search term when browsing entries in the subject index, and especially to increase the "navigable" subject headings displayed with each full bibliographic record, by means of which the searcher could retrieve related items. It is well known that Library of Congress MARC bibliographic records contain, on average, fewer than two subject headings per record. This is scant subject information upon which one may branch out to find related items of interest. Since the relationship of Library of Congress class numbers (the source of these added headings) is one to many, adding "subject headings" derived from the LCC captions will likely yield new points of departure and links to related items for the subject searcher. Figure 3.4 shows a typical page of this LCC Schedule.

Each MARC bibliographic record has stored in its '050" field the LCC class number assigned to the work by a cataloguer. Subfield 'a' of the field contains the subject class number as it appears on the printed page of the Schedule. Subfield 'b' contains the "Cutter number", a book number assigned to a particular document. In printed and online displays of a document's LCC "call number" the book number follows the last '.' (not a decimal point) in the notation. Together the notational data in subfields a and b make up the familiar shelf location device known as the "call number" found on the spine of a book, for example, and on a printed catalogue card or online display of the record.

During the loading of the database, a "virtual" subject heading field was added to each incoming record, and a copy of the data in subfield a of the 050 field, the subject class number, was placed in that added subject field to serve as a meaningful token. These class numbers were included in the subject heading index, and, due to their peculiarity, were easy to identify during the editing process.

SUBCLASSES H-HJ

HD HD

ECONOMIC HISTORY AND CONDITIONS

	Labor
	Labor market. Labor supply and demand - Continued
	Communication of information
5701.8	General works
.85	Information services
	Study and teaching. Research
5702	General works
.5	By region or country, A-Z
5706	General works, treåtises, and advanced textbooks
5707	General special
	Statistics, see HD 5711+
	Unemployment
	Cf. HD6331+, Technological unemployment
.5	General works
5708	Social and psychological effects
	Job security
.4	General works
.45	By region or country, A-Z
	Under each country:
	.x General works
	.x2 Local, A-Z
	Structural unemployment
.46	General works
.47	By region or country, A-Z
	Under each country:
	.x General works
	.x2 Local, A-Z
	Layoffs. Plant shutdowns. Redundancy
	Cf. HF5549.D55, Dismissal of employees (Personnel management)
.5	General works
.55	By region or country, A-Z
	Under each country:
	.x General works
	.x2 Local, A-Z
	Frictional unemployment
.65	General works
.67	By region or country, A-Z
	Under each country:
	.x General works
	.x2 Local, A-Z
	Seasonal unemployment, see HD5855+
	Disguised unemployment
.7	General works

Figure 3.4 Page From Library of Congress Classification Schedules

Most class numbers have multiple documents associated with them, so it was not necessary to edit all 30,000 bibliographic records. When the index entry was changed from the class number to its natural language caption and the index updated, the virtual field in each associated bibliographic record was updated automatically. Approximately 3,000 class number index entries were updated in this way.

3.5.3 Thesaural Relationships in the Library of Congress Classification Schedules

On the intellectual side, the editing process was multi-leveled and complex, requiring more than a simple substitution of a single caption term for the class number. In adding this classification-based subject information to the bibliographic records and the search index, the aim was to present the verbal and conceptual context behind the class number. Svenonius (1983) refers to this particular use of a "perspective classification" to contextualize search terms. The class number implies the perspectival context of a subject, and can aid online subject searching, especially precision, as Chan points out (1989), because class numbers bring out the specific focus and perspective of a work.

At the first level of the editing process, the basic "subject heading" representing the class number was created. It is this subject heading that was added to each individual document record that shared the class number, to be indexed and displayed as part of the full citation. The objective at this step was to create a heading from the caption information in the printed Schedule that would be minimally meaningful to the searcher. Two problems with the Library of Congress Classification system had to be confronted here: 1) as Williamson points out (1989), LCC notation, being an enumerative, non-expressive system, does not reflect the hierarchical relationships among topics and sub-topics in the system. "Rather it is the topics themselves which display these relationships"and 2) many captions, considered in isolation, are completely lacking in expressiveness. Such terms had to be edited into something meaningful. A look at Figure 3.4 shows that merely substituting "general works, treatises, and advanced textbooks" for HD5706 would not provide much meaningful information to the searcher. How many levels of the hierarchy would be needed was decided on a case-by-case basis. In many cases it was necessary to "back-up" the page and the indented LCC hierarchical structure to discover the required information.

Although LCC's notation is not expressive of its hierarchical and other structures, the Schedules do employ a somewhat consistent format to indicate a formal, intellectual structure. Moving "down" the enumerative system one usually goes from the general to the specific, topically speaking. Other customs also apply; within each sub-class of a major discipline, further subdivisions are provided to specify form of publication, place (e.g., country), time period, and subject or topical aspects. In LCC, aspects of a subject are pre-coordinated and enumerated. Form divisions and other common divisions are enumerated under each subject. Form of publication or type of work (periodicals, collections, etc.) is found early-on in the topic's class range. Works on a topic are frequently sub-divided by "region or country," where works primarily about a country (or any other geopolitical category) are sub-divided by topic, as well as by type of work, etc. Little notational synthesis can be found in LCC. The numbering and class number extension schemes (to add book numbers) used to express these intra-subject distinctions and subject relationships are not applied consistently even within a single sub-class, one major reason the LCC numbers are not expressive in themselves.

The editor must learn these idiosyncratic rules and customs and scan the appropriate pages of the printed schedules to put together a meaningful descriptor for a single class number. Usually more than one term or phrase was chained together to create the subject heading that would express the meaning of the class number and be added to each bibliographic record that shared that class number (in MARC subfield a of field 050). The last descriptor (labelled "SUBJECT GROUP") in the citation shown in Figure 3.5 is an example of one of these LCC-derived subject headings (colons were used to distinguish these headings from the Library of Congress Subject Headings). Compare this with the minimal, out of context meaning of HD5706 as depicted in Figure 3.4. Generally, it was necessary to move back and up the LCC Schedule 1-2 levels to extract sufficient information to translate the class number into a meaningful subject descriptor for access and display purposes.

```
POINT & PRESS ENTER TO LOCATE RELATED BOOKS

TITLE:          The theory of unemployment reconsidered
AUTHOR:         Malinvaud, Edmond.
EDITION:        2nd ed.
PUBLISHER:      B. Blackwell ; New York, NY, USA
PUB. DATE:      1985
SERIES:         Yrjö Jahnsson lectures
NOTES:          Includes bibliographical references and index.
LC CALL NO:     HD5706.M156 1985

   This and related books are about (Library subject descriptor):

==>  SUBJECT GROUP: Keynesian economics.
     SUBJECT GROUP: Unemployment - Mathematical models.
     SUBJECT GROUP: Labor : labor market, labor supply and demand : general
                    works, treatises, and advanced textbooks

 >> To look for related books, point to SUBJECT GROUP & Press ENTER <<

      NO MORE listings for search just conducted
Select line, or <F1 for MAIN MENU> <F2 to BACKTRACK> <F4 for PREVIOUS SCREEN>
```

Figure 3.5 Full Citation Display With Added LCC-derived Subject Heading

In the design of the experimental online catalogue a vocabulary or "thesaurus" display was created to allow the editorial entry and online display of additional contextual and structural information for these newly-created subject class decriptors. Figure 3.6 shows an example of this expanded vocabulary and class context as presented to the online catalogue user.

```
POINT & PRESS ENTER TO LOCATE RELATED BOOKS

SUBJECT GROUP:        Labor : labor market, labor supply and demand :
                      general works, treatises, and advanced textbooks
  CALL NUMBER(S):     HD5706

IN SUBJECT CLASS:     Economic History and Conditions : Labor : Labor
                      Market
  SHELF BROWSE AREA:  HD5701-HD6000.7

  *** With Call Number, Try BOOKSHELF BROWSING, from MAIN MENU <F1> ***

Below are works within the above SUBJECT GROUP :
(Point to Title and press ENTER Key to see if the book might be useful)

    Title : Fiscal measures for employment promotion in developing countries.
    Title : Longitudinal analysis of labor market data
    Title : Managing the changing work force : work force implications of
            economic restructuring
==> Title : The theory of unemployment reconsidered

            *MORE DATA* - Use <Pg Up> or <Pg Dn> key
Select line, or <F1 for MAIN MENU> <F2 to BACKTRACK> <F4 for PREVIOUS SCREEN>
```

Figure 3.6 Experimental Online Catalogue "Thesaurus" Display

All titles indexed by this class number (HD5706) and "SUBJECT GROUP" descriptor appear in the lower segment of the screen and can be scrolled if there are more titles than can fit on a single screen. In the upper, vocabulary segment of the display, additional contextual or related term or record information is recorded.

"SUBJECT CLASS" data indicates the broader class area in which the work and related works are subsumed. The verbal components for the description of this broader "SUBJECT CLASS" area were usually acquired from the LCC printed schedules by moving up the schedule page to identify one or two more inclusive captions. "SHELF BROWSE AREA" reports the inclusive class shelf range which matches the "SUBJECT CLASS" area. This shelf range was displayed to encourage the searcher to browse online in this shelf area or range for related works of potential interest. A third item, added when available from the printed LCC Schedule, is "RELATED TOPIC," for example, "Technological unemployment (HD6331+)." When the user chooses to navigate from the descriptor, "Labor : labor market, labor supply and demand : general works, treatises, and advanced textbooks," displayed in a full citation (see Figure 3.5), he traverses to this "thesaurus" display. Here linked document titles can be viewed, or the user can review this structured, pre-coordinated classification information, information that may lead to and support another search strategy (e.g., "BOOKSHELF BROWSING").

Chan (1989) reminds us that classification "can be a powerful tool for access, as giving a work a class number not only groups it with similar works but also gives it a place in a systematic hierarchy and array of related subjects." Taken together, the "SUBJECT GROUP" descriptor "chain" and the "SUBJECT CLASS" phrase "chain" place the associated class number in its hierarchical context.

All the LCC-derived "SUBJECT GROUP" descriptor chains were integrated into the subject headings index along with the Library of Congress Subject Headings. These headings are interfiled and displayed alphabetically when that index list is presented for browsing (see Figure 3.7). Selection of an LCC descriptor from this alphabetical list would yield the special classification information display (Figure 3.6). This approach to constructing a chain index to the classified catalogue was inspired by John Mills (1955). It was not possible, however, in the time available to apply fully his detailed method in what he calls the "Chain Procedure" (a chain being a series of successively subordinate terms) for constructing such an index. This operation is made difficult and complex by the lack of an hierarchical notation in LCC and the inconsistent patterns and levels of conceptual structure and term relationships found in the printed LCC Schedules.

```
 BROWSE List: To Skip, Scroll (PgDn, PgUp), or SPEED LEAP (F10)
    Labor : labor market, labor supply and demand : by region or country :
         Great B (32)
    Labor : labor market, labor supply and demand : by region or country :
         United  (69)
    Labor : labor market, labor supply and demand : congresses (conferences,
         sympo (6)
    Labor : labor market, labor supply and demand : developing countries
              (9)
    Labor : labor market, labor supply and demand : foreign trade/investments
         and  (9)
--> Labor : labor market, labor supply and demand : general works, treatises,
         and  (7)
    Labor : labor market, labor supply and demand : job vacancies,
         opportunities   (2)
    Labor : labor market, labor supply and demand : manpower policy
              (9)
    Labor : labor market, labor supply and demand : occupational training and
         retr (40)
    Labor : labor market, labor supply and demand : occupational training and

                  << Move Arrow & Press Enter to Select >>
 Select line, or <F1 for MAIN MENU> <F2 to BACKTRACK> <F4 for PREVIOUS SCREEN>
```

Figure 3.7 Alphabetical Subject Heading Index Display

3.6 Catalogue Database Search Access Options

At the time the database structure is being modelled and designed, the designer must have a clear idea of the primary catalogue access or "entry" points he wishes to provide to users of the system. The creation of distinct record sets is the first step in this process (see Figure 3.1). Partitioning the record sets into sub-sets by type, as in the "Author" set, allows additional flexibility in the definition of primary and secondary catalogue access options, as well as the pre-structuring of search trees. Once the database access options and search definitions are set up by the application designer using the TINman development tools, the system administrator (or researcher) can easily select or change the options presented to any group of users by selecting from among the original set of pre-defined options.

Figure 3.8 shows the experimental catalogue's primary access points as they are displayed on the "MAIN MENU" screen.

MAIN MENU: Catalogue Access Options <F1>

To select catalogue access point move arrow down to it and press ENTER key

→ TOPICS OF INTEREST
BOOKSHELF BROWSING (BOOKS ARRANGED BY SUBJECT CALL NUMBER)
BOOK TITLES IN ALPHABETICAL ORDER
AUTHORS
****
DIRECT SEARCH

NO MORE listings for search just conducted

Select line, or <F1 for MAIN MENU> <F2 to BACKTRACK> <F4 for PREVIOUS SCREEN>

Figure 3.8 Experimental Catalogue Main Menu

TINman allows the designer to partition the primary catalogue search access options into secondary or specially defined search options, all at Level One of the user-system interface (recall Figure 3.2). For example, search by "AUTHORS" is further defined as illustrated in Figure 3.9.

```
                    Specific BROWSE Options
AUTHORS

        **      : All Authors (Persons, Organizations, & Conferences), or...
        **      : --Search for Book Titles by Personal Authors' Names
        **      : --Search for Book Titles by Issuing Organizations/Agencies
  -->   **      : --Search for Book Titles by Conference/Meeting Name

Select line, or <F1 for MAIN MENU> <F2 to BACKTRACK> <F4 for PREVIOUS SCREEN>
```

Figure 3.9 Experimental Online Catalogue "Author" Search Menu

Selection of an access option from this menu would yield a browse list of indexed names displayed in alphabetical order (Figure 3.10).

```
        BROWSE List: To Skip, Scroll (PgDn, PgUp), or SPEED LEAP (F10)
    Conference Board.
    Conference of Commonwealth Caribbean Government Statisticians
    Conference of Europeanists Washington, D.C.) (1979 :
    Conference of Financial Institutions Arusha, Tanzania) 1985 :
    Conference of First Ministers
    Conference of Foreign Ministers of Non-aligned Countries, Georgetown,
         Guyana, 1972
    Conference of Heads of State or Government of Non-aligned Countries
--> Conference of National Experts on the Future of Migration
    Conference on Advertising and Consumer Psychology
    Conference on Africa and the Market Economy University of London) (1985 :
    Conference on Agriculture and the Environment
    Conference on Agriculture in the Economic Development of Sri Lanka,
         Peradeniya, Sri Lanka, 1974
    Conference on American Agriculture Washington, D.C.) (1977 :
    Conference on Appalachia University of Kentucky) (1986 :
    Conference on Applied Time Series Analysis of Economic Data Arlington,
         Va.) (1981 :
    Conference on "Bermuda's Energy Future"

                 << Move Arrow & Press Enter to Select >>
Select line, or <F1 for MAIN MENU> <F2 to BACKTRACK> <F4 for PREVIOUS SCREEN>
```

Figure 3.10 Experimental Online Catalogue Conference Name Browse List

All primary access options except "BOOKSHELF BROWSING" were further defined into more specific kinds of access points or pathways. For this research study, BOOKSHELF BROWSING was confined to scanning a shelf list arranged by Library of Congress Classification numbers, but the option to browse a

Dewey Decimal Classification-arranged shelf list was built into the system and could easily be provided, either singly or along with the LCC browsing option. One question future research might address is how these two classification systems compare in search performance by shelf list browsing for the same queries or research topics.

3.7 Three Test Online Catalogues

Three different search interfaces were defined for the purposes of this research study. The human subjects recruited as searchers in these tests were divided into three groups, and each group searched only one of the three online catalogues. The test online catalogues differed only in two respects: 1) the display format of a single, full citation, and 2) the navigation search capability. Thus, the same initial screen displays (Levels One and Two of the interface) were presented to all test subjects. Figures 3.11 - 3.18 illustrate a typical search that might be conducted by Group-1 subjects (those allowed to navigate on displayed subject headings, labelled "SUBJECT GROUP") using the Group-1 online catalogue.

```
EXPERIMENTAL CATALOGUE: INTRODUCTION TO BROWSE & NAVIGATE
---------------------------------------------------------
To conduct a search of the library catalogue, first choose a
type of search on the next screen (e.g., topic, author), then:

 * BROWSE the resulting lists of book titles, topics, or names
                          - or -
 * POINT to data in a book record to move on to related books.

 ====================EASY AS 1-2-3========================
 1. Use the up and down arrows on the keyboard to position
    the ARROW Pointer (—>) on the screen.
 2. Use <PgDn> or <PgUp> keys to scroll the display lists.
 3. Press the ENTER key to Select the highlighted item.

Press the ENTER key now to proceed:
→  BEGIN search of the catalogue
   ******************************
```

Figure 3.11 Group-1 Search Display Sequence (Figs. 3.11 - 3.18)

```
MAIN MENU: Catalogue Access Options <F1>

To select catalogue access point move arrow down to it and press ENTER key

--> TOPICS OF INTEREST
    BOOKSHELF BROWSING (BOOKS ARRANGED BY SUBJECT CALL NUMBER)
    BOOK TITLES IN ALPHABETICAL ORDER
    AUTHORS
    *************
    DIRECT SEARCH

NO MORE listings for search just conducted
Select line, or <F1 for MAIN MENU> <F2 to BACKTRACK> <F4 for PREVIOUS SCREEN>
```

Figure 3.12 Group-1 Search Display Sequence (Continued)

```
Specific BROWSE Options

TOPICS OF INTEREST

       **     : Search by Title Words (Words From Book Titles)
-->    **     : Search by "SUBJECT GROUP" Headings (Library-assigned
                Subject Descriptors)
       **     : Search by region, country, locality

Select line, or <F1 for MAIN MENU> <F2 to BACKTRACK> <F4 for PREVIOUS SCREEN>
```

Figure 3.13 Group-1 Search Display Sequence (Continued)

:

:

```
BROWSE List: To Skip, Scroll (PgDn, PgUp), or SPEED LEAP (F10)

    Women executives - Great Britain - Biography.
             (1)
    Women executives - India - Bombay.
             (1)
    Women executives - India - Case studies.
             (1)
    Women executives - India - Rajasthan.
             (1)
    Women executives - Training of.
             (1)
--> Women executives - United States.
             (11)
    Women executives - United States - Addresses, essays, lectures.
             (1)
    Women executives - United States - Bibliography.
             (1)
    Women executives - United States - Biography.
             (2)
    Women executives - United States - Case studies.

<< Move Arrow & Press Enter to Select >>
Select line, or <F1 for MAIN MENU> <F2 to BACKTRACK> <F4 for PREVIOUS SCREEN>
```

Figure 3.14 Group-1 Search Display Sequence (Continued)

```
POINT & PRESS ENTER TO LOCATE RELATED BOOKS
SUBJECT GROUP!        Women executives - United States.

   *** With Call Number, Try BOOKSHELF BROWSING, from MAIN MENU <F1> ***

Below are works within the above SUBJECT GROUP :
(Point to Title and press ENTER Key to see if the book might be useful)

Title : Breaking the glass ceiling : can women reach the top of America's
        largest corporations?
Title : Breakthrough: women into management
Title : Games mother never taught you : corporate gamesmanship for women
Title : Male a study of MBAs
Title : Racism and sexism in corporate life : changing values in American
        business
→ Title : Success and betrayal : the crisis of women in corporate America
Title : Women leading
Title : Women like us : what is happening to the women of the Harvard

*MORE DATA* - Use <Pg Up> or <Pg Dn> key
Select line, or <F1 for MAIN MENU> <F2 to BACKTRACK> <F4 for PREVIOUS SCREEN>
```

Figure 3.15 Group-1 Search Display Sequence (Continued)

```
POINT & PRESS ENTER TO LOCATE RELATED BOOKS
TITLE:            Success and betrayal : the crisis of women in corporate
                  America
AUTHOR:           Hardesty, Sarah.
AUTHOR:           Jacobs, Nehama.
EDITION:          1st Touchstone ed.
PUBLISHER:        Simon & Schuster ; New York
PUB. DATE:        1987, c1986
NOTES:            Bibliography: p. 449-452.
NOTES:            Includes index.
LC CALL NO:       HD6054.4.U6H37 1987

    This and related books are about (Library subject descriptor):

  SUBJECT GROUP: Women executives - United States.
  SUBJECT GROUP: Women in the professions - United States.
→ SUBJECT GROUP: Labor : classes of labor : woman labor : women executives

 >> To look for related books, point to SUBJECT GROUP & Press ENTER <<

          NO MORE listings for search just conducted
Select line, or <F1 for MAIN MENU> <F2 to BACKTRACK> <F4 for PREVIOUS SCREEN>
```

Figure 3.16 Group-1 Search Display Sequence (Continued)

```
POINT & PRESS ENTER TO LOCATE RELATED BOOKS
SUBJECT GROUP!        Labor : classes of labor : woman labor : women
                      executives
  CALL NUMBER(S)!     HD6054.3-6054.4

IN SUBJECT CLASS!     Economic History and Conditions : Labor : Classes
                      of Labor
  SHELF BROWSE AREA!  HD6050-HD6305

   *** With Call Number, Try BOOKSHELF BROWSING, from MAIN MENU <F1> ***

Below are works within the above SUBJECT GROUP :
(Point to Title and press ENTER Key to see if the book might be useful)

Title : Breaking into the boardroom : when talent and hard work aren't
        enough
→ Title : Breaking the glass ceiling : can women reach the top of America's
        largest corporations?
Title : A Development programme for women in management

*MORE DATA* - Use <Pg Up> or <Pg Dn> key
Select line, or <F1 for MAIN MENU> <F2 to BACKTRACK> <F4 for PREVIOUS SCREEN>
```

Figure 3.17 Group-1 Search Display Sequence (Continued)

```
          POINT & PRESS ENTER TO LOCATE RELATED BOOKS
TITLE:          Breaking the glass ceiling : can women reach the top of
                America's largest corporations?
AUTHOR:         Morrison, Ann M.
AUTHOR:         Van Velsor, Ellen.
AUTHOR:         White, Randall P.
ORGANIZATION:   Center for Creative Leadership.
PUBLISHER:      Addison-Wesley Pub. Co. ; Reading, Mass.
PUB. DATE:      c1987
NOTES:          Bibliography: p. 219-224.
NOTES:          Includes index.
LC CALL NO:     HD6054.4.U6M67 1987

    This and related books are about (Library subject descriptor):

--> SUBJECT GROUP: Success in business - United States.
    SUBJECT GROUP: Women executives - United States.
    SUBJECT GROUP: Labor : classes of labor : woman labor : women executives

 >> To look for related books, point to SUBJECT GROUP & Press ENTER <<

          NO MORE listings for search just conducted
Select line, or <F1 for MAIN MENU> <F2 to BACKTRACK> <F4 for PREVIOUS SCREEN>
```

Figure 3.18 Group-1 Search Display Sequence (End)

In Figure 3.16, the searcher chooses to navigate from a "SUBJECT GROUP" to all the titles linked to that subject heading (see Figure 3.17). With navigation, there is no pre-defined "stopping point" or final level of a search. The searcher may choose to navigate through the database at will, or back-up a level at a time to scan browse lists, or return at any time to the MAIN MENU.

Searchers in Group-2 were presented a different citation display (see Figure 3.19) and were permitted to navigate only on keywords from the title. The movement from a selected title keyword to a new "results" set is illustrated in Figure 3.20. When more titles are retrieved than can be displayed on a single screen, the list can be scrolled up and down using the arrow or Page Up and Page Down keys on the keyboard.

```
          POINT & PRESS ENTER TO LOCATE RELATED BOOKS
TITLE:          Women in management worldwide
AUTHOR:         Adler, Nancy J.
AUTHOR:         Izraeli, Dafna N.
PUBLISHER:      M.E. Sharpe : Armonk, N.Y.
PUB. DATE:      c1988
NOTES:          Includes bibliographies and index.
LC CALL NO:     HD6054.3.W66 1988
SUBJECT:        Women executives.
SUBJECT:        Labor : classes of labor : woman labor : women executives

       Select a keyword from this book title to continue searching:
    Title Keyword: management
--> Title Keyword: Women
    Title Keyword: worldwide
 >> To look for related books, point to Title Keyword & Press ENTER <<

          NO MORE listings for search just conducted
Select line, or <F1 for MAIN MENU> <F2 to BACKTRACK> <F4 for PREVIOUS SCREEN>
```

Figure 3.19 Group-2 Online Catalogue Full Citation Display

```
POINT & PRESS ENTER TO LOCATE RELATED BOOKS

TITLE KEYWORD : women

Below are books containing this keyword in title :
(Point to Title and press ENTER Key to see if the book might be useful)

Title : Administrative arrangements for handling questions relating to
        women workers.
Title : African women in agricultural development : a case study in
        Sierra Leone
Title : Alone in a crowd : women in the trades tell their stories
→ Title : American women managers and administrators : a selective
        biographical dictionary of twentieth-century leaders in business,
        education, and government
Title : Arab women workers.
Title : ASPA women in public management directory
Title : At any cost : corporate greed, women, and the Dalkon Shield
Title : At the very least she pays the rent : women and German
        industrialization, 1871-1914

*MORE DATA* - Use <Pg Up> or <Pg Dn> key
Select line, or <F1 for MAIN MENU> <F2 to BACKTRACK> <F4 for PREVIOUS SCREEN>
```

Figure 3.20 Group-2 Navigation Results Screen Display

Group-3 searchers viewed a full citation display format like the one depicted in Figure 3.21. This is a more conventional online catalogue "labelled" display format. The subject headings are not highlighted in a "boxed" window, and no navigation is suggested or permitted (thus the absence of the pointer arrow). This group served as the "control" group for experimental purposes.

```
Current Search Results Set (Book Title or Titles)

TITLE:           Breaking the glass ceiling : can women reach the top of
                 America's largest corporations?
AUTHOR:          Morrison, Ann M.
AUTHOR:          Van Velsor, Ellen.
AUTHOR:          White, Randall P.
ORGANIZATION:    Center for Creative Leadership.
PUBLISHER:       Addison-Wesley Pub. Co. : Reading, Mass.
PUB. DATE:       c1987
NOTES:           Bibliography: p. 219-224.
NOTES:           Includes index.
LC CALL NO:      HD6054.4.U6M67 1987
SUBJECT GROUP:   Success in business - United States.
SUBJECT GROUP:   Women executives - United States.
SUBJECT GROUP:   Labor : classes of labor : woman labor : women executives

NO MORE listings for search just conducted
Select line, or <F1 for MAIN MENU> <F2 to BACKTRACK> <F4 for PREVIOUS SCREEN>
```

Figure 3.21 Group-3 Online Catalogue Full Citation Display

Searchers in all three groups were encouraged to try the "BOOKSHELF BROWSING" option as a search strategy. Figures 3.22 - 3.28 illustrate a search begun in this manner.

```
MAIN MENU: Catalogue Access Options <F1>

To select catalogue access point move arrow down to it and press ENTER key

TOPICS OF INTEREST
→ BOOKSHELF BROWSING (BOOKS ARRANGED BY SUBJECT CALL NUMBER)
BOOK TITLES IN ALPHABETICAL ORDER
AUTHORS
**************
DIRECT SEARCH

NO MORE listings for search just conducted
Select line, or <F1 for MAIN MENU> <F2 to BACKTRACK> <F4 for PREVIOUS SCREEN>
```

Figure 3.22 Bookshelf Browsing Search Display Sequence (Figs. 3.22 - 3.28)

```
Specific BROWSE Options

BOOKSHELF BROWSING (BOOKS ARRANGED BY SUBJECT CALL NUMBER)

→      **       : Select this line (Library of Congress Class Outline below)
                 NOTE: HB 1-3840  Econ. theory; demography; business cycles
                       HC 10-1085 Econ. history/conditions (region/country)
                       HD 28-9999 Econ. history & contemporary conditions:
                                  production; land use; agriculture;
                                  industry/corporations; labor; trades
                       HF 1-6182  Commerce: trade; tariffs; business admin;
                                  personnel mgmt; accounting; advertising
                       HG 1-9999  Finance: money; banking; credit;
                                  financial mgmt; trusts; investment;
                                  lotteries; insurance
                       HJ 9-9995  Public finance: budgets/budgeting;
                                  revenue/taxation; customs; expenditure;
                                  public credit/debt; local finance;
                                  public accounting

Select line, or <F1 for MAIN MENU> <F2 to BACKTRACK> <F4 for PREVIOUS SCREEN>
```

Figure 3.23 Bookshelf Browsing Search Display Sequence (Continued)

:

:

```
BROWSE List: To Skip, Scroll (PgDn, PgUp), or SPEED LEAP (F10)

HC102.5.A2 =  Business entrepreneurs in the West
HC102.5.A2 =  Biographical directory of the Council of Economic Advisers
HC102.5.A2 =  Entrepreneurs of the old West
HC102.5.A2 =  The age of the moguls
HC102.5.A2 =  The vital few : the entrepreneur and American economic
      progress
→ HC102.5.A2 =  American women managers and administrators : a selective
      biographical dictionary of twentieth-century leaders in business,
      education, and government
HC102.5.A2 =  Rare breed : the entrepreneur, an American culture
HC102.5.A2 =  A response to industrialism : liberal businessmen and the
      evolving spectrum of capitalist reform, 1886-1960
HC102.5.A2 =  People in business and industry in North America :
      summaries of biographical articles in history journals
HC102.5.C5 =  Half interest in a silver dollar : the saga of Charles E.
      Conrad
HC102.5.C7 =  American progress : the growth of the transport, tourist,
      and information industries in the nineteenth-century West, seen
      through the life and times of George A. Crofutt, pioneer and

<< Move Arrow & Press Enter to Select >>
Select line, or <F1 for MAIN MENU> <F2 to BACKTRACK> <F4 for PREVIOUS SCREEN>
```

Figure 3.24 Bookshelf Browsing Search Display Sequence (Continued)

```
                POINT & PRESS ENTER TO LOCATE RELATED BOOKS
   Library of Congress Classification No. : HC102.5.A2L37 1985

    - Press the ENTER Key to see if the book might be useful
    - Press <F2-BACKTRACK> to see related books nearby on shelf

-> Title : American women managers and administrators : a selective
           biographical dictionary of twentieth-century leaders in business,
           education, and government /By: Leavitt, Judith A. (Published in
           1985)



               NO MORE listings for search just conducted
 Select line, or <F1 for MAIN MENU> <F2 to BACKTRACK> <F4 for PREVIOUS SCREEN>
```

Figure 3.25 Bookshelf Browsing Search Display Sequence (Continued)

```
                POINT & PRESS ENTER TO LOCATE RELATED BOOKS
  TITLE:              American women managers and administrators : a selective
                      biographical dictionary of twentieth-century leaders in
                      business, education, and government
  AUTHOR:             Leavitt, Judith A.
  PUBLISHER:          Greenwood Press ; Westport, Conn.
  PUB. DATE:          1985
  NOTES:              Bibliography: p. [307]-311.
  NOTES:              Includes index.
  LC CALL NO:         HC102.5.A2L37 1985
  |     This and related books are about (Library subject descriptor):     |
->  SUBJECT GROUP: Women executives - United States - Biography.
    SUBJECT GROUP: Economic History and Conditions : By Region or Country
                   (General Works Only) : United States : biographies,
                   collective
  L>> To look for related books, point to SUBJECT GROUP & Press ENTER <<-

               NO MORE listings for search just conducted
 Select line, or <F1 for MAIN MENU> <F2 to BACKTRACK> <F4 for PREVIOUS SCREEN>
```

Figure 3.26 Bookshelf Browsing Search Display Sequence (Continued)

```
                POINT & PRESS ENTER TO LOCATE RELATED BOOKS
  SUBJECT GROUP:      Women executives - United States - Biography.

    *** With Call Number, Try BOOKSHELF BROWSING, from MAIN MENU <F1> ***

  Below are works within the above SUBJECT GROUP :
  (Point to Title and press ENTER Key to see if the book might be useful)

  Title : American women managers and administrators : a selective
          biographical dictionary of twentieth-century leaders in business,
          education, and government
-> Title : Women leading



               NO MORE listings for search just conducted
 Select line, or <F1 for MAIN MENU> <F2 to BACKTRACK> <F4 for PREVIOUS SCREEN>
```

Figure 3.27 Bookshelf Browsing Search Display Sequence (Continued)

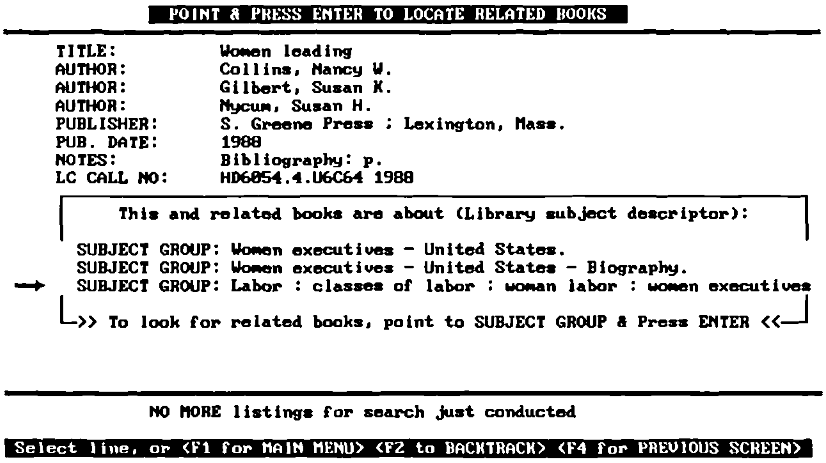


Figure 3.28 Bookshelf Browsing Search Display Sequence (End)

3.8 Design of the User Interface

The user interface component of computerized interactive information retrieval systems like online library catalogues is the locus in time and space, typically defined by a particular mix of hardware and software facilities, where the user and the information system interact and communicate to carry out useful information seeking tasks. In today's online catalogues this user interface is primarily manifest through a particular online catalogue's input devices and screen displays. However, these tangible components are only part of the story. The user interface in information systems is a complex environment in which system features must match up appropriately with a bewildering variety of users' personal characteristics, cognitive abilities, and task requirements. In the best of cases, this environment, with its brew of tangibles and intangibles, affords the user a comfortable, supportive "space" to carry out information seeking tasks. These tasks require not only appropriate information input and output, but comprehensible decision making support facilities as well.

Looking for documents or other publications in an online catalogue is not just a mechanistic information seeking activity. It is a dynamic, decision making activity which requires that careful consideration be given not only to the information to be provided, but to the manner in which that information is presented in displays, and also to the set of decision making facilities available to assist the user in carrying out primary tasks and sub-tasks. Among these tasks are identifying and locating documents, reviewing them, selecting some as suitable to the need or interest, and using retrieved, found data to modify or continue a search strategy. Thus, a major goal of information system design is to develop a user interface that will facilitate the cognitive tasks of user comprehension and decision making. This goal is only partially accomplished by presenting easy-to-use search input screens and legible displays of bibliographic information.

There is much discussion about the "usability" of computer systems designed for and used by "end users." There seems to be agreement that system design features greatly determine the usability of information systems for their primary clients, and, further, that usability is a dimension that may have a profound influence on both search performance and users' satisfaction with the search system. Given the variety of things one might use a computer system to do, usability is surely a relative measure. Furthermore, as Allen (1993) has noted, "Specific design features can combine with specific user characteristics to ensure that information systems are more usable by some people than others." System designers, especially designers of user interfaces, must take into account the primary tasks to be performed with the system and the characteristics brought to the tasks by the users of the system. An understanding of these tasks and characteristics will inform the design of appropriate information search, presentation, review, selection, and related decision making facilities. Too often in online catalogue interface design only one or two of these facilities have been optimized. For example, search input may be simplified, but no dynamic review/feedback facility is provided to support search continuation or enhancement based on information that has already been found and displayed.

Although much has been written about the design and use of online catalogue user interfaces and screen displays, actual design is still more of an art than a science. There has been surprisingly little research on the sequencing of online catalogue display screens appropriate to a dynamic search and review process, or on information requirements of the process beyond what is displayed as bibliographic information. Online catalogue user interfaces have been "acceptance tested" more often in the marketplace than in the laboratory or controlled field experiments. Nonetheless, a great deal of research from related areas and experience gained through 15 years of online catalogue interface design, use and evaluation can be brought to bear on the design of user-system interaction styles and methods, and on useful, informative screen displays. (For a useful summary of this research and experience, see Shneiderman, 1992.)

At many points, this accumulated knowledge and experience has informed the design of the online catalogue user interface and screen displays developed for use in this experimental research project. This interface and its displays have been illustrated in Figures 3.8 - 3.28. It may be useful now to review the rationale behind the design of the user interface for the experimental online catalogue, and to highlight some of the principles and goals I had in mind when developing the prototype. Specific problems that were addressed will be enumerated.

Some attention has been given to how best to display discrete bibliographic records (presumably resulting from a search) on an online catalogue's VDU screen (see for example, Reynolds, 1985, Fryser and Stirling, 1984, Matthews, 1986, Shires, 1992, Allen, 1993a). Both content and presentation issues have been addressed. Great effort has been extended to provide online user assistance and "help" features to ease the use of online catalogues. Less concern has been shown for the dynamic aspects of the communicative, decision making interaction between the user and the system during the search process, and the information and display requirements for supporting that interaction. Such requirements include the proper sequencing or formatting of separate screens, and also include a dynamic, proactive role for individual displays of bibliographic information. In traditional library catalogues, the bibliographic record was thought to be the end-point, or some sort of stopping-point in the search process. Some early online catalogues reflected this tradition by displaying "The End" at the bottom of a screen which displayed a complete bibliographic record.

Reflections on the online catalogue user interface as a complex environment for supporting search, selection, review and related decision making activities led this author to the articulation of principles and goals which guided the design and development of the experimental online catalogue interface. The first of these is that the online catalogue system should never permit a user's search attempt to fail to retrieve one or more bibliographic records for review and action. Many searches in present-day online catalogues fail to retrieve even a single record, and most online catalogues offer little or no assistance to the searcher when this result occurs. The assumption behind this principle (always retrieve something for display and review) is that something in an heterogeneous online catalogue database might satisfy the request to some degree, or serve even in its rejection by the user to supply useful information that can be used to further the search

A second principle applied is: never assume the display of a bibliographic record is the end of a search, merely to be selected or rejected, then "set aside." Bibliographic records are for use not just as location devices, but as informationladen devices for furthering the search. This action role of bibliographic displays is often overlooked in system design. Bibliographic records can be generative; they may have a spring-board effect in the search process, or serve as information "seeds" to fertilize subsequent searching.

Searching and browsing are non-deterministic, dynamic processes; it may be best to think of even the most precisely-formed queries in conventional query-oriented systems as dynamic queries, subject to change in the search process. The user may know precisely what he wants and uses the online catalogue merely to locate that particular item and determine its availability. Yet, this single-minded user may choose from a variety of ways of searching for the item, may encounter other interesting items while searching for the desired item, or may even lose interest in the original item as alternatives are brought to his attention. For these reasons, found data -- terms, titles, subject descriptors, entire records -- should be able to serve as useful data for expanding a search or revising a search strategy. In short, it ought to be easy for search output to serve as search input. The display formats and prompts, point and click, and linked-record navigation facilities employed in the experimental online catalogue were developed to satisfy these principles and requirements.

Research has identified several key problem areas in the use of conventional online catalogues that can be alleviated through interface design. Good reviews of these research findings can be found in Larson,(1991a),and Hildreth,(1989b).Some of the problems addressed in the development of the experimental online catalogue are listed below:

1. Initial system entry and orientation. Bates (1986) calls it the "docking" problem.

2. Required use of unfamiliar commands or excessive keyboarding (Trenner, 1991).

3. Entering or finding suitable search terms.

4. Modifying a search strategy or query to achieve better results.

5. No way to provide feedback to retrieved information so that it can be exploited to yield enhanced search results.

6. Knowing where one is in the search process or knowing what may be done next.

7. Interpreting and understanding information in bibliographic displays to support decisions regarding the suitability and usefulness of retrieved items.

8 General user frustration in carrying out search and selection tasks efficiently.

Another look at the display screens illustrated in Figures 3.11 - 3.18 will indicate how many of these problems were addressed through the design of the interface. The interactive "feel" of the interface will, of course, be lacking. With the point and click, menu-selection interface, the user is not required to use commands or to do excessive keyboarding. Indexes may be scanned to identify suitable search terms. Thus, users do not have to type in search terms. The "SPEED LEAP" key (see Figure 3.14) proved to be very popular among the test subjects. This feature enabled searchers to quickly jump around in a lengthy index list to a desired place in the ordered list of terms. To what extent searchers were able to find suitable search terms in this manner is reported in a subsequent chapter. The findings were encouraging.

The problem of users having difficulties with initial system use and "docking" was addressed through both the "direct-manipulation" interface, and the choice of terms used and the layout of the opening screens (Figures 3.11 - 3.13). For these experiments, the online catalogue was optimized to support subject searching. "TOPICS OF INTEREST" was placed first on the initial menu of search choices. Pilot testing of earlier versions of the online catalogue led to changes in wording on the opening screens. For example, "Title keywords" was changed to "Title Words." Since 'Search by "SUBJECT GROUP" Headings was used to identify one of several alternative kinds of subject search, "TOPICS OF INTEREST" was used as the inclusive term.

Two kinds of evidence gathered indicated that the online catalogue was found easy to enter for beginning a search. All subjects were able to perform searches after only a ten-minute spoken introduction to the system. No subject reported on the post-search questionnaire having difficulty getting started. During the test sessions, no separate search aids were provided, and the monitor was absent from the room.

Each screen that contained bibliographic information, information that had been retrieved, included "next step" options to guide the searcher, and also a prompt which indicated that the retrieved information could be used to find related materials. This was done in the belief that subject searchers often find what they want through recognition rather than through description. Once a useful item is found, the interface should provide a simple mechanism by which the searcher can gather additional items "like" the one already found. A combination of prompts, labels, special formatting, and use of the point and click navigation feature were implemented to provide this mechanism to the user (see Figure 3.16). In this manner, retrieved records or parts of them can be used to link to related items or to direct a search down related avenues of interest. Where more than a single subject heading appears in a bibliographic record, the additional headings usually make it possible to narrow the search or to pursue specific aspects of the topic.

It has become commonplace to label unique data elements in displayed bibliographic records. Other than this practice, there is as yet no uniform or standard practice followed in the presentation of bibliographic records, with regard to choices of labels for data elements, order of data elements, or screen layout and typography. Previous catalog research has indicated that users frequently do not notice the subject descriptors assigned to a work and included in the bibliographic record, and do not understand their collocative function for identifying similar or related works. In the design of the experimental online catalogue interface, the decision was made to display the title of the work first, and to bring the subject descriptors and their function directly to the attention of the user (see Figures 3.16 and 3.18). A box outline appears around the subject descriptors to highlight them, and the interposed prompts make it clear that these descriptors may have "related books" associated (linked) with them. The label "SUBJECT GROUP", rather than just "SUBJECT", was chosen to indicate this as well. In this way a part of the bibliographic record is singled out to serve as a stepping-stone to additional potentially useful works. The dynamic query, which can be begun in a variety of ways, can be extended or modified quite simply on the basis of what has been found and displayed.

A common problem with flexible, hypertext retrieval systems which offer many alternative search paths is the feeling of disorientation users experience after searching for a time. Faced with many choices and paths to pursue, users typically begin to wonder where they are, and how they got there. Lacking sufficient markers and prompts, they often feel lost. This experience is exacerbated in non-linear hypertext search systems that have been implemented in earlier screen technologies developed to support only linear modes of searching. With these earlier technologies, one screen is displayed at a time, containing a single logical unit of information which represents a single stage or level in the search process. Related screens that may provide search and browse context, history, or alternative directions to pursue are simply not displayed simultaneously to the user. Newer graphical user interface (GUI) display technologies offer some solutions to this problem through the use of multiple windows and related devices.

For the most part, the experimental online catalogue interface presented logical units of information one screen at a time. Place or location markers were not provided, and users expressed some difficulty in remembering where they had been, or how they had gotten to a particular display. Many indicated that they thought they had come upon a particular record more than once by another search path, but had no way of being certain of this so that redundant searching could be avoided. This need for "geographical" navigational aids was not met well by the experimental online catalogue. Future GUI versions of the interface will be able to employ a rich mix of tools to help manage this problem.

On the subject of information displays, Reynolds (1985) has written:

> *The initial impression created by any display of information can have a strong influence on users' attitudes towards that information. They will almost certainly form judgements about whether the display is likely to be easy or difficult to use or, indeed, whether it will be worth their while attempting to use it at all.*

The design of the full bibliographic record displays incorporated decisions made about data content, format, order of data elements, labeling, and typography. Data in the MARC record judged to be extraneous to the tasks at hand were omitted from the displays. Considerations of both task and user characteristics must be included in the remaining aspects of the displays. Reynolds goes on to say, "... a good presentation is, first and foremost, one which makes clear the structure and sequence of the information content and which takes into account the way in which the information will be used." Data field labels were chosen carefully to avoid jargon and to indicate not only the meaning of the data, but, in the case of the subject headings, their use and function. With regard to sequence and structure, the MARC format structure, even with its arcane numeric labels disguised, was deemed unsuitable for end users and was not followed at all. In the experimental online catalogue bibliographic record displays, the title field was the first in order, and like data elements were grouped together, unlike MARC which separates "added entries" from the "main entry." Recent research by Allen (1993b) suggests that displaying subject headings first in the display, at the top of the bibliographic record, improves subject searching performance on some search tasks. He attributes this influence to the perceptual speed factor in identifying appropriate elements in a bibliographic display. As described, a different approach was employed in this research project. However, the goal was the same: to bring the subject headings to the notice of the searcher. This approach, which involved special prompts, labeling, and formatting of the subject data in the bibliographic record, seemed to have had a positive influence on the search performance of inexperienced users.

The typographical conventions used in the bibliographic displays followed the findings of Fryser and Stirling (1984). This research showed that users preferred labeled displays and conventional upper-lower case typography for the presentation of bibliographic information.

Effective bibliographic displays are influenced by both content and presentation factors. The design goal is to facilitate user comprehension and decision making. Key decisions involved in the bibliographic search process include accurate identification of a work, suitability of a retrieved work for a particular need, and the desirability of modifying a search strategy or expanding a search. The data content of the records in the database is often out of the hands of the system designer. The designer has to use the available tools to present information in the most useful way contemplated. To date, there has been a paucity of empirical research that addresses issues involved in the effective display of bibliographic information. Although the research reported here did not directly address these issues, the users of the experimental online catalogue expressed general satisfaction with the displays and reported no difficulties in the use of the test versions that could be attributed to factors associated with the bibliographic displays.

3.9 Summary

This chapter discussed the design of the prototype online catalogue developed to conduct the tests reported in this thesis, as well as tests planned for future research. After a general discussion of a design framework appropriate for developing browsing systems, the online catalogue database and the browse and navigate search features were described. Actual screen displays were included to illustrate these search features, the user-system interaction style and methods, and the differences between the three online catalogues used in the experiment. The chapter concluded with a discussion of the design rationale, goals, and principles which guided the development of the experimental online catalogue. The next chapter discusses the experimental methodology and test procedures.

Chapter 4

Methodology, Part II: Testing the Experimental Online Catalogues

4.1 Chapter Overview

In this chapter all aspects of the testing of the experimental online catalogue are described and discussed. These include the design and setting of the experiment, the recruitment and testing of human subjects, and the specific test procedures and data collection methods employed. Appendixes A-G contain examples of the major procedural documents used in the experiment. The formation of three independent groups of subjects, one designated as the control group, is explained. The performance measures used to evaluate search results, including the familiar measures of recall and precision, are defined in this chapter. The discussion of the various test procedures is presented in the order followed in the actual test sessions. The chapter ends with a summary of the data collection methods used in the experiment.

4.2 Design of the Retrieval Test

4.2.1 Structure of the Experiment

Stated simply, the primary aim of the retrieval test was to compare the relative retrieval effectiveness of alternative navigation search and browse methods and their impact, if any, on users' subject search performance in online catalogues. One of the secondary aims was to investigate users' responses to, and the impact on search performance of, an online emulation of bookshelf browsing as it typically takes place in libraries. The main hypothesis tested was that the provision and use of a navigation search and browse function would significantly improve overall online catalogue retrieval effectiveness and the subject searching performance of online catalogue users.

In design, the test may be characterized as a multi-factor, multi-level comparison of three independent groups, with pair-wise comparisons intended. Human subjects were recruited to conduct subject searches on the test online catalogues in a controlled environment. Each subject used only one of the three different online catalogues tested for comparison purposes. Thus, the subject searching performance of three separate groups of searchers, each group using a different online catalogue, was measured and evaluated.

Group-1 and Group-2 (as they will be referred to in the following text and on data graphs) searched the online catalogues which featured navigation as a search method. The Group-1 OPAC allowed navigation only on the subject headings displayed with a document's citation. The Group-2 OPAC also allowed navigation, but only on key words from the title of a displayed document reference. Group-3 served as the control group and searched the OPAC lacking the navigation search capability. The control OPAC featured a conventional full-record display format. Thus, subjects in Group-3 were not permitted to navigate (and they were not told about this "missing" feature); that is, it was not possible for Group-3 searchers to point to a selected data element in a displayed citation to move on to related terms or citations linked to that data element.

Navigation, then, is the primary "treatment factor" or experimental variable of interest in this study. Three "levels" of this system factor were investigated: no navigation; navigation only on subject headings; and navigation only on title keywords. Thus, the original hypothesis must be refined and restated as two hypotheses, each referring to the specific type of navigation tested. Bookshelf-like browsing online is another independent variable of interest, but it was tested in a less rigorous manner than navigation.

Several performance measures, including recall and precision, were used to score the search performance of the individual searchers in each group. These scores provide the basis for evaluating and comparing the effectiveness of navigation-enhanced subject searching in improving users' subject search performance. Also, the search performance scores of those searchers who said they used the "BOOKSHELF BROWSING" option were compared to the scores of those who did not use this option.

A control treatment or group is incorporated into an experiment when the general effectiveness of the treatment factor(s) under study is not known, or when the factor is not expected to be equally and consistently effective in all its variations or levels. Prior to this study, it was not known if navigation would be effective in improving subject search performance in online catalogues, or if one method of navigation would be more or less effective than another. To assist in answering research questions like these, a control group is tested to provide a baseline of performance data against which the performance of the experimental groups can be compared and evaluated. The performance of the control group serves as a standard of comparison. The mean scores of the three groups on the various performance measures are compared. This makes it possible to determine not only the general superiority of one method over another, but also the relative degree of that superiority, if any.

In the planning stages of this experiment, it was decided that ANOVA and T-test procedures would be used to compare the mean scores of the groups and to ascertain if there were any statistically significant differences in these scores. The recruitment and selection of human subjects for the three groups was done in a manner to greatly reduce the chances of introducing "sample selection bias" into the experiment. After personal data was gathered for the participants in the study, Chi Square tests were performed to determine if the actual groups were comparable in makeup, and if the groups were truly independent samples.

4.2.2 Search Performance Measures Used

The performance measures used to analyze and evaluate the search results of individual searchers, and to provide a basis for the comparison of the overall performance of the three groups, are defined in the following paragraphs.

<u>SELECTS</u> - The number of documents retrieved and judged (i.e., "selected") by the searcher during the interactive search session to be "useful" to the chosen or assigned research task and topic. Note that this is not the number of relevant documents retrieved (difficult to ascertain in a browsing system), but the number of documents viewed and selected by the searcher as useful for the research task. By instruction, this selection decision was to be made only when the full citation for the document displayed, and the selection was implemented by the searcher pressing a function key labeled "Useful". (This resulted in the capture of the selected citation to a coded disk file for later analysis.)

<u>ZSCORE</u> - A transformed, standard score expressed as a deviation from the mean in standard deviation units, that is,

$$Z = \frac{x-\bar{x}}{\sigma}$$

The ZSCORE is a measure of the location of the original score within the particular distribution. Scores higher than the mean have positive ZSCORE values, and scores lower than the mean have negative ZSCORE values. Subjects in this experiment chose different topics for their first search task (one topic from among nine topic choices). Not surprisingly, the distributions of scores for each topic have different means and standard deviations. ZSCOREs permit the meaningful comparison of the scores achieved by searchers of these different topics. The original score transformed into a ZSCORE is the number of SELECTS for a given topic. In the data graphs, this first-search topic is labelled "TOPIC-A", and its measure, "ZSCORE-A".

N.B. RELEVANCE - the definitions of all other performance measures used in this study are derived from the meaning of relevance adopted for this study. Relevance, as a characterization of the relationship of particular documents to given research topics/tasks, is surely a subjective notion. It may also be a matter of degree; that is, one document may be judged somewhat relevant to a given topic, but may be more or less relevant to that topic than another document. The following quantitative measures of retrieval effectiveness and search success used in this study require both the consistent use of the concept of relevance and the determination of the relevance of particular documents in specific cases.

Relevance is defined here operationally. It is assumed that the concept centers on the utility of a document to the performance of a particular topic-task. Presented with the description of a particular task and topic (often loosely called the "information need") and the set of all documents SELECTed for that topic by searchers in the experiment, relevance assessments were obtained from experts in the topic area for each of the SELECTed documents. Furthermore, a three-point scale was applied by the experts to indicate the degree of relevance of particular SELECTed documents. 3 points were awarded to each document judged to be clearly and very relevant to the topic; 1 point was awarded to documents judged to be partially or possibly relevant; and 0 points were given to documents judged to have no relevance at all to the topic. Thus, documents awarded 3 points or 1 point comprise the set of "relevant" documents. These values are referred to as "relevance-points", and were used to calculate the Q-SCORES (see below).

<u>RELEVANT SELECTS</u> - SELECTed documents subsequently judged by subject experts to be relevant or partially relevant to a given topic. Printed lists of catalogue records for all documents selected by all searchers for a particular topic were given to subject experts for assessment on a three-point scale: R - for clearly and directly relevant to the topic, P - possibly relevant to some aspect of the topic, and N - not

relevant at all to this topic. Appendix - H contains the instruction sheet given to these judges.

<u>RECALL</u> - Recall as used in this study is an estimated, relative measure used for purposes of comparison. Where conventionally "recall" is defined as the proportion of relevant documents in the database retrieved, in this study RECALL is defined as the proportion of all RELEVANT SELECTS (for a given topic) selected by a particular searcher. This generally follows the practice of Saracevic and Kantor (1988) in their landmark study of online information seeking and retrieving, in which they define recall in this manner:

> *Recall was calculated only as a comparative measure for searches of the same question, but not for a question as a whole. It is a fraction of relevant or partially relevant (R + pR) items in a search in relation to all R + pR items in the union of all 9 searches for a question. An overall recall for a question cannot be established because we do not know what relevant items were left unretrieved in the file.*

<u>PRECISION</u> - Precision as used in this study is an estimated, relative measure. Where conventionally "precision" is defined as the proportion of retrieved documents that are relevant, in this study PRECISION is defined as the proportion of documents selected by a particular searcher that are RELEVANT SELECTS.

<u>FALLOUT</u> - Where conventionally "fallout" is the proportion of non-relevant documents in the database retrieved, in this study FALLOUT is defined as the proportion of the set of non-relevant (0-point) documents selected by all searchers selected by a particular searcher.

<u>Q-SCORE</u> - The sum of relevance-points of the documents selected (SELECTS) by a particular searcher. For example, if a searcher selected five documents, two of which were awarded 3 points, two of which were awarded 1 point each, and the fifth select was awarded no points (because it was assessed as not relevant), then the searcher's Q-SCORE for that topic-task would be "8" (the sum of two 3-pointers and two 1-pointers).

<u>E-SCORE</u> - After van Rijsbergen's E measure, a weighted combination of RECALL and PRECISION that provides a single measure of overall retrieval performance.

The E-SCORE ranges between 0 and 1; lower values of the E-SCORE indicate better performance. In formal terms, the E-SCORE is (P = precision; R = recall):

$$E - SCORE = 1 - \frac{1}{a(\frac{1}{P}) + (1-a)\frac{1}{R}}$$

Where:

$$\alpha = \frac{1}{\beta^2 + 1}$$

The value of the β parameter can be adjusted to give more weight to either recall or precision. When $\beta = 1$, equal weight is given to recall and precision. β may be set to a value higher than 1 if recall is considered more important than precision, and to less than 1 if more importance is placed on precision than recall. In short, the E-SCORE "measures the effectiveness of retrieval with respect to a user who attaches β times as much importance to recall as precision." (van Rijsbergen, 1979)

4.3 Setting and Participants in the Experiment

4.3.1 Setting and Conditions

The online catalogue experiment was conducted over a period of three weeks in the library of Sangamon State University at Springfield Illinois. Sangamon State University (SSU) is a small public university (4,500 students enrolled) which began in the 1960s as a non-residential, "upper division" institution specializing in public affairs (read, "government") education and related professional studies. "Upper division" refers to the level which students have attained in their university careers and includes 3rd and 4th-year students and students enrolled in Masters degree programs. In recent years Sangamon State has added many degree programs in the liberal arts and sciences, and enrolls students who are beginning their university education. Nonetheless, SSU largely retains its unique character as a non-residential, community institution which "provides innovative responses to the special needs of students of all ages" (Sangamon State University, 1989-90).

Many of the SSU students are adults who have already begun their employment or professional careers and have returned to university to resume earlier education programs or to undertake studies in special continuing education

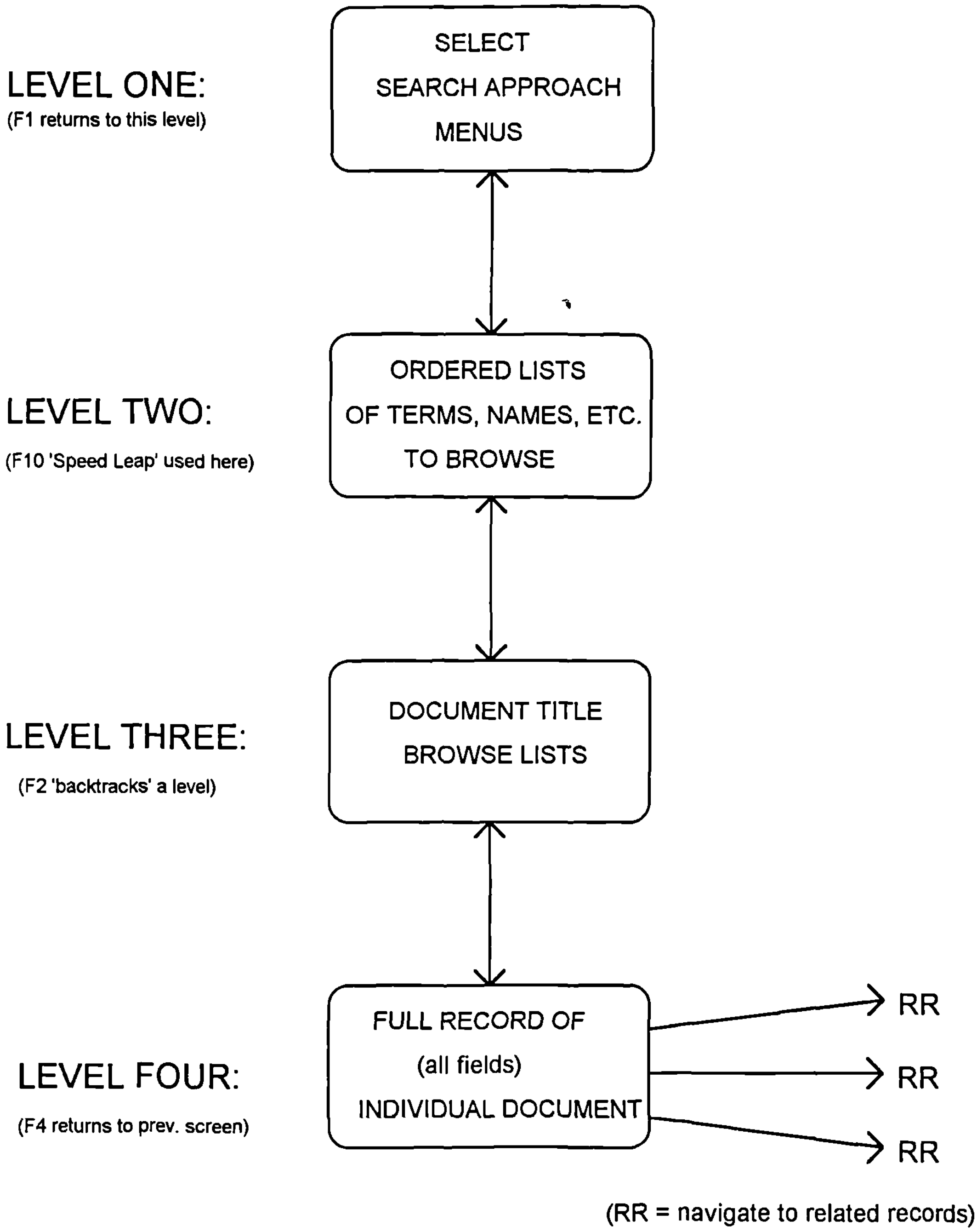


Figure 3.2 Experimental Online Catalogue Levels of Access

or professional support programs on a part-time basis. There is little on-campus housing at the university, and most of it is reserved for foreign students. Most SSU students commute from their homes or offices in the community to the university which is located on the edge of the City of Springfield.

Brookens Library is one of the few purpose-built, centrally-located buildings on the SSU campus. In addition to the library which occupies most of the 4-story building, there are classrooms and a small auditorium. The library is the primary place the commuting students spend their before and after-class time to meet with friends or to study.

Catalogue access to the library's collection is provided through online terminals to the statewide academic "LCS" circulation control and search system. This system contains the databases of more than 40 university and college libraries in the state of Illinois. Users may search the combined bibliographic and item status database by author, title, subject heading, or call number. In the menu-based interface presented to students, keyword searching and the use of Boolean operators is not supported. Library staff provide introductory training sessions for students who wish to avail themselves of this service. Computer-based access to periodical indexes is provided at CD-ROM search workstations, although this technology had been in place for only a short time at the university when this research study was conducted. These article-level indexes could not be searched from the OPAC terminals, as the systems were not linked in any way.

The experimental online catalogue was set up in a small library conference room reserved for the duration of this experiment. The microcomputer-based system was simply placed on the conference table and two chairs were provided, one for the test participant and one for the investigator who directed the initial stages of each session and administered the pre-search and post-search questionnaires. The only other items at the test workstation were the procedural documents (to be described in the next section) and a stand-up placard placed next to the microcomputer. This placard displayed a series of four small photographs which depicted a library user approaching the classified open bookstacks, selecting a range of shelves, and then viewing a small number of books shelved together on a single bookshelf.

4.3.2 Recruitment and Scheduling of Participants in the Experiment

Subjects were recruited for the experiment from among upper division undergraduate and first-year graduate students at the university. One-hour appointments were required for participation in the search tests. Initially, SSU faculty members were contacted and asked to encourage their students to volunteer for the research, and notices were placed on key bulletin boards at the library. These recruitment methods yielded only a few participants, who, as it turned out, were used in pilot testing. This pilot testing led to a streamlining of procedures. The decision was then made to offer a payment of ten dollars (about six pounds) to each participant in the study. A new call for participants, contained in Appendix-A, was published in the weekly campus newsletter, and flyers were posted on current information bulletin boards near several academic department offices around the university. These revised methods proved to be effective in recruiting a sufficient number of students for the experiment.

The scheduling of students for the test was placed in the hands of an administrative secretary at the library. Students could sign up for a single one-hour appointment on the day and time of their choosing. The one-hour slots were available from noon to nine o'clock in the evening, Monday through Thursday, and noon to four o'clock on Fridays and Saturdays. Neither the students nor the appointments secretary had any knowledge of the test OPACs or knew which of the three groups the students would be assigned to by the investigator. Evening and Saturday appointments were offered because students employed full-time generally came to the university at those times. Since the two groups or "blocks" of participants (daytime students and evening or weekend students) might differ in ways that could affect search performance scores, care was exercised in the assignment of subjects to each of the three groups to ensure a balanced mix of daytime and evening/weekend students in each test group.

The experimental design may be characterized as a restricted or haphazard randomization design (Neter, Wasserman, and Kutner, 1985). Sample selection bias was avoided in that "assignment" of human subjects to Groups 1, 2, and 3 was done in an entirely unsystematic, haphazard way. There was no self-selection of a group by any of the participants (recall that each group was defined by the particular OPAC it used). The subjects had no prior knowledge of the test OPACs or when each OPAC would be tested.

The intoduction of bias by the experimentor was avoided in that the experimentor did not know any of the participants (having no other role at the university) and did not schedule their appointments. Furthermore, there was no predetermined schedule for testing a particular OPAC or for changing over to another one, other than to use each of the three OPACs in roughly equal amounts of daytime and evening/Saturday time blocks. The objective was to test approximately twenty subjects on each of the three online catalogues. When 20-25 sessions were completed on a particular online catalogue, an overnight change was made in the software profiles to bring up another test OPAC for the following day's appointments. None of the subjects knew that more than one online catalogue was being tested and, thus, none knew they might be in the control group. The same test procedures were applied consistently to all subjects in all three groups. Only the "treatment factor," navigation (and the associated full citation display format), the primary independent variable of interest, varied from group to group.

4.4 Test Procedures and Data Collection Methods

4.4.1 Overview of Procedures and Data Collection Methods

The subjects who volunteered for the experiment were required to undertake two search tasks during the one-hour sessions, spending about 20 minutes on each task. The first task consisted of looking up "publications that will be useful in your preparation for and writing of an essay or term paper on the topic." In this first task, each subject was required to select one research topic from among a list of nine pre-selected topics. All subjects were required to complete this second search task: "Assume you are preparing to lead a series of class discussions on the topic below. Find the key books you would like to include on a list of recommended readings on the topic." All subjects were assigned the same new topic for the second search task (It was not one of the nine topics of the first search task.).

In each session, the subject was given a brief introduction to the study and a 10-minute "hands-on" demonstration of the OPAC to provide basic familiarity with the use of the system. Each subject completed an initial pre-search questionnaire and a post-search questionnaire. Figure 4.1 contains an outline of the test procedures and data collection methods, in the order followed in each session.

ONLINE LIBRARY CATALOG EXPERIMENT

OUTLINE OF TEST PROCEDURES

(Each subject session = 60 minutes)

1. Give subject brief written introduction to the study.
2. Have subject complete initial, written pre-search questionnaire.
3. Guide subject through "hands-on" demonstration search.
4. Give search topic selection sheet to subject. (Select one)
5. Give subject selected query "scratch" sheet.
6. Subject conducts search task #1 with no assistance from human monitor.
7. Give subject final "common" query "scratch" sheet.
8. Subject conducts search task #2 with no assistance from human monitor.
9. Have subject complete written post-search questionnaire.

Note: Subjects will be instructed to press the "blue <USE> key" (prints screen to disk) when they judge a citation to be useful to their queries.

Figure 4.1 Outline of Test Procedures

Upon entering the conference room at the appointed hour, the subject was asked to read the printed "INTRODUCTION" to the study (see Appendix-B). The purpose of this initial procedure was to provide all subjects the same background and orientation information on the project, and to place them somewhat at ease. It was important to inform them that their personal knowledge and search skills would not be tested or evaluated. It was hoped that this would help them to focus on the search topics and be less self-conscious about how well they used the computer system.The final paragraph of the "INTRODUCTION" describes the subject coverage of the catalogue database and the types of materials it includes. Online catalogue users seem to expect to find references to the periodical literature in the library catalogue. This potential misconception was addressed before the search tasks got underway.

4.4.2 Personal Data Collection: Pre-Search Questionnaire

After reading the "INTRODUCTION" document, each subject was asked to complete the brief questionnaire contained in Appendix-C. By this means, the desired descriptive data on each subject was gathered. This data is of two types: personal data, and library catalogue use data. The personal data collected included the subject's age, sex, grade level, major field of study, prior education (number of courses completed) in the fields of economics, business, administration, finance, etc. Catalogue use data included the subject's experience with and frequency of use of online computer library catalogues, and the subject's most frequent search needs and aims (see questions 9 and 10).

The personal and catalogue use data collected would be used to examine the influence, if any, of these factors (e.g., sex, university level, knowledge of the subject area) on search performance and participants' impressions of the experimental online catalogue, and to ensure that the three test groups were comparable in their make-up of subjects.

Much online catalogue use research indicates that most of the searching done is for information or materials on a subject or topic. Within the broader library profession, however, this issue of "known-item" vs. "subject" searching, namely, which type of search is most frequently conducted by searchers, is not settled. The purpose of questions 9 and 10 was to gather additional data pertinent to this issue.

4.4.3 Hands-on Training in System Use

Although the experimental online catalogue is easy to use with its self-guiding and self-explanatory user interface, it was desired to bring all test subjects up to the same level of familiarity with the system and competency in the use of the system to conduct searches. Pilot testing revealed that some users grasped the "mechanics" of using the system quite readily without assistance, while others displayed some anxiety and were hesitant to proceed on their own. When "talked-through" the basic steps and simple keyboard actions needed to conduct any search (e.g., how to point the selection arrow, how to scroll lists, how to back up), the latter group became equally comfortable with the system and eager to begin the test.

In this brief training (8-10 minutes) in system use, the subject sat directly at the workstation's keyboard and display monitor. The investigator/session monitor sat to the side. No printed materials were used. A search script had been developed and memorized by the investigator for this training purpose, and the script was followed consistenly with each subject in each group. The subject was asked to read the introductory screen (see Figure 3.11), then to begin a search as directed. When the main menu of search options appeared, the investigator told the subject which option to choose and how to use the keyboard to make selections. In this manner, the subject was orally guided through a search, using the browse and navigate techniques where appropriate. In this initial training, emphasis was placed almost entirely on teaching the subject the use of the keyboard - including the special function keys - to carry out searches and to move as desired among the "levels" of system interaction and displays. It was assumed that while doing this first guided-search, the subject would begin to get a "feel" for the online catalogue's dialogue style and search environment, and, in the case of subjects in Groups 1 and 2, acquire an operational understanding of searching by navigation.

One of the most important parts of this training for the experiment was the instruction in the use of the "USE-ful" key on the keyboard. The subject was instructed to press this key, located on the upper right of the keyboard, when and only when a single full bibliographic record retrieved and displayed on the screen was judged to be relevant ("useful" was the term actually used) to the research task and topic in which they were engaged. Subjects were told that this action would cause the record to be stored on disk, along with any others they judged and selected as useful during the search session. It was explained that this would enable the researcher to review the results of their search efforts, and to compare the records selected as "useful" by one subject to the records selected by other subjects.

The function key labeled "USE-ful" was actually the "Print Screen" key. A special software program converted the ordinary function of this key to a "save-to-disk" function. Each time the key is pressed, the contents of the screen are dumped to a named file on the disk. Later screen dumps are appended to the earlier ones.

Each participant in the experiment was assigned a uniquely-numbered file on disk. Each bibliographic record for a work judged and selected by a subject as useful for the defined research task was stored in the subject's file, <u>if the subject pressed the USE-ful key</u> when the full bibliographic record was displayed on the screen. For this reason, the importance of this action was emphasized during the initial training. Subjects were also assured that nothing disruptive would happen to the record displayed or to their current search when they pressed the USE-ful key. The subjects were guickly put at ease when they first tried it, seeing that the screen only flickered for a second and the record remained on display. Many of them said this was a good way to "mark" items found during their searches. At the beginning of each search task, subjects were once again reminded to press the USE-ful key when they found an item they thought would be useful to the search task at hand. The investigator explained that no other aspect of their searching would be monitored or recorded, and that each subject's file of selected and stored records would be identified only by a number.

4.4.4 First Search Task

When the brief training in the use of the system was completed, the subject was given a list of nine topics (see Appendix-D) along with the instruction which follows:

> *Choose the topic below (only one) in which you have the most interest. Then, use the experimental online catalogue to look up publications that will be useful in your preparation for and writing of an essay or term paper on the topic.*

The nine topics were grouped under these five general headings to help the subject focus on an area of interest: International Economics, History of Economic Thought and Economic Theory, Business Management and Organization, Public Finance, and Labor Economics. Most subjects picked a preferred search topic very quickly. No subject spent more than a minute or two reviewing this list before making a selection.

The subjects were given a list of topics from which to choose one of interest in order to strengthen their motivation to use the system in a sincere manner and to reduce somewhat the artificiality of the test situation. This situation was artificial in the sense that the research task was not a real one the students had to undertake in the course of their formal studies. Permitting them to search on any topic of personal interest would have made comparisons of search performance difficult or meaningless. It is highly unlikely that a search topic researched by a subject in one group would have matched one pursued by a subject in another group. As it turned out, nine topics was probably too many. Each of the nine topics was selected by at least one subject, but only two topics, numbers 3 and 5, were selected by enough subjects to permit meaningful statistical analysis across the three groups. In hindsight, it would have been more useful to limit the number of "first-search" topics to two or three. The intended and primary benefit of this first search task to the experiment was that it encouraged the subjects to search in a serious and interested way, and thus learn to exploit the system's features to search more effectively whatever the topic might be. This first search task can be viewed, then, as another preparatory, training step completed by all subjects before they undertook the second search task in which the topic was the same for all subjects in all three groups.

After subjects selected a topic from the list of nine for their first search task, they were handed a sheet of paper on which was printed only the text of the topic selected and these instructions (see Appendix - E for an example):

> This is the topic you have selected to research.
>
> Look up publications that will be useful in your preparation for and writing of an essay or term paper on the topic, publications that you would like to list at the end of this research paper.
>
> REMEMBER -- When you view a detailed description of a publication you think will be useful, press the blue <USE> key, then continue.

Subjects were told they could make notes on the blank part of the sheet. At this point in the test session, the investigator told subjects that they would have about 20 minutes to search on their own and that they would not be observed or monitored in any way during this period. The investigator then left the room.

4.4.5 Second Search Task

After 20 minutes had passed, the investigator reentered the room and directed the subject to stop searching on the first topic. The subject was then handed a sheet with the second search task and topic (see Appendix - F). Note that the task described is different than the first search task:

Assume you are preparing to lead a series of <u>class discussions</u> on the topic below. Find the <u>key books</u> you would like to include on <u>a list of recommended readings</u> on the topic.

The task assigned to each subject for the second and final search was to find some "key books" on the topic in order to prepare for leading class discussions and to compile a list of recommended readings. The assumption was that searchers would be more discriminating in selecting "useful" works as part of this search task than in the first "term paper" task.

All subjects were assigned the following topic for their second search task:

"Has there been a proportionate gain of women as top-level managers and executives in business? How do women executives and their male counterparts compare in levels of compensation? Have women executives been given as much decision-making responsibility as male executives?"

After informing the subjects that they would have about 20 minutes to conduct the search, the investigator again left the room. When the 20 minutes had elapsed, the investigator reentered the room to thank the subject for participating in the test and to administer the final, post-search questionnaire.

4.4.6 User Responses to the Experimental Online Catalogue: Post-Search Questionnaire

Appendix - G contains the post-search questionnaire each subject was required to complete. This brief questionnaire was designed with three aims in mind. The first was to gather data on the subject's use of the alphabetical term-browsing lists and the "BOOKSHELF BROWSING" search option (Questions 1-3). The second aim of the questionnaire was to give the subjects an opportunity to record their impressions of the experimental online catalogue (Questions 4 and 5). Questions 6 and 7 were included to elicit from subjects any suggestions they might have for improving the online catalogue, and, especially, suggestions for enhancements to the bibliographic record that would help a catalogue user determine the relevance or usefulness of a particular work.

4.5 Summary

The post-search questionnaire completed the data collection process for this study. This process consisted of four stages: 1) administering the pre-search questionnaire to gather personal data on each subject; 2) recording to disk subjects' search results (i.e., works selected by the searcher as "useful") for their first search task; 3) recording subjects' search results for the second search task; and 4) gathering data on subjects' use and impressions of the experimental online catalogue, and eliciting their suggestions for system improvements and enhancements to the bibliographic data record. The next chapter will report on the analysis of this data and discuss the findings of the experiment.

Chapter 5

Data Analysis and Test Results

5.1 Chapter Overview

This chapter presents the results of all the analyses performed on the data collected in this study. Many of the results of this data analysis are reported in tabular form, as well as discussed in the text. There were three sources of the data gathered for this analysis: the pre-search questionnaire, the post-search questionnaire, and the set of disk files which contained the SELECTS (bibliographic records) of "useful" documents made by each subject in the experiment. The pre-search questionnaire served to gather personal and catalogue use data. The post-search questionnaire recorded subjects' responses to the online catalogue they searched in the experiment, and their suggestions for enhancements or additions to the online catalogue.

The chapter contains five major parts. The first of these is a discussion of the initial review of the files of SELECTS made by the searchers in the tests. The compilation of sets of unique records for each subject and for each search task is discussed. The use of "experts" to assess and grade the relevance level of these original SELECTS is explained. The initial analysis of these SELECTS yields the frequency counts by task, topic, score, and group. This data is then used in the "overlap" analysis which discusses the degree of agreement among searchers in items selected, for each search task. The degree of agreement on relevant documents between the searchers and the secondary judges is also discussed.

The second major part of the chapter describes the design and creation of the database used to contain all the values (observations and tabulations) for the independent and dependent variables, and to support the various statistical analyses of this primary data.

The first results of this analysis provide information on the characteristics of the searchers (personal and catalogue use data) and of each of the three groups. Chi Square tests for homogeneity were conducted on the group data, and the results of these tests are discussed.

The fourth part of the chapter presents the results of the analysis of the search performance of the three groups. Summary statistics of all performance measures used in the study are reported for each group. This is followed by the results of the group performance score comparisons and the actual testing of the study's hypotheses. The findings of a correlation analysis of the recall and precision scores are also discussed.

The fifth and last part of the chapter reports on user responses to the experimental online catalogue. These responses were collected through the use of the post-search questionnaire.

5.2 Analysis of Search Results

5.2.1 Preliminary Analysis of Results

After the test sessions involving human subjects were completed, the data collected from the individual sessions were put in a form suitable for analysis. The responses of subjects to questions contained in the pre-search and post-search questionnaires were entered into a special database created to support statistical analysis of the data. This database and its use will be discussed in the sections that follow this section.

The disk files which held the "SELECTS" (documents judged to be "useful" for the research topic and task) of each subject for each of the two search tasks were printed for review and analysis. Initially, printouts were produced for 62 subjects. These printouts showed exactly what was displayed on the screen when the subject pressed the "USE-ful" key. In most cases, the full, detailed bibliographic record for a single document selected as useful was captured and recorded to disk. A look at these "SELECTS" files indicated that most subjects had understood the instruction in the use of the USE-ful key. The printed output of the subjects' SELECTS did, however, include other screen displays not useful for this analysis. A few subjects selected screens that contained multiple document titles. These screens had to be discarded as there was no way to determine which of the titles, if any, had been selected by the searcher.

This review and weeding process led to the rejection of eight subject's search results and the withdrawal of the eight subjects from the experiment. The reasons for this were based solely on the review of the contents of the subjects' disk files. Two subjects apparently never pressed the USE-ful key and were judged to be insincere searchers. During the tests, each subject was asked if he found any useful books. Each subject replied that they had found something. The other "rejects" used the USE-ful key indiscriminately. Thus, 54 test sessions were retained for analysis. Table 5.1 shows the total number of subjects by group.

Table 5.1 Total Number of Subjects By Group

GROUP	NO. OF SUBJECTS (n)
Group-1	22
Group-2	16
Group-3	16

Duplicate records (SELECTS), when they occurred, were weeded from each subject's file to produce a set of unique bibliographic records for each search task in each test session. Duplicate records for the same search task did not appear often in subjects' individual SELECTS files, but when this was discovered it was assumed that the searcher did not recall having selected the same document earlier in the search. When duplicate records appeared immediately together in the file, it was assumed that the searcher had mistakenly pressed the USE-ful key twice, or did so just to make sure the SELECT was recorded. For purposes of the tabulation of search performance scores, each unique record selected as useful in a search was counted only once. This elimination of "same-session" duplicates aided in the compilation of the list of all unique records selected by all subjects for each search topic. These lists were used by secondary "expert" judges to assess the relevance of the documents selected to the search topic and task. The weeding of same-session duplicates was also a prerequisite for conducting the overlap analysis of search results.

As explained previously, all 54 subjects were assigned the same search topic for their second search task (Task-B) in the test sessions. Thus, a total of 54 sets of Task-B search results were obtained from Group-1 (22), Group-2 (16), and Group-3 (16). For Task-A, subjects could choose any one of nine topics for their first search task in the test sessions. Table 5.2 shows the number of subjects who selected a particular Task-A topic, by group. Only one subject chose topic 9 for the first search, and that subject was among those withdrawn from the study.

Table 5.2 Task-A Topic Selection Totals By Group

GROUP / FREQUENCY / EXPECTED / TOT PCT / ROW PCT / COL PCT	TOPICA-NUM 1	2	3	4	5	6	7	8	TOTAL
1	4	2	4	4	5	1	2	0	22
	2.0	2.4	3.7	3.3	5.3	2.4	0.8	2.0	
	7.4	3.7	7.4	7.4	9.3	1.9	3.7	0.0	40.7
	18.2	9.1	18.2	18.2	22.7	4.5	9.1	0.0	
	80.0	33.3	44.4	50.0	38.5	16.7	100.0	0.0	
2	1	2	2	1	5	3	0	2	16
	1.5	1.8	2.7	2.4	3.9	1.8	0.6	1.5	
	1.9	3.7	3.7	1.9	9.3	5.6	0.0	3.7	29.6
	6.3	12.5	12.5	6.3	31.3	18.8	0.0	12.5	
	20.0	33.3	22.2	12.5	38.5	50.0	0.0	40.0	
3	0	2	3	3	3	2	0	3	16
	1.5	1.8	2.7	2.4	3.9	1.8	0.6	1.5	
	0.0	3.7	5.6	5.6	5.6	3.7	0.0	5.6	29.6
	0.0	12.5	18.8	18.8	18.8	12.5	0.0	18.8	
	0.0	33.3	33.3	37.5	23.1	33.3	0.0	60.0	
TOTAL	5	6	9	8	13	6	2	5	54
	9.3	11.1	16.7	14.8	24.1	11.1	3.7	9.3	100.0

The aim of the experiment was to compare search performance among the three groups, each group using a different online catalogue. Table 5.2 shows that only topics 3 and 5 were chosen and searched on by enough subjects in Task-A to attempt any meaningful comparisons across the three groups. Furthermore, the low numbers of searchers for topics 3 and 5 must temper the "findings" resulting from the statistical analysis of this Task-A data.

5.2.2 Secondary Relevance Judgments of SELECTS

While the number of unique SELECTS by a searcher on a topic was tabulated to provide a basic measure of retrieval effectiveness and search performance, a careful review of the session printouts of user-selected documents indicated that some of the selected documents were not likely to be relevant to the topic at all, and that some were far more likely to be relevant than others. This discovery occasioned the thought that the analysis of search results could be extended, and the comparison of group performances refined, if the documents selected as useful by the subjects were further assessed and "graded" by subject experts to provide data for additional measures of retrieval effectiveness and search performance.

Printed lists of bibliographic records were compiled containing all the unique records of documents selected as useful by all searchers of Task-A topics 3 and 5, and Task-B. These three lists may be thought of as bibliographies on their topics, bibliographies prepared by students. The bibliographic record of each document represented on one of these three lists was printed in the full record, labeled display format used in the Group-3 online catalogue. The order of documents records in the lists was random.

These lists were then given to pre-selected judges for further relevancy assessments. The selected judges, one for each topic, consisted of two university professors who taught in the topic area and a senior librarian who had bibliographic expertise in the topic area. Further review of these secondary assessments was made by this investigator, but none of the judges' decisions were altered.

Each judge was given the appropriate list of bibliographic records and a statement of the research topic identical to that presented to subjects during the tests (see Appendix-H). The instructions to each judge were as follows:

> In your review of the library book catalog records attached, please assess and mark each (to the right) as to the book's relevance to the above research topic.
>
> Use only this single-letter marking scheme:
>
> R - for clearly and directly relevant to the topic
>
> P - possibly relevant to some aspect of the topic
>
> N - not relevant at all to this topic
>
> <u>Please assign only one mark to each book</u>

The judges were asked to use only the list in hand to make their relevancy assessments.

As explained in the preceding chapter, section 4.2.2, the graded, marked results of these secondary relevance assessments were turned into numerical scores, using a three-point scale. Each document marked "R - for clearly and directly relevant to the topic" was awarded 3 points. Each document marked "P - possibly relevant to some aspect of the topic" was awarded a 1 point. "N" documents judged to have no relevance at all to the topic were each given 0 points. Documents awarded 3 points or 1 point by the judges comprise the set of relevant documents retrieved by all searchers on a particular topic.

In this analysis, these 1-point and 3-point documents are referred to as the "RELEVANT SELECTS." RELEVANT SELECTS is one of several measures used in this study to evaluate the search performance of the subjects and to compare the retrieval effectiveness of the three test OPACs. The measures of RECALL, PRECISION, FALLOUT, Q-SCORE, and E-SCORE defined for this study are all derived from the measure, RELEVANT SELECTS. The Q-SCORE, for example, is the sum of relevance points (1 or 3) of the documents selected (the SELECTS) by a particular searcher.

5.2.3 Overall Search Results: Overlap Analysis

Tables 5.3 - 5.5 report the total number of unique SELECTS, and the breakdown by relevance-points awarded, for Task-A, Topics 3 and 5, and for Task-B.

Table 5.3 Task-A, Topic 3 SELECTS

Relevance-points	No. of SELECTS	%
3	16	33.3
1	17	35.4
0	15	31.3
Total SELECTS =	48	100.0

Table 5.4 Task-A, Topic 5 SELECTS

Relevance-points	No. of SELECTS	%
3	17	31.5
1	19	35.2
0	18	33.3
Total SELECTS =	54	100.0

Table 5.5 Task-B SELECTS

Relevance-points	No. of SELECTS	%
3	46	27.2
1	68	40.2
0	55	32.5
Total SELECTS =	169	100.0

The first thing that comes to mind after viewing these tables is the large number and wide range of documents selected as useful for a particular research task or problem by different searchers. Analysis reveals that a mean number of 8.2 documents were selected by Topic-3 searchers (n=9); a mean number of 6.7 documents were selected by Topic-5 searchers (n=13); and a mean number of 7.7 documents were selected by Task-B searchers (n=54). Obviously, different searchers found and selected different sets of documents considered useful for the research task.

Of the 48 documents selected by searchers of Topic-3 (n=9), each of 37 were selected by no more than a single searcher. Only 2 of the 48 documents were selected by five or more searchers. Similar results were found for Topic-5 and Task-B. 43 of the 54 documents selected by searchers of Topic-5 were selected by no more than a single searcher. Only 1 document was selected by a majority of the Topic-5 searchers (n=13). In Task-B, each of 84 of the 169 selected documents were selected by no more than a single searcher (115 were selected by no more than two searchers). No single document was selected by a majority, or even half of Task-B searchers. The document most frequently selected was selected by only 15 searchers.

This low "overlap" or degree of agreement among documents retrieved and selected as useful by searchers of the same topic is similar to the findings of low overlap in "items retrieved" in the comprehensive study of document retrieval reported by Saracevic and Kantor (1988). The authors conclude that, "the degree of agreement or overlap in human decisions related to representing, searching, and retrieving of information is relatively low -- the agreement hardly reaches about one fourth or one third of the cases involved." The findings of the present study support this conclusion.

Saracevic and Kantor also found that "although searchers disagree substantially in the items they retrieve in searching the same question, when they do agree they are likely to be producing relevant items." This finding, too, seems to be confirmed by this study, albeit arrived at in a different manner. The mean number of subjects who selected 3-point, 1-point, and 0-point documents for each topic was tabulated (see Tables 5.6 - 5.8). This analysis revealed that those documents judged by the experts to be 3-point documents were selected by more searchers than selected 1-point and 0-point documents. In fact, documents judged by the experts as 3-point documents were 2-3 times more likely to be selected by the searchers than 1-point or 0-point documents.

Table 5.6 Mean No. of Selectors of Relevant Documents, Topic-3

Document Relevance Points	Mean No. of Selectors
3	2.10
1	1.41
0	1.13

Table 5.7 Mean No. of Selectors of Relevant Documents, Topic-5

Document Relevance Points	Mean No. of Selectors
3	2.94
1	1.00
0	1.00

Table 5.8 Mean No. of Selectors of Relevant Documents, Task-B

Document Relevance Points	Mean No. of Selectors
3	4.37
1	2.15
0	1.20

Saracevic and Kantor (1988) suggest that one "super-strategy" for the conduct of an online search would be to have several searchers search a topic or problem independently, and then to examine the intersection (overlap) of their retrieved sets to increase the probability of finding relevant items. This present study lends little support to the efficacy of this suggestion. For example, the top seven most-selected documents in Task-B were selected by only 15, 14, 13, 11, 9, 8, and 8 of the 54 searchers, respectively. (Recall that 46 documents were judged to be highly relevant.) A more effective strategy might be to identify the common class numbers or subject headings assigned to the documents selected by high numbers of searchers of the same topic, then to look for relevant documents in the sets of documents associated with these class numbers and subject headings.

This study revealed that searching on only 2 or 3 subject headings, or six class number areas, would retrieve most of the documents judged to be relevant for Task-B. The class numbers seem to focus with more specificity on aspects of the topic than do the Library of Congress Subject Headings. However, documents identified by these class numbers would be separately located in four different shelf areas in a large library. The subject headings, on the other hand, when used for retrieval, tend to bring together these scattered items. Thus, the search strategy described above (retrieval by relevant-document subject headings or class numbers), whether supported by navigation or not, can be sub-divided into two or more different strategies that could be followed separately, or in combination, depending on the needs and intent of the searcher.

Did these search results overlap findings and the findings regarding the level of agreement between searchers and experts on document relevance vary by group and OPAC used? This question is addressed by the data shown in Tables 5.9 - 5.11. In all three groups, searchers were more likely to select documents judged to be 3-point documents than documents judged to be 1-point or 0-point documents. Tables 5.9 - 5.11 contain three indicators of overlap (or lack thereof) by searchers in each of the three groups for Topic-3, Topic-5, and Task-B. These indicators are: number of unique SELECTS by all searchers in the group; proportion of unique documents selected by no more than a single searcher; and the average number of unique SELECTS per searcher in the group.

Table 5.9 Topic-3 Overlap By Group

Group	# Unique SELECTS	Avg./Searcher	% Selected by Single Searcher
1 (n=4)	28	7	82.1
2 (n=2)	20	10	90.0
3 (n=3)	12	4	91.7

Table 5.10 Topic-5 Overlap By Group

Group	# Unique SELECTS	Avg./Searcher	% Selected by Single Searcher
1 (n=5)	30	6	76.7
2 (n=5)	29	5.8	82.8
3 (n=3)	10	3.3	90.0

Table 5.11 Task-B Overlap By Group

Group	# Unique SELECTS	Avg./Searcher	% Selected by Single Searcher
1 (n=22)	109	4.95	58.7
2 (n=16)	74	4.63	68.9
3 (n=16)	74	4.63	64.9

These data indicate that for all three search tasks, Group-1 searchers display slightly more agreement in their SELECTS than do Group-2 and Group-3 searchers. But these differences between the groups are not great or consistent across all three tasks. Group-2 searchers seem to have higher agreement in their SELECTS than Group-3 searchers for Topic-3 and Topic-5, but not for Task-B.

Another way of comparing the overlap in SELECTS by searchers in the three groups is to calculate the proportion of searchers in each group that selected the "top" (i.e., most likely to be relevant) documents for a particular search task. For this analysis, the "top" documents were the seven most-selected documents by all Task-B searchers. Not surprisingly, all seven were graded as 3-point documents by the expert judges. Table 5.12 shows the results of these calculations for Task-B.

Table 5.12 Task-B Top-7 Document Selection Analysis By Group

Group	Number of Selectors	Avg.Selectors/ Top Doc.	% of Group
1 (n=22)	30	4.29	19.5
2 (n=16)	21	3.00	18.8
3 (n=16)	27	3.86	24.1

This analysis indicates that a larger proportion (24.1%) of Group-3 searchers selected the top-7 documents than searchers in Groups 1 and 2. However, this "lead" is not held by Group-3 when the top-document list is expanded to include the 17 most-selected documents for Task-B (all but one of which were judged by the experts to be 3-point documents). Table 5.13 shows these results.

Table 5.13 Task-B Top-17 Document Selection Analysis By Group

Group	Number of Selectors	Avg.Selectors/ Top Doc.	% of Group
1 (n=22)	47	2.76	12.5
2 (n=16)	38	2.24	14.0
3 (n=16)	28	1.65	10.3

The shift shown by this analysis in the proportion of a group's searchers who select the top documents, when the set of top documents is expanded to include more of the retrieved documents, suggests that greater recall was achieved by searchers in Groups 1 and 2 than by searchers in Group-3. On the other hand, perhaps greater precision was achieved by Group-3 searchers. The analysis of group-by-group performance scores which follows will provide more precise data that bear on these questions.

5.3 Creation of the Database for Statistical Analysis

The data collected from the pre-search and post-search questionnaires, and the data derived from the analysis of the SELECTS contained in each subject's disk files, was coded and entered into a structured database for purposes of analysis. A "Shareware" software product, KWIKSTAT, was used to create the database and to perform the various statistical analyses of the data. KWIKSTAT, created by Alan

Elliot (1991), is a statistical data analysis program which includes modules to support a variety of descriptive statistical analyses and a rich set of modules for performing inferential statistical analyses.

The study's database consists of 26 fields. 14 fields represent the independent variables of the study and 12 fields contain the values for the dependent variables. The entire database of 54 records (one for each subject retained for analysis) with the values for all fields is contained in Appendix-I. All the data values for the independent variables were gathered from the questionnaires. The values for the dependent variables, the search performance measures, were tabulated or calculated from the SELECTS data captured on disk files for each subject. The measures used in the evaluation include the number of unique SELECTS by each searcher for each search task, a transformed Z-SCORE for the results of the first search task, Task-A, RELEVANT SELECTS (e.g., REL_HITS_A), RECALL, PRECISION, Q-SCORE AND FALLOUT (for Task-B). Table 5.14 lists all the variables examined in the study and explains the coding used to enter the values for the variables into the analysis database.

Table 5.14 Independent and Dependent Variables Examined in the Study

Independent variables

1. GROUP -	group subject assigned to (coded 1,2, and 3)
2. SEX -	female or male (coded 0 and 1)
3. AGE -	four categories (20-25, 26-30, 31-40, 41+)
4. U-LEVEL -	undergraduate or graduate student (coded 0 or 1)
5. MAJOR -	area of study (coded E for economics or business, C
for	computer-oriented, O for other)
6. ECON-KNOW -	courses completed in economics, business, etc.
(coded	0 for less than 3, 1 for 3 or more)
7. OPACS-USED -	no. of OPACs previously used (coded 0 for none, 1
for	one, 2 for two or more)
8. USE-FREQ -	frequency of use of library computer catalogue
(coded	0 for no use, 1-4 for increasing frequency of
use - see	Appendix C)
9. SEARCH-AIM -	most used type of search, specific known item or subject search (coded KN or SU)
10. BOOK-KNOW -	when using the catalogue, how often do you know in advance specific books wanted? (coded A for always, M for most of the time, H for half the time, S for seldom, and N for never)
11. BS-BROWSE -	use BOOKSHELF BROWSE search option? (0 for
no,	1 for yes)
12. TERMFIND -	how often did you find a desired search term in the BROWSE lists? (A for always, M for most of the
time,	H for half the time, S for seldom, and N for never)
13. PROBLEMS -	number of difficulties in use of test OPAC listed (0
for	none, 1 for one, 2 for two or more)
14. TOPICA-NUM -	Task-A topic selected for the first search (1-9)

Dependent variables (previously defined)

15. SELECTS-A	21. RECALL_B
16. SELECTS-B	22. PRECIS'N_A
17. ZSCORE-A	23. PRECIS'N_B
18. REL_HITS_A	24. Q-SCORE_A
19. REL_HITS_B	25. Q-SCORE_B
20. RECALL_A	26. FALLOUT_B

Although by design the variable "GROUP" is the primary grouping variable for purposes of statistical analysis and the testing of hypotheses, with KWIKSTAT, any of the other independent variables may be designated as the grouping variable. When so used, the response categories of the independent variables would, then, identify the different groups. For example, those subjects who said they used the

BOOKSHELF BROWSING search option would comprise one "group" whose performance measures could be compared with the performance measures of all those in the "group" who said they did not use the BOOKSHELF BROWSING search method. This grouping feature was useful for evaluating and comparing the performance of categories of searchers within any one of the primary groups, 1, 2, or 3. To facilitate this sort of "within-group" analysis, three independent, smaller "subset" databases were created. These separate databases contained the values of Group-1, Group-2, and Group-3, respectively.

At a later stage in the analysis, three dependent variables and their values were added to the primary analysis database. These variables were the E-measures defined in chapter 4, and included the basic E-measure, the E-measure weighted toward recall and the E-measure weighted toward precision. Calculated for both Task-A and Task-B searches, these measures added six fields to the initial database.

5.4 Characteristics of Searchers and Groups

5.4.1 Personal and Catalogue Use Data

Tables 5.15 - 5.19 report the frequencies of observations for each of the personal variables for which data was collected: sex, age, university level, study major, and level of economic/business knowledge. Refer to Table 5.14 to review the definitions of these variables and their associated response categories. These data tables show a good balance among the human subjects who participated in the tests, although this investigator would have preferred to test a greater number of students from the economics and business departments.

Table 5.15 Frequencies: Sex

SEX	COUNT	%
Female (0)	29	53.7
Male (1)	25	46.3
Total	54	100

Table 5.16 Frequencies: Age

AGE	COUNT	%
20-25	16	29.6
26-30	19	35.2
31-40	15	27.8
41- +	4	7.4
Total	54	100

Table 5.17 Frequencies: University Level

UNIV - LEVEL	COUNT	%
Undergrad (0)	23	42.6
Graduate (1)	31	57.4
Total	54	100

Table 5.18 Frequencies: Major Area of Study

MAJOR	COUNT	%
Computer (C)	8	14.8
Economics (E)	11	20.4
Other (O)	35	64.8
Total	54	100

Table 5.19 Frequencies: Level of Economic Knowledge

ECON-KNOWL	COUNT	%
0-2 (0)	28	51.9
3 + (1)	26	48.1
Total	54	100

Data on each subject's use of online catalogues was collected via the pre-search questionnaire. Four variables represent this use data: opacs-used, use-frequency, search-aim most often pursued (i.e., search by a known item or by a subject), and book-knowledge, that is, how often when beginning a search are the specific books needed or desired known of in advance. Tables 5.20 - 5.23 report the frequencies of observations for each of the catalogue use variables. One of the more interesting findings regards the type of searching conducted at the online catalogue. 75.5% of the subjects reported that they usually search for materials or information on a topic. Also, 75.9% reported that in half or more of the times they search the catalogue they do not know in advance specific books that might satisfy their search needs. In other words, three-fourths of this sample of university students report that they usually search the online catalogue for yet to be discovered, unknown materials or information on a subject or topic.

Table 5.20 Frequencies: Number of OPACs Used

OPACS-USED	COUNT	%
None (0)	2	3.7
One (1)	32	59.3
Two or More (2)	20	37.0
Total	54	100

Table 5.21 Frequencies: OPAC Use Frequency

Use Frequency	COUNT	%
No use (0)	9	16.7
1-2X a term (1)	11	20.4
1-2X a month (2)	16	29.6
1-2X a week (3)	10	18.5
> 2X a week (4)	8	14.8
Total	54	100

Table 5.22 Frequencies: Known-item vs. Subject Search

Search Aim	COUNT	%
Known-item (KN)	13	24.5
Subject (SU)	40	75.5
Total	54	100

Table 5.23 Frequencies: Prior Book Knowledge

Book-Knowledge	COUNT	%
Always (A)	2	3.7
Mostly (M)	11	20.4
Half the time (H)	16	29.6
Seldom (S)	23	42.6
Never (N)	2	3.7
Total	54	100

Tables 5.24 - 5.26 report the frequencies of observations for three variables used to examine each subject's use of and response to the experimental online

catalogue. 92.6% of the subjects said that they found a desired search term in the index browsing lists either all the time (29.6%) or most of the time (63.0%). Most of the subjects (72.2%) expressed experiencing no "difficulties or confusions" in the use of the online catalogue, and no subject among the other 27.8% reported having more than one problem in the use of the online catalogue. Only 19 of the 54 subjects said they used the BOOKSHELF BROWSING option, but additional analysis suggests that those who did use it achieved better search results.

Table 5.24 Frequencies: Found Term in Browse Lists

Term-Find	COUNT	%
Always (A)	16	29.6
Mostly (M)	34	63.0
Half the time (H)	3	5.6
Seldom (S)	1	1.9
Never (N)	0	0.0
Total	54	100

Table 5.25 Frequencies: Experienced Difficulties or Confusion

No. of Problems	COUNT	%
None (0)	39	72.2
One reported (1)	15	27.8
Two or more (2)	0	0.0
Total	54	100

Table 5.26 Frequencies: Used BOOKSHELF BROWSING Option

BS-BROWSE	COUNT	%
No (0)	35	64.8
Yes (1)	19	35.2
Total	54	100

5.4.2 Characteristics of Groups and Tests for Homogeneity

The frequencies of observations for each of the personal and catalogue use variables were further analyzed on a group-by-group basis. These frequencies are reported in Tables 5.27 - 5.35. In addition to the frequencies, each table gives the results of the Chi Square test for the homogeneity of the three test groups. This test determines whether the values of the independent variables follow the same distribution in all three groups, that is, whether the three groups are homogeneous and comparable in makeup of subjects. These tests, conducted at a significance level equal to 0.05, indicate that the groups are comparable across all variables (i.e., p-value is > 0.05 in all cases). However, one variable, U-LEVEL, may be considered a borderline case. Group-1 has a significantly larger number of graduate students than Group-3. Since more graduate students have a higher knowledge of economics and business (measured by courses completed) than undergraduate subjects, this imbalance must be kept in mind when interpreting the results of the search performance measures applied to each group.

Table 5.27 Frequencies by Group: Sex

GROUP / SEX FREQUENCY EXPECTED TOT PCT ROW PCT COL PCT	0	1	TOTAL
1	10	12	22
	11.8	10.2	
	18.5	22.2	40.7
	45.5	54.5	
	34.5	48.0	
2	8	8	16
	8.6	7.4	
	14.8	14.8	29.6
	50.0	50.0	
	27.6	32.0	
3	11	5	16
	8.6	7.4	
	20.4	9.3	29.6
	68.8	31.3	
	37.9	20.0	
TOTAL	29	25	54
	53.7	46.3	100.0

CHI SQUARE = 2.15 with DF= 2 p-value = 0.343

Table 5.28 Frequencies by Group: Age

GROUP	FREQUENCY / EXPECTED / TOT PCT / ROW PCT / COL PCT	20-25	26-30	31-40	41-++	TOTAL
1	FREQUENCY	8	7	5	2	22
	EXPECTED	6.5	7.7	6.1	1.6	
	TOT PCT	14.8	13.0	9.3	3.7	40.7
	ROW PCT	36.4	31.8	22.7	9.1	
	COL PCT	50.0	36.8	33.3	50.0	
2	FREQUENCY	4	6	5	1	16
	EXPECTED	4.7	5.6	4.4	1.2	
	TOT PCT	7.4	11.1	9.3	1.9	29.6
	ROW PCT	25.0	37.5	31.3	6.3	
	COL PCT	25.0	31.6	33.3	25.0	
3	FREQUENCY	4	6	5	1	16
	EXPECTED	4.7	5.6	4.4	1.2	
	TOT PCT	7.4	11.1	9.3	1.9	29.6
	ROW PCT	25.0	37.5	31.3	6.3	
	COL PCT	25.0	31.6	33.3	25.0	
TOTAL		16	19	15	4	54
		29.6	35.2	27.8	7.4	100.0

CHI SQUARE = 1.17 with DF= 6 p-value = 0.978

Table 5.29 Frequencies by Group: University Level

GROUP	FREQUENCY / EXPECTED / TOT PCT / ROW PCT / COL PCT	0	1	TOTAL
1	FREQUENCY	6	16	22
	EXPECTED	9.4	12.6	
	TOT PCT	11.1	29.6	40.7
	ROW PCT	27.3	72.7	
	COL PCT	26.1	51.6	
2	FREQUENCY	7	9	16
	EXPECTED	6.8	9.2	
	TOT PCT	13.0	16.7	29.6
	ROW PCT	43.8	56.3	
	COL PCT	30.4	29.0	
3	FREQUENCY	10	6	16
	EXPECTED	6.8	9.2	
	TOT PCT	18.5	11.1	29.6
	ROW PCT	62.5	37.5	
	COL PCT	43.5	19.4	
TOTAL		23	31	54
		42.6	57.4	100.0

CHI SQUARE = 4.71 with DF= 2 p-value = 0.096

Table 5.30 Frequencies by Group: Major Area of Study

GROUP	MAJOR	C	E	O	TOTAL
1	FREQUENCY	2	6	14	22
	EXPECTED	3.3	4.5	14.3	
	TOT PCT	3.7	11.1	25.9	40.7
	ROW PCT	9.1	27.3	63.6	
	COL PCT	25.0	54.5	40.0	
2	FREQUENCY	3	1	12	16
	EXPECTED	2.4	3.3	10.4	
	TOT PCT	5.6	1.9	22.2	29.6
	ROW PCT	18.8	6.3	75.0	
	COL PCT	37.5	9.1	34.3	
3	FREQUENCY	3	4	9	16
	EXPECTED	2.4	3.3	10.4	
	TOT PCT	5.6	7.4	16.7	29.6
	ROW PCT	18.8	25.0	56.3	
	COL PCT	37.5	36.4	25.7	
TOTAL		8	11	35	54
		14.8	20.4	64.8	100.0

CHI SQUARE = 3.51 with DF= 4 p-value = 0.477

Table 5.31 Frequencies by Group: Level of Economic Knowledge

GROUP	ECON-KNOW	0	1	TOTAL
1	FREQUENCY	9	13	22
	EXPECTED	11.4	10.6	
	TOT PCT	16.7	24.1	40.7
	ROW PCT	40.9	59.1	
	COL PCT	32.1	50.0	
2	FREQUENCY	10	6	16
	EXPECTED	8.3	7.7	
	TOT PCT	18.5	11.1	29.6
	ROW PCT	62.5	37.5	
	COL PCT	35.7	23.1	
3	FREQUENCY	9	7	16
	EXPECTED	8.3	7.7	
	TOT PCT	16.7	13.0	29.6
	ROW PCT	56.3	43.8	
	COL PCT	32.1	26.9	
TOTAL		28	26	54
		51.9	48.1	100.0

CHI SQUARE = 1.91 with DF= 2 p-value = 0.386

Table 5.32 Frequencies by Group: Number of OPACs Used

GROUP / FREQUENCY / EXPECTED / TOT PCT / ROW PCT / COL PCT	OPACS-USED 0	1	2	TOTAL
1	1	13	8	22
	0.8	13.0	8.1	
	1.9	24.1	14.8	40.7
	4.5	59.1	36.4	
	50.0	40.6	40.0	
2	0	12	4	16
	0.6	9.5	5.9	
	0.0	22.2	7.4	29.6
	0.0	75.0	25.0	
	0.0	37.5	20.0	
3	1	7	8	16
	0.6	9.5	5.9	
	1.9	13.0	14.8	29.6
	6.3	43.8	50.0	
	50.0	21.9	40.0	
TOTAL	2	32	20	54
	3.7	59.3	37.0	100.0

CHI SQUARE = 3.59 with DF= 4 p-value = 0.465

Table 5.33 Frequencies by Group: OPAC Use Frequency

GROUP / FREQUENCY / EXPECTED / TOT PCT / ROW PCT / COL PCT	USE-FREQ 0	1	2	3	4	TOTAL
1	3	4	8	5	2	22
	3.7	4.5	6.5	4.1	3.3	
	5.6	7.4	14.8	9.3	3.7	40.7
	13.6	18.2	36.4	22.7	9.1	
	33.3	36.4	50.0	50.0	25.0	
2	1	5	4	2	4	16
	2.7	3.3	4.7	3.0	2.4	
	1.9	9.3	7.4	3.7	7.4	29.6
	6.3	31.3	25.0	12.5	25.0	
	11.1	45.5	25.0	20.0	50.0	
3	5	2	4	3	2	16
	2.7	3.3	4.7	3.0	2.4	
	9.3	3.7	7.4	5.6	3.7	29.6
	31.3	12.5	25.0	18.8	12.5	
	55.6	18.2	25.0	30.0	25.0	
TOTAL	9	11	16	10	8	54
	16.7	20.4	29.6	18.5	14.8	100.0

CHI SQUARE = 7.43 with DF= 8 p-value = 0.492

Table 5.34 Frequencies by Group: Known-item vs. Subject Search

GROUP	SEARCH-AIM	KN	SU	TOTAL
1	FREQUENCY	3	18	21
	EXPECTED	5.2	15.8	
	TOT PCT	5.7	34.0	39.6
	ROW PCT	14.3	85.7	
	COL PCT	23.1	45.0	
2	FREQUENCY	6	10	16
	EXPECTED	3.9	12.1	
	TOT PCT	11.3	18.9	30.2
	ROW PCT	37.5	62.5	
	COL PCT	46.2	25.0	
3	FREQUENCY	4	12	16
	EXPECTED	3.9	12.1	
	TOT PCT	7.5	22.6	30.2
	ROW PCT	25.0	75.0	
	COL PCT	30.8	30.0	
TOTAL		13	40	53
		24.5	75.5	100.0

CHI SQUARE = 2.65 with DF= 2 p-value = 0.267

Table 5.35 Frequencies by Group: Prior Book Knowledge

GROUP	BOOK-KNOW	A	H	M	N	S	TOTAL
1	FREQUENCY	0	7	3	0	12	22
	EXPECTED	0.8	6.5	4.5	0.8	9.4	
	TOT PCT	0.0	13.0	5.6	0.0	22.2	40.7
	ROW PCT	0.0	31.8	13.6	0.0	54.5	
	COL PCT	0.0	43.8	27.3	0.0	52.2	
2	FREQUENCY	0	5	5	2	4	16
	EXPECTED	0.6	4.7	3.3	0.6	6.8	
	TOT PCT	0.0	9.3	9.3	3.7	7.4	29.6
	ROW PCT	0.0	31.3	31.3	12.5	25.0	
	COL PCT	0.0	31.3	45.5	100.0	17.4	
3	FREQUENCY	2	4	3	0	7	16
	EXPECTED	0.6	4.7	3.3	0.6	6.8	
	TOT PCT	3.7	7.4	5.6	0.0	13.0	29.6
	ROW PCT	12.5	25.0	18.8	0.0	43.8	
	COL PCT	100.0	25.0	27.3	0.0	30.4	
TOTAL		2	16	11	2	23	54
		3.7	29.6	20.4	3.7	42.6	100.0

CHI SQUARE = 13.01 with DF= 8 p-value = 0.115

The group frequencies of the subjects' use of and response to the experimental online catalogue are reported in Tables 5.36 - 5.38. The Chi Square tests indicate no significant differences among the three groups with regard to the variables BS-BROWSE, TERMFIND, and PROBLEMS.

Table 5.36 Frequencies by Group: Used BOOKSHELF BROWSING option

GROUP	BS-BROWSE	0	1	TOTAL
1	FREQUENCY	12	10	22
	EXPECTED	14.3	7.7	
	TOT PCT	22.2	18.5	40.7
	ROW PCT	54.5	45.5	
	COL PCT	34.3	52.6	
2	FREQUENCY	11	5	16
	EXPECTED	10.4	5.6	
	TOT PCT	20.4	9.3	29.6
	ROW PCT	68.8	31.3	
	COL PCT	31.4	26.3	
3	FREQUENCY	12	4	16
	EXPECTED	10.4	5.6	
	TOT PCT	22.2	7.4	29.6
	ROW PCT	75.0	25.0	
	COL PCT	34.3	21.1	
TOTAL		35	19	54
		64.8	35.2	100.0

CHI SQUARE = 1.85 with DF= 2 p-value = 0.396

Table 5.37 Frequencies by Group: Found Term in Browse Lists

GROUP	TERMFIND	A	H	M	S	TOTAL
1	FREQUENCY	7	0	15	0	22
	EXPECTED	6.5	1.2	13.9	0.4	
	TOT PCT	13.0	0.0	27.8	0.0	40.7
	ROW PCT	31.8	0.0	68.2	0.0	
	COL PCT	43.8	0.0	44.1	0.0	
2	FREQUENCY	2	2	12	0	16
	EXPECTED	4.7	0.9	10.1	0.3	
	TOT PCT	3.7	3.7	22.2	0.0	29.6
	ROW PCT	12.5	12.5	75.0	0.0	
	COL PCT	12.5	66.7	35.3	0.0	
3	FREQUENCY	7	1	7	1	16
	EXPECTED	4.7	0.9	10.1	0.3	
	TOT PCT	13.0	1.9	13.0	1.9	29.6
	ROW PCT	43.8	6.3	43.8	6.3	
	COL PCT	43.8	33.3	20.6	100.0	
TOTAL		16	3	34	1	54
		29.6	5.6	63.0	1.9	100.0

CHI SQUARE = 9.10 with DF= 6 p-value = 0.171

Table 5.38 Frequencies by Group: Experienced Difficulties or Confusion

GROUP	PROBLEMS: FREQUENCY / EXPECTED / TOT PCT / ROW PCT / COL PCT	0	1	TOTAL
1	FREQUENCY	15	7	22
	EXPECTED	15.9	6.1	
	TOT PCT	27.8	13.0	40.7
	ROW PCT	68.2	31.8	
	COL PCT	38.5	46.7	
2	FREQUENCY	12	4	16
	EXPECTED	11.6	4.4	
	TOT PCT	22.2	7.4	29.6
	ROW PCT	75.0	25.0	
	COL PCT	30.8	26.7	
3	FREQUENCY	12	4	16
	EXPECTED	11.6	4.4	
	TOT PCT	22.2	7.4	29.6
	ROW PCT	75.0	25.0	
	COL PCT	30.8	26.7	
TOTAL		39	15	54
		72.2	27.8	100.0

CHI SQUARE = 0.30 with DF= 2 p-value = 0.860

5.5 Search Performance Analysis

5.5.1 Summary Statistics of Performance Scores By Group

To compare the retrieval effectiveness of the three online catalogues with regard to navigation on subject headings, navigation on title words, or the absence of the navigation feature (the control group's OPAC), several performance measures were employed. These measures yield a set of numerical scores that are quantitative measures of the results of the activity being investigated. A standard way of comparing scores across independent samples or groups is to calculate the mean performance scores and other measures of central tendency for each sample or group. Tables 5.39 and 5.40 report summary group performance scores for Task-A and Task-B.

Table 5.39 Task-A Summary Group Performance Scores

--------- GROUP = 1

FIELD	N	MEAN	STD	SEM	MIN	MAX	SUM
SELECTS-A	22	7.9	4.3	0.9	1	16	173
ZSCORE_A	22	0.0607	0.9473	0.2020	-1.6090	2.1300	1.3360
REL_HITS_A	9	7.1	3.6	1.2	2	14	64
RECALL_A	9	0.2054	0.1022	0.0341	0.0560	0.3890	1.8490
PRECIS'N_A	9	0.8066	0.1359	0.0453	0.6250	1.0000	7.2590
Q-SCORE_A	9	16.0	8.2	2.7	4	34	144

--------- GROUP = 2

FIELD	N	MEAN	STD	SEM	MIN	MAX	SUM
SELECTS-A	16	8.8	4.1	1.0	1	16	141
ZSCORE_A	16	0.3270	0.6797	0.1699	-1.3020	1.1740	5.2320
REL_HITS_A	7	5.6	3.2	1.2	1	10	39
RECALL_A	7	0.1607	0.0941	0.0356	0.0280	0.3030	1.1250
PRECIS'N_A	7	0.7531	0.2860	0.1081	0.1820	1.0000	5.2720
Q-SCORE_A	7	13.3	7.3	2.8	3	22	93

--------- GROUP = 3

FIELD	N	MEAN	STD	SEM	MIN	MAX	SUM
SELECTS-A	16	8.1	10.7	2.7	1	45	130
ZSCORE_A	16	-0.4107	1.0236	0.2559	-1.6160	1.9340	-6.5720
REL_HITS_A	6	3.8	1.9	0.8	1	6	23
RECALL_A	6	0.1120	0.0572	0.0233	0.0280	0.1820	0.6720
PRECIS'N_A	6	0.9250	0.1173	0.0479	0.7500	1.0000	5.5500
Q-SCORE_A	6	9.2	4.5	1.9	3	16	55

Table 5.40 Task-B Summary Group Performance Scores

--------- GROUP = 1

FIELD	N	MEAN	STD	SEM	MIN	MAX	SUM
SELECTS-B	22	8.5	4.1	0.9	2	18	186
REL_HITS_B	22	7.4	3.7	0.8	2	16	162
RECALL_B	22	0.0645	0.0326	0.0070	0.0180	0.1400	1.4200
PRECIS'N_B	22	0.8810	0.1286	0.0274	0.6250	1.0000	19.3830
Q-SCORE_B	22	14.7	6.9	1.5	2	27	324
FALLOUT_B	22	0.0198	0.0232	0.0049	0	0	0

--------- GROUP = 2

FIELD	N	MEAN	STD	SEM	MIN	MAX	SUM
SELECTS-B	16	7.0	4.2	1.1	2	16	112
REL_HITS_B	16	5.8	4.5	1.1	1	15	92
RECALL_B	16	0.0505	0.0394	0.0098	0.0090	0.1320	0.8080
PRECIS'N_B	16	0.7667	0.2392	0.0598	0.2000	1.0000	12.2670
Q-SCORE_B	16	13.5	11.6	2.9	1	43	216
FALLOUT_B	16	0.0227	0.0217	0.0054	0	0	0

--------- GROUP = 3

FIELD	N	MEAN	STD	SEM	MIN	MAX	SUM
SELECTS-B	16	7.3	5.6	1.4	2	25	116
REL_HITS_B	16	5.9	3.0	0.7	1	12	94
RECALL_B	16	0.0516	0.0258	0.0065	0.0090	0.1050	0.8250
PRECIS'N_B	16	0.8884	0.1929	0.0482	0.4400	1.0000	14.2140
Q-SCORE_B	16	13.4	6.7	1.7	1	26	214
FALLOUT_B	16	0.0250	0.0638	0.0159	0	0	0

Several measures of search performance or retrieval effectiveness are used because optimal performance, or "search success," is not a singular and absolute attainment. Retrieval effectiveness and good search performance are relative to the requirements and search aims of the user. Alternative measures of "good" or optimal performance are needed to evaluate retrieval systems, search strategies, and search results. Effective retrieval involves bringing to the user proportions of the set of all documents likely to be relevant to that user's task or problem, according to one or more measures of effectiveness that satisfy the user's search requirement and support his search aim or objective. Van Rijsbergen (1979) recognized this, in part, and wrote, "When we have assumed that effectiveness is determined by precision and recall we have committed ourselves to the importance of proportions of documents rather than absolute numbers".

A user who wants to retrieve all documents likely to be relevant in any way to his interest or problem task may wish to have different system features or search strategies "optimized," than a user who wants only the few key documents most likely to be relevant to his interest or problem. As Van Rijsbergen (1979) has noted, "users may attach different relative importance to precision and recall," depending on their information requirements and the nature of their research tasks. Furthermore, much information retrieval research has indicated that "trade-offs" between recall and precision may have to be made to satisfy different user requirements. Why this is the case is not clear. Does this condition hold for all retrieval systems and searchers? The research reported by Saracevic and Kantor (1988) found that no negative linear relationship existed between recall and precision in the search results they measured and analyzed. In fact, their data on 360 separate searches showed a weak but positive relationship (correlation = 0.16) between recall and precision: "as one rose slowly, so did the other." The findings on recall and precision in the present study, discussed in the next section, are in line with the Saracevic and Kantor findings.

For Task-A (Table 5.39), if the "raw" uninterpreted performance of the test searchers is to be examined (i.e., the SELECTS), the score to compare across groups is the ZSCORE-A. The ZSCORE is preferred to the SELECTS statistic because the Task-A subjects searched on eight different topics. Some of the topics may have been more complex than others, or the database may have contained unequal numbers of documents relevant to the various topics. The ZSCORE (as explained in Chapter 4, Section 4.2.2) is a "within topic" measure; it is a measure of the location of the subject's score (in this case, the number of SELECTS) within the distribution of scores for a particular topic. The ZSCORE permits the meaningful comparison of the scores achieved by the searchers of the eight different topics of Task-A, each subject's first search task.

In looking at Table 5.39, recall that the measures of REL_HITS (SELECTS awarded either 3 points or 1 point by the experts), RECALL, PRECISION, and Q-SCORE, were calculated only for searches on Topics 3 and 5. This explains the smaller "N" totals for these measures. For all measures of Task-A search results except precision, Group-1 and Group-2 results are superior to Group-3's. Precision was highest in Group-3, and suffers most in Group-2. However, Group-2 achieved the highest ZSCORE. On recall and the Q-SCORE, Group-1 searchers achieved the best results.

The ZSCORE was not needed as a measure of comparative performance in Task-B, as all subjects searched on the same topic. The degree of difference among the group performances along most measures is much smaller for Task-B than the Task-A statistics indicated. There is little difference between group mean scores in SELECTS, RECALL and Q-SCORE. However, precision is highest in Group-3 and suffers somewhat in Group-2. Yet, fallout (the proportion of non-relevant documents retrieved and selected by all searchers) is the highest (lower fallout scores are better) in Group-3. This relationship between precision and fallout values in Group-3 for Task-B was not expected, and it is somewhat puzzling. Precision was nearly as high in Group-1 as Group-3, but Group-1's fallout statistic was much lower (better) than Group-3's.

The data graphs illustrated in Figures 5.1 - 5.6 show the group mean search performance scores in a manner which permits easy comparison of the groups.

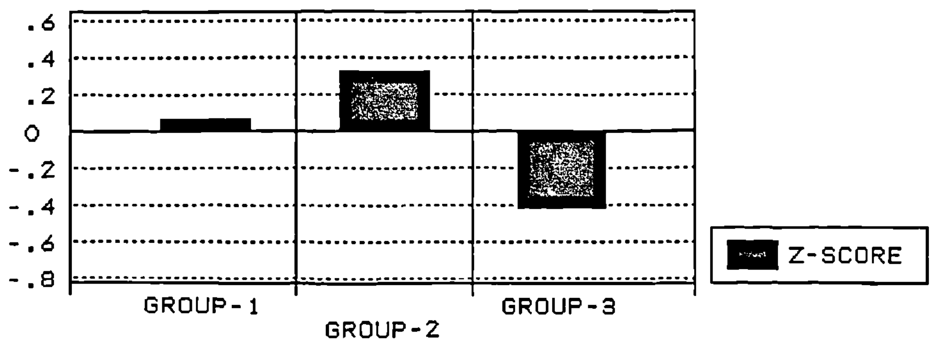


Figure 5.1 Mean ZSCORES, Task-A SELECTS by Group

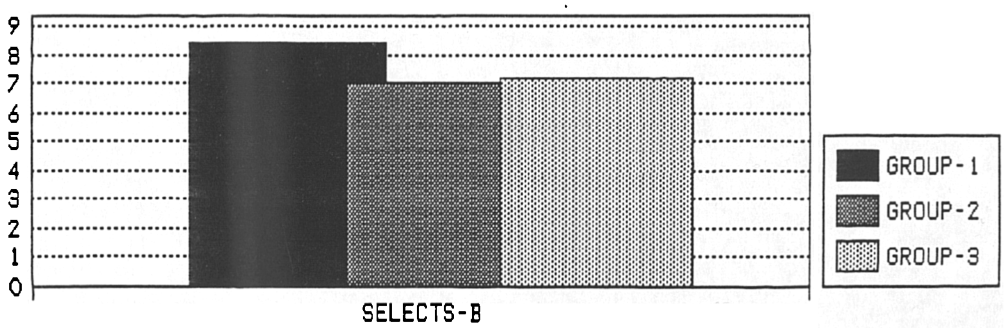


Figure 5.2 Mean Task-B SELECTS by Group

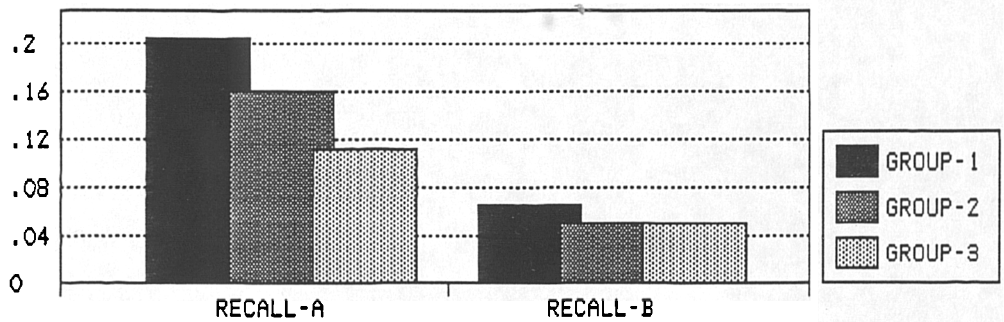


Figure 5.3 Mean Recall Scores by Group and Task

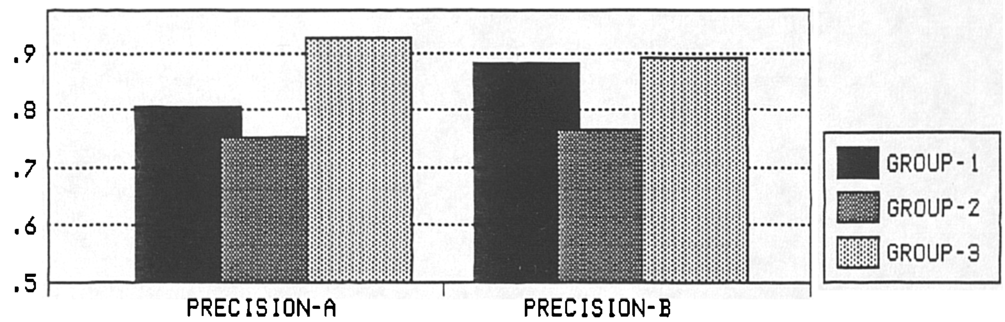


Figure 5.4 Mean Precision Scores by Group and Task

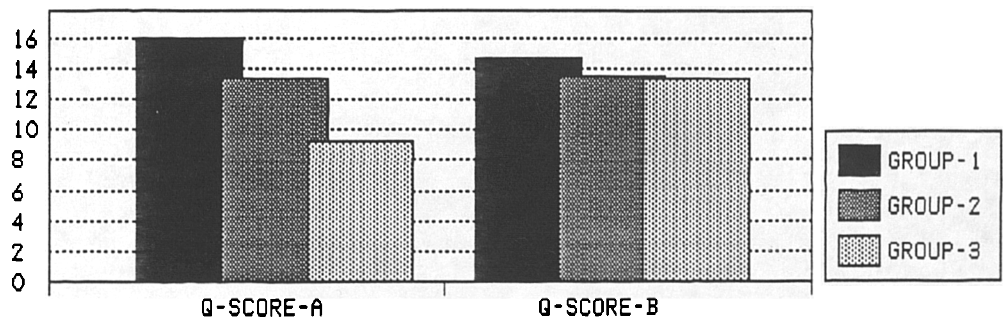
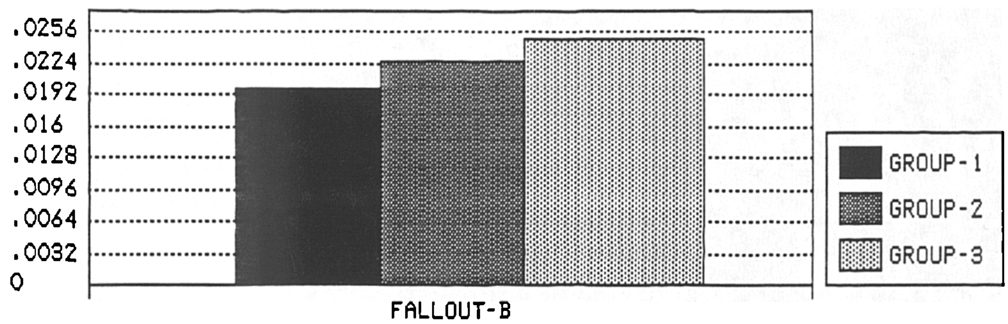


Figure 5.5 Mean Q-SCORES by Group and Task



(Lower fallout values indicate better performance)

Figure 5.6 Mean Task-B Fallout Scores by Group

Analysis of the search results was also performed using Van Rijsbergen's (1979) E measure, a weighted combination of recall and precision that provides a single measure of overall search performance. The "E-SCORE" was calculated for each subject's search task results. The E-SCORES range in value from 0 to 1; lower values of E indicate better performance. In the calculation of the E-SCORE, adjustments can be made to give more weight to either recall or precision. More weight is given to recall, for example, if we wish to compare performance optimized for this measure.

Van Rijsbergen introduced the β parameter for the E measure. Values can be assigned to this parameter to indicate relative effectiveness of retrieval in terms of recall or precision.

> *What we want is therefore a parameter (β) to characterise the measurement function in such a way that we can say: it measures the effectiveness of retrieval with respect to a user who attaches β times as much importance to recall as precision.*

When the β parameter is 1, equal weight is given to recall and precision. "It corresponds to a user who attaches equal importance to precision and recall." When β is 2, for example, the measure is appropriate for users who attach twice as much importance to recall as precision. When β is 0.5, the measure is appropriate for users who value (require, perhaps?) recall only one-half as much as precision, that is, for these users, precision in search results is twice as important as recall.

Table 5.41 reports the E-SCORES for Task-A and Task-B, respectively. Each table contains three measures: the equally weighted E-SCORE (β = 1, recall and precision are considered equally desirable), the E score weighted (β = 0.5)for precision (e.g., E-PRECSN-A), and the E score weighted (β = 2) for recall (e.g., E-RECALL-B).

Table 5.41 Average E Scores by Group, Task-A and Task-B

	Task-A			Task-B		
	E-PRECSN-A	ESCORE-A	E-RECALL-A	E-PRECSN-B	ESCORE-B	E-RECALL-B
β =	0.5	1.0	2.0	0.5	1.0	2.0
Group-1	0.51840	0.68308	0.76124	0.76045	0.88152	0.92111
Group-2	0.60350	0.74613	0.81179	0.81019	0.90700	0.93823
Group-3	0.64145	0.80413	0.86488	0.80192	0.90455	0.93684

According to these measures (a lower E score is better), on Task-A, Group-1 performed better than Group-2, and Group-2 performed better than Group-3. On Task-B, the performance of all groups was about the same, with a slightly better performance by Group-1 when the E measure is weighted for a recall preference. The main advantage of Group-1's navigation by subject heading feature appears to be relatively higher precision than achieved by the other groups, as indicated by the Group-1 E-PRECSN-A and E-PRECSN-B values in Table 5.41.

Figures 5.7 - 5.9 provide a graphical comparison of the group ESCORES. The apparent advantage of Group-1 and Group-2's navigation search feature in increased recall on Task-A did not hold for Task-B, the second search conducted by each subject.

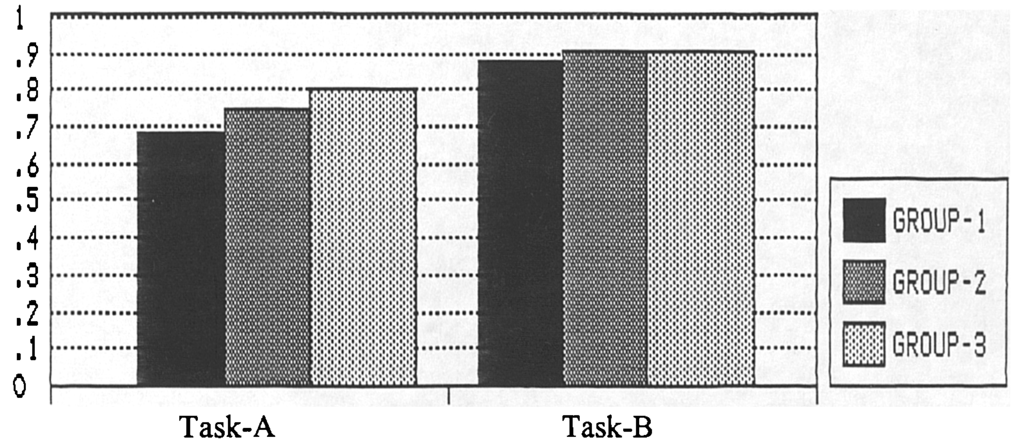


Figure 5.7 ESCORES by Group and Task

[N.B. Group-1: navigation only on subject hdgs.; Group-2: navigation only on title words; Group-3: no navigation]

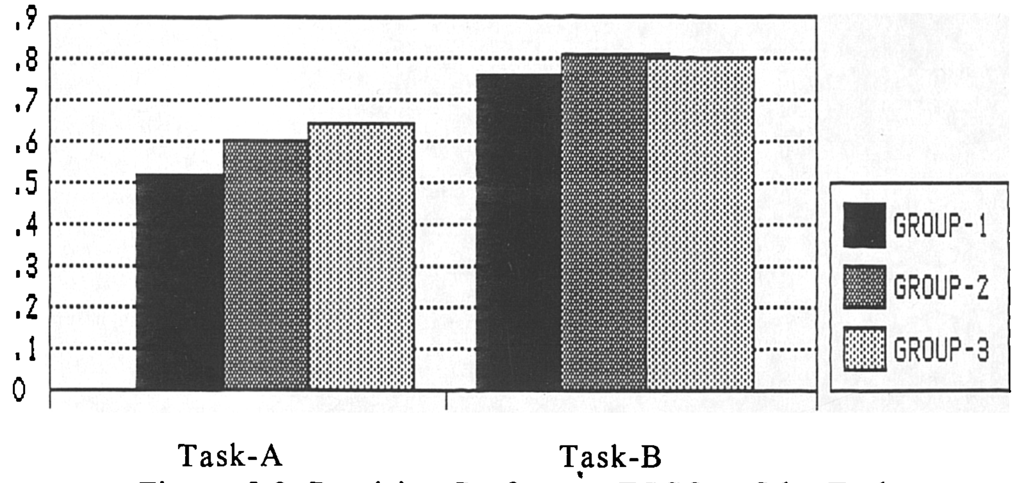


Figure 5.8 Precision-Preference ESCORES by Task

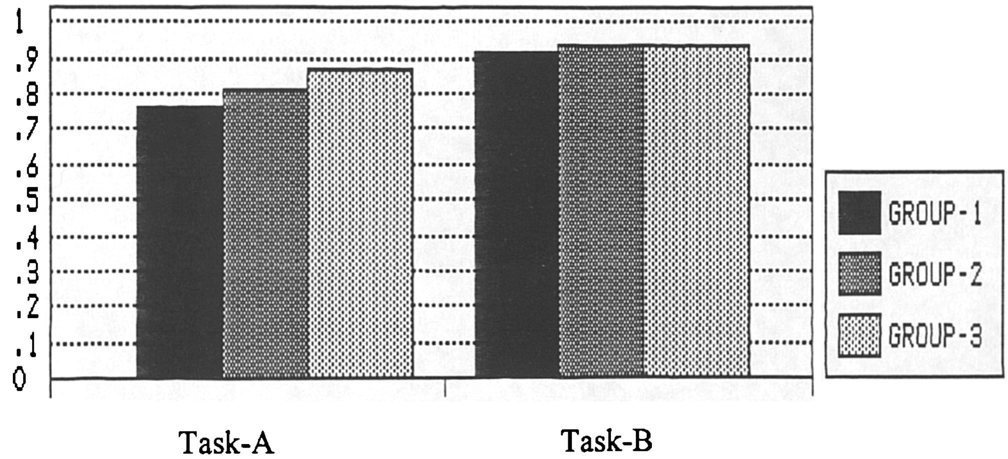


Figure 5.9 Recall-Preference ESCORES by Task

Online bookshelf browsing was a variable of considerable interest in this study. This search option was included on the MAIN MENU, and subjects were encouraged to try it by suggestive prompts which appeared on a number of display screens. How many subjects would choose to use this search option? What would be their responses to this feature? On the post-search questionnaire, subjects were asked if they had used the BOOKSHELF BROWSING option, and, if not, why not. Those who said they tried it were also asked to comment on it. 19 (35.2%) of the 54 subjects reported that they had used this search option. Table 5.36 is repeated here to show the distribution of this response across the 3 groups.

Table 5.36 Frequencies by Group: Used BOOKSHELF BROWSING option

```
GROUP       BS-BROWSE
FREQUENCY|
 EXPECTED|
 TOT PCT |
 ROW PCT |
 COL PCT |      0|      1|   TOTAL
-------------------------
        1|     12|     10|     22
         |   14.3|    7.7|
         |   22.2|   18.5|   40.7
         |   54.5|   45.5|
         |   34.3|   52.6|
-------------------------
        2|     11|      5|     16
         |   10.4|    5.6|
         |   20.4|    9.3|   29.6
         |   68.8|   31.3|
         |   31.4|   26.3|
-------------------------
        3|     12|      4|     16
         |   10.4|    5.6|
         |   22.2|    7.4|   29.6
         |   75.0|   25.0|
         |   34.3|   21.1|
-------------------------
TOTAL          35      19      54
             64.8    35.2   100.0
```

All of the comments in response to the BOOKSHELF BROWSING questions on the post-search questionnaire, and all the other responses gathered by this questionnaire are contained in Appendix-J.

Tables 5.42 and 5.43 report summary performance statistics for all browsers and non-browsers. Note that although the mean number of SELECTS is about the same for browsers and non-browsers in both search tasks, both the recall and precision scores of the browsers are higher than those of the non-browsers, in both tasks.

Table 5.42 Summary Statistics for Browsers and Non-Browsers, Task-A

--------- BS-BROWSE = 0

FIELD	N	MEAN	STD	SEM	MIN	MAX	SUM
SELECTS-A	35	8.1	7.7	1.3	1	45	285
ZSCORE_A	35	-0.0855	0.8926	0.1509	-1.6160	1.9340	-2.9920
REL_HITS_A	14	4.4	2.6	0.7	1	10	61
RECALL_A	14	0.1275	0.0772	0.0206	0.0280	0.3030	1.7850
PRECIS'N_A	14	0.8122	0.2417	0.0646	0.1820	1.0000	11.3710
Q-SCORE_A	14	10.4	5.9	1.6	3	22	145

--------- BS-BROWSE = 1

FIELD	N	MEAN	STD	SEM	MIN	MAX	SUM
SELECTS-A	19	8.4	4.5	1.0	1	16	159
ZSCORE_A	19	0.1573	1.0047	0.2305	-1.6090	2.1300	2.9880
REL_HITS_A	8	8.1	3.0	1.1	4	14	65
RECALL_A	8	0.2326	0.0853	0.0302	0.1210	0.3890	1.8610
PRECIS'N_A	8	0.8388	0.0789	0.0279	0.7270	1.0000	6.7100
Q-SCORE_A	8	18.4	7.0	2.5	10	34	147

Table 5.43 Summary Statistics for Browsers and Non-Browsers, Task-B

--------- BS-BROWSE = 0

FIELD	N	MEAN	STD	SEM	MIN	MAX	SUM
SELECTS-B	35	7.4	5.1	0.9	2	25	259
REL_HITS_B	35	6.0	3.8	0.6	1	15	209
RECALL_B	35	0.0525	0.0332	0.0056	0.0090	0.1320	1.8360
PRECIS'N_B	35	0.8320	0.1888	0.0319	0.4400	1.0000	29.1190
Q-SCORE_B	35	13.0	8.7	1.5	1	43	455
FALLOUT_B	35	0.0260	0.0454	0.0077	0	0	1

--------- BS-BROWSE = 1

FIELD	N	MEAN	STD	SEM	MIN	MAX	SUM
SELECTS-B	19	8.2	3.5	0.8	2	16	155
REL_HITS_B	19	7.3	3.7	0.8	1	16	139
RECALL_B	19	0.0641	0.0323	0.0074	0.0090	0.1400	1.2170
PRECIS'N_B	19	0.8813	0.1940	0.0445	0.2000	1.0000	16.7450
Q-SCORE_B	19	15.7	7.7	1.8	1	27	299
FALLOUT_B	19	0.0153	0.0213	0.0049	0	0	0

Does this advantage hold within groups, for both search tasks (6 cases)? In Group-1, both recall and precision are higher for the browsers than for the non-browsers. Recall scores are higher for browsers in all cases. In Task-A, however, the non-browsers in Group-3 had much higher precision scores than the browsers (95% to 80%). In Task-B, the non-browsers in Group-2 had higher precision scores than the browsers (78% to 73.7%).

Tables 5.44 and 5.45 permit a comparison of the ESCOREs of browsers and non-browsers for Task-A and Task-B. In Task-A, browsers had a large advantage over non-browsers in terms of precision. This precision advantage seems to hold for Task-B as well.

Table 5.44 Avg. E values for browsers and non-browsers, Task-A

B =	0.5	1.0	2.0
Browse-Yes	0.46608	0.64342	0.73011
Browse-No	0.64359	0.78914	0.84872

Table 5.45 Avg. E values for browsers and non-browsers, Task-B

B =	0.5	1.0	2.0
Browse-Yes	0.75939	0.88188	0.92161
Browse-No	0.80272	0.90350	0.93585

Figures 5.10 and 5.11 graphically illustrate the mean ESCORES and mean Q-SCORES for Task-A and Task-B:

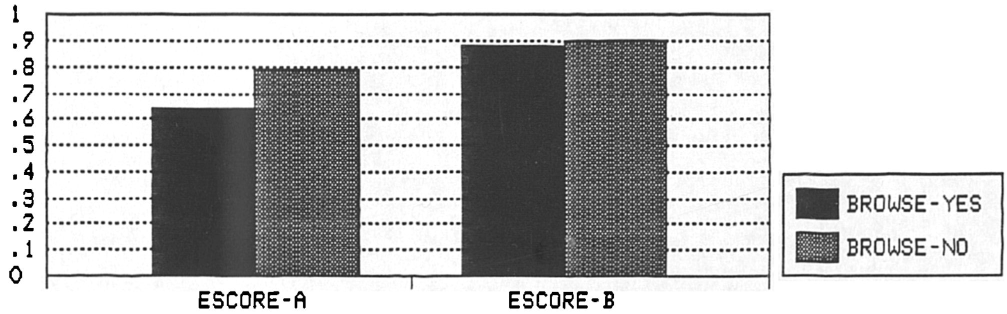


Figure 5.10 Mean Browser and Non-Browser ESCORES for Task-A and Task-B

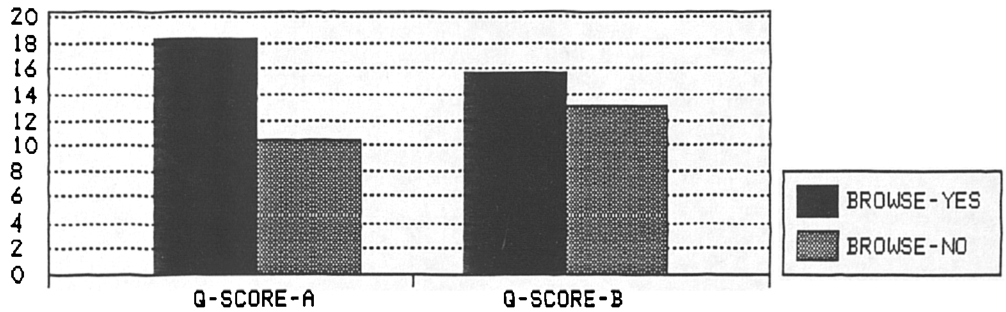


Figure 5.11 Mean Browser and Non-Browser Q-SCORES for Task-A and Task-B

5.5.2 Results of Group Performance Score Comparisons

The hypotheses tested in this study all derive from the primary objective to compare and evaluate the retrieval effectiveness of the three online catalogues used by Groups 1,2 and 3. Simply stated, the hypotheses were that both the Group-1 and Group-2 online catalogues would be superior in retrieval effectiveness to the Group-3 (the control group) online catalogue, which had no navigation feature. In addition, it was hypothesized that Group-1 would perform better than Group-2.

The measures used for this evaluation are measures of the search performance, under controlled conditions, of the users of these three online catalogues. Two common ways of comparing the performance of experimental groups is to compare the mean or median scores of the groups. For many measures, a higher mean score or value indicates better performance. This is true for the measures used in this study, except for the ESCORE and FALLOUT measures. Lower values for these measures indicate better performance.

The summary statistics by Task and Group indicate that by most measures, Groups 1 and 2 outperformed Group-3 on Task-A (see for example, the ZSCORE-A and Q-SCORE-A results). Smaller differences in performance between Group-1 and Group-2 on Task-A are indicated. On Task-B, however, the mean scores for all groups seem to be very close, except Group-2's precision scores are noticeably lower than Group-3's. Overall on Task-B, Group-1 appears to have performed only slightly better than either Group-2 or Group-3.

To determine whether any of these differences in group performance (and by implication, retrieval effectiveness) are significant enough to permit acceptance of any of the hypotheses outlined above, statistical tests were conducted to compare the means of the groups and to determine the existence (if any) of significant differences among the means of the groups. For all measures, analysis of variance (ANOVA) tests were used to compare the means among all three groups. T-tests were used to compare the mean scores of one group with another. Since a normal distribution of scores could not be assumed for some of the measures (e.g., precision), non-parametric procedures (the Mann-Whitney test) were used for comparing these scores between any two groups. Non-parametric procedures use the ranks of the data values within groups and test whether there are differences in the medians of the groups.

When all three groups were analyzed together, the ANOVA tests indicated no statistically significant differences among the means of the groups when tested at the 0.05 significance level. That is, there was not sufficient evidence to reject the null hypothesis -- namely, that there would be no significant differences in performance among the three groups (and, hence, no difference in the retrieval effectiveness of their online catalogues) -- at the 0.05 significance level. The ANOVA tests indicated, as shown in Table 5.46, that at a slightly higher level of significance (0.073), a significant difference exists in the mean ZSCORE_A scores (the standardized Task-A SELECTS) among the three groups.

Table 5.46 Results of ANOVA on Group ZSCORE_A's

```
-------------------------------------------------------------------------------
Independent Group Analysis Summary                                CHMAIN92.dbf
-------------------------------------------------------------------------------
Grouping variable is GROUP
Analysis variable is ZSCORE_A

Group Means and Standard Deviations

1: mean= 6.072729E-02           s.d.= .9473333           n= 22
2: mean= .327                   s.d.= .6796778           n= 16
3: mean=-.41075                 s.d.= 1.023607           n= 16


Analysis of Variance Table

Source                S.S.       DF          MS          F         Appx P
---------------------------------------------------------------------------
Total                45.98       53
  Treatment           4.49        2         2.25        2.76      0.073
  Error              41.49       51         0.81
```

This lead was followed-up by conducting T-tests to compare mean scores of all performance measures between Groups 1 and 3, 2 and 3, and 1 and 2. The T-tests confirmed a statistically significant difference between the performance of Groups 2 and 3 on Task-A as measured by the ZSCORE (p=.023). That is, as measured by their number of SELECTS, Group-2 subjects performed better on Task-A than subjects in Group-3 (see Table 5.47).

Table 5.47 Results of T-test on ZSCORE_A's of Groups 2 and 3

```
-------------------------------------------------------------------------------
Independent Group Analysis Summary                                GRUP2&3.dbf
-------------------------------------------------------------------------------
Grouping variable is GROUP
Analysis variable is ZSCORE_A

Group Means and Standard Deviations

2: mean= .327                   s.d.= .6796777           n= 16
3: mean=-.41075                 s.d.= 1.023607           n= 16

Test for equality of variance: F=  2.27      p=0.062   DF= 15 , 15


  Equal variance:Calculated t=    2.40 with   30   D.F.        p=0.023

Unequal variance:Calculated t=    2.40 with   26.0 D.F.        p=0.024
```

On all other measures, the T-tests indicated no other significant differences in performance between Groups 2 and 3.

Additional T-tests indicated no statistically significant differences between the mean scores of Groups 1 and 3, on either Task-A or Task-B, at the 0.05 significance level. That is, at this level, there is not sufficient evidence to reject the null hypothesis that Group-1's online catalogue is not more effective than Group-3's, Thus, the claim cannot be made that the Group-1 online catalogue is superior to the control online catalogue. If the significance level is raised, say, to 0.10, one could claim (with greater risk of being wrong) that on Task-A, topics 3 and 5, according to the measures of Q-SCORE-A, RECALL-A and ESCORE-A, Group-1 subjects performed significantly better than subjects in Group-3. Even at this relaxed level of significance, however, it cannot be claimed on the basis of any of the performance measures that Group-1 performed better than Group-3 on Task-B.

Considering all performance scores for both Task-A and task-B, The T-tests indicate only one significant difference in performance between Groups 1 and 2. Group-2 had the lowest precision scores on Task-B. By the measure of precision, Group-1 performed significantly better than Group-2 on Task-B. Group-3 also had higher Task-B precision scores, on average, than Group-2, but the difference in the group means was not statistically significant at the 0.05 significance level.

The Mann-Whitney tests indicated no significant differences in scores between Groups 1 and 2, and no significant differences between any groups on Task-B. The significant difference between Group-2 and Group-3 in the number of Task-A SELECTS (Group-2 is better) was confirmed again (see Table 5.48). Mann-Whitney does indicate that, according to the Q-SCORE measure, Group-1 performed significantly better than Group-3 on the first search task (see Table 5.49).

Table 5.48 Results of Mann-Whitney Tests on Group-2 and Group-3 Task-A ZSCORES

```
------------------------------------------------------------------------------
Non-Parametric Independent Group Comparison                       GRUP2&3.dbf
------------------------------------------------------------------------------

Group variable = GROUP   Observation variable = ZSCORE_A

Mann-Whitney U =         187.50

Rank sum group 2    =     323.5    N =    16   Mean Rank =   20.22
Rank sum group 3    =     204.5    N =    16   Mean Rank =   12.78

Significance may be estimated using the z statistic.
Z =    2.241      p= 0.025
```

Table 5.49 Results of Mann-Whitney Tests on Group-1 and Group-3 Task-A Q-SCORES

```
-------------------------------------------------------------------------------
Non-Parametric Independent Group Comparison                        GRUP1&3.dbf
-------------------------------------------------------------------------------

Group variable = GROUP   Observation variable = Q-SCORE_A   Missing= 23

Mann-Whitney U =         44.00

Rank sum group 1    =     89.0   N =    9  Mean Rank =    9.89
Rank sum group 3    =     31.0   N =    6  Mean Rank =    5.17

Significance may be estimated using the z statistic.
Z =    1.998      p= 0.046
```

5.5.3 The Correlation Between Recall and Precision

In much information retrieval research it has been observed that an inverse relation exists between recall and precision. It has not been uncommon for data analyses of the search results in experimental studies to indicate a strong negative linear relationship between recall and precision. That is, as one goes up, the other goes down. Some go so far as to say that this inverse relationship is one of the established "principles" of information retrieval, and that its implications should be taught to all prospective searchers of online or CD-ROM databases.

The search results data in this study indicate the opposite relation between recall and precision. Figures 5.12 and 5.13 provide scatter plots of precision and recall for all subjects' Task-A and Task-B search results. The linear regression lines are plotted for recall as the independent variable and precision as the dependent variable.

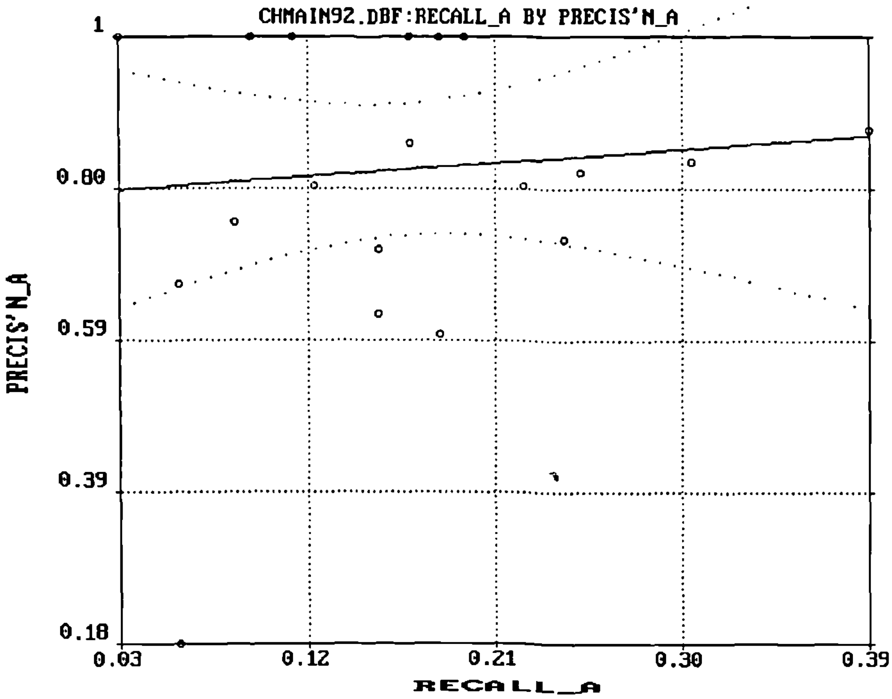


Figure 5.12 Plot for Precision and Recall for All Task-A, Topic 3 and 5 Searches (n=22)

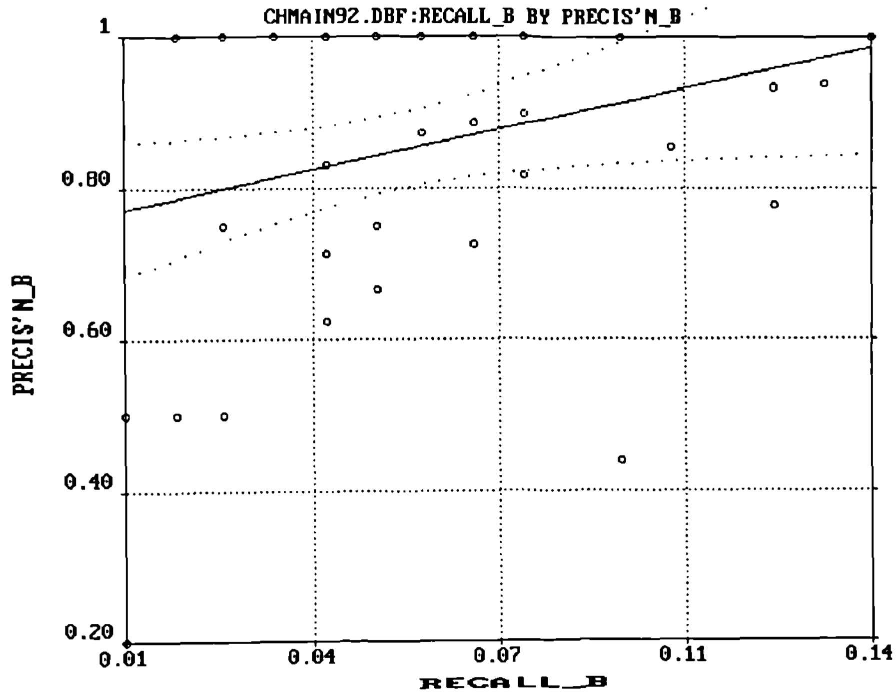


Figure 5.13 Plot for Precision and Recall for All Task-B Searches (n=54)

These results were not anticipated. The correlation (Pearson's r) between precision and recall for Task-A is .096, and for Task-B the correlation is .284. Both the Task-A and Task-B results show a positive, direct relationship between precision and recall, and for Task-B, the relationship is fairly strong. As precision increased, so did recall, and vice versa.

These results were obtained from plotting the recall and precision scores of all test subjects from all groups, with no accounting for the particular group to which they belonged. Would these relationships hold when correlation and linear regression analyses were performed separately on the recall and precision scores of each group? The analysis of the Task-A search results showed a weak to moderate *positive* linear relationship between precision and recall for all three groups (Group-1: r = .2505, Group-2: r = .2494, Group-3: r = .1626).

When correlation analysis was performed separately on the Task-B recall and precision data from each group, a fascinating discovery was made. Figures 5.14 - 5.16 provide the scatter plots of precision vs. recall for the Task-B results of Group-1, Group-2, and Group-3, respectively. The precision - recall relationship is weak but positive for Group-1 (r = 0.1120). For Group-2, the relationship is positive and strong (r = 0.6114). For Group-3, however, the relationship between precision and recall is *negative* but somewhat weak (r = -0.1617). When precision went up in the control Group-3 scores, there was a slight tendency for recall to go down.

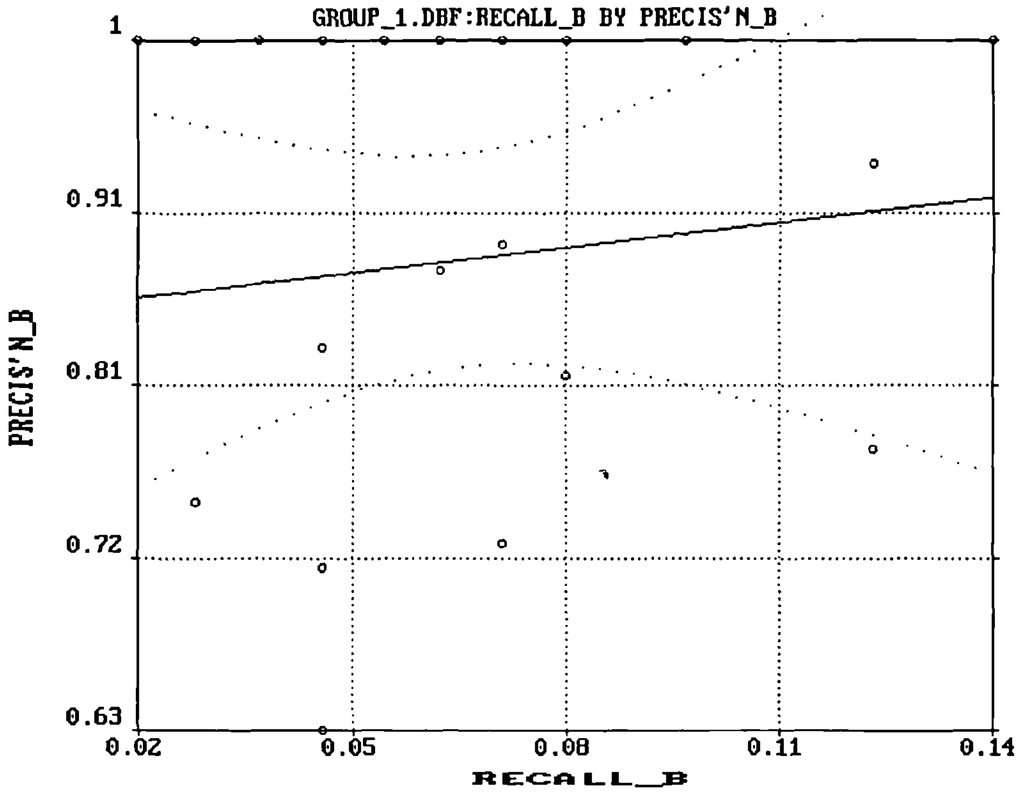


Figure 5.14 Plot of Group-1, Task-B Precision and Recall Scores

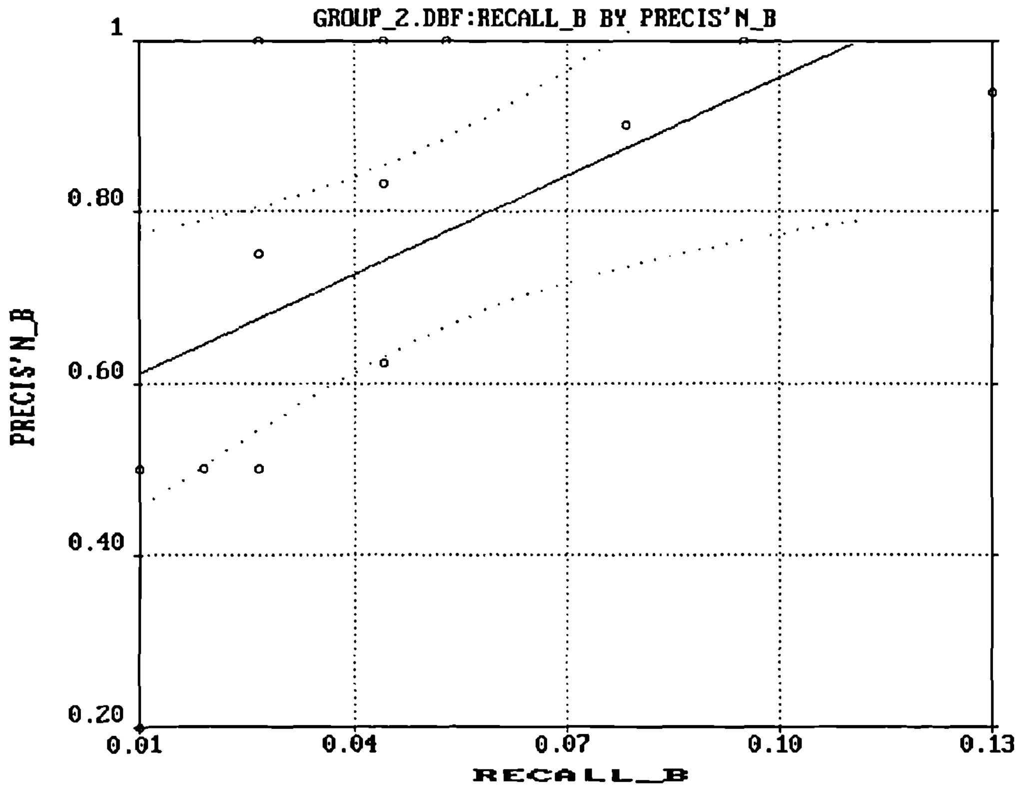


Figure 5.15 Plot of Group-2, Task-B Precision and Recall Scores

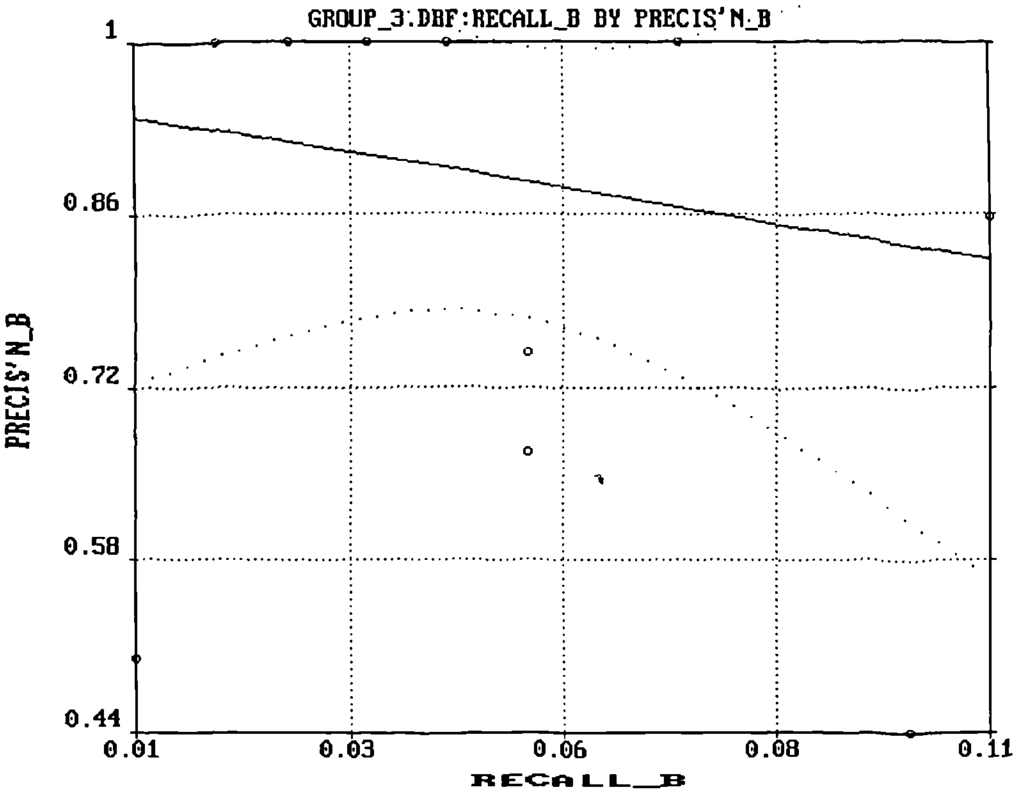


Figure 5.16 Plot of Group-3, Task-B Precision and Recall Scores

To sum up, analysis of the search performance data of Groups 1 and 2 indicated a positive linear relationship between recall and precision. In Group-2's Task-B results, that positive relationship was very strong. Analysis of Group-3's results indicated a positive but weak relationship between recall and precision for Task-A (the weakest "positive" of the three groups). For Task-B, the relationship was negative and somewhat weak. These findings suggest that navigation may be a determining factor in improving search performance by boosting recall without a proportionate decrease (i.e., "tradeoff") in precision. Alternatively, navigation may play a role in eliminating or minimizing the decrease in recall which seems to accompany an increase in precision in both conventional and probabilistic document retrieval systems.

5.6 User Responses to the Experimental Online Catalogue

The post-search questionnaire (see Appendix-G) was used to gather data on several items of interest regarding the use of the online catalogue, problems encountered in its use, and suggestions from users for improvements to the online catalogue or the bibliographic data record. Appendix-J contains the results of all the data collected using this instrument. The responses to the first two questions are summarized in a graphic manner. For the remainder of the open-ended questions (3 - 7), Appendix-J contains a transcript of all the comments written by all subjects in response to these questions

Users reported having little difficulty finding a "desired" search term in the term browse lists. 92.6% of them said they found the desired search term all (29.6%) or most (63%) of the time. This supports the view that it easier to recognize a suitable search term than to think of one or to recall one that might match a term in the system (but seldom does).

Users' reactions to the BOOKSHELF BROWSING feature were generally positive. This search and browse approach was highlighted in the initial "hands-on" training. A greater proportion (45.5%) of subjects in Group-1 said they used this search option than subjects in Groups 2 (31.3%) and 3 (25.0%). Asked to comment on this option, most subjects who used it had favorable opinions. These responses fall into two categories: some subjects stated that shelf browsing was their customary and preferred way of searching; others said the feature was new to them and they liked it. Some representative comments from the online bookshelf browsers follow:

Sub. 14: Yes. I liked it because it browses a "bookshelf" as I do, in hopes of finding "an angle" previously unthought of.

Sub. 34: Yes. This is one of the most frequent methods I employ, so it was helpful to me. This is an option I did not know I was missing on the School's system.

Sub. 36: Yes. Able to spot titles I wasn't aware of before. I am used to going down the stacks in a given area.

Sub. 60: Yes. If you found a book of interest you could look at the call number to see if there were others on the same topic.

Sub. 11: Yes. Prompted new ideas. Immediately showed the richness of an area

Sub. 24: Yes. I liked how it showed me books that are related and would be on the shelf upstairs - like being "there".

Sub. 45: Yes. Neatly arranged by subject just as in library - uncanny!

The comments of those who said they did not use the BOOKSHELF BROWSING search option fall into four categories: 1) it was an unfamiliar way of searching for books and/or it was not their usual method; 2) they did know specific call numbers or the classification scheme used; 3) they found the other search options "quicker," "easier to use," "more convenient," or "more efficient;" and 4) there was not enough time in the test session to try it but they would have liked to use it.

Reflecting their North American background, most of the non-users seemed to be unfamiliar with or uncomfortable with a classified approach to searching, or they preferred the other subject and title search methods. Some comments from the non-shelf browsers follow:

Sub. 12 No. More complicated - more reading through information.

Sub. 17: No. Because I was not able to get to the subject I was searching for very quickly.

Sub. 44: No. That's not my usual method of research.

Sub. 71: No. I was still looking through search topics and different terms. This is the technique I use most of the time. Bookshelf browsing is a technique that usually doesn't come to mind until I'm in the library stacks. If on a computer, I could get into the habit of using it and it would probably become routine.

Sub. 33: No. I was following specific subject leads concerning the topics I was tracing. I found in this search no need to browse as I found much of my needs fulfilled in my search. I would however use browse often.

Sub. 58: No. It is not for people to use. It's only for the library to organize the books.

4. Did you encounter any particular difficulty or confusion while using this computer catalog? Please describe:

Two-thirds of the respondents to this question said "no" or "none." The difficulties described by only a few searchers were of two kinds: 1) confusion about which of three labeled function keys to use to backup a level, return to the previous screen, or return to the MAIN MENU, and 2) finding the best search term or combination of search terms. Vocabulary deficiencies in the system's indexes (e.g., no term combinations in the keyword index and no cross-references) and bibliographic records were mentioned as shortcomings of the catalogue.

Overall, the subjects found the system easy to use and reported very few problems.

5. What did you like most about this computer library catalog?

Generally, the subjects were very positive in their reactions to the experimental online catalogue, even enthusiastic. What they said they liked most about the computer catalogue was that it was easy to learn and easy to use (most mentioned); it was fast, speedy, productive, and time-saving (second most mentioned quality); its advantages over the card catalogue; its "browse list approach;" and its "clues" to, or "branching out" to additional topics or related documents. Some of the more thoughtful comments follow:

Sub. 12: Very easy to use and the increased subject search ideas were great!

Sub. 23: "Subject Groups" under title references helped me confirm or reject the title as being on my subject. I also used these listings to branch out.

Sub. 26: It is very easy to use, and you are connected to the subject index while you are seeing a bibliographic reference on the screen. Also the "speed leap" search.

Sub. 70: It is much easier to use than a conventional card catalog. It makes it much easier to change the perspective of the search.

Sub. 33: I didn't have to play with cards in catalog, didn't have to jot down search numbers. Many options are afforded to use at the punch of a key.

Sub. 52: Not having to remember and punch in many letters. Using arrow keys instead, and browsing through options.

Sub. 64: It's very simple to use. The screen is very logical and I had a choice of types of searches - from general topics to specific titles.

Sub. 65: More efficient. It gave me hundreds of more ideas on a topic than I would have thought of on my own.

6. Is there a particular enhancement/addition you could suggest to improve the computer catalog's
a. book data records
b. screen displays
c. searching features/options

Only a few subjects chose to respond to this open-ended 3-part question and make specific suggestions. This probably reflects their timidity or uncertainty about how to express themselves on matters relating to computer systems or library catalogues. While few subjects responded to this question, almost all responded to the next and final question on the questionnaire. The suggestions made reflect an interest in seeing more data in the bibliographic record, updated screen display technology which includes color and windowed display capabilities, and the ability to combine search terms from the browse lists or terms displayed in bibliographic citations. It probably would have been more productive had this researcher listed specific enhancements or additions as response categories, than to pose this as an open-ended question.

7. What sort of additional data supplied by the computer, if any, would help you decide if a particular book might be useful to your research or class preparation?

This somewhat leading question evoked a large and singular response from the subjects who participated in the experiment. Unlike question 6, the subjects displayed no hesitancy in answering this question. This fact is all the more telling because it came at the end of a very long 60 minutes, and the subjects could have ignored or glossed over this last requirement just prior to receiving their small remuneration for participation in the study.

The singularity of the responses should not go unheeded by those who create bibliographic records and by designers of future library catalogue systems. What is most needed by users of library catalogues to help them decide if a document might be relevant or useful for their research tasks or information needs? The answer is plain: more information about the actual contents of a document. All the responses, however expressed, point to this need. Among the keywords used are "summaries," "abstracts," "synopses," "contents," "specific subjects," "book descriptions," and "book reviews." Clearly, then, the expanded online catalogue cannot arrive too soon.

Chapter 6

Discussion and Conclusion

6.1 Key Findings of the Study

In the comparisons of the search performance of the two navigation online catalogues, one against the other, and each with the non-navigation "control" online catalogue, none of the online catalogues emerged as the clear "winner," superior by all measures for all search requirements. Assessing the role and value of navigation in improving subject searching performance in online catalogues turned out to be a more complex undertaking than first imagined. The results of the study were not as definitive and "stunning" as hoped for, nonetheless, several important and interesting findings emerged from the analysis of the data collected. Some of these discoveries were not anticipated when the study was in the planning stages.

One of the more interesting findings came from the overlap analysis of documents selected by each searcher. Very large numbers of documents were selected by all searchers of the same topic (48 for Topic-3, 54 for Topic-5, and 169 for Task-B), and most of the documents were selected by only a single searcher. In Task-B, no single document was selected by as many as one-third of the searchers. As noted, very low overlap of relevant items retrieved was also observed in the Saracevic and Kantor study. The authors report (1988) that, "When the outputs of different searches for the same question are compared to each other, we found that most of the items are retrieved only once. However, the more often the same item was retrieved (by different searches for the same question), the more likely it was to be relevant. In other words, when different searchers searched the same question, the sets they retrieved had a low overlap or degree of agreement, however, for the items retrieved in common (i.e., for which there was multiple retrieval) the odds that they were relevant increased most significantly."

The Saracevic and Kantor study revealed that searchers searching the same question (referred to in the present study as "search tasks") or topic used a wide variety of search terms and had a low degree of agreement in choice of search terms. Saracevic and Kantor offer this explanation: "...different searchers seem to extract different language from a question (or see different things in a question) and retrieve different sets from the same file." This is a plausible explanation that may well account for both the large number of unique items selected for each search task and the low degree of agreement in items selected for the same search task. When presented with a written problem task, each searcher may interpret it in his own way, and think of different search terms. In this way, a single problem task may become several different search tasks.

Did the different online catalogues used by each group account for the different sets of documents selected? There is little evidence to support this. Group-2 did select a larger number of "0-point" documents than Groups 1 and 3. When measured by "single-searcher" SELECTS, overlap in items selected for Task-B was slightly higher in Group-1 than Group-3, and lowest in Group-2. 51 of the 74 (68.9%) unique documents selected by searchers in Group-2 were selected by only a single searcher, compared to 58.7% for Group-1, and 64.9% for Group-3. These percentages of single-searcher SELECTS for the same search task are comparable to the findings of the Saracevic and Kantor (1988) study: "In considering retrieval from 9 different searches for a question, about 69% of retrieved items were retrieved only once."

Saracevic and Kantor report that items selected more than once (i.e., by more than one searcher) were more likely to be relevant. This study lends support to that finding, as well. The most highly selected documents were those judged to be 3-point documents (directly and highly relevant) by the secondary judges; next came the 1-point documents, and the 0-point documents (judged to be not relevant at all) were the least selected. However, as noted, Group-2 selected the largest percentage of 0-point documents. This relatively high degree of agreement among the student searchers and the judges was not anticipated. The Q-SCORE is a good measure for comparing the relative level of this agreement between searchers and judges among the three groups. Group-1 searchers appear to have the highest level of agreement with the judges, and Group-3 searchers have the lowest. Recall that Group-3's "success rate" in selecting the most selected (and 3-point) documents falls when the number of those highly selected documents increases. This would indicate that navigation provides an advantage to searchers who want more than a few highly-likely-to-be-relevant documents that bear on their problem or research task.

An analysis of the bibliographic records for the selected documents revealed that 2-3 Library of Congress (LC) subject headings would retrieve most of them, whereas the LC class numbers assigned to the documents grouped them into several discrete categories and dispersed them in separate shelf areas. The implications for broadening a search, on the one hand, and for narrowing or focusing a search, on the other, are obvious. Navigation provides an easy way to pursue either direction from a displayed single bibliographic record for a highly relevant document. The system could inform the user as to the likely outcome of navigating on a subject heading, as contrasted with navigating on the class number.

It was not anticipated that all three groups would perform nearly equally well on Task-B, the second search task. The navigation groups outperformed the control group (Group-3) on the Task-A topics. The difference between Group-2 (best scores) and Group-3 was statistically significant. These results suggest that the navigation approach may be especially helpful to novice and first-time system users. Once familiarity with the system has been achieved (e.g., by completing the first search task), the navigation "advantage" may be less of a contributing factor to search performance.

This interpretation is supported by the correlation analysis of the factors associated with search performance. Showing a weak but positive association with higher performance scores was the number of SELECTS made, female subjects, online bookshelf browsers, and those subjects who expressed having the most problems in using the online catalogue. Moderate but negative associations with better search performance scores were indicated by those having the lowest experience with other online catalogues and by those who use the library's automated catalogue most infrequently. That is, as online catalogue experience and catalogue use frequency lowered, performance scores on the test online catalogues with navigation rose.

These findings are no more than tentative and suggestive of the need for further research on the benefits of a browse and navigate online catalogue. The positive value of related-record navigation in improving subject searching in OPACs was not clearly determined. The navigation groups performed significantly better than the control group on the first search task, but all three groups performed nearly equally well on the second search task. Navigation on subject headings or title keywords resulted in higher recall scores, especially among first time, novice users of the system, but precision suffered significantly in title-word navigation. In fact, the control group achieved higher precision scores on both search tasks. Navigation did not seem to aid subject searching performance after greater familiarity with the system was achieved.

The E measure analysis results for group-by-group comparisons were comparable to the Q-SCORE results. This analysis revealed, however, that navigation on subject headings leads to higher recall, but would be especially advantageous to a searcher who attached more importance to precision than recall. How can this finding be squared with the fact that Group-3 had the highest precision scores on both search tasks? Analysis of the recall - precision score relationship provided the answer. When precision and recall were plotted against each other, they were not inversely related, except in Group-3's Task-B scores. In all the other cases, as recall rose so did precision; as precision rose so did recall. In Group-3, Task-B search results, recall and precision had a weak but negative correlation. As precision rose, recall decreased; as recall rose, precision decreased slightly. This helps to explain why Group-3 had the worst fallout scores and the best precision scores. Searchers in Groups 1 and 2 who had higher precision tended to have higher recall and vice versa.

This finding suggests that online catalogues which support navigation searching may be superior in increasing recall for persistent searchers, with little or no cost in decreased precision. Group-1 searchers achieved both the best recall scores and the lowest (best) fallout scores on Task-B. The more documents the Group-3 searchers selected, the less likely they were to find something relevant.

The findings regarding online bookshelf browsing are somewhat teasing. In short, those subjects who said they used this search method achieved better performance scores than those who did not use it. The bookshelf browsers had significantly higher recall scores on Task-A than the non-browsers. Bookshelf browsers also had higher precision scores than the non-browsers. In fact, bookshelf browsing correlates more highly with good search performance than Group or online catalogue used. Unfortunately, this variable of interest was not subjected to rigorous control in the experiment. There was no confirming observation that the subject did indeed use this search method. No evidence was gathered regarding the extent of its use, or even when it was used, in Task-A or Task-B or both. Other factors may have interfered to contribute to the search performance of the bookshelf browsers who "self-selected" this search option. For example, they may have chosen this search method because they knew the LC classification scheme and were familiar with searching in this manner. Clearly, this is a question that invites additional research and experimentation.

6.2 Conclusion

Simply put, the objectives of any research consist of marshaling the resources needed and conducting the research activity in a manner that will enable one to address and find answers to the research questions of interest. The research interests and questions largely determine the definition of research objectives. These objectives typically describe the aims of the research and, to a certain extent, the activities needed to accomplish these aims.

The list of original objectives of this research study is repeated here for review.

1. To build an online catalogue retrieval system, including the design of the database, that could support a variety of subject browsing and display approaches to be used as an experimental tool and demonstration system to address these and related research questions.

2. To evaluate the usability and effectiveness of the linked-term, cross-document navigational approach to subject searching and browsing.

3. To examine the acceptance and use of bookshelf-like browsing at the online catalogue.

4. To employ a variety of quantitative performance measures to assess the retrieval performance of the different search approaches tested.

5. To explore which qualitative factors, if any, have an effect on subject searching performance (e.g., sex, subject knowledge, educational level, online catalogue experience, etc.).

Each of the five objectives has been accomplished and these accomplishments are described in this thesis.

To conclude, each of the original research questions posed is repeated here, accompanied by closing comments.

1. What is the role of unconventional, nonlinear, hypertext-like methods of subject searching and browsing in online catalogues, and for which type of user and search task are they the most appropriate?

This study is only a small step in investigating this question. In Chapter 2, a case was argued for the need to expand our understanding of the variety of information seeking activities and to design browsing systems to support what is largely a loosely constrained, self-directed, recognition-based search activity, rather than a query-based activity. The navigation approach to subject searching and browsing was tested to provide information on its acceptance by users and its contribution to search performance. The findings reported provide some answers to the questions regarding which kind of searcher and search task can most benefit from navigation-enhanced subject searching in online catalogues.

2. Does the use of an unconventional browse and navigational approach to subject searching in an online catalogue lead to improvements in search performance, specifically,

a. When navigation is permitted only via the subject headings of a controlled vocabulary?
b. When navigation is permitted only via significant title words?

As reported, the results are neither definitive nor convincing, and more research is called for. Navigation-enhanced subject searching seems to benefit novice searchers more than experienced searchers, with a slight edge going to navigation via controlled vocabulary terms, as opposed to navigation via title words. Precision suffers when navigation is permitted only on single title words. The ability to combine title words, not permitted in these tests, would probably improve precision in search results. For the searcher who wants to persist and identify many relevant documents, navigation seems to have a distinct advantage over more conventional methods.

3. What is the effectiveness of a classified approach to subject searching, namely, navigation via call numbers and online "Bookshelf Browsing", in the online catalogue?

Not stated well, this question is about the advantage of online bookshelf browsing over other browse and navigate methods in subject searching. The evidence suggests that bookshelf browsing was even more effective than navigation on subject headings in increasing recall without much loss of precision. However, nothing should be concluded because this independent variable was not controlled well in the experiment, and other factors may have interfered. The finding does suggest, however, an excellent hypothesis for a future experiment.

4. What qualitative factors influence searchers' retrieval performance?

Several personal factors were analyzed to determine the existence of any significant associations with search performance. None of the factors, for example, sex, age, university level, level of knowledge of the subject area, previous online catalogue use, showed a strong association with search performance. Test online catalogue used and bookshelf browsing correlated much more highly with good search performance than any of these personal factors. Undergraduates and the less experienced online catalogue users performed slightly better on the navigation online catalogues than graduate students and experienced online catalogue users.

5. What difficulties are encountered in their use and how do users assess these alternative subject searching approaches:

a. Alphabetical term browsing?
b. Navigation?
c. Bookshelf Browsing?

Users reported great success in finding good search terms in the alphabetical term browse lists. A few users expressed the need for finding or creating search term combinations that would make their searches more specific or more focused.

The response to navigation-enhanced subject searching was very positive. The users commented on its "point and enter" ease-of-use and the convenient way it takes the searcher to related items. Disorientation in the search process - not knowing if they had seen a particular citation before, or not knowing how they arrived at a certain point - was expressed verbally by a few participants in the tests.

Bookshelf browsing was tried by only 19 of the 54 subjects. Those who tried it seemed to be more familiar with the classified approach to searching than the others. Most who used the bookshelf browsing option liked it very much, and there is some evidence that it was a very effective way to search. Those who did not use it and commented said they preferred the other search methods to shelf browsing.

Users of the experimental online catalogues were very positive about the ease-of-use and retrieval effectiveness of these systems. Very few expressions of problems in their use were received. The results indicate that almost all of the subjects searched competently, with only a minimum of training and no prior experience with any of the test online catalogues.

This study has reached completion, and has yielded a rich set of ideas for continuing exploration and experimentation. Some of these questions can be investigated with the aid of the experimental online catalogue developed for this research study. Hopefully, what has been learned from this study will benefit any future investigations.

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Appendix - A

VOLUNTEERS NEEDED TO PARTICIPATE IN LIBRARY RESEARCH PROJECT

Earn $10.00 for One Hour of Assistance

August/September 1989

Brookens Library is hosting an advanced research project which includes the testing of an experimental online computer library catalog. This project provides a unique opportunity to catch a glimpse of future computer-based library and information search systems. Such systems will be very easy to use yet more powerful and helpful than today's systems.

Student participants in the research are asked to look up publications on a topic of their choice, using the experimental microcomputer-based online library catalog. The database to be searched consists of 30,000 publications in economics, history, and business fields. Records for the database were provided by the U.S. Library of Congress and represent works in its collections as well as those of the British Library and the National Library of Canada. Most of the works included were published between 1960-1988, although there are some earlier works as well.

Variables to be tested include subject indexing languages and terms, and specific search and browse functions. No prior training on the system is required, and the individual participant's search abilities will not be tested or evaluated.

To sign up for participation in the research project stop by Room 204 at Brookens Library or call Diane at 786-6597 for a one-hour appointment to use the experimental online catalog. From 21 August to 9 September times are available from noon to nine Monday through Thursday, and noon to four Friday and Saturday.

Appendix - B

INTRODUCTION

Online Computer Library Catalog Research Study

At an increasing pace libraries are automating their familiar card catalogs to provide computer terminal-based search access to materials in their collections. These computer-based library catalogs have become known as "online catalogs", "interactive catalogs", or "online public access catalogs." They permit library users to look up sources of information on a topic or to find descriptive citations or references to published books, reports, journals, and other materials. Library users of a variety of early online computer catalogs have not always found them easy to use or effective when conducting searches for information on a specific topic or in a subject area.

This experiment involves the evaluation of some new design, indexing, and catalog access approaches. By taking part in this experiment you will be helping us investigate solutions to some of these problems. Your individual abilities, knowledge, and search performance will in no way be evaluated. Data related to the performance of system design variables will be evaluated initially as part of my Ph.D. research project at The City University, London.

The system you will be using is an experimental online catalog developed specifically for this research project. It includes a sample database of what librarians call "bibliographic records", that is, citations or references to 30,000 publications in economics and business fields. These publications include books, research or technical reports, special collections of essays or readings on a topic, government or "think-tank" issued or sponsored reports and monographs, and published proceedings of conferences and seminars. Journal, magazine, and newspaper articles are not included. Although generally limited to English-language publications, the collection of publications represented is truly international in scope. Most of the works included were published between 1960-1988, but there are some earlier works as well.

Thank you for your participation in the study. I hope you will enjoy it.

##################################

Appendix - C

ONLINE LIBRARY CATALOG EXPERIMENT

Pre-Search Questionnaire

1. Subject's gender?
   a. Male __
   b. Female __

2. Subject's age?
   a. 20-25 __
   b. 26-30 __
   c. 31-40 __
   d. 41+ __

3. Major program or field of study?

4. Undergraduate? a. __ Graduate? b. __ Other? c. __

5. How many courses have you completed altogether in any of these fields: economics, business, management, administration, public affairs?
   a. None __
   b. 1-2 __
   c. 3-4 __
   d. 5-7 __
   e. 8+ __

6. Brookens Library at Sangamon State University provides the LCS/FBR computer catalog to look up books and other library materials.
   Have you used it?
   a. Yes __
   b. No __

7. If Yes, on average how often do you use it?
   a. 1-2 times a term __
   b. 1-2 times a month __
   c. 1-2 times a week __
   d. More than 2 times a week __

8. Have you used any other computer catalog (not LCS/FBR) at any other library?
   a. Yes __
   b. No __

9. When using a library's catalog do you most often look up:
   a. one or more specific books you know about ___
   -or-
   b. any publication that may have information on a specific topic or subject area ___

10. When you use the library's catalog, how often do you know in advance precisely which books you want?
    a. Always __
    b. Most of the time __
    c. Half the time __
    d. Seldom __
    e. Never __

Appendix - D

ONLINE LIBRARY CATALOG EXPERIMENT

Choose the topic below (only one) in which you have the most interest. Then, use the experimental online catalogue to look up publications that will be useful in your preparation for and writing of an essay or term paper on the topic.

International Economics

1. In the arena of international trade policies and practices, what is the "new protectionism"? Describe the expanded use of trade-restricting, nontariff barriers to the flow of imports, including voluntary export restraints (VERs) and orderly marketing agreements (OMAs). Do these measures violate the spirit of the General Agreement on Tariffs and Trade (GATT)?

2. In light of the current Third World external debt crisis, what proposals are being put forth by economists on ways the advanced industrial countries (AICs) should assist in the financing of economic development (or at least in stemming the reverse capital flow) in Third World countries? Does it make sense for the commercial banks of the AICs to continue lending to these debtor nations? What should be the role of the World Bank?

History of Economic Thought and Economic Theory

3. Select and describe some important 20th century Marxist critiques of advanced capitalism as it exists in the western democracies.

4. Explain Keynes' theory of unemployment. How does it differ from "classical unemployment"?

Business Management and Organization

5. How have computer-aided design (CAD) and computer-aided manufacturing (CAM) technologies affected production planning and manufacturing strategies? How are they being used to help U.S. industries become more competitive?

6. It is claimed that organizational structure must adapt to and support the firm's changing corporate strategies. Describe some views of organizational innovation in mature industries. What are some of the advantages of the multidivisional organization structure?

Public Finance

7. The U.S. federal tax system is primarily an income-based taxation system (e.g., taxes on personal income, corporate taxes, and social security taxes). The value-added tax (VAT) is a consumption-based tax which has been adopted by many individual European countries and the European Economic Community (EEC). What are the advantages of a value-added tax? Why hasn't a VAT system been enacted by the U.S. Congress to replace or supplement income tax revenues?

Labor Economics

8. Describe current methods and criteria for determining "comparable worth" wage/salary adjustments for women vis-a-vis male employee counterparts.

9. Explain the different policy approaches to reducing unemployment and controlling inflation put forth by "demand side" theorists, on the one hand, and "supply side" monetarists, on the other.

Appendix - E

ONLINE LIBRARY CATALOG EXPERIMENT

This is the topic you have selected to research.

Look up publications that will be useful in your preparation for and writing of an essay or term paper on the topic, publications that you would like to list at the end of this research paper.

REMEMBER -- When you view a detailed description of a publication you think will be useful, press the blue <USE> key, then continue.

5. How have computer-aided design (CAD) and computer-aided manufacturing (CAM) technologies affected production planning and manufacturing strategies? How are they being used to help U.S. industries become more competitive?

(You may use this paper as a "scratch" sheet)

Appendix - F

ONLINE LIBRARY CATALOG EXPERIMENT

This is your final search task

Assume you are preparing to lead a series of class discussions on the topic below. Find the key books you would like to include on a list of recommended readings on the topic.

TOPIC:

Has there been a proportionate gain of women as top-level managers and executives in business? How do women executives and their male counterparts compare in levels of compensation? Have women executives been given as much decision-making responsibilty as male executives?

REMEMBER -- When you view a detailed description of a publication you think will be useful, press the blue <USE> key, then continue.

Appendix - G

1989 ONLINE LIBRARY CATALOG EXPERIMENT

Final Post-Search Questionnaire

1. How often were you able to find a desired search term or name in the initial "BROWSE" lists?

   Always __ Most of the time __ Half of the time __ Seldom __ Never __

2. Did you use the search option "BOOKSHELF BROWSING" FROM THE MAIN MENU?

   a. Yes __
   b. No __

3. If "No", why didn't you use this option? If "Yes", what did you like or dislike about this way of searching for materials on a topic?

4. Did you encounter any particular difficulty or confusion while using this computer catalog? Please describe:

5. What did you like most about this computer library catalog?

6. Is there a particular enhancement/addition you could suggest to improve the computer catalog's

   a. book data records

   b. screen displays

   c. searching features/options

7. What sort of additional data supplied by the computer, if any, would help you decide if a particular book might be useful to your research or class preparation?

**** THANK YOU ****

Appendix - H

Online Library Catalog Experiment

Evaluation of Search Results

Please return this list and your evaluations to:

Charles R. Hildreth
127 Springbrook Dr.
Springfield, IL 62702

RESEARCH TOPIC:

Select and describe some important 20th century Marxist critiques of advanced capitalism as it exists in the western democracies.

In your review of the library book catalog records attached, please assess and mark each (to the right) as to book's relevance to the above research topic.

Use only this single-letter marking scheme:

R - for clearly and directly relevant to the topic

P - possibly relevant to some aspect of the topic

N - not relevant at all to this topic

<u>Please assign only one mark to each book</u>

THANK YOU for your assistance!

Appendix - I

OPAC_MAIN_DB 10-13-1992 page:1

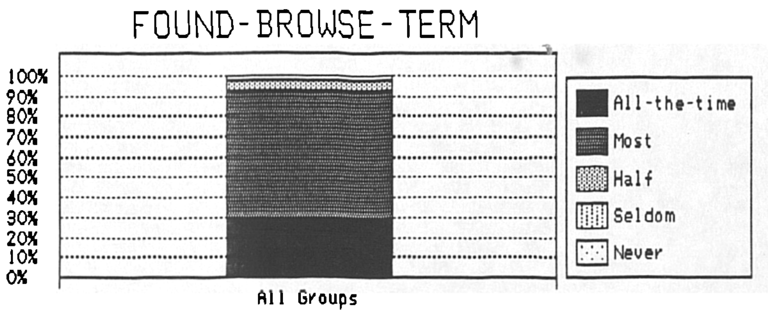
RECORD	GROUP	SEX	AGE	U-LEV	MAJOR	ECON-	OPACS	USE-F	SEARCH-AIM	BOOK-	BS-BR	TERMF	PROBL	TOPIC	SELECT S-A	SELECT S-B	ZSCORE_A	REL_HITS_A	REL_HITS_B	RECALL_A	RECALL_B	PRECIS'N_A	PRECIS'N_B	Q-SCORE_A	Q-SCORE_B	FALLOUT_B
1	1	1	26-30	0	O	1	1	3	KN	M	1	M	1	2	9	11	-0.362	0	8	0.000	0.070	0.000	0.727	0	20	0.055
2	1	0	31-40	1	E	1	1	2	SU	S	0	M	0	5	7	3	0.071	7	3	0.194	0.026	1.000	1.000	17	9	0.000
3	1	1	31-40	1	E	1	2	3	ZZ	H	1	M	0	4	14	2	1.096	0	2	0.000	0.018	0.000	1.000	0	2	0.000
4	1	0	20-25	0	O	1	1	3	SU	S	1	A	0	3	12	8	1.170	10	8	0.303	0.070	0.833	1.000	18	18	0.000
5	1	1	20-25	1	C	0	2	4	SU	M	0	M	1	5	4	18	-0.616	4	14	0.111	0.123	1.000	0.778	12	24	0.073
6	1	1	26-30	0	E	1	1	3	SU	S	0	A	1	1	6	8	0.000	0	5	0.000	0.044	0.000	0.625	0	13	0.055
7	1	1	26-30	0	O	1	1	0	SU	S	1	M	0	6	1	8	-1.609	0	7	0.000	0.061	0.000	0.875	0	15	0.018
8	1	1	41-++	0	0	0	0	0	SU	S	1	M	1	1	1	7	-1.078	0	7	0.000	0.061	0.000	1.000	0	17	0.000
9	1	0	20-25	1	O	0	2	4	SU	H	0	A	0	4	8	11	-0.129	0	9	0.000	0.079	0.000	0.818	0	13	0.036
10	1	1	26-30	1	C	0	1	2	SU	H	0	M	0	5	3	4	-0.844	2	3	0.056	0.026	0.667	0.750	4	5	0.018
11	1	1	26-30	1	O	1	2	1	SU	H	0	M	0	4	13	4	0.892	0	4	0.000	0.035	0.000	1.000	0	8	0.000
12	1	1	41-++	1	E	1	1	2	SU	S	1	M	0	5	16	9	2.130	14	8	0.389	0.070	0.875	0.889	34	18	0.018
13	1	0	31-40	1	O	0	2	2	SU	S	1	A	0	1	12	7	1.293	0	5	0.000	0.044	0.000	0.714	0	7	0.036
14	1	0	26-30	0	O	1	2	2	KN	H	0	M	0	2	4	6	-0.680	0	6	0.000	0.053	0.000	1.000	0	16	0.000
15	1	1	26-30	1	O	0	1	3	SU	H	0	M	1	3	8	6	-0.068	5	5	0.152	0.044	0.625	0.833	13	11	0.018
16	1	0	31-40	1	O	0	1	1	SU	S	1	A	0	3	11	16	0.861	8	16	0.242	0.140	0.727	1.000	16	26	0.000
17	1	0	20-25	1	O	1	2	2	SU	H	1	M	0	4	6	9	-0.537	0	9	0.000	0.079	0.000	1.000	0	19	0.000
18	1	1	20-25	1	O	0	1	1	KN	M	0	M	0	7	12	5	0.708	0	5	0.000	0.044	0.000	1.000	0	7	0.000
19	1	0	20-25	1	E	0	1	0	SU	S	1	A	0	5	11	11	0.986	9	11	0.250	0.096	0.818	1.000	19	27	0.000
20	1	0	20-25	1	E	1	1	2	SU	S	0	M	0	7	6	7	-0.708	0	5	0.000	0.044	0.000	0.714	0	11	0.036
21	1	0	31-40	1	O	1	1	1	SU	S	0	M	1	1	2	15	-0.862	0	14	0.000	0.123	0.000	0.933	0	24	0.018
22	1	1	20-25	1	O	1	2	2	SU	S	0	A	1	3	7	11	-0.378	5	8	0.152	0.070	0.714	0.727	11	14	0.055
23	2	1	26-30	1	C	1	1	2	KN	M	1	A	0	5	6	5	-0.158	6	1	0.167	0.009	1.000	0.200	16	1	0.073
24	2	1	26-30	1	E	1	2	2	KN	M	1	M	0	2	13	6	-0.107	0	5	0.000	0.044	0.000	0.833	0	15	0.018
25	2	0	20-25	1	O	0	1	4	SU	N	0	M	1	5	11	16	0.986	2	15	0.056	0.132	0.182	0.938	4	35	0.018
26	2	1	26-30	0	O	0	2	3	KN	M	0	M	0	2	2	3	-0.808	0	3	0.000	0.026	0.000	1.000	0	7	0.000
27	2	1	31-40	0	O	0	1	4	SU	H	1	H	1	5	7	11	0.071	6	11	0.167	0.096	0.857	1.000	14	19	0.000
28	2	0	20-25	0	O	0	2	4	SU	H	0	M	0	6	10	6	0.061	0	3	0.000	0.026	0.000	0.500	0	7	0.055
29	2	1	31-40	0	O	0	1	1	SU	S	1	M	0	5	10	10	0.757	8	9	0.222	0.079	0.800	0.900	20	17	0.018
30	2	0	31-40	1	O	0	1	0	SU	S	0	A	0	3	12	6	1.170	10	6	0.303	0.053	0.833	1.000	22	18	0.000
31	2	0	26-30	1	O	0	1	4	SU	H	0	H	1	4	12	4	0.688	0	3	0.000	0.026	0.000	0.750	0	7	0.018
32	2	0	41-++	1	O	1	2	2	SU	H	0	M	0	6	16	8	1.174	0	5	0.000	0.044	0.000	0.625	0	11	0.055
33	2	1	31-40	1	C	1	1	2	KN	H	0	M	1	1	9	5	0.647	0	5	0.000	0.044	0.000	1.000	0	13	0.000
34	2	0	31-40	1	O	1	1	1	SU	S	0	M	0	6	12	6	0.432	0	5	0.000	0.044	0.000	0.833	0	13	0.018
35	2	0	20-25	0	O	0	1	1	KN	M	0	M	0	3	10	16	0.551	6	15	0.182	0.132	0.600	0.938	14	43	0.018
36	2	0	20-25	0	O	0	1	3	SU	N	0	M	0	8	5	4	0.535	0	2	0.000	0.018	0.000	0.500	0	4	0.036
37	2	1	26-30	0	O	0	1	1	SU	S	1	M	0	8	5	4	0.535	0	3	0.000	0.026	0.000	0.750	0	5	0.018
38	2	1	26-30	1	C	1	1	1	KN	M	0	M	0	5	1	2	-1.302	1	1	0.028	0.009	1.000	0.500	3	1	0.018
39	3	0	20-25	0	O	0	1	0	KN	S	0	A	0	4	1	5	-1.557	0	5	0.000	0.044	0.000	1.000	0	13	0.000
40	3	0	31-40	0	O	0	1	4	SU	A	0	A	0	3	6	8	-0.687	6	8	0.182	0.070	1.000	1.000	12	16	0.000
41	3	0	41-++	0	O	0	1	0	SU	S	0	M	1	8	6	5	1.070	0	5	0.000	0.044	0.000	1.000	0	9	0.000
42	3	1	31-40	1	C	1	1	2	KN	M	0	A	1	5	6	8	-0.158	6	6	0.167	0.053	1.000	0.750	16	18	0.036
43	3	0	31-40	0	E	1	2	1	SU	S	0	M	0	8	2	2	-1.070	0	1	0.000	0.009	0.000	0.500	0	1	0.018
44	3	0	26-30	0	E	1	2	1	SU	H	0	M	0	6	13	25	0.618	0	11	0.000	0.096	0.000	0.440	0	19	0.255
45	3	0	26-30	1	O	0	0	0	SU	H	1	S	0	8	2	8	-1.070	0	8	0.000	0.070	0.000	1.000	0	22	0.000
46	3	1	26-30	0	E	1	1	0	KN	M	0	M	0	4	3	5	-1.149	0	5	0.000	0.044	0.000	1.000	0	7	0.000
47	3	1	26-30	0	C	1	2	3	KN	M	0	A	0	5	4	2	-0.616	3	2	0.083	0.018	0.750	1.000	7	4	0.000
48	3	0	26-30	1	O	0	2	2	SU	S	1	M	0	3	5	4	-0.997	4	4	0.121	0.035	0.800	1.000	10	10	0.000
49	3	0	31-40	1	O	0	2	4	SU	H	0	A	0	3	3	8	-1.616	3	8	0.091	0.070	1.000	1.000	7	20	0.000
50	3	1	20-25	0	E	1	1	0	SU	S	1	M	0	6	6	14	-0.681	0	12	0.000	0.105	0.000	0.857	0	26	0.036
51	3	0	20-25	0	O	1	2	2	SU	H	0	A	0	2	15	9	0.021	0	6	0.000	0.053	0.000	0.667	0	12	0.055
52	3	0	31-40	1	O	0	2	2	SU	S	0	M	1	2	45	5	1.934	0	5	0.000	0.044	0.000	1.000	0	13	0.000
53	3	0	20-25	0	O	0	1	3	SU	S	1	H	0	4	12	5	0.688	0	5	0.000	0.044	0.000	1.000	0	15	0.000
54	3	1	26-30	1	C	0	2	3	SU	A	0	A	1	5	1	3	-1.302	1	3	0.028	0.026	1.000	1.000	3	9	0.000

Appendix - J

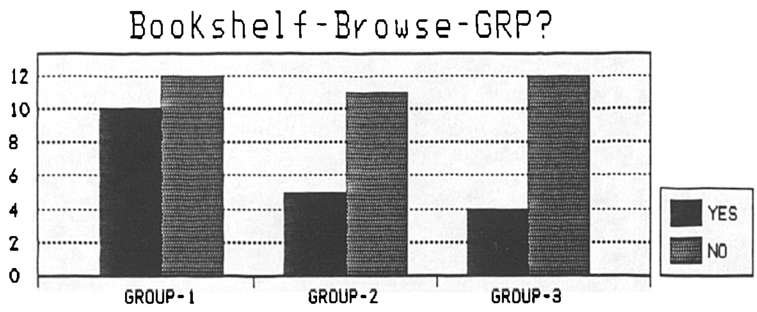
Final (Post-Search) Questionnaire

User Comments

1. How often were you able to find a desired search term or name in the initial "BROWSE" lists?



2. Did you use the search option "BOOKSHELF BROWSING" from the MAIN MENU?



3. If "No", why didn't you use this option? If "Yes", what did you like or dislike about this way of searching for materials on a topic?

Group-1 Subjects:

Sub. 11: Yes. Prompted new ideas. Immediately showed the richness of an area

Sub. 12 No. More complicated - more reading through information.

Sub. 13: Yes. (No comment.)

Sub. 14: Yes. I liked it because it browses a "bookshelf" as I do, in hopes of finding "an angle" previously unthought of.

Sub. 15: No. On selecting the Topic of Interest, the program guided the user (me) to the list of titles directly.

Sub. 16: No. Did not have enough information.

Sub. 17: No. Because I was not able to get to the subject I was searching for very quickly.

Sub. 18: Yes. It listed the books by subject.

Sub. 19: Yes. But it seemed to have a limited selection - or I did something wrong.

Sub. 20: No. I didn't feel knowledgeable about the topics and able to distinguish useful/non-useful books by title alone.

Sub. 21: No. I was able to find the book through the "Title" in the menu.

Sub. 22: No. I found the other options to be quicker and easier methods of locating desired resources.

Sub. 23: Yes. Did not like having to go through many unfamiliar titles/topics to find my item or area of interest with other approaches.

Sub. 24: Yes. I liked how it showed me books that are related and would be on the shelf upstairs - like being "there".

Sub. 25: No. I ran out of time. That is, I would have after I finished searching by keyword.

Sub. 26: No. I am used to the traditional subject search.

Sub. 27: Yes. I like this option because it provides another way to search, but it would not be my first choice. Don't think I would use it too much.

Sub. 28: No. Didn't like that option because I prefer "Subject" or "Region".

Sub. 67: Yes. I used it but did not put any into the note pad. I didn't come upon any book that would lend itself to the questions I was addressing. If you had time to know what call letter you wanted it would be very beneficial.

Sub. 68: No. Didn't think to do so.

Sub. 69: Yes. I had no idea what the call numbers were for a specific topic.

Sub. 70: No. I find it much easier to search under "Topics of Interest" and then I can branch out from there to other areas that I find are related. It would be helpful if you knew the general area where your subject could be found in a library.

Sub. 71: No. I was still looking through search topics and different terms. This is the technique I use most of the time. Bookshelf browsing is a technique that usually doesn't come to mind until I'm in the library stacks. If on a computer, I could get into the habit of using it and it would probably become routine.

Sub. 72: No. I wanted to see my options and this did not seem to me the most efficient way.

Group-2 Subjects:

Sub. 29: No. I do not know the call numbers.

Sub. 30: Yes. Because it allows me to search through other books close to the originals (usually lots of other books are always in a close location).

Sub. 31: Yes. I found this method very useful for quickly locating specific materials available within a certain subject.

Sub. 32: No. I don't know call number of books.

Sub. 33: No. I was following specific subject leads concerning the topics I was tracing. I found in this search no need to browse as I found much of my needs fulfilled in my search. I would however use browse often.

Sub. 34: Yes. This is one of the most frequent methods I employ, so it was helpful to me. This is an option I did not know I was missing on the School's system.

Sub. 35: No. Not familiar with the numbering system - Library of Congress system.

Sub. 36: Yes. Able to spot titles I wasn't aware of before. I am used to going down the stacks in a given area.

Sub. 37: No. Already many good titles to explore by subject-->title. May have gone to that option as a secondary step after getting initial promising sounding titles.

Sub. 38: No. I didn't remember call numbers.

Sub. 39: No. I didn't feel there was a wide enough range of different classifications to make it useful; and probably because I wasn't writing them down I didn't see the pattern.

Sub. 40: No. Not enough time. Would be good I think.

Sub. 41: No. Not enough time. Found a lot of useful books in "subject" searching.

Sub. 42: No. I found it more convenient to use the other resources.

Sub. 43: No. Didn't check to see what the call number was in that area.

Sub. 44: No. That's not my usual method of research.

Sub. 45: Yes. Neatly arranged by subject just as in library - uncanny!

Group-3 Subjects:

Sub. 46: Yes. I like it because sometimes I found books faster this way than by subject. Maybe I was just lucky. Sometimes you tell what the book is about by its title.

Sub. 47: No. I thought the first two options were easy to use. It was so easy to find subjects.

Sub. 48: No. I was so caught up into the actual researching that I just forgot about that option.

Sub. 49: No. I didn't have time to get into that option.

Sub. 52: No. I found other options to be more useful, and quicker results.

Sub. 53: No. I thought "Topics" would give me a better variety, however within the amount of time alotted, I would use this method to select books faster.

Sub. 54: No. I find it more helpful to research by "Topics of Interest".

Sub. 56: Yes. I probably could have used this feature more extensively, but I liked subject/topic searching best and stuck with it.

Sub. 57: No. For the time I had available to me I did not use it. I may have if I was really going to write a paper.

Sub. 58: No. It is not for people to use. It's only for the library to organize the books.

Sub. 59: No. I like to use "Topic of Interest". When you don't know the book name and author, you can describe what you want and get it.

Sub. 60: Yes. If you found a book of interest you could look at the call number to see if there were others on the same topic.

Sub. 61: No. No time.

Sub. 62: Yes. I was able to get right to the topic.

Sub. 63: No. I had never used this method before and was very unfamiliar with it. The system basically followed my own access in doing research.

Sub. 64: No. I was searching for subject headings.

Sub. 65: Yes. Because it allowed me to go from a broad area to a narrower one yet it showed me a lot of other topics I hadn't thought of.

Sub. 66: No. Would have, but did not exhaust my search terms for other searches when the time was up.

4. Did you encounter any particular difficulty or confusion while using this computer catalog? Please describe:

Group-1 Subjects:

Sub. 11: Occasionally the machine beeped when I tried an incorrect key sequence.

Sub. 12: No.

Sub. 13: No.

Sub. 14: No.

Sub. 15: Yes, initially regarding the selection of "useful" items. Towards the end, the usage was pretty clear.

Sub. 16: No.

Sub. 17: The Browse list could have been composed of 2 words instead of one so as to obtain a more accurate location.

Sub. 18: The first assignment was tough getting used to.

Sub. 19: I tried to speed leap to a specific catalog abbreviation.

Sub. 20: No.

Sub. 21: No.

Sub. 22: John Maynard Keynes listed twice, one with his birth year, one without.

Sub. 22: Not really. Just need a bit more practice on the mechanics.

Sub. 24: No.

Sub. 25: No.

Sub. 26: Yes. The use of different keys to go back through the different levels. One key would have been easier.

Sub. 27: No.

Sub. 28: Not really.

Sub. 67: No. It was very straight forward in the layout of the program.

Sub. 68: No.

Sub. 69: No.

Sub. 70: No.

Sub. 71: I was sometimes confused when going through subject topics listed at bottom of the book description. I'm not sure if I got through all the titles in a particular subject area since I might have changed subject topics under a book title description.

Sub. 72: At first I had difficulty getting back to previous screen after looking at a title. However, I quickly realized how to do it.

Group-2 Subjects

Sub. 29: No.

Sub. 30: No.

Sub. 31: No.

Sub. 32: Yes. At first I was confused by the title word of books. But not the second time.

Sub. 33: No real difficulty, it is an effective search.

Sub. 34: In the second search concerning female executives I found that the term "executive" limited my search in a way that made it difficult. I was unable to access "executive" and "female executive" in a way that satisfied me.

Sub. 35: Not really. All mistyped function keys were easily fixed.

Sub. 36: No.

Sub. 37: No.

Sub. 38: Getting back to a previous list after I had selected a source as "useful". Had a problem with the topics to select after I got the detailed description of the source.

Sub. 39: No. Confused the use of F2 and F4 sometimes, but this would be resolved with use.

Sub. 40: No.

Sub. 41: A little bit of confusion between F2 and F4 keys.

Sub. 42: None.

Sub. 43: No.

Sub. 44: No.

Sub. 45: None.

Group-3 Subjects:

Sub. 46: There wasn't any difficulty. I did hit the wrong function key a couple of times.

Sub. 47: No.

Sub. 48: None.

Sub. 49: I needed to write down choices made or I'd forget in search for different options. I felt limited in searching under topic. I couldn't get specific enough when typing it in.

Sub. 52: No confusion, but if we use the same key like F2 or ESC for jumping to different levels, it may be clearer than using F1, F2, and F4.

Sub. 53: No.

Sub. 54 Not at all. You just use common sense.

Sub. 56: No.

Sub. 57: No. I am a little unfamiliar with the keypad.

Sub. 58: It takes time to know about F1, F2, F4 functions (only a few minutes).

Sub. 59: When I don't know the author and the book, I am very worried, but I use "Topic of Interest". So my problem s solved.

Sub. 60: No. Most of the time it was a problem in trying to decide what the best way was to approach the essay question. There weren't any computer problems - only in nailing down the best descriptive word to fit the topic of the essay.

Sub. 61: No - easily understood.

Sub. 62: None at all.

Sub. 63: No.

Sub. 64: I was frustrated in the second search. I could only use one reference title (subject title) at a time. I wish I could have cross-referenced some subjects (like with ERIC).

Sub. 65: Sometimes the topic I wanted wasn't listed and I had to really fish for the subjects.

Sub. 66: When using keywords from title search, F4 did not work, to backup, only F2.

5. What did you like most about this computer library catalog?

Group-1 Subjects:

Sub. 11: Ease of use. Productivity.

Sub. 12: Very easy to use and the increased subject search ideas were great!

Sub. 13: It was easy to use.

Sub. 14: Very user friendly and the detailed description provided additional topics.

Sub. 15: Well, basically the collection of records for the topic chosen by me was pretty good. There were a variety of titles and it gave me lots of choice to prepare my topic paper.

Sub. 16: Fast.

Sub. 17: Browse list approach.

Sub. 18: Easy use.

Sub. 19: Fast, and different alternatives or approaches.

Sub. 20: Alpha subject list online - rather than referring to Library of Congress headings, for example.

Sub. 21: Excellent

Sub. 22: It's easy to learn, and a comparatively fast way of accessing needed materials.

Sub. 23: "Subject Groups" under title references helped me confirm or reject the title as being on my subject. I also used these listings to branch out.

Sub. 24: Speedy and easy to use.

Sub. 25: It's fast. It also gives clues to taking other "tacks" in searching.

Sub. 26: It is very easy to use, and you are connected to the subject index while you are seeing a bibliographic reference on the screen. Also the "speed leap" search.

Sub, 27: Just a few simple steps to learn. Not difficult to use. Also, screen was easy to read.

Sub. 28: Quick, and easy to change menus.

Sub. 67: Time saving, useful organizational methods.

Sub. 68: Speed of finding titles.

Sub. 69: Very easy to understand the directions, to use the keyboard in conjunction with directions, and large catalog.

Sub. 70: It is much easier to use than a conventional card catalog. It makes it much easier to change the perspective of the search.

Sub. 71: The cross references of similar subjects helps to do a more thorough search. Also having everything on computer makes it easier and saves time.

Sub. 72: With any general topic you were able to get at information which you were looking for.

Group-2 Subjects:

Sub. 29: It is a lot easier to use than the other system.

Sub. 30: Speed Leap function key. Bookshelf browsing menu-driven.

Sub. 31: The "Bookshelf Browsing" option.

Sub. 32: Very good! Especially the backtrack. I like it.

Sub. 33: I didn't have to play with cards in catalog, didn't have to jot down search numbers. Many options are afforded to use at the punch of a key.

Sub. 34: I especially appreciated the backtrack features. I do not like losing my place and this was helpful.

Sub. 35: It was easier to specifically access the particular information needed/wanted.

Sub. 36: Very fast and thorough.

Sub. 37: Speed, selection, and ease.

Sub. 38: Interesting sources.

Sub. 39: You can access the subject you want directly. I like the Speed Leap feature. I liked the idea of "Bookshelf Browsing" even if I didn't use it on this search.

Sub. 40: It is quicker than the card catalogs.

Sub. 41: Menu driven. "Browse" - (even though I didn't use it).

Sub. 42: It was simple and self-explanatory. If I had more time I would have used the other options like Book shelf browsing.

Sub. 43: It's easy. I could go straight to a subject I was interested in and find information.

Sub. 44: The ability to return to a previous screen without repeating the steps necessary to recall the information.

Sub. 45: Very user-friendly. No questions about where I am or what I am looking at.

Group-3 Subjects:

Sub. 46: I found it easier to find books on a particular topic then using the card catalog.

Sub. 47: The computer catalog is about 100 times faster than microfiche or card catalogs. One would spend much less time using the online computer catalog, which gives more time for the paper itself.

Sub. 48: I enjoy this way of looking for topics much better than the old way. Computers don't scare me.

Sub. 49: It was quick and gave variety of options.

Sub. 52: Not having to remember and punch in many letters. Using arrow keys instead, and browsing through options.

Sub. 53: User friendly...and concise...not a lot of reading to determine what you had to do.

Sub: 54: The cursor highlights each line for ease of viewing. It's very easy to use.

Sub. 56: It's fast and easy (user-friendly for those of us who are not proficient with computers).

Sub. 57: I felt it was easy to learn and use.

Sub. 58: Easy to learn how to use this system. And finding books takes only very little time.

Sub. 59: Even though you don't know anything, you try and find out some book and to enjoy yourself. You can find it from this computer library catalog.

Sub. 61: Information was easily attained. Instructions were clear and easily followed.

Sub. 62: Easy, and very proficient. Really liked it and think it will be a big help.

Sub. 63: The subject search by complete phrases and the Speed Leap.

Sub. 64: It's very simple to use. The screen is very logical and I had a choice of types of searches - from general topics to specific titles.

Sub. 65: More efficient. It gave me hundreds of more ideas on a topic than I would have thought of on my own.

Sub. 66: Browse lists.

6. Is there a particular enhancement/addition you could suggest to improve the computer catalog's

a. book data records

Group-1 Subjects:

Sub. 11: More

Sub. 17: 2 word topics for the browse list.

Sub. 22: Brief capsule descriptions of contents or thesis of each entry would be nice.

Sub. 67: Narrower subject topics.

Sub. 70: A short review of the books in the fourth level.

Group-2 Subjects:

Sub. 39: Could this be combined with an indicator about where the book can be found?

Group-3 Subjects:

b. screen displays

Group-1 Subjects:

Sub. 11: Better monitors. Possibly make very important prompts blink.

Sub. 14: The detailed description screen seemed a tad overwhelming (a lot of words, few spaces).

Sub. 15: Possibly you can explain the functioning of each of the menu options on the main menu.

Sub. 16: Double displays (for comparison).

Sub. 23: Color. More definition.

Sub. 26: Color.

Sub. 67: Color - maybe would avoid glare.

Sub. 68: Modifying the screen displays for different levels - so you could tell at a glance where you were at.

Sub. 71: The function keys in the screen corner would help user if he wanted to go back to another stage.

Group-2 Subjects:

Sub. 30: No specific direction command available on the screen. I don't like to remember.

Sub. 34: Perhaps a slit screen that could access previous information.

Sub. 39: No. They are very clear and easy to read, and instructions clear - never did get hung up.

Group-3 Subjects:

Sub. 46: Have different color screens so you can tell what level you are on.

Sub. 52: Screen could be less crowded by information.

Sub. 53: Highlight "F" function keys at bottom of screen.

Sub. 54: When getting a list of the books chosen, there is a possibility of getting duplicates, since you can't remember which ones you designated. The computer should not print duplicates.

Sub. 59: When you find what you want computer could put it into a window in screen.

Sub. 63: Some of the book descriptions said the exact same thing. It would be nice if some were more specific.

Sub. 64: I like the displays. They are very straight forward.

c. searching features/options

Group-1 Subjects:

Sub. 11: By publishers.

Sub. 13: When looking for subject you could only use one word phrase.
It should be at least 2 word phrase.

Sub. 15: Well, the indexing of records for access is good....very fast.

Sub. 68: Speed control for scrolling up and down.

Sub. 71: If several titles could be selected at once to see the detailed description it would save time, since you would not have to return to the list and call up the next book title.

Group-2 Subjects:

Sub. 31: The key word from title option should be able to be linked to the subject being researched.

Sub. 35: Couldn't access subject references when not in title search mode. Especially when subject matter didn't match keywords.

Sub. 45: Maybe a subject-to-call number relationship, for less experienced students.

Group-3 Subjects:

Sub. 46: Type in a topic and have the computer list all the books on the topic as well as authors on the same screen.

Sub. 49: More flexibility in typing in choices.

Sub. 63: Would be nice if the call numbers were in red or the screens changed color so your eyes don't get so tired.

Sub. 64: Cross-referencing topics. E.g., women executives + comparable worth...

Sub. 66: Too short a search time to tell.

7. What sort of additional data supplied by the computer, if any, would help you decide if a particular book might be useful to your research or class prepar-ation?

Group-1 Subjects:

Sub. 11: More information in notes section.

Sub. 12: A more detailed explanation about topics included in the book - titles can be deceiving at times.

Sub. 14: Description of contents - especially when title may be deceiving.

Sub. 15: Possibly one can collect a summary data file for the major topic listings.

Sub. 18: More of the actual contents.

Sub. 22: Brief capsule descriptions of contents or thesis of each book.

Sub. 23: Abstract of the book would be a great help.

Sub. 25: An abstract, in the same manner as scientific journals, would be helful.

Sub. 26: A description of the contents of the book and maybe references to other books the author has written.

Sub. 27: Can't think of any additional data needed.

Sub. 28: An abstract of particular book or subject area.

Sub. 67: Narrower subject topics listed under book.

Sub. 68: If possible, a descriptive paragraph of the book's contents.

Sub. 69: Perhaps a mini-summary of each book once it has been chosen by title.

Sub. 70: A review of the book, so that it can be determined if it would be under the specific area you are searching for in a broad category. Otherwise you have to go read parts of the book.

Sub. 71: If books with only the title as an indicator of book contents had a one-line sentence synopsis it would be helpful.

Sub. 72: A brief description of information in book.

Group-2 Subjects:

Sub. 29: To have a book description about the subject.

Sub. 31: Chapter and/or section headings, or an abstract of principle themes or subjects.

Sub. 32: Year, like 1980-1989, a period.

Sub. 33: Include video bibliographies

Sub. 34: The detailed info. on each title and its search avenues that opened up on keywords.

Sub. 35: A brief synopsis of general information.

Sub. 36: Further description of contents of book or article.

Sub. 37: Annotated description of each title would help with the election process even further.

Sub. 38: Little bit more about book content.

Sub. 39: Number of pages of the book or article. Maybe some indication of whether it was developed for the popular or academic market.

Sub. 40: Brief description of book.

Sub. 41: Brief content of the books.

Sub. 42: If each title had a summary of what the book was about.

Sub. 45: More descriptive subject listings.

Group-3 Subjects:

Sub. 46: Give a little summary about the major aspects of the book.

Sub. 47: Display an intro to the book - more than 1 or 2 lines. Maybe a table of contents. More of a summary of what the book entails.

Sub. 48: A longer description.

Sub. 49: Synopsis of material.

Sub. 52: Key words. Maybe more subject headings.

Sub. 53: Provide abstract for each book entry.

Sub. 54: If not available in this library, where else could I find a particular book.

Sub. 56: A brief abstract or summary, but this would likely not be feasible.

Sub. 59: Topics.

Sub. 61: One or two line summary of book. Editors.

Sub. 63: Book descriptions should have complete sentences or a paragraph of what the book has information on.

Sub. 65: Info if the library the computer was in had the book available right then, instead of having to go to the shelf and find out that it has been checked out.

Sub. 66: Definitely abstracts. Difficult to tell if book is useful from limited data in book record. Also tables of contents and more subjects.

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