APPLIED RESEARCH

SUMMARY

- Describes some usability issues resulting from conversion of paper documents to Adobe PDF format
- Reports that users preferred the full-text search tools but got more accurate results with an electronic back-of-the-book index

Index Versus Full-text Search: A Usability Study of User Preference and Performance

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"Information by itself is not valuable unless it is accessible: Value is created by pathfinders through the information" (Grimstead 2001, p. 13). As technical communicators, content developers, or information architects (depending on the title we use to characterize the work we do), we certainly recognize that access to the information we create, regardless of the medium, is an essential tenet of effective technical communication.

If our specialty is indexing, we understand that a well-composed index is one that matches the thinking process and vocabulary of our users. With books and other print references, such as documentation, the usefulness of the product is frequently dependent on the effectiveness of the index. But does the same hold true when the book is an e-book and the users have access to text-search tools and can quickly search the text for whatever word combination they wish?

Publishers who engage in e-publishing are leading the trend that bypasses the indexer in the belief that readers can function just as well without an index when offered software that allows them to do full-text searches instead. This belief is based on the increasing familiarity users have with text-search tools to look up information and the publishers' desire to better control publishing costs and production schedules.

But, as many who have experienced the results of a search know, search engines frequently produce hundreds of "hits," some of them relevant, many of them not so relevant in the context that the user is looking for. Simple keyword text searching is the type of searching most familiar to most people. Type the desired text string in the dialog box, and the search engine will find every occurrence of the string of characters, regardless of the value or significance to the user.

Search engines are most effective for the typical user when there is a single objective answer to a simple query, as, for instance, is the case with a search for a particular book title on Amazon.com. If you know the name of the book or the author, your search is likely to be fruitful. If you know the topic category—usability, for instance—you are also likely to get a list of books that will be of interest.

More complex queries, however, are another matter. If, for instance, you are searching the Web for *index usability*, you might get more than 200,000 hits covering topics such as indexing, usability, and indexes of sites on usability. You may not find any studies of index usability, or you may give up exploring the options after examining the first 10 or 20 items in the results list. As well, the order of the list of hits may have no meaning or usefulness to you, and, to narrow your search, you might need to use the dreaded "advanced search" button, which will likely add to your anxiety if you are like most people who know very little about effective advanced searching techniques such as Boolean logic.

In this article, we report on the results of testing two versions of an information product, *Usability testing and research*: one version, an e-book with an index with the locators hyperlinked to the page reference for each entry; the other version, the same e-book without an index, but with full-text search capabilities. We describe the methodology for testing, the testing results, our conclusions, and implications for future research. Before discussing these issues, however, we summarize the current literature regarding human indexing and information retrieval by machine (search engines).

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LITERATURE REVIEW

Human indexing and advances in machine information retrieval

When a business looks to improve its standing in a competitive market, the cost of labor is generally the most significant expense, and therefore receives the focus of management's attention to keep the business competitive. In the area of information retrieval, information science technology is making remarkable advances that promise a cost-effective method to index, classify, and catalog the explosive growth in information available through electronic sources and the Internet. How does this rapidly advancing technology compare with human indexing, and what does the future hold for each? We begin this discussion by reviewing the profession of indexing and the value that a well-prepared index adds to documents and database information retrieval. We will see that an index is much more than just an alphabetical listing of a document's contents and that conformance to a firm set of rules doesn't necessarily make a good index.

Information science experts James D. Anderson and José Pérez-Carballo (2001a, p. 237) reaffirm what the professional indexing community says about the role of indexers:

> *The general consensus among indexers and theoreticians is that human indexers perceive (read, view, examine, listen to) a text, interpret the message encoded in the text as they understand it (influenced by previous experience and current personal knowledge, including their interpretations of any instructions given them), and then describe their version of the message, plus any important text or document features, in accordance to rules and patterns for the type of index they are working on. Not much more detail than that is provided by experts in indexing.*

The authors cite the work of noted indexing experts Nancy Mulvany, Lois Mai Chan, Robert Fugmann, Dagobert Soergel, Hans Wellisch, and others to support their critical assessment of the profession and the underlying reliance on the indexer's good judgment. The authors also point out that "modern indexing algorithms go well beyond simply generating lists of words, and that indeed, judgments are made based on a wide range of criteria, including those encoded in knowledge bases, reflecting the significance of subject area and cultural understanding of their creators. Nevertheless, effective human indexing relies on a very sophisticated use of human intelligence" (Anderson and Pérez-Carballo 2001a, p. 238).

Indeed, sophistication is very much a part of human indexing. A well-composed index is the result of a complex thought process whereby the indexer bridges the author's perspective of the subject to the likely keyword that the user will consider. To make the connection between the author and the user, the indexer may use words or "coined modifications" that are not specifically mentioned in the document but that will be recognizable to a majority of users of the index. Weinberg (1996) points out that about 10% of the average index's entries are "coined modifications, formulated by a human indexer to reflect the text being analyzed."

According to noted indexing experts Ann P. Bishop, Elizabeth D. Liddy, and Barbara Settel (1991), a reader uses a back-of-book (BOB) index for two purposes:

- To identify and locate particular information within the book
- To get an idea of a book's scope and detail, and the nature of a particular subject

However, indexes are not routinely present, even in books that we would normally associate indexes with, such as in the disciplines of humanities, fine arts, social sciences, and science and technology. The authors found that out of the 659 books examined in these disciplines, 117 (17.8%) had no index (Bishop, Liddy, and Settel 1991, pp. 24–25).

With the advent of machine indexing, some worry that the profession of indexing will disappear. Experts in information science don't believe that machine information retrieval is a passing technology, especially with the youngest of users growing up completely comfortable with the Internet, information-searching techniques, and the desire to use the path of least resistance to get what they are looking for (see Peek and Hane 1998). They are, however, concerned with the dispersion of core information from the relatively few quality information sources to an expanding host of sources with diluted information quality, such that if the text query matches something in the document, then the document must be relevant.

Anderson and Pérez-Carballo (2001b, p. 267), believe that both types of information retrieval will play a valuable role in the future. Because of the rising cost of human indexing and the amount of new information created everyday, machines are indispensable as information retrieval and indexing tools. However, the day when machines replicate the intellectual processes that human indexers provide isn't foreseeable anytime soon. The question, then, is "Where should the dividing line be for human indexing and information retrieval by machine?"

Research by Anderson and Pérez-Carballo shows that users desire both methods (machine and human indexing), depending on what they are trying to find, and that "users find them, on balance, more or less equally effective" (2001a, p. 233). Weinberg (1996) goes further, stating that "complex information systems required human intermediaries."

Most information retrieval experts agree that just be-

cause technology can provide a wealth of information in a few keystrokes doesn't mean that we should use it. Rather, we should be careful with how we apply the technology, because the quality of information will degrade while the quantity of information will continue to grow exponentially. However, the same argument can be made about indexing by humans: "What we cannot afford to continue to do is to treat all documents that enter our collections and our IR [information retrieval] databases as if they were all equally important and equally deserving of our expert analysis and indexing. They simply are not, and to continue to do so is to waste precious resources" (Anderson and Pérez-Carballo 2001b, p. 274).

Usability testing of indexes and search engines

How to make back-of-book indexes more efficient and effective for users has been an important subject of researchers for a long time. Evidence of this work is apparent in the available standards on indexing, books on indexing, and style guides on indexing (see Milstead 1990). For example, the chapter on indexes in *The Chicago manual of style* (University of Chicago Press 1993) provides recommendations on arrangement of entries, of subentries, on locator numbering scheme, information to index, and the use of cross references (that is, *see* and *see also*). Most publishers impose a particular standard or style guide for their indexers, but the content of the index is at the discretion of the indexer. Thus, the experience and objectivity (although not total objectivity) of the professional indexer in creating professional indexes will be extremely beneficial to users, given their time constraints, the space constraints of the document, and the complexity of indexing (University of Chicago Press 1993).

Recent works in usability testing and research of BOB indexes include Susan C. Olason's *Let's get usable! Usability studies for indexes* (2000); an extensive index quality study of 433 books of various genres (that is, history, literature, science, and technology) by Ann P. Bishop, Elizabeth D. Liddy, and Barbara Settel (1991); and Ryan and Henselmeier's study at Macmillan (2000).

Olason's work assesses the impact, including quantitative results, of the following design features of BOB indexes:

- Run-on versus indented style
- Sub-entries beginning with prepositions or conjunctions
- Other access paths readers use to find information in the book

Her results concerning the first two items in this list correlate well with the indexing recommendations of *The Chicago manual of style* (University of Chicago Press 1993). She shows that users are well served by the selection of an index's main entries that considers the user's familiarity with the subject.

The indexing study of Bishop, Liddy, and Settel (1991) indicates that there is considerable variability in indexing among the books of various disciplines reviewed and that the recommendations of the 1993 edition of *The Chicago manual of style* are not strictly followed.

In the American Society of Indexers' newsletter, *Key words,* Ryan and Henselmeier (2000) describe the process they used to conduct a usability test of four books (each book for a different user group). Twenty-two participants were instructed to answer questions by looking up information using the index, the table of contents, glossaries, or whatever method they found most useful. The test observers, all Macmillan indexers, "were surprised at what participants looked up," with several observers commenting that participants "searched for terms they would never have thought of including in the index" (Ryan and Henselmeier 2000, p. 201).

The observers also found that some users liked to find a general area in the book and then narrow down their search by skimming pages, while others didn't want to read pages at all, but instead wanted the index to take them directly to the information. This "surprise" factor—what we learn from users—is a common occurrence in usability testing, pointing up the necessity to test all aspects of an interface, including the index, for information on how the interface matches users' own search and look-up vocabulary and strategies.

When it comes to the Internet, however, the studies are fewer. A search of the literature on Internet text searching brought us repeatedly to the Web site of User Interface Engineering (UIE). In their first reports on usability testing, (Spool and colleagues 1997, p. 47), they tested 10 information Web sites and reported that one-third of their users tried "search" as their first strategy for looking for information. Their results showed that more often than not, users were unsuccessful because of two problems:

- They didn't understand the scope of the search.
- They had trouble interpreting the search results.

Since those initial tests, UIE has continued to investigate the use of search as a look-up strategy, reporting the results in its e-mail newsletter, *UIEtips*, and in articles on its Web site (http://www.uie.com) with titles that include "Why on-site searching stinks," "Are there users who always search?" "Users don't learn to search better," and "People search once, maybe twice." The findings from this research reaffirm that users have great difficulty understanding the dynamics of a full-text search, and as a result, they give up easily because "full-text searches are different from looking something up in an index, but users didn't seem to grasp this." (User Interface Engineering 1997).

For example, when users typed in "tire" on the Car Talk Web site (http://www.cartalk.com), they were sur-

prised by the results that contained "entire," and "I'm tired." The search default was set to find partial word matches, and although users could change the default to search for entire words, no one did. If they misspelled or mistyped the word, they got zero results, but they didn't realize that the problem was spelling. With full-text searching, they received results that were clearly irrelevant. In one study, even a seemingly straightforward search task for "return policy" on Amazon.com resulted in 43 books on the topic but nothing on the return policy at Amazon.com (Ojakaar and Spool 2001).

In another UIE study, when users searched for information on dinosaurs in *Smithsonian* magazine online, the first hit they received was about the American steel industry, described as "one of the great American industrial dinosaurs." As UIE concludes, "An index is a more precise tool. No self-respecting human indexer would have referenced the steel industry under 'dinosaurs.' Good indexing is a skill; humans do it better than machines. We anticipate that professional indexers may become more involved in web site design in the future" (User Interface Engineering n.d.).

Reporting on the results of another study, UIE found that when people search Web sites for content, they often use the search engine. However, they find their target content only 34% of the time. Within this group who used search, 47% tried only once. Another 30% tried twice. Fewer than 25% tried more than twice, despite designers' efforts to encourage more search strategies through tips. Although these results were based on tests of e-commerce sites, UIE asserts that "for years, we've been seeing these results on intranets, corporate and institutional information sites, and any other type of site with a search capability" (User Interface Engineering 2001). Jakob Nielsen (2001) reports very similar results from his studies of e-commerce Web sites. He also reports on intranet studies (Nielsen 2002) in which "poor search was the single greatest cause of reduced usability across intranets."

Seth Maislin, an indexer, information developer, and author of "Building search smarts" (2000), states the problem succinctly: "To succeed, search engines must emulate human judgment." Fred Leise, in "Improving usability with a Website index" (2002), says much the same thing in attributing successful indexes to the fact that "a human has looked at and analyzed the text."

As Weinberg, Spool, Maislin, Leise, and others have pointed out, the current capabilities of software that automates the index preparation process cannot take the place of a human indexer in sorting, organizing, and even supplying additional words and concepts to help users locate information they need. When indexing software or a search engine is used in place of a qualified indexer, "The burden of effective searching is often on the user, and the user is rarely as familiar with the site structure as the writers, editors, and programmers" (Maislin 2000).

Algorithms that improve search engines are being written, and research is ongoing to understand other ways to present search options to users to improve the result (see Spink 2002). Companies are aware of the value of an effective search engine for their Web sites. Forrester Research reported that 77% of the firms they surveyed rated search as "extremely important," yet only 24% rated their own Web sites' search capabilities as "extremely useful" (see Hearst and colleagues 2002).

Google.com, the search engine of choice for many because of its ease of use in search queries, explains its search technology on its Web site. With tongue firmly in cheek, Google reports that its patented technology, based on the work of behavioral psychologist B. F. Skinner is built around low-cost pigeon clusters (PCs) that can

> *. . . compute the relative value of web pages faster than human editors or machine-based algorithms. . . . . When a relevant result is observed by one of the pigeons in the cluster, it strikes a rubber-coated steel bar with its beak, which assigns the page a PigeonRank value of one. For each peck, the PigeonRank increases. Those pages receiving the most pecks are returned at the top of the user's results page with the results displayed in pecking order.*

We obviously do not have access to the secret of Google's success, and we are not likely to be able to apply similar resources to creating algorithms that work for users in common look-up tasks. Therefore, we are left with the question of whether e-books are less useful when search replaces a traditional index. In the next section, we describe the methodology we employed in planning a usability test to compare full-text searching versus looking up information with an index.

METHODOLOGY

Richard Evans, past president of the American Society of Indexers, former technical communicator and current member of STC, former human factors engineer at IBM, and the indexer for *Usability testing and research,* broached the idea of conducting a comparative evaluation of an index versus full-text search. Because the issue of the superiority of one over the other is of interest to the indexing community, as well as to the larger community of technical communicators, Carol Barnum felt that it would make a challenging project for her graduate students in a usability testing course in the master's program in technical communication at Southern Polytechnic State University.

Information obtained from a query posted to a private usability listserv suggested that either of two approaches

could be used to design a usability test sequence to minimize the possibility of testing-order bias:

- The *between-subjects* method, in which one user group tests product A while a different user group tests product B. If the user groups are similar, then the performance of products A and B can be directly compared. This method relies on minimizing the differences (variables) between the two user groups.
- The *within-subjects* method, which controls for variables in the user groups, but which introduces the possibility of variables in the tasks for each product. Two options can be used with this method:
  1. Half the users test product A first; the other half test product B first, with the tasks for product A and B being similar but not identical.
  2. For a more complex task/user approach, user 1 might test product A using tasks 3, 5, 4, 1, 2, followed by testing product B, using tasks 9, 8, 6, 10, 7. The second user would follow the same task combination but reverse the order of the products. The order of the tasks would vary for each subsequent user.

Considering the logistics of analyzing the data if we chose option 2 above, we decided on the approach described in option 1: varying the order of the products used in a within-subjects design, in which the tasks for each product would be of similar difficulty and approach, but different for each product. As the test sponsor, Evans converted the electronic Quark file of the book to Adobe Acrobat 5.0 Portable Document Format (PDF) and used a software tool (Activate by Virginia Systems) to hyperlink the index entry locators to the corresponding electronic text pages.

From this file, we created two versions of the product in PDF files: one with the hyperlinked index just described and the other with the index removed, but with the full-text search tools provided with Adobe Acrobat Reader. Because we anticipated that users might need some brief training on the use of the search tool and on the features of the hypertext-linked version, we developed a tutorial for them to complete before the usability test.

Two teams of graduate students received orientation on the product, the process, and the issues of interest from the sponsor. Each team worked independently on creating a test plan, recruiting users, conducting the tests, evaluating the results, and reporting the findings. Of the seven students in the class, two are coauthors of this article, which is based on the findings of both teams.

Test plan development

The two teams were known as the Monday group and the Saturday group, in recognition of their separate meeting days. Both groups used information provided in *Usability testing and research* (Barnum 2002) to guide their test planning. Some of the main elements of their test development process are listed in Table 1.

Heuristic evaluation The first step in the plan was to conduct a heuristic evaluation, or rule-based, expert review that provides a list of specific and conceptual issues to guide the development of the test plan. Both teams developed their heuristics from the American Society of Indexers' "Indexing evaluation checklist" (2000) and Quesenbery's five characteristics of interface usability (n.d.). Table 2 summarizes Quesenbery's five characteristics.

Although the evaluators doing the heuristic evaluation had no formal training in compiling back-of-book indexes, the checklist and Quesenbery's characteristics of usability provided the evaluators with a list of objectives and a method of problem characterization. However, a basic question still needed to be answered: "Was the index being evaluated representative of a quality index?" To answer this question, we depended foremost on the credentials of the book's indexer—an indexer with extensive experience in book indexing and association with the American Society of Indexers.

We also compared the book to the recommendations and format for indexing in *The Chicago manual of style* (University of Chicago Press 1993) and to the index research and usability testing of Bishop, Liddy, and Settel (1991) and Olason (2000). Although a rigorous comparative analysis is beyond the scope of this article, we found that this book's index is typical of those found in other quality scholarly documents.

The test teams' heuristic evaluations revealed some important issues about both versions of the electronic textbook. Some of the issues involving the indexed version in electronic form contradict what would be considered good practice for a back-of-book index, as explained below. It should be noted that the index for the book was not usability tested prior to the comparative study reported here.

TABLE 1: MAIN ELEMENTS IN TEST PLAN DEVELOPMENT

Step	Description
1.	Heuristic evaluation
2.	Participant profile and recruitment
3.	Test scenarios
4.	Testing methodology
5.	Information gathering

TABLE 2: QUESENBERY'S FIVE CHARACTERISTICS OF INTERFACE USABILITY

Characteristic	Description
Effective	An interface is effective if users can achieve specified goals completely and accurately.
Efficient	An interface is efficient if users can complete the tasks for which they use the product quickly and accurately.
Engaging	An interface is engaging if it is pleasant and satisfying to use
Error tolerant	An error-tolerant interface is designed to prevent errors caused by the user's interaction and to help the user in recovering from any errors that do occur.
Easy to learn	An interface is easy to learn if it allows users to build on their knowledge without deliberate effort.

Heuristic evaluation of the indexed version revealed the following issues.

- The lack of contrasting typeface treatments obscures the hierarchy of information within the index. This is not a significant issue in the hardcopy version, probably because of easier eye scanning of the hardcopy version, and the PDF version has a slightly darker typeface, making entries and sub-entries look similar.
- The book's index has three columns on each page instead of the usual two columns, probably making the index pages look denser than normal, especially in PDF format. In addition, the PDF index entry locators were somewhat challenging to click on because of the close proximity of the numbers.
- When the user clicks on the index entry's hyperlinked locator, the associated page is displayed without highlighting the desired text on the page. This is a feature of the linking tool, which links the entry to the top of the page, not to the entry itself. This method of linking may violate our participants' mental model of how hyperlinks work. (Also, because about 10% of a typical index's entries are "coined," it's not possible to link all index entries directly to highlighted text on a document page.)

Figure 1 shows a partial view of the index as a PDF document with the hyperlinked locator.

Heurisitic evaluation of the text-search version revealed the following issues.

- The user does not have access to possible synonyms or cross-references typically provided by an indexer to help guide the user.
- The Adobe Acrobat Reader text-search tools are not tolerant of misspellings.
- Simple searches are easy to do, while advanced searches require more knowledge of the Adobe Acrobat text-finding functions, such as word stemming, "Match Whole Word Only," and "Match Case."
- The Adobe Acrobat "PREVIOUS HIGHLIGHT" icon is not intuitive for the user. Users may wish to review a previous text match, not just go back pages in the document.
- Users may not understand the difference between the Adobe Acrobat "SEARCH" and "FIND" options. The SEARCH tool is faster, is more versatile, and has the ability to search multiple documents. SEARCH scans an alphabetic listing (also called an index) of every word occurrence in the document, while FIND scans each word within a document.

Figures 2, 3, and 4 provide screen captures with descriptions of the Adobe Acrobat functions (SEARCH and FIND) that a typical user would use to locate information in a PDF document. Figures 3 and 4 provide screen captures of the actual product used in the usability test with the text-search dialog boxes displayed. To obtain the dialog box, the user positions the mouse cursor over the desired icon and right clicks the mouse. Also displayed in the dialog boxes are some advanced text-search options. In our tests, some users used search only; others used both search and find features. The choice of features for search did not have an impact on the search results. Therefore, when we refer to search results, we are combining what users found when using SEARCH or FIND features in Adobe Acrobat Reader.

It is important to acknowledge that users with advanced search skills may be able to effectively counter some of the drawbacks of full-text searching. Nonetheless, our assumption is that *typical* users do not use, nor do they

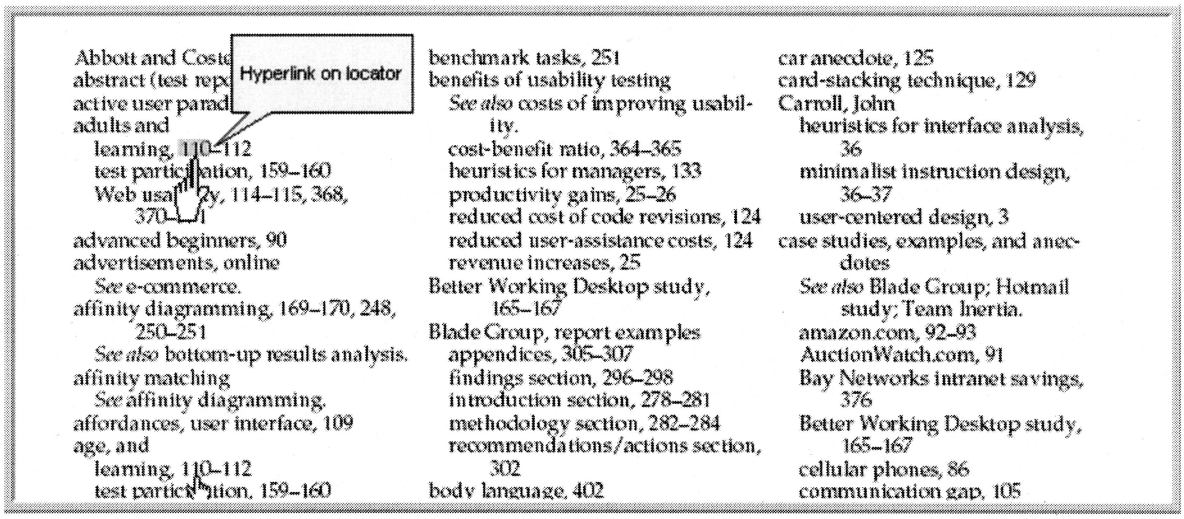

Figure 1. Partial screen capture of book index with hyperlinked locator.

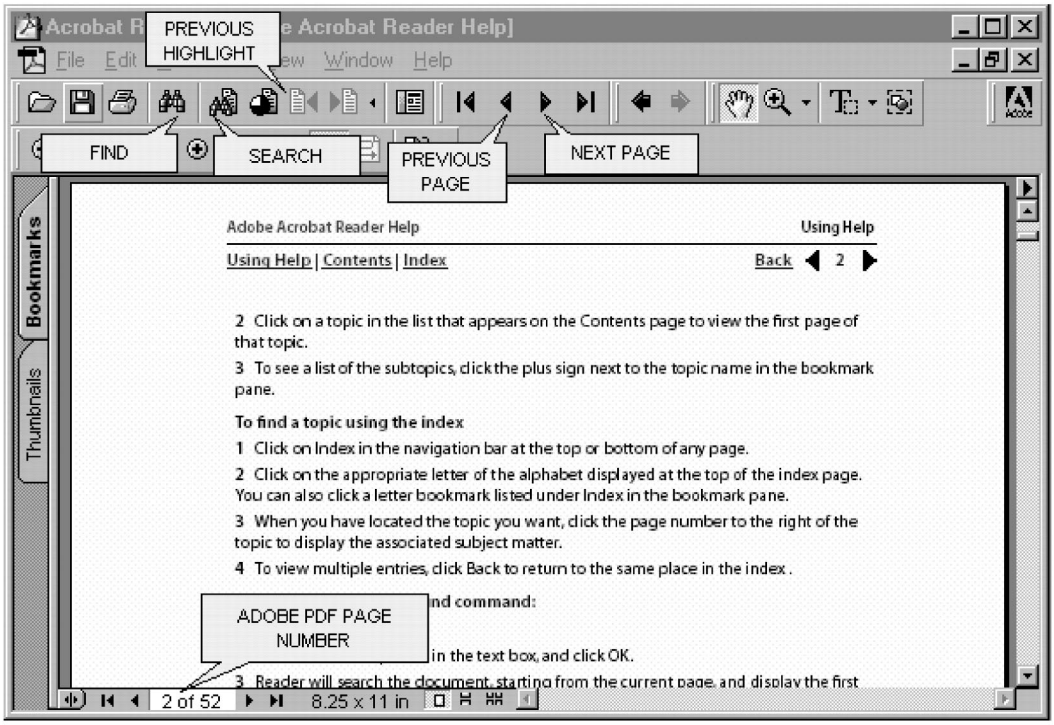

Figure 2. Typical Adobe Acrobat Reader tools for text searching and page scanning.

have knowledge of, advanced searching techniques. We define typical users as those using the following most commonly used Adobe Acrobat Reader shortcuts, as described in numerous tutorials available on the Internet (see http://getit.rutgers.edu/tutorials/shortcuts/media/shortcuts.pdf):

- Ctrl + G = find again
- Ctrl + L = full screen

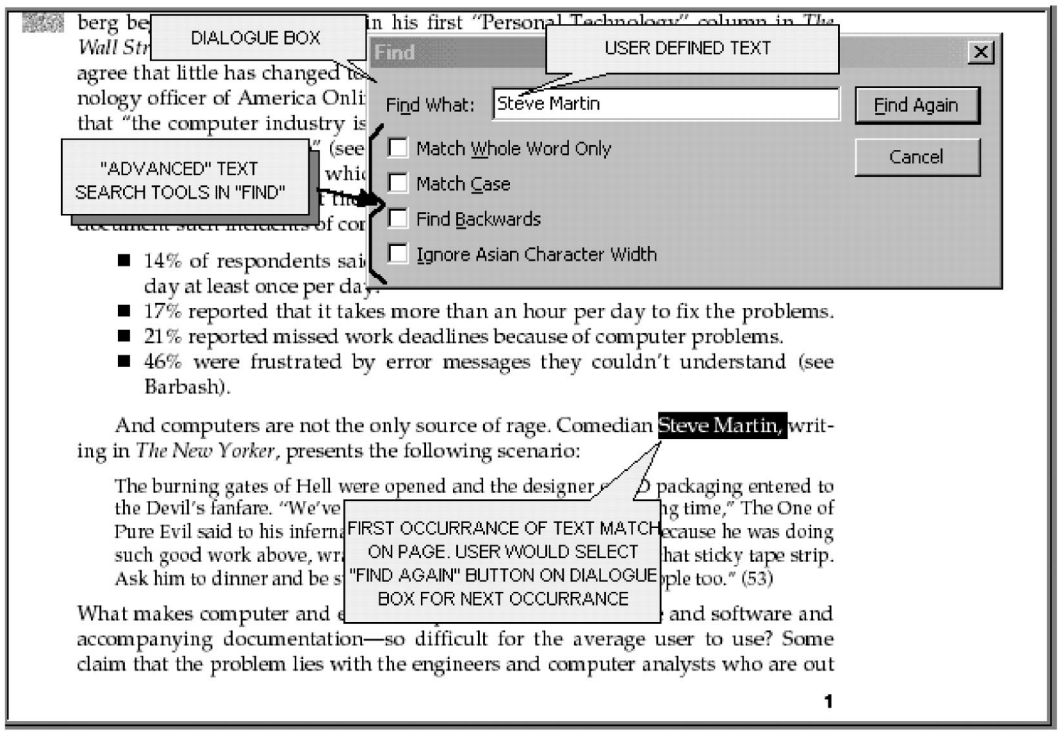

Figure 3. Usability test product (e-book) with "FIND" dialog box activated.

- Ctrl + M = zoom to
- Ctrl + N = go to page (insert number in box)
- Ctrl + Q = quit program
- Ctrl + + = zoom in
- Ctrl + − = zoom out

We categorized our participants as typical users because, as noted in the section on participant profile, the majority of our participants indicated that they were familiar with, but not experts at, using Adobe Acrobat Reader search/find features. Consequently, to ensure that we tested the typical user, we did not tutor our participants on these advanced text-search options. Moreover, we did not tell our participants that these options could or could not be used; as a result, our participants' opting not to use advanced search techniques serves to further justify their being categorized as typical users.

Participant profile Both teams agreed that there are two primary audiences for the book: students of usability testing and professionals with an interest in, or familiarity with, usability testing. Students would presumably read the book as assigned by their instructor and generally have limited use for the index. Professionals, on the other hand, use indexes extensively to quickly find the information necessary to complete their tasks. Based on this assumption, both teams decided to target technical communication professionals, using the following criteria:

- Have at least an undergraduate college degree
- Have participated in or planned at least one usability test or are familiar with usability testing (familiarity was determined to be important because knowledge of vocabulary and terminology was required for look-up tasks)
- Have at least one year's experience using a computer on a weekly basis
- Have familiarity with using electronic documents
- Have at least one year's experience using text-search in an electronic document or Internet-use capacity on at least a monthly basis
- Have familiarity using Adobe Acrobat Reader software and PDF files

Participant recruiting Although both teams agreed on the criteria for test participants, the pools from which each group chose were different. The Monday group targeted technical communicators who worked in the training and instructional design field, whereas the Saturday group targeted technical communicators who were members of STC's Atlanta chapter Usability Special Interest Group (SIG). Since all members of the Monday group worked in the training and instructional design field, it was relatively

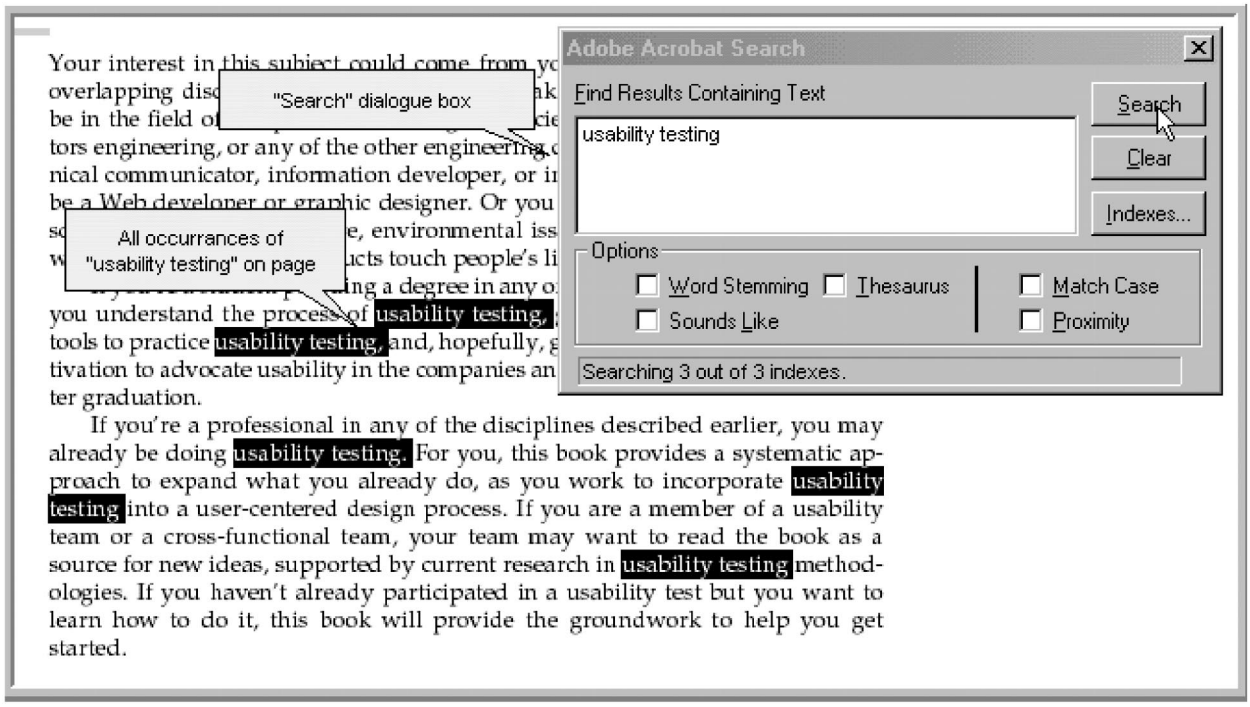

Figure 4. Usability test product (e-book) with "SEARCH" dialog box activated.

easy for each of them to contact members of their respective training groups and peers that worked at different companies but in the same field. They originally contacted 20 potential participants and screened them according to the recruitment process below. The Saturday group, on receiving permission from the Atlanta chapter Usability SIG, sent an e-mail to the entire SIG mailing list to begin the recruiting process.

Despite the differences in the makeup of the two test groups, the recruitment process for both was very similar, following these steps:

1. Send a cover letter and screening questionnaire to potential participants. Analyze questionnaire responses to determine how well the potential participants matched the desired participant profile.

2. Contact each of the top candidates by e-mail until six participants and one alternate agreed to participate at a specific time and date.

3. E-mail all scheduled participants a copy of the consent form and confirm their intent to participate at least three days before the scheduled test date.

Table 3 describes the characteristics of the six Monday group participants recruited from the training/instructional design field.

Table 4 describes the characteristics of the six Saturday group participants, recruited from the Atlanta chapter Usability SIG. A comparison of participant characteristics between Tables 3 and 4 reveals that the information gathered for the participant profiles varies slightly between the Monday and Saturday test groups because of the independent approach used by the two usability test teams in selecting participants. However, all participants met the usability test profile.

Test scenarios Both teams developed six test scenarios (three for each version of the electronic text). Using each scenario, the teams created tasks for the participants emulating "real-life situations when possible" (Ryan and Henselmeier 2000, p. 199). Three scenarios anticipate participants using text search to find the requested information, while the other three anticipate participants using the hyperlinked index. Our scenarios had the following characteristics:

TABLE 3: USABILITY TEST PARTICIPANTS' CHARACTERISTICS—MONDAY GROUP

Participant characteristics	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6
Age	21–30	31–40	21–30	31–40	41–50	31–40
Sex	Female	Male	Male	Female	Female	Male
Education	Bachelor's	Master's	Bachelor's	Master's	Master's	Master's
Right-left-handed	Right	Right	Left	Right	Right	Right
Time spent accessing documents from the Internet	More than 20 hours per week	More than 20 hours per week	More than 20 hours per week	More than 20 hours per week	More than 20 hours per week	10 to 20 hours per week
Usability testing familiarity	Have planned or performed more than one usability test	Have planned or performed more than one usability test	Have planned or performed a usability test	Have planned or performed a usability test	Have planned or performed more than one usability test	Have read about usability testing but never planned or performed a test
Familiarity with the Internet	Use the Internet daily	Use the Internet daily	Use the Internet daily	Use the Internet daily	Use the Internet daily	Use the Internet daily
Familiarity with electronic search functions	Have used search functions for at least one year	Have used search functions for at least one year	Have used search functions for at least one year	Have used search functions for a less than one year	Have used search functions for at least one year (Google, Yahoo, etc.)	Have used search functions for at least one year
Experience with the search/find function in Acrobat Reader	Use regularly (at least once a week)	Use regularly	Used a few times	Used a few times	Used a few times (only when people insist on putting paper documents on the Internet)	Used a few times
Technical communication experience	More than one year	More than 5 years	More than 9 years	More than 4 years	More than 5 years	More than 5 years

TABLE 4: USABILITY TEST PARTICIPANTS' CHARACTERISTICS—SATURDAY GROUP

Participant characteristics	Participant 1 (pilot)	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6
Age range	41–50	41–50	51+	41–50	21–30	41–50
Sex	Female	Female	Female	Female	Male	Male
Education	Master's or higher	Master's or higher	Bachelor's	Master's or higher	Bachelor's	Bachelor's
Usability testing familiarity or experience	Familiar	Experience 6–12 months ago	Experience more than 12 months ago	Experience more than 12 months ago	Experience 6–12 months ago	Familiar
Computer familiarity	Comfortable	Comfortable	Very comfortable	Very comfortable	Very comfortable	Comfortable
Computer experience	Business	Business	Research	Business	Leisure	Business
Document medium preference	Hardcopy	Hardcopy	No preference	No preference	Hardcopy	No preference
Number of electronic documents read (see Note 1)	Many	Many	A few	Many	Many	A few
Frequency of use of electronic documents (see Note 1)	Sometimes	Often	All the time	All the time	Sometimes	Often
Frequency of use of text search functions in electronic documents (see Note 1)	Sometimes	Rarely	All the time	All the time	Often	Sometimes
Preference in finding information in electronic documents (see Note 2)	Search	No preference	Search	Search	Search	Search
Adobe Acrobat Reader familiarity and experience (see Note 3)	Familiar	Expert	Familiar	Expert	Familiar	Familiar
Technical communication experience	1–5 years	1–5 years	5+ years	5+ years	Less than 1 year	Less than 1 year

Notes:

1. *There appears to be a discrepancy between participants 3 and 6's reply to the number of electronic documents read ('few') and the use of electronic documents ("all the time") and the use of electronic text-search tools ("all the time" and "often"). Since we did not try to quantify the participants' responses to these questions, the responses are subjective relative to the participants' experiences. The usability test team wanted users familiar with electronic text-search tools.*
2. *Notice that all but one of the Saturday group participants preferred text-search tools to locate information in electronic documents. This response is probably due to the widespread use and popularity of search tools.*
3. *We expected the response to this question to range from "familiar" to "expert" because of the widespread use of Adobe Acrobat; our own experience with the search tool showed that the more time spent with the product, the better our understanding of how to use it effectively. Thus, our participants may be overstating their true level of proficiency.*

- They would be written from the perspective of an individual familiar with usability testing, but not necessarily the specific jargon or terminology used in the textbook.
- Each scenario should require 10–20 minutes.
- To complete the scenario, participants would write down the book's page number(s) where they thought the information that satisfied the scenario task was located. (This provided the test team with a method to check the successful completion of the task.)
- Each scenario would contain three to five tasks or questions for the participants to work through.

Although both teams used the same approach in creating the scenarios, there were a few differences in the content. For example, both teams asked participants to locate or define information or terms, but the information or terms were different. For example, one group asked participants, "How and at what point do you decide what tasks the user will do?" while the other group asked, "What stage of design is best to schedule a usability test?" The result is that the two teams' combined coverage of the electronic text was broader than would generally be achieved by one test with five or six participants. However, because of the differences in the look-up tasks requested by each team, the results of specific findings on some terms and information could not be combined.

Testing methodology Discount usability testing is a well-documented and industry-accepted testing method that provides quick and satisfactory results at minimum cost and with greater flexibility to support product development and schedules. Virzi, Nielsen, Lewis, and others claim that over 80% of the usability problems associated with a product are detected by testing only four to five users with carefully constructed scenarios (see Barnum 2002, pp. 11–12). By using this discount usability testing method, we decided that five to six users would provide reliable results and cover any unplanned situations.

To guard against the influence of testing order, both teams alternated the version sequence administered to the users. For example, user 1 received the indexed version of the test first and then the text-search version, while user 2 received the text-search version first, then the indexed version.

Although we wanted and screened for participants comfortable with using Adobe Acrobat Reader and PDF files, we knew from our heuristic evaluations that our users would probably have varying skill levels with the software, and that this fact might introduce unwanted variables in our testing. We suspected that their responses to the prescreening questionnaire were optimistic as to their ability and true comfort level with the software. Some of the issues we anticipated included the following:

- What useful time performance data could be obtained if a user didn't recognize the Adobe Acrobat Reader functions or icons that made text searching much easier?
- Would our users understand the pop-up dialog boxes?
- Would our users be familiar with how the hyperlinked index version worked, especially with its unique format created by the hyperlinking software tool?

To ensure that all our users were similarly prepared to use Adobe PDF files, Acrobat Reader software, and the layout of the electronic text versions, we provided a tutorial before the start of each testing session. The users clicked and navigated their way through the Acrobat Reader software, demonstrated their efficiency with the text-search tools, and became familiar with the use and limitations of the hyperlinked indexed version of the electronic text. We also provided a quick-reference job aid of Acrobat Reader navigation and the main points of using the electronic text's index in case the users needed a guide to refer to during testing.

Information gathering To capture meaningful and retrievable data on which to base conclusions and recommendations, we wanted both qualitative and quantitative data. Using the usability lab at Southern Polytechnic State University provided us with the means to capture both. The lab is a three-room setup: executive viewing room for visitors, control room for observing and recording users, and evaluator room for the user, with the following equipment:

- Three remote-controlled cameras to capture different angles of the user and the computer screen on videotape.
- A microphone to project and record comments made by the user.
- A one-way mirror to allow the test team in the control room to directly observe the users performing their tasks.
- A computer in the control room with data logging software to allow a team member, serving as logger, to enter comments by users and the team during the observations.

The users completed pre-test, post-task, and post-test questionnaires. The questionnaires, designed in part on a 5-point Likert scale, provided a rich source of quantitative data. Comment sections were also included in the questionnaires that allowed the users to express their opinions about the tasks.

Table 5 provides an overview of the testing sessions.

Figure 5 provides an overview of the entire usability

TABLE 5: TESTING SESSIONS

Session characteristics	Monday Group					
	Participant 1	**Participant 2**	**Participant 3**	**Participant 4**	**Participant 5**	**Participant 6**
Length of session	1:08:42	1:20:23	1:34:21	1:19:16	1:23:28	1:38:36
Test date	3/25	3/25	4/1	4/1	4/8	4/8
Testing sequence	Index first	Search first	Index first	Search first	Index first	Search first
Session characteristics	**Saturday Group**					
	Participant 1	**Participant 2**	**Participant 3**	**Participant 4**	**Participant 5**	**Participant 6**
Length of session	1:15:14	1:19:00	1:04:08	1:49:25	59:43	56:28
Test date	3/18	3/23	3/23	3/30	4/6	4/5
Testing sequence	Search first	Search first	Index first	Index first	Index first	Search first

testing process.

Following each test session, the test teams tabulated quantitative data (times, success rate) and subjective information from the questionnaires, such as users' ratings of ease of use, on a 5-point Likert scale. From the observations of the users, we also gathered a large amount of qualitative information, such as comments and facial expressions. Table 6 provides some typical examples of quantitative and qualitative information.

RESULTS

Performance results

We asked our users to find specific information requested in each scenario. We collected data on their responses and the time spent searching for the information. We then compared how our users performed with the two versions of the electronic text. Because the teams worked independently, the success rate determination was different for each test team. The Monday group's success rate was based on users finding the correct information within a time constraint. The Saturday group rated the task successful if users found the correct information without a time constraint. Table 7 presents the users' performance in terms of successfully finding the requested information and the cumulative time spent on each task.

Because the two independent teams used different scenarios and different acceptance criteria, the two groups' performance ratings are not meant to be directly compared, but results between the two groups are similar. We can see from Table 7 that most users performed better using the indexed version. Furthermore, as distinct groups, we see that each group of users performed better using the indexed version in terms of user success and the lesser amount of time to complete the tasks.

Without telling our users how they did in the scenarios, we asked them in post-test questionnaires which version—index or text search—they preferred to use. Contrary to the performance data, just as many of our users preferred the text-search version as preferred the indexed version (see Figure 6). Two of our users had no preference as to which method they used.

Now that our users had experienced a usability test with challenging tasks, we wondered if any of them had changed their minds from their initial, pre-test opinions of their preferences for performing information look-up tasks. We were able to analyze this question by looking at the responses of the six users from the Saturday group because we asked them before they were tested which method they preferred. Figure 7 shows the six Saturday group participants' pre- and post-test preferences for looking up information in electronic documents.

Figure 7 shows that two of the users changed their minds from initially preferring text search to using an index to look up information in electronic documents. We should note that these two users strongly preferred the indexed version. Of the original five users who preferred text search, two indicated a strong preference for the search tool in the post-test questionnaire, while the other two who preferred search did so moderately.

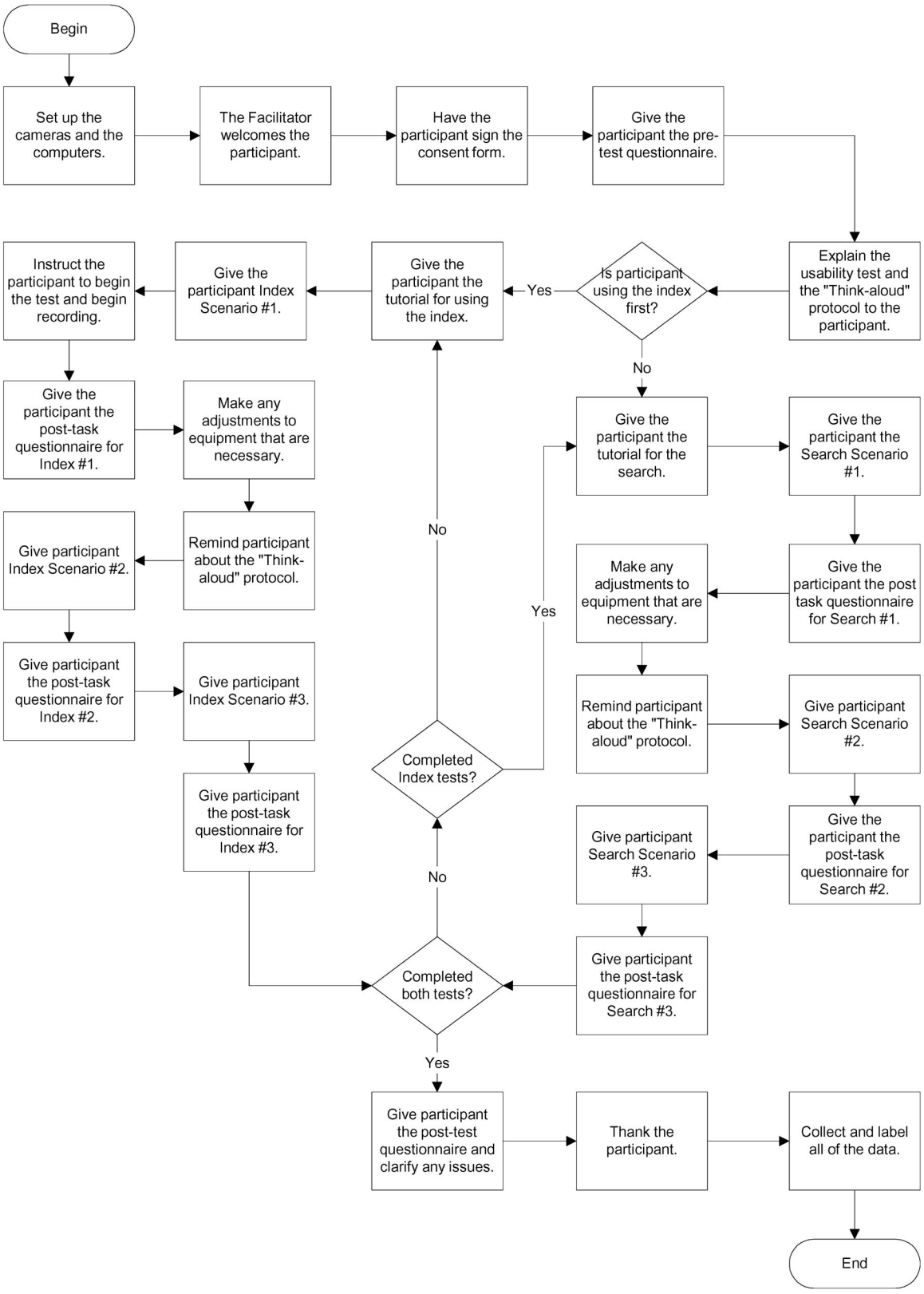

Figure 5. Flow chart of the usability testing process.

TABLE 6: EXAMPLES OF QUANTITATIVE AND QUALITATIVE DATA

Quantitative information	Qualitative information
User took 12:35 minutes to complete the task	He said "Darn" when he lost the page number.
User returned to the index three times during the task	She makes a face of frustration when hyperlink didn't work.
She rated usefulness of the index version as a "5" on the Likert scale (0 = Not Useful, 5 = Very Useful)	She comments that the textbook is interesting and she would like to read it.
He completed the task "successfully."	He smiled when the answer was obvious.

User satisfaction results

While performance data and user opinions expressed in post-task and post-test questionnaires provide important information in a usability test, users' displays of emotions and their comments while thinking out loud as they try to complete a task also provide rich information about the user experience and potential areas for improvement. Because the usability testing facilities at Southern Polytechnic State University allowed us to capture and record users at work while we observed them from a separate room through a one-way mirror, we were able to learn a lot from our users, both at the time of testing and afterward in reviewing the videotaped sessions. Below we provide an overview of our significant qualitative findings that helped complete the picture of our users' experiences with the electronic documents.

User self-confidence As we expected from the user profiles, our users showed confidence in their ability to work with electronic documents. None of the users indicated that they were overwhelmed by the technology. Most users found that it was easy to navigate through the electronic documents. Some users smiled and one laughed when the correct answer to a question was found. Another commented that she was "liking the search function better now," after using it for a few searches. One user even sang while using the search function.

User determination We noted the users' diligence in seeking a correct answer, some going as far as reading pages of text (because of interest or being up to the challenge) and noting other locations for future reference where they could look for additional information. None of the users made disparaging remarks about the subject or the technical content of the text. One user commented that the book was very interesting and she would like to read it.

Users' desire to use the table of contents Our observations showed us how important the table of contents is to electronic document users. The strategy we observed most users employ when searching was to type in a word or string of words from the scenario, hoping for a text match to complete the task. However, the teams had carefully avoided using terms in the scenarios that would lead users to specific entries in the text, hoping instead to learn what terms users would want to search on. After a few unsuccessful attempts at word matching, many users resorted to the table of contents to find appropriate entry points. Users also used the table of contents extensively in the indexed version of the test.

Book as an electronic document The users were clearly knowledgeable about the advantages of using an electronic document—namely, speed and the tools necessary to quickly narrow their searches. This familiarity may be due to the nature of the situation the users were placed in, requiring them to look up information in an electronic document that they probably hadn't used before from scenarios that increased in difficulty as they went along. The users could use the speed and features of the application software to help them zero in on information through trial and error. We also noted that half of our users in the Saturday group pre-test questionnaire stated that they prefer hardcopy documents in both pleasure and work situations. Two users said during testing that they would have preferred using a hardcopy text.

User frustration We observed that all users showed the following signs of frustration with both the indexed and text-search versions as they attempted the tasks within

TABLE 7: COMPARISON OF USER PERFORMANCE

		Monday group (see Note 1)		Saturday group (see Note 1)	
User	**Method used to find information in scenarios**	**User success**	**Cumulative time to complete scenarios**	**User success**	**Cumulative time to complete scenarios**
1	Text-search	100%	30:31	71%	36:13
	Index	100%	38:11	71%	19:26
2	Text-search	67%	50:59	100%	34:38
	Index	33%	39:44	100%	16:22
3	Text-search	67%	49:21	57%	16:48
	Index	100%	45:00	86%	25:56
4	Text-search	100%	38:10	71%	43:37 (Note 2)
	Index	100%	41:06	100%	50:21 (Note 2)
5	Text-search	67%	47:29	86%	29:05
	Index	100%	35:59	86%	14:38
6	Text-Search	67%	61:09	57%	21:20
	Index	100%	37:27	86%	14:37
Group average performance (see Note 3)	Text-search	76%	46:36	74%	30:20
	Index	84%	33:52	86%	23:33

Notes

1. *Since each usability test group performed independent testing, the scenarios are not identical for the two groups.*
2. *User number 4 of the Saturday group was very diligent in researching her information and reading the text, likely skewing her performance time.*
3. *For example, the Monday group average time to complete all the scenarios using the text search tools would be (30:31 + 50:59 + 49:21 + 38:10 + 47:29 + 61:09) / 6 = 46:36 (minutes:seconds).*

each scenario:

- Unfruitful match results when using the text-search version due to typing errors or inability to come up with appropriate synonyms
- Missing synonyms that the users thought should be in the index
- Difficulty clicking on hyperlinks in the index
- ". . . too many go to's—go here, go there, etc. (cross references). The search words did not match the questionnaire."

Document design for an electronic document

"Converting paper formats to a PDF makes [the page] very small and difficult to read." This comment by one user is typical of the problem experienced by users viewing the print version converted to an electronic

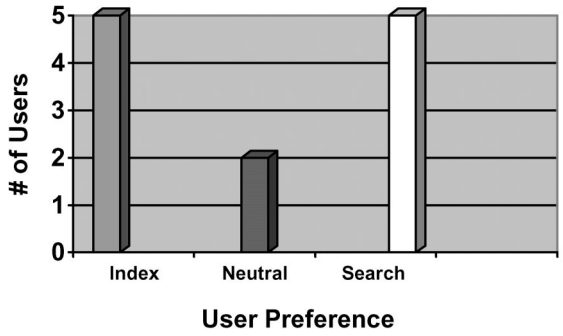

Figure 6. User preference to find information from post-test responses.

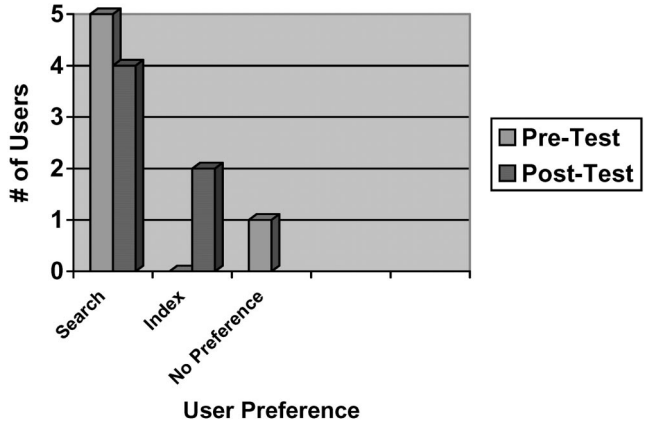

Figure 7. Comparison of Saturday user group pre- and post-test preference for information look-up.

document. Even though the users could have resized the on-screen display by selecting the size button and the drop-down size choices or selecting the "ZOOM" option from the VIEW menu, most did not resize the document, perhaps because they were not aware of this option. We found that issues such as this, arising from conversion of the book from print to electronic format, would not be issues in a traditional hardcopy version, and users' mental models were not the same for electronic versions and hardcopy versions of the same document. Specific instances of conversion problems experienced by users are noted below:

- "Information is buried in the text." Two users made similar statements when the words on the hyperlinked page to the indexed entry weren't highlighted (the full page was shown on the screen, which is similar to the way in which a look-up task would be performed in a hardcopy index).
- Four users expressed the feeling that they had lost their bearings in the electronic document because full-page figures from the paper version interrupted the flow of the text (one page at a time was displayed on the computer screen as is typical of PDF documents).
- The pagination of the PDF file was different from the book's pagination, causing four users to start searching on the wrong page because front matter pages with Roman numerals for page numbers (for example, ii, iii, iv) were included in the PDF. (The document's page number is shown directly on the document while the PDF page number is shown in the lower left corner of the screen in the status bar.) This situation caused some initial frustration for some of the users, especially those using the Table of Contents, which was not hyperlinked, but they quickly caught on to the differences between the two numbering schemes and concentrated on the document's pagination instead of the PDF pagination. Anyone using the index presumably followed a hyperlink.

Other comments, though expressed by a single user, were observed to be issues for several users:

- "They were paper designs forced online. They were NOT designed for online."
- "Search and index tasks are time-consuming and cumbersome. Would prefer hardcopy."
- "The columns are confusing in the index; you have to scroll down and then back up to the next column." (We noted earlier that this index had three columns versus the two columns suggested by the *Chicago manual of style*).

Although we provided quick reference cards and help documents for Acrobat Reader navigation and word search enhancements, our participants never used these tools. Users seemed to prefer to scroll through pages of text, hoping to find something related to the task or repeat searches that had already proved to be futile instead of stopping and reading instructions that might have helped them in their task. The following comments show the level of frustration experienced by some users:

- "Have never liked Adobe Acrobat products."
- "If I were a real user, I would have given up on a few tasks."
- "Steps! Still can't find steps!" (User was searching for information about steps in designing a usability test.)
- "Take the stupid thing out if it doesn't work properly." (One user's reaction when receiving an error message while using the search function.)

As noted by four of our users, the usability lab's computer screen "flickered" while users were performing tasks. Although this wasn't necessarily a usability issue, we noticed a look of apprehension on their faces.

Issues affecting user performance and satisfaction

Returning to the primary goals of the usability test—*Which is more efficient, effective, and satisfying for looking up information in an electronic text—a traditional index or a text-search tool?*—we combined our analysis of the qualitative and quantitative data gathered during testing with the information from the heuristic evaluations in an attempt to explain the performance and choices made by the users. In Table 8, we summarize the findings that had a significant impact on users' performance and attitude toward both versions of the electronic document we tested.

CONCLUSION

Yogi Berra once said, "You've got to be very careful if you don't know where you're going, because you might not get there." Although the baseball legend wasn't talking about finding information in a document, his proverbial message rings loud and clear for us as technical communicators: our users may not know where they are going, but we will have to help them get there anyway. This usability test brought the point home to us that Yogi was right; users will struggle and become frustrated when seeking information if the effort isn't easy and intuitive. Furthermore, users often can't gauge their relative success or performance, and they resort to tried, and sometimes untrue, past experience, regardless of performance.

Our usability test results suggest that users looking for specific information in an electronic document probably should use the index, if one is provided. Of the 12 users we tested, 10 of them found more correct information when using the index as compared with the full-text search tools available in Adobe Acrobat Reader software. With the index, users found 86% of the answers correctly, while the same users averaged a 74% success rate when using the full-text search software. Furthermore, users found the information faster using the index—on average about 10 minutes faster—as compared with the text-search tool.

Our users should have been content and should have been able to see just how much an index helps them find information, but they were not. Here's the paradox that our usability test helped to uncover. Of our 12 users, only five showed a preference for using the index in post-test questionnaires with only two of those indicating a strong preference for the index. Five users still preferred the text-search tool, and two didn't really care which information-finding method they used.

We found that the users' satisfaction with the index and text-search tool was influenced by the level of effort required to find information and in the context of working in an electronic document environment. For example, a user's level of effort increases when working in an electronic document because of the computer's ability to find every occurrence of a word string, or because the user flips back a page or two to review a previous "hit" but can't remember the exact page number or figure out how to work the back button icon. As a result, the user has to focus his or her attention on the immediate task of interpreting what is displayed on the screen and how to react to it, instead of the user's primary goal of completing the task.

Our results indicate that some users valued the ability to quickly advance through the text, scanning the paragraphs that contained their highlighted search words to quickly "conquer" the task at hand without much regard for the quality of the results of their search method. However, this ability to scan text in the highlighted area of the search word quickly became fatiguing after the first five or six unsuccessful tries, leading to user frustration and "close enough" answers. Granted, using the advanced word search capabilities of Adobe Acrobat Reader would have helped users significantly in their word searches, but nobody used them. As we observed, users typed a word or, sometimes, a rephrasing of the task question into the search or find dialog box and waited to see what would happen. When word-searching in this manner, users generally settled for answers that were incorrect or less precise than they sought in their original word search.

We also found that our users liked synonyms, lots of them, in the index. Although most of our users found the existing synonyms in the index helpful in shaping their thought process about where to look for information, many of them expressed a desire for the synonyms that they thought of but that weren't in the index. This finding, coupled with the findings from the Macmillan study, suggests that additional synonyms, perhaps discovered through usability testing, can enhance the usability of an index.

In comparing the interactions of the users with the computer, such as clicking, scanning pages, and covering volumes of text, the search-find tools clearly provided more "action" for the users. The indexed version was slower in computer "action" than the text search because the electronic index functioned like a hardcopy index in a significant way: the hyperlinked index entry took the users to the page where the information could be found, but it didn't highlight the portion of the page where the desired information was located. This behavior clearly violated the users' mental model of how hyperlinked words in an index of an electronic text should work. Many users felt that they had to read unnecessary sections or pages of text to complete the task, something that they didn't like to do, regardless of the quality of the information found.

Something that we didn't expect was the users' desire to use the table of contents as a hyperlinked complement or alternative to both the index and the search tool, especially when they were initially unsuccessful in locating the

TABLE 8: PRIMARY FINDINGS AFFECTING USER PERFORMANCE AND ATTITUDE

Main issue	Description of user's action	Number of participants affected from both usability test groups
	Text-search version	
Issues that affect the user's ability to find the right answer	User doesn't know what terms to use for text-search entry and looks for hints in the table of contents.	9
	User pages through the document instead of using text-search.	4
	User has to look back and study question when initial text-search is unsuccessful.	5
User's thoughts on ease of use	User expresses frustration with text-search, inability to find a significant word match, and numerous insignificant "hits" throughout text.	12
	Indexed version	
Issues that affect the user's ability to find the right answer	Index does not contain user terminology.	9
	User finds the hyperlinked number associated with the index entry difficult to click on.	5
User's thoughts on ease of use	User expresses frustration with hyperlink design in index.	12
	User expresses regret at having to read sections or pages of text because the indexed version doesn't highlight the desired word match in the body of the text.	3
	Functionality of the table of contents in an electronic document	
User's expectations	User expects table of contents to assist in finding key word or words and to provide a hyperlink to desired location in text (see Olason 2000).	12
	Electronic document design	
Conversion of textbook designed for hardcopy to electronic textbook	Figures overlap pages in text that interfere with user navigation and cause confusion.	2
	Electronic document search software	
Learning to navigate efficiently and effectively	PDF pagination is different from the actual textbook's page numbers, causing user confusion, especially when using the indexed version.	4
	Users didn't use some of the basic navigation tools provided by Adobe Acrobat Reader.	10
	Users didn't use the provided tutorial and job aids.	10

desired information. This use of the table of contents was surprising because we didn't tell the users that they could use it or even mention it. Previous hardcopy document index usability testing by Olason (2000) showed that users rely on a table of contents as an index surrogate. Many of our users were disappointed when the table of contents wasn't hyperlinked to the text.

The results of our test indicate that superior performance doesn't necessarily go hand-in-hand with user preferences in locating information in electronic documents. Here we summarize the results of our usability test:

- The hyperlinked index is the more effective look-up tool.
- The hyperlinked index is the more efficient look-up tool.
- Users considered the search version slightly more engaging.
- Users considered the search version slightly more error tolerant.
- Users considered both the search and the hyperlinked index versions easy to learn.
- Users slightly preferred the search version to the hyperlinked index version.
- The average time spent performing a look-up task in the hyperlinked index version was less than the time spent completing a task of similar difficulty in the search version.

Although our users considered both versions easy to use, each version had software design peculiarities that may have influenced their preference for one version over the other. Some of the peculiarities that we thought could have been a factor in our users' decisions are listed below.

- Clicking on the index entry page number in the index took users to the top of the page of interest—nothing more. Users may have been expecting the specific word of interest from the index to be highlighted, possibly violating the users' mental model of how a hyperlinked index should work.
- The page numbers in the table of contents did not correspond to the page numbers in the PDF document because Adobe Acrobat Reader displays the first page of the file as page 1; as the text starts with front matter, the actual page 1 doesn't correspond to page 1 in the PDF.
- Many participants used the table of contents in searching for information in both the indexed and search versions even though we didn't anticipate that users would use this resource.

RECOMMENDATIONS FOR ADDITIONAL RESEARCH

Limitations of our findings from testing, which clearly had an impact on the results, involved conversion issues from the print version to the PDF version of the book, as well as limitations of the software used for linking indexed items to the pages where the information was located. We recognize that the conversion of the book to a different medium raises a number of usability and readability issues, as we have reported in users' comments. Yet the practice of making such conversions from print to PDF is a common occurrence in companies because of the speed and seeming cost-savings that result from eliminating paper documentation.

Our findings, based on issues resulting from the conversion to PDF files, match those of other usability experts, as reflected in a discussion of this topic on a private usability listserv. In response to the query for information about the arguments for and against putting user guides online, one usability expert reported that "users simply didn't understand how the documents worked, in spite of the fact that we tried some easy design changes to target online delivery, such as underlining and changing text color of hyperlinks. Users got confused when Acrobat Reader opened as a separate application, and they got frustrated because there was no context-sensitivity, so they always had to look for the information they wanted." The product shipped without print manuals, despite the findings from the usability tests. Technical support calls were high (Weimer 2001).

Another described a typical scenario observed in testing the PDF converted from print documentation:

> *I have a job to do with this software. I can't figure out how to do one little thing that would keep me from completing my task and going home for the day. I find the online documentation by accident; it takes a few seconds to load the PDF. What was my problem? Oh, yes, I remember now. But how do I use this "book"? If there are links, will they behave the same way as the links on a web page? Can't I just flip through the pages? How do I do that? All right, I'm going to the index. I've found an entry that matches what I'm looking for, but now I have to find the page that matches the number. How do I do that? [Time passes . . . .] Maybe, I'll just call the Help Desk. (Chisnell 2001)*

This description of the typical user experience with the converted paper document matches what we observed. As we discovered in our tests, even when we provided tutorials and quick reference cards for our users, they did not refer to them, thereby failing to "learn" the search strategies available to them for searches that are more successful.

In addition to the common practice of eliminating paper manuals and documentation in favor of electronic documents, companies are increasingly converting their various administrative manuals to electronic documents for their intranet sites. Information look-up is frequently lo-

cated using the table of contents, standard search tools, or advanced Boolean logic operators. Most companies don't question the effectiveness of the search tool or the effect it has on employee productivity.

As Nielsen (2002) remarks about this common practice, "Special mention must be reserved for the single, simple design mistake that causes huge usability problems for the users in our study: unconverted PDF files." Nielsen further notes, "Poor search was the greatest single cause of reduced usability across intranets . . . . Search usability accounted for an estimated 43% of the difference in employee productivity between intranets with high and low usability." In a more recent *Alertbox* column on this topic, entitled "PDF: Unfit for human consumption," Nielsen (2003) characterizes most PDF files as "immense content chunks with no internal navigation. They also lack a decent search, aside from the extremely primitive ability to jump to a text string's next literal match."

In future usability tests of search versus index for look-up tasks, the elimination of the problems found with the PDF documents should be a major consideration. As well, a different software tool that links index entries to the actual content or embedding index entries in the text of a Microsoft Word document as it is being created would eliminate the frustration experienced by our users because of the limitations of the software tool we used.

Perhaps more qualitative research should also be done regarding user perception of performing electronic searches and using indexes in look-up tasks. If users have negative perceptions of these tools or processes prior to being tested, their perception may skew not only their performance but also their willingness to invest in the product. Some current research is focusing on look-up tasks, although the conclusion so far is that the search tools currently available are not up to the task of satisfying users (Ojakaar and Spool 2001; Spink 2002; Nielsen 2003). If, however, current trends persist and the majority of users claim to be satisfied with simple search queries, full-text search will increasingly replace indexes as an option in electronic documents. When this happens, according to Richard Evans (2002), "Important information will no longer be made retrievable. Instead, information will become important simply because it is retrievable." T**C**

REFERENCES

American Society of Indexers. 2000. Indexing evaluation checklist. http://www.asindexing.org/site/checklist.shtml

Anderson, J. D., and J. Pérez-Carballo. 2001a. The nature of indexing: How humans and machines analyze messages and texts for retrieval. Part I: Research, and the nature of human indexing. *Information processing and management* 37:231–254.

———, 2001b.The nature of indexing: How humans and machines analyze messages and texts for retrieval. Part II: Machine indexing, and the allocation of human versus machine effort. *Information processing and management* 37:255–277.

Barnum, C. M. 2002. *Usability testing and research.* New York, NY: Longman.

Bishop, A. P., E. D. Liddy, and B. Settel. 1991. Index quality study, Part I: Quantitative description of back-of-book indexes. *Indexing tradition and innovation.* Proceedings of the 22nd annual conference of the American Society of Indexers. Wheat Ridge, CO: American Society of Indexers, pp. 15–51.

Chisnell, D. 2001. Private usability listserv. Used with permission.

Evans, R. T. 2002. Usability test: Index vs. full-text search. Presentation at Southern Polytechnic State University, Marietta, GA, January 10.

Google. n.d. Our search: Google technology. http://www.google.com/technology/pigeonrank.html

Grimstead, D. 2001. Ten tenets of technical communication. *Technical communication* 48:13.

Hearst, M., A. Elliott, J. English, R. Sinha, K. Swearingen, and K. Yee. 2002. Finding the flow in Web site search. *Communications of the ACM* 45 (9): 42–49.

Leise, F. 2002. Improving usability with a website index. *Boxes and arrows.* http://www.boxesandarrows.com/archives/print/002848.php

Maislin, S. 2000. Building search smarts. *Hyperviews* 3 (1). http://taxonomist.tripod.com/websmarts/searchsmarts.html

Milstead, J. L. 1990. Indexing standards. *Indexing tradition and innovation.* Proceedings of the 22nd annual conference of the American Society of Indexers. Wheat Ridge, CO: American Society of Indexers, pp. 1–13.

Nielsen, J. 2001. Search: Visible and simple. *Alertbox.* http://www.useit.com/alertbox/20010513.html

———. 2002. Intranet usability: The trillion-dollar question. *Alertbox.* http://www.useit.com/alertbox/20021111.html

———. 2003. PDF: Unfit for human consumption. *Alertbox.* http://www.useit.com/alertbox/20030714.html

Ojakaar. E., and J. E. Spool. 2001. *Getting them to what they want.* Best Practices Series. http://www.uie.com

Olason, S. C. 2000. Let's get usable! Usability studies for indexes. *The indexer* 22:91–95.

Peek, R., and P. J. Hane. 1998. Will abstracting-and-indexing services become passé? *Information today* 15 (3):46.

Quesenbery, W. n.d. Getting started: Using the 5Es to understand users. http://www.WQusability.com/articles/getting-started.html

Rutgers Writing Program: Get IT. Adobe PDF Tutorial. http://getit.rutgers.edu/tutorials/shortcuts/media/shortcuts.pdf

Ryan, C. N., and S. Henselmeier. 2000. Usability testing at Macmillan USA. *Key words* 8:188, 199–202.

Spink, A. 2002. A user-centered approach to evaluating human interaction with Web search engines. *Information processing and management* 38:401–426.

Spool, J., T. Scanlon, W. Schroeder, C. Snyder, and T. DeAngelo. 1997. *Web site usability: A designer's guide.* North Andover, MA: User Interface Engineering.

University of Chicago Press. 1993. "Indexes." In *Chicago manual of style.* 14th ed. Chicago, IL: The University of Chicago Press, pp. 701–760.

User Interface Engineering. 1997. On-site searching. *UIEtips.* http://www.uie.com

———. 2001. People search once, maybe twice. *UIEtips.* http://www.uie.com

———. n.d. Why on-site searching stinks. http://www.uie.com

Weimer, T. 2001. Private usability listserv. Used with permission.

Weinberg, B. H. 1996. Complexity in indexing systems—Abandonment and failure: Implications for organizing the internet. American Society for Information Science annual conference, October 19–24. http://www.asis.org/annual-96/ElectronicProceedings/weinberg.html

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