INSTRUCTIONAL TEXT: THE TRANSITION *from* PAGE *to* SCREEN

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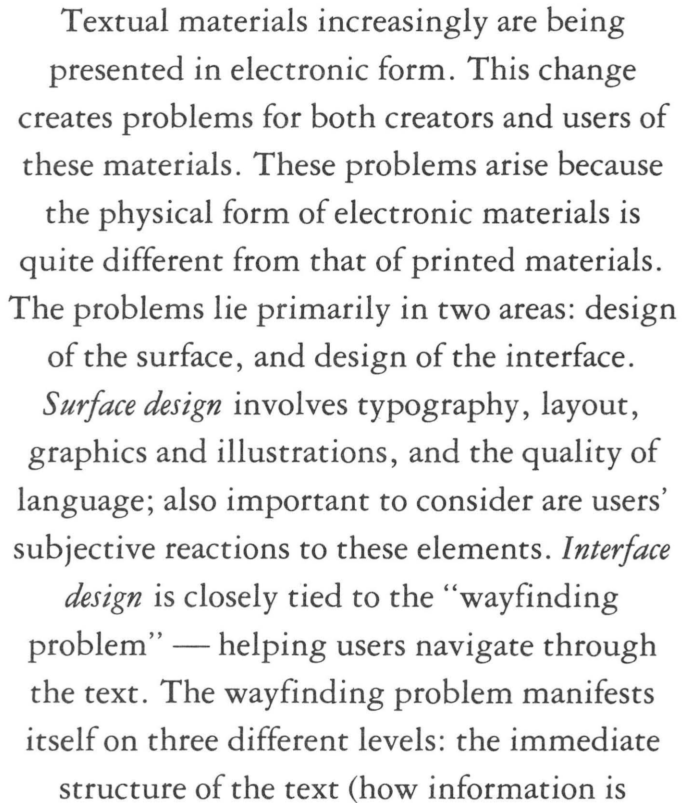

Textual materials increasingly are being presented in electronic form. This change creates problems for both creators and users of these materials. These problems arise because the physical form of electronic materials is quite different from that of printed materials. The problems lie primarily in two areas: design of the surface, and design of the interface. *Surface design* involves typography, layout, graphics and illustrations, and the quality of language; also important to consider are users' subjective reactions to these elements. *Interface design* is closely tied to the "wayfinding problem" — helping users navigate through the text. The wayfinding problem manifests itself on three different levels: the immediate structure of the text (how information is

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provided at the page level), the internal structure (how such information is provided within a given document), and the external structure (navigational aids that allow users to move from one document to another). Three directions for further research are identified: realistic studies of use and search through electronic text; studies of how users represent to themselves the structure of text; and how users might best be introduced to environments incorporating electronic text.

Scenario

The student reaches out a hand and picks up a text. In working one of the problems contained therein, the student needs to refer to a table of figures at the back of the book; to refresh memory on how to use that table, the student must also consult an earlier chapter and page in the text. Finding that point requires using the book's index. Holding a finger in the book at the point where the problem is given, and placing the thumb at the place where the table occurs, the student proceeds to use the index, checks the point where information on how to use the table is given, refers to the table, and returns to the page with the original problem. All this takes a matter of seconds.

Another student is working with similar material presented as an interactive computer program. The problem is stated on one screen, but knowing how to get to the table requires knowing a command sequence. The student refers to a small printed card to find the correct command sequence to find the table, enters the appropriate keystrokes, makes a mistake and succeeds in finding the table on the second try. On seeing the table and realizing that using it correctly will require reference to a part of the program different from that currently being used, the student checks yet another command sequence, enters keystrokes, and eventually finds the information needed to make sense of the table. Moving back and forth between the table and the material explaining it takes a series of commands on each instance; the student does this several times before feeling comfortable that the interpretation of the table is on target and the data extracted from it correct. The student then faces the task of relocating the point in the program from which he originally came. That, too, requires some keystrokes, together with a tolerance for working through several frames of information and problems that the student has already seen (some of them more than once).

The examples are hypothetical ones, but the problems portrayed in the second set are real — all too real for many learners who would use for research and learning instructional text and other materials presented electronically through computers or other electronic telecommunication systems. While not all such systems generate the kinds of difficulties shown here, many do, and even in those that are well designed and make it easier for the experienced user to find the information needed, the transfer from one system to another rarely allows that user to use what he or she knows without some modification to the particularities of the new system. The problem is one of how to navigate, how to find one's way in the information presented in order to use it easily and efficiently.

INTRODUCTION: INSTRUCTIONAL TEXT *and the* WAYFINDING PROBLEM

The agenda here will be first to define further the nature of the question, and then to compare briefly the nature of electronic and printed textual materials. Wayfinding as a practical and psychological problem is considered next. There follows a review of what we know about the design of textual surfaces and interfaces. Included here are discussions of the legacy of research on print-based text and how users learn to search for information there, as well as information from the current crop of studies on screen design and interface design for computerized systems. Finally, some proposals for further work to be done in the field are offered.

THE TRANSITION *from* PRINT *to* SCREEN

The shift from the use of printed materials for learning and instruction to the use of electronic systems is one of the most interesting aspects of the advent of computers in offices, factories, schools and homes. It may be that the most significant changes these developments bring with them are not at all the most obvious or publicly discussed ones — the high levels of motivation that seem to come with using computer-based instructional materials, the apparent improvement in test scores that follows upon regular practice with computer-based programs. Rather, the important shifts may be in the less visible habits of mind that accompany our work with information presented in textual form.

Our ways of working with printed materials are so long established — so closely interwoven into our unexamined view of what learning, teaching, searching for and using information are — that it is very difficult to step back and see clearly just how many things we take for granted. Even between cultures, for example, we generally know what a book or a journal "looks like," what conventions will be followed in its preparation and presentation. A book published in the USSR may have its table of contents at the back of the volume rather than at the front, but we soon adjust to those minor differences and learn to cope. We may become frustrated on delving into historical materials from the last century on finding that they typically lack indexes (though some made up for this by having elaborate and detailed tables of contents). And we also may note that some had elaborate title

pages that seemed to perform virtually the same function as today's dust jackets and inner-cover notes.

When we move further back in history toward the origins of printing, we begin to find that the look of the printed page diverges more and more from what we are used to, and that the wayfinding aids we usually take for granted are scarce. Consider, for example, the development of the conventions surrounding the title page: incunabular books typically had no separate title page. The work simply began, and often books were identified only by the first few words of the text itself. As the number of printed works grew, and as printers came to see the potential value to readers (not to mention themselves) of providing more information about the provenance of a particular work, title pages appeared and came to include a larger and larger variety of material — the title, to be sure (often supplied by the printer and not the author), but also the printer's name and location, sometimes the date, sometimes illustrations, and frequently elaborations of the title that we might today mistake for advertisements. (The best single discussion of how these features of early books developed may be found in Febvre and Martin, 1976.)

As we move yet further back we can trace in handwritten texts the development of yet other conventions that seem now so basic we have difficulty imagining what it would have been like to read, study, or write without them. These include such basic organizing features of text as upper- and lower-case letters, punctuation marks, spacing between works, separation of sentences and paragraphs, and the direction in which words move on a page — Greek "boustrophedontic" writing prior to the fourth century BC went alternately from right to left, then from left to right. All these conventions had to be developed and did not spring complete from the mind of some original writer. (See Ong, 1982, for a treatment of pre-literate consciousness, and Bateson, 1983, for remarks on the development of punctuation.)

ELECTRONIC TEXT *as* INSTRUCTIONAL TEXT

It is important at this point to distinguish the sense in which "instructional text" is used here. First and foremost, I want to imply a broader definition than simply a "textbook" in the commonly understood meaning of that word. While the book used in a high school course is surely one species of instructional text, there are others: the manuals and diagrams that teach aircraft mechanics a new skill, the videodisc that provides auto dealers with information about new models, and the documentation and job aids that lead a novice computer user into the intricacies of a new operating system are different, but no less instructional than their bookish counterparts.

Similarly, all manner of directories, dictionaries, catalogs, and other reference materials ought rightly to be considered instructional, for they are a common source (especially for adult learners) of new information that allows a job to be performed better or of review material that permits previously learned procedures to be recalled and carried out. Indeed, Sticht (1985) makes the point

that "reading to do" (using manuals and reference aids as a supplement to memory) is much more typical of adults' reading patterns than is "reading to learn" (attempting to transfer material from the text into long-term memory) that we more commonly take as a model of the reading process.

"Reading to do" appears to involve not only knowing how to read, but also knowing how to use the instructional material itself as an aid to memory. Most research (on questions ranging from typography to text comprehension to development of reading skills) and most efforts at creating a well-founded theory of reading have been focused on the problems inherent in "reading to learn." "Reading to do," on the other hand, has suffered from less attention by researchers and theorists, although it has been the target of applied efforts by instructional designers and developers.

Most instructional text presented electronically seems to fall somewhere in between "reading to learn" and "reading to do." Good instructional programs offered via computer give the learner the opportunity to move around, to branch to a point farther on in the program when responses indicate mastery of the material currently being presented, or to branch backwards in the case of lack of mastery. Another image of electronic instructional text that links it with "reading to do" is seen in the potential use of large, remote databases of computerized information as resources for learning and teaching. In both these cases, designers of instructional materials have been handicapped by a lack of good models, a difficulty in imagining what the final electronic product should look like. It is clear that "page turning" is an inappropriate metaphor for electronic text and for most reading-to-do applications.

THE NATURE *of the* WAYFINDING PROBLEM

A significant problem in any of these applications is how to "navigate" in electronic space. Part of the reason for this is the *invisibility* of the problem: because we are so accustomed to using books and other print materials, often we fail to consider carefully enough how to translate print-derived wayfinding strategies into a format suitable for electronic text. (This in spite of the fact that 35% of the total investment in software production is spent preparing the user interface; Smith & Mosier, 1984.)

A second reason that there is no single unified approach to the wayfinding problem is that it demands an *interdisciplinary* solution. Consider the bewildering array of researchers who have a stake in wayfinding: psychologists (of various kinds), librarians, educators, computer scientists and engineers, human factors specialists, and even such farther-afield folk as graphic designers, typographers, publishers, and architects. Relevant research and reports of applied development activities appear regularly in the publications of all these groups. The problem is in trying to extract a common perspective.

A third reason that wayfinding is a distinctly difficult problem is that it involves different processes carried out at different levels of conscious activity. Finding one's way in electronic text requires

skill in problem recognition and problem solving — knowing that one has a problem that access to information might solve, knowing how to define and limit the problem, knowing where to look, and knowing what the solution might look like. It is also a matter of having requisite mechanical and search strategies — knowing the keystroke sequences necessary to shift from one part of a program to another, knowing command sequences for different databases. And it is finally a matter of context — the urgency with which the user needs the information, prior experience in using electronic materials, tolerance for delay and uncertainty (in many present-day systems), and the degree of precision required in the solution to the original problem.

THE DESIGN *of the* SURFACE *and the* INTERFACE

Two aspects of electronic text design warrant our special attention: the preparation of the surface and of the interface. By surface, I mean the part of the text that is visible at any given moment to the user. For print materials, this usually means a single page of material; for electronic materials, it means a single screen or frame of information. By interface, I mean the system or structure that gives the user access to the text at a place the user desires or in a way that the user desires. For print materials, this includes the whole system of indexes and guides to the text, as well as typographic and other cues to the user's location (some have referred to this as the metastructure of the text, to distinguish it from the primary textual structure of meaning as presented in writing); for electronic materials, it includes those parts of the text that allow the user to call up different screens, to switch back and forth from one screen to another, and to change levels within the text or database.

For both surface and interface we can refer to the body of available research results for guidance on similarities and differences between print and electronic textual materials. My aim here is not merely to review those results, but also to extract relevant differences and suggest implications these may have for those who do research on and those who design electronic text.

Surface Design

The surface that the user encounters when using printed or electronic materials includes a number of separate characteristics: typography (the shape of individual letterforms), layout (the arrangement of text and white space on the surface), the use of illustrations and graphics of various sorts, the quality of the text as language (its readability, logical structure, and so on), and finally the reaction that the surface of the text calls forth in the user (the perceived value of the material, reaction to how it is arranged, and so on). In each case, what is true for printed text may not hold true (or more often, may vary subtly) for electronic text.

Typography. The way in which letterforms themselves are displayed varies, of course, between print and electronic forms. Print typography, with a history of centuries of development, offers numerous possibilities for the designer. Varieties of style, weight,

size, and mixtures of upper- and lower-case have been studied for their contribution to comprehension and ease of use. Readers of printed text seem to have little difficulty in working with any reasonably simple and consistent type style, although they experience difficulties if forced to use type that has too many cues (e.g., old english or black letter typefaces) or too few (e.g., type that lacks serifs or ascenders/descenders; many dot matrix printers are at fault on these counts). Hartley (1978) and Jonassen (1982) have useful comments on these matters. (For an excellent annotated listing of sources on both print and electronic surface design, see McGee & Matthews, 1985.)

In electronic text there is today must less variety in the letterforms that can be physically shown, though that may change with improved displays. One phenomenon observed in several studies is a preference on the part of users of electronic text for smaller characters and more of them per line — i.e., a 70- instead of 35-character line (Kolers, Duchnicky, & Ferguson, 1981). Another survey reported that 56% of the users of a teletext service wanted to see more information on each screen, a change that would be a function of letter size as well as layout (Teletext, 1982). Whether this preference is simply a residue of users' experiences with printed text remains to be seen. As is the case with printed text, reading all upper-case material from a CRT seems to be difficult and tiring (Foster & Champness, 1982).

Layout. The arrangement of the information on the screen is another important factor in both formats. How much blank space is worked into the text plays an important role in how users perceive the material, and how easy they find it to work with. Inter-section spacing, headings of various sizes and weights, and the conventions for grouping items on page or screen (e.g., sidebars and boxes) all play a role here. Considerable work has been done in this areas recently, and it seems clear that these elements play a major role in helping users not only to understand the material being presented, but also to encode it for long-term storage and retrieval (Anderson & Armbruster, 1985; Glynn, Britton, Tillman, & Muth, 1984).

The work that has been done on electronic text shows that these layout variables are, if anything, even more important in this mode of presentation. Both Marcus (1982) and Grabinger (1984), for example, found that leading or line skipping led to improved performance. Tullis (1983) went so far as to suggest that measures of text density could provide one simple index of display quality without having to conduct empirical tests.

This apparent preference for more spacing on CRT displays conflicts with the desire for more information per screen noted above. Users have clearly not yet come to grips with the visual world of the display, and it may take the advent of more sophisticated devices that can show more material on each screen to make people feel more comfortable with reading and using electronic text.

The use of color is another aspect of layout that should not be ignored. In printed material, color is a considerable added expense and so is used sparingly. While it has been shown to be an effective cue in some situations, its use is rarely perceived as mandatory (see, e.g., Waller, Lefrere, & MacDonald-Ross, 1982). In contrast, designers of electronic text can use color freely and without expense (except to the user, who must have a color monitor). And studies have shown again and again that electronic color is an attractive nuisance — a feature that users will ask for and like, even if it adds nothing to performance (Christ, 1975).

A final point relevant to both typgraphy and layout is that humans perceive differently information that is presented via reflected light (as in print) as compared with that presented via emitted light (as on a CRT). What stands out on a white paper background (e.g., the color red) appears muddy and indistinct on a glowing black CRT background. Designers have had to learn to take a new set of luminance values into account when working with emitted light (Bruce & Foster, 1982; Reynolds, 1979).

Illustrations and graphics. How graphic enhancements are used in text is another aspect of the design of surfaces. To display information pictorially is complex for the designer but often beneficial for the user, who may find it helpful to see concepts or relationships displayed in a non-verbal way. Recent studies suggest that, while users often find these materials helpful, the designer may not simply assume that the user has all the cognitive structures needed to decode graphic information. Here, as with printed text, the conventions must be learned. But — especially for novices coming to a topic or field for the first time — graphic images may help develop new concepts rapidly (Dwyer, 1978; Easterby & Zwaga, 1984; Tufte, 1984).

The case of graphics in electronic materials is very similar — though here again, we can observe the attractive nuisance phenomenon: while users of printed texts do not automatically expect graphic materials, users of electronic text (especially databases designed for general consumer use) seem to expect them. Studies of field trials of videotex and teletext services, for example, reveal that subscribers are more likely to use, enjoy, and continue to subscribe to those systems that incorporate many graphics (Carey & Siegeltuch, 1982; Irving, Elton, & Siegeltuch, 1982; Teletext, 1982). And in other studies with more traditional computer-based learning materials, researchers discovered similar effects — users will ask for and use more readily displays that incorporate graphics (Stone, 1984; Tullis, 1981).

Language. A further important quality of the surface is the way in which language is used — the readability of the text, its complexity, and so forth. Here, we observe some distinctive differences between print and electronic forms, with considerable emphasis being placed in electronic text on short, compressed sentences and paragraph chunks. One effect of this telegraphic writing style is to allow users to scan over screens quickly, looking for relevant information, to a greater extent than would be the

case with printed materials (Siegeltuch, 1982). A related set of studies focuses on the value and use of abbreviations, thus allowing the designer to make best use of limited screen space available (Ehrenreich, 1985).

User's reactions. Finally, the reader's subjective reaction to the surface of the text should not be ignored. Performance may not be affected if the reader finds the text unpleasant to work with, but the long-term impact may be to decrease the user's enthusiasm for the subject or job being studied. And, in the case of materials that users can choose to work with or not, the result may be that the texts simply will not be consulted (Kern, 1985). In electronic text the perceived usefulness of the text to the reader has emerged as one of three key factors that describe users' reactions (Champness & DiAlberdi, 1981; the others: "attractiveness" and "clarity." Grabinger's [1984] work also supports these notions).

A way of increasing users' positive reactions to electronic text systems has been to involve them directly in design decisions. This may be done either by letting them determine the format in which material will be presented on their individual screens (Geiselman & Samet, 1982), or by giving them some control over the structure of the system itself — what the command structure is to look like, or what keywords to use in a database system.

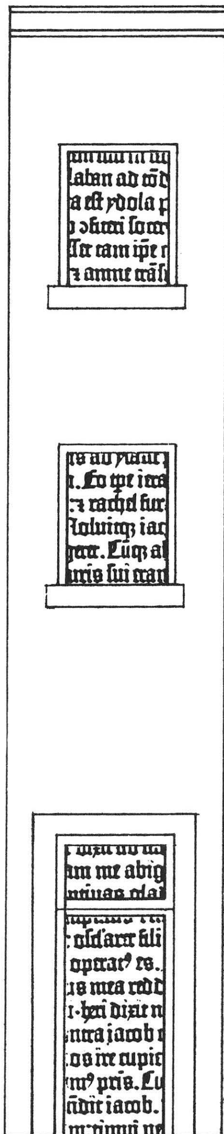
Summary. These varied findings suggest that screen design, while different in some important ways from page design, should be carried out with many of the same rules in mind that expert page designers have used for years. These include use of distinctive typefaces, carefully determined (and generous) allocation of white space and headings in text, intelligent application of graphics and color (making full use of the capabilities of the technology), and design with the user's need to have the text itself be interesting to read. If there is nothing dramatically new here, there is at least the reaffirmation that many of the design principles that hold true for print also are worth adhering to in electronic environments.

Interface Design

If the design of the surface offers few surprises, the preparation of the interface is clearly quite a different matter. There are several aspects of the interface that bear examination here: (1) the immediate structure (the directions and finding aids that are provided on the page or screen), (2) the internal structure (the helps for using the material that are part of it, but not always present on any given page or screen; an index in a book, and a help system available with one or more keystrokes in electronic text would be examples), and (3) the external structure (aids that are external to the material itself; an external index or abstract system for printed materials, documentation for a computer program). Also critical is the user's psychological context — the ability to correctly formulate questions about the nature of the task at hand, the technical skills needed to navigate, and the understanding the user has of the system, its functions, and the structure of the information it contains. In most of these areas, there are marked

differences in form and function between wayfinding systems used in print space and those employed in electronic space.

Immediate structure: Wayfinding on the page level. In printed materials there is typically not much provided in the way of an immediate structure of directions on the page. True, we take page numbers for granted now, although they were not universal for many years after the advent of printing. And footnote numbers give direction for where to find sources or further detail about a particular subject. Materials that serve a reference function may have additional on-page helps: abstract numbers or keyword designations at the top of an index page, bold-faced headings within columns, and so on. We have virtually lost the routine use of the catch word in narrative text, an aid that enjoyed popularity for several centuries into the development of printed text.



In electronic text, however, the immediate structure of navigational aids is often very obvious. Menus, icons or symbols, color coding — all these serve to help the user orient her or himself in the material at hand. In particular, the use of on-screen menus for wayfinding in electronic text has been the subject of considerable work over the past few years. Much of this has been directed as determining the appropriate level of breadth or depth to incorporate in menu systems. Since a deeper menu structure offers fewer choices to the user at any one time, we might suppose that it would be easier to use. In fact, the reverse appears to be the case: users seem to prefer and work more effectively with menus that present medium or large numbers of choices on each screen (Landauer & Nachbar, 1985; Lee & MacGregor, 1985; McFarland, 1982; Snowberry, Parkinson, & Sisson, 1983).

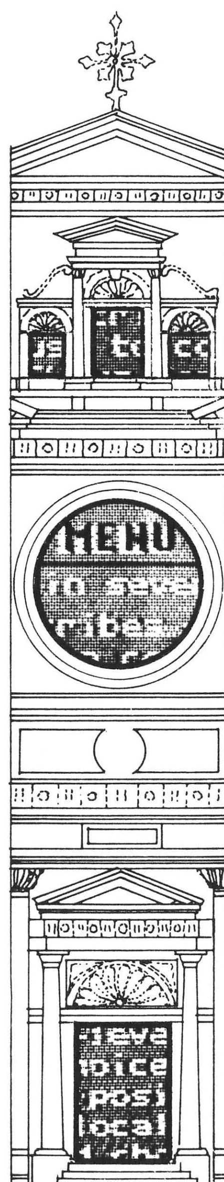
In spite of all best efforts, however, menus appear not to be a panacea for information search. Numerous problems have been reported: the fact that many errors occur at the initial menu level (where users are least likely to know what categories are subsumed under the top-level items; in one study, 18% of all search time was spent using the top-level menu [Irving, Elton, & Siegeltcuch, 1982]). Another difficulty is the tendency of users to become frustrated and distracted by working up and down through layers of menus without finding desired information, and therefore to give up even though they may know that "the information is in there somewhere" (28% of all users in one study [Latremouille, Mason, McEwen, Phillips, & Whalen, 1981]; 20% in another [Carey, 1981]).

One solution that has been proposed to the problem of complex structure of menus is the use of keywords for information searching. Several studies have shown that users can figure out keyword-based systems sufficiently well to employ them effectively (Orsnaes, 1982), that they will usually prefer to use keywords rather than menus in searching (Geller & Lesk, 1982), but that occasional users probably will not retain the structure of keywords well enough to use them over time (Shneiderman, 1982). The ways that users think about keywords and their understanding of the concepts that lie behind them may be the most

significant determinant of success or failure in locating desired information (Weyer, 1982). One study that investigated both keywords and menus concluded that there seemed to be little objective reason to prefer one approach over the other, and that users' problems seemed to lie in realms other than the mechanics of access (Van Nes & Van der Heijden, 1982).

The use of icons or other graphic way-finding aids has also been proposed as a way of helping the reader to find desired information. Some current computer operating systems (Macintosh, Lisa, Xerox Star) have been developed with icons playing a key supporting role. Icons are increasingly used for wayfinding in transit systems and in public buildings (see, e.g., AIGA, 1982, and Dreyfuss, 1972). But validating their usefulness empirically has been a problem (Mackett-Stout & Dewar, 1981; Kerr et al., 1985). Some have suggested that learning to use an icon-based system may be no easier — just different — than learning one based on text or menus (Cahill, 1975; Samet, Geiselman, & Landee, 1982). Much further work remains to be done in this area to determine how valuable iconic wayfinding systems truly are.

Internal structure: Wayfinding on the document level. The internal structure of the material also can provide users with clues as to where they are and where to go for further information. In printed materials, such aids as the table of contents, index, appendices, and footnotes may provide this sort of information. They are internal to the book itself, but they do not intrude on the user's attention unless they are specifically sought.



Internal help systems in electronic text have been harder to evaluate than on-screen aids, probably because the systems themselves vary so much in form and comprehensiveness. That users want help and look to the systems they work with to provide it is without doubt. Carey & Dozier (1985), for example, found that students offered access to electronic text systems that included both instructional and library materials frequently mentioned greater navigability of the text as a desirable feature. And a number of navigation methods that are remindful of print forms have been proposed (Benest & Jones, 1982; Benest & Potok, 1984; Engel et al., 1983; Lochovsky & Tsichritzis, 1981). Some of these use a kind of on-screen menu-plus-text system that allows the user to keep track of where he or she has been, while at the same time permitting fast retracing through previous menus to backtrack to an earlier point (Spence & Apperley, 1982).

More traditional kinds of help systems that provide information on the structure of commands in an operating system have also been evaluated. Interestingly, one such study found that a considerable number of system users (22%) saw their work with the help system as a tutorial rather than just a memory jog. Those who kept paper manuals and documentation up to date were less likely to use the system than those who did not have such materials, leading the researchers to conclude that both types of help systems would probably continue to be required (Stoddard, Berkbigler, Wheat, & Peter, 1985).

THE ON-LINE CATALOG: AN EXAMPLE *of* WAYFINDING *on the* DOCUMENT LEVEL

Another way to provide navigational aid within the structure of a document is to incorporate help in a variety of formats and allow the user to choose the approach that best matches personal needs and preferences. This method was demonstrated in a project to create a prototype hierarchically structured on-line university catalog (Kerr, 1984).

Figure 1 shows the overall structure of the database as the user encountered it; there were eight main categories of information, each of which was further divided into three to eight subcatagories (which were themselves also subdivided, occasionally to a total of six levels). This information was available on request, but served only as an overview of the system and not as a navigational aid from within the database. Figure 2 shows the varieties of help that a user could call on at any given time. These ranged from a simple description of commands to more complex graphic images of current locations and routes. The information shown in Figure 2 remained constant regardless of an individual's location within the catalog.

In "The Big Picture" (Figure 3) the user got a chance to see the present location vis à vis the other major categories of the database. This would be useful if it were important to recall top-level categories; it would likely appeal most to the very occasional user. Figure 4 shows "The Route," the path the user took to get to the present location. In contrast to "The Big Picture," it provided more detail about specific choices made at each stage in the process. (Note that labels for categories and subcategories of information were omitted in this prototype version, but including them would have presented problems given current limitations on commonly available video screen resolution. Compare the very telegraphic style of abbreviation required to fit even one level of subcategory labels in Figure 1.)

"The Neighborhood" (Figure 5) shows a very different type of wayfinding cue. In contrast to "The Big Picture" and "The

Figure 1. Overview of top two levels of information in a prototype on-line university catalog.

Route," each of which situated the user in a context of top-level categories or choices made with respect to those categories, "The Neighborhood" showed the user's position in relation to the items of information in closest proximity. The user saw in high relief items on the same branch of the database tree, rather than getting a less detailed picture of the whole tree itself. This might appeal to those wanting to browse for information in a particular part of the database.

The last of these illustrations shows "Topics Related" (Figure 6). This was a quite different approach, and assumed that the database could be accessed not only hierarchically but also through a relational structure of connections and associations. In this case all topics related to the topic at the user's present position were displayed, even though they might be from quite different parts of the database tree.

The potential advantage of this sort of system is that it offers the user a variety of display formats that may match either different needs for information or different preferred ways of representing that information internally. Providing for different individual styles of cognitively representing information structures is an especially intriguing and important possibility that we shall have occasion to return to below.

External structure: Wayfinding among documents. The design of external structures in aid of wayfinding is an even less fully researched area than those discussed above. In the case of print materials, such systems as indexes, card catalogs, and bibliographic listings obviously play a role. There is a considerable literature in the fields of library and information science dealing with search strategies and techniques (see Bates, 1981, for a particularly comprehensive review). Indeed, the advent of computer-based bibliographic retrieval systems seems to have pushed this issue much into the forefront of librarians' attention. But most of the work in this area is focused on the librarian's role in helping

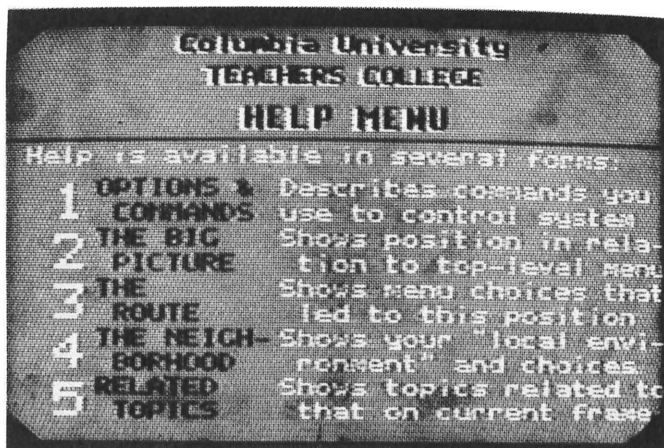


Figure 2.
Types of help available in the prototype on-line university catalog.

the user to clarify search questions and providing information on strategies (e.g., Lynch, 1983), rather than with the processes of the search itself.

For electronic text systems the external wayfinding aids are usually either minimal or nonexistent. Documentation on how to use a system or job aid cards are perhaps the most familiar forms that such external structures take. But in many cases the text and its access structure are all there together, rolled up into a single ball. This unified and non-transparent form of the materials may make them particularly difficult to deal with in that users will simply assume that whatever the computer provides is what they need (Estabrook, 1983).

Rules and guidelines for the preparation of documentation to accompany electronic textual materials haave been proposed, but these have most frequently been issued as rules of thumb; occasionally, they have been designed using instructional development or traditional print layout procedures. Little attention has been given to the ways in which users make the jump back and forth between documentation and electronic materials.

Psychological context of the user. In both types of systems the user's psychological state can make a difference in the way in which navigation is carried out. In fact, this may be the most critical part of the whole process. Certainly librarians have defined their roles for years as consummate wayfinders, and in doing so have written extensively about the need to understand the user's needs, to help him or her formulate questions, and to provide guidance on the physical aspects of the system as needed.

Vigil (1983), for example, notes that relatively few users seem to have a very precise sense of how to go about searching for information whether in print collections or on-line catalogs. Hills (1983) suggests that designers of electronic materials will need to provide built-in structures of keywords and check points that are attuned more directly to user needs — perhaps by adopting some

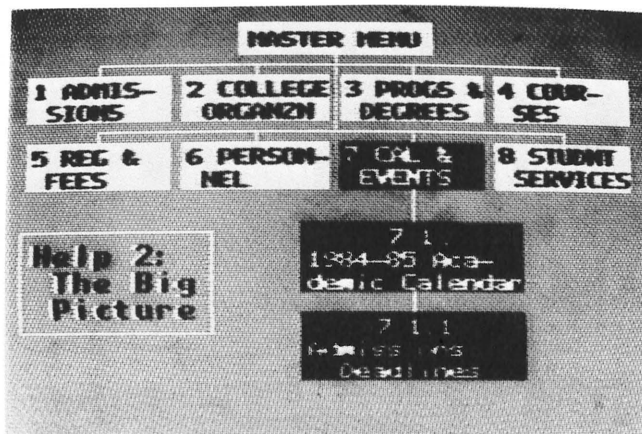


Figure 3. "The Big Picture" shows user's location vis à vis top levels of information.

sort of common thesarus of terms. And Waern and Rollenhagen (1983), on reviewing studies relating reading and video display terminals, observe that relatively few studies have tried to integrate what we know about metacognitive processes (setting goals, planning strategies to reach them, knowing when a problem has been encountered, and so forth) with the use of electronic text.

More than one researcher recently has come to the conclusion that the key decisions to make in designing electronic text are not those that have to do merely with the specification of mechanical aspects of the interface. Rather, the most critical elements seem to be to understand how the user conceptualizes the system and the material he or she is faced with — how the system works, what categories of information it contains, how it is organized, and so on. In one recent study, after finding some differences among users working with seven different operating-system interfaces, the authors nonetheless noted that "Many problems were the result of users not understanding the structure of [the conceptual space within which they had to navigate] or the rules for moving in it. These difficulties cut across all interface styles and all levels of user experience." (Whiteside, Jones, Levy, & Wixon, 1985, p. 189).

The centrality of user understanding. This shift from a concern with mechanical aspects of the interface to developing a better picture of how users understand and represent information to themselves is visible in much recent work in the field of human factors and human-computer interaction. Several distinct aspects of this work bear mention. There is a broad concern with users' understandings of how a system works, what is in it, how to make the system do what one wants ot yield the information that one needs. These understandings are often developed out of a user's familiarity with some aspect of the non-electronic world which is similar to the electronic system that the user needs to understand.

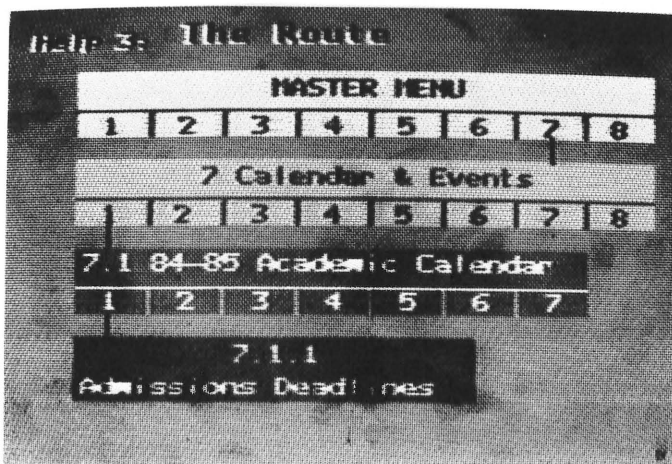


Figure 4.
"The Route" shows user's choices as they led to present position.

Related to this is an interest in how users explain the functions or operations of the system. These explanations often arise from interactions with the system and may derive from or themselves contribute to broader understandings of system operations. Another aspect of how users conceptualize electronic environments is the way they represent to themselves the structure of information the system contains. (While a good deal of work has been done on knowledge representation from the standpoint of developing expert systems, this has mostly focused on determining how an acknowledged expert in a given field represents the structure of information in that field to him or herself, rather than on the issue of how to represent for others a body of knowledge that has already been structured through practice and convention.)

Finally, all of these elements — understandings, explanations, and representations — may be seen as aspects of mental models that users must develop and bring to bear as they operate in electronic environments. (See, for example: Gentner & Stevens, 1983; Mark, 1985; Quinn & Russell, 1986; and the further works referenced below.) Several points seem clear from the work that has been done on mental models and users' understandings. First, users will construct models of how an electronic environment works and what it contains, and they will develop explanations that are rationally satisfying to them even if those explantions are flawed or plain wrong (Suchman, 1985). This seems to be necessary for continued use of the system to take place. Second, explanations and models can be functional even when they are flawed. A user may have developed a way of coping with parts of the interface that the user (from the interface designer's point of view) poorly understands, but if that way of coping allows the job to be done, it may suffice even though inefficient and time-consuming (Lewis, 1986).

Figure 5.
"The Neighborhood" shows user's location in relation to information in close proximity.

When users do develop models of electronic environments that mirror more closely the designed capabililities and functions of those environments, they probably base their initial understandings on metaphors with similar aspects of the real world. Linguistic and grammatical conventions, for example, often are incorporated into computer languages intentionally by their creators in the hope that users will continue to make assumptions electronically that they have always entertained when speaking, reading, or writing in the non-electronic world (diSessa, 1986). Designers of electronic information systems seem to capitalize on a similar set of assumptions by encouraging users to think of trees when working with hierarchically structured databases, or graphic Venn diagrams when dealing with Boolean search operations.

Users' mental models are probably most important when the user first learns how to work with a system, or when the user returns to working with it after a long hiatus (Norman, 1986). This raises a set of interesting questions, for research in related contexts suggests that while one can train people to use a particular mental model in addressing a particular task, this may not always be the best thing to do. The problem is that people differ in their abilities to figure out appropriate models for themselves, and that supplying a new model to someone who already has a satisfactory internal understanding of how to solve the problem may actually interfere with that understanding. On the other hand, supplying a model may be very efficient when the user is not capable of generating an internal model of how to proceed (Salomon, 1979).

The trade-off, then, may be between efficiency for occasional or less representationally capable users on the one hand (who presumably should have models supplied) and long-term satisfaction and effectiveness for frequent or more representationally capable users on the other. Unfortunately, we have no good measures to

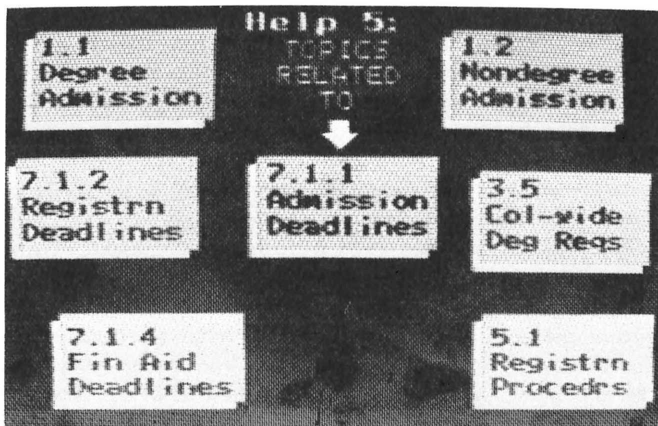


Figure 6.
"Topics Related" shows information conceptually related to topics at the user's present location.

tell us how good users are at generating their own models or building correct understandings. Further complicating matters is the apparent influence exerted on the development of these understandings not only by an individual's own internal state but also by the social context in which he or she works. For example, Brown & Newman (1985) speak of the possible "creation of distributed authoring tools for building community knowledge bases, in which knowledge sharing and a process of annotation and dialectical exchange become the vehicles for learning among community members." (p. 375). Sorting out these elements and deciding how to provide best for learning a system, constructing appropriate mental models, and using those models effectively will take a good deal of intensive research.

Summary. The key features of interface design, then, seem to include providing a collection of aids that allow the user to maneuver with as little extra effort as possible. Broad rather than deep menus, user-defined keywords or menu terms, audit trails and backtracking systems that allow mistakes to be undone quickly and paths retraced, help systems that provide tutorial information as well as remind the user, and on-screen information on basic options — all these seem to make users feel more comfortable in reading and working with text presented electronically.

Several key differences between print and electronic text were highlighted in this section, and it is worth recapitulating them here. First, with print materials we have made the structure of the interface at its various levels (immediate, internal, external) relatively small and unobtrusive. The user is not forced to come in contact with it, may become aware of it only unconsciously, and the producer probably spends relatively little time worrying about it since its form and structure are well established. For electronic text, however, the user has no choice but to learn a new approach that may be more or less generic to other systems. This must be mastered in some rudimentary way before the text may even be approached. The interface is very much in the foreground, and the amount of effort the designer must pour into its creation and refinement is correspondingly large. In print, the interface has become optional; in electronic text, it is still unavoidable.

Another central difference between navigation in print and electronic text is the way in which electronic information layers virtually all aspects of the interface within the material itself. A database system, for example, may serve as a gateway to a number of separate sub-databases, each with its own command structure or set of keywords. And the indexing structure, help system, and other user tools for each of these sub-systems may all be on-line — within the original database, but with relatively little external documentation for the user. The material is all there, but it is at the same time all invisible. It is as if the text of the books of a library were to be typed on index cards and interfiled with the title-author-subject cards and the shelf-list cards in the main card catalog.

But perhaps the most important fact that emerges from this part of the analysis is a sense that the focus may need to move away from the physical aspects of interface design — the specifics of menu choices, screen design, and graphic icons — and toward a more careful analysis of how users conceptualize the environment in which they are working and moving. Some of the implications of this conclusion are explored in the section that follows.

DIRECTIONS *for* FURTHER WORK *on the* WAYFINDING PROBLEM

What is known about the design of surfaces and interfaces for electronic and printed instructional text may be less important than what is still unknown. The foregoing analysis suggests that further work in several relatively unexamined areas could be especially productive.

1. How Do Users Search?

This question may seem overly simple, but it is basic and we seem to know little about it. What are the occasions, for example, on which users realize that they have a problem for which further or different information might provide an answer? What do users self-generated search strategies look like, and how might those be used to guide the development of interfaces? Some preliminary work in information science has already shed light on this issue, and certainly much of the work on metacognition and problem solving would also be relevant here. This problem is especially relevant if large electronic databases are going to be used in any broad way in the educational system. We need to be able to define differences in search strategy among readers as they approach electronic materials.

2. How Do Users Conceptualize the Shape of the Text?

A second important question to ask may be how users think about the shape of the data they are working with, or the shape of the problem space within which they are operating. Several recent studies (Borgman, 1983; Vigil, 1983) have pointed out the possible value of working with spatial metaphors and mental models that concentrate on developing a user's image of what electronic text is and how it may be organized. Others (Dumais & Jones, 1985), while expressing doubt about the value of spatially organized interfaces, conclude that there may be a way of designing them so that they are in fact effective.

This approach seems to tie in with other work being done on thinking and problem solving. Newell (1980), for example, discusses how thinking practices might be seen as ways of moving through a "problem space." Research in such diverse areas as learning to read maps (Thorndyke & Stasz, 1980) also deals with processing of information in spatial terms. Indeed, there is a growing consensus that many reasoning and problem solving activities may be conceptualized using spatial metaphors and models (Sternberg, 1982).

The continuing work on mental models and user understandings within the human-factors and human-computer-interaction communities also needs to be more fully integrated into work on electronic text. If, for example, metaphors and associations to

non-electronic environments are important for developing those understandings, then what is the relationship between how users think of dictionaries, encyclopedias, textbooks, or other reference materials, and how they come to think of electronic text environments? Are flaws in understanding the structure or operation of one environment transferred to the other? And, perhaps the most interesting question, how can we encourage users to develop models of electronic environments that are both accurate and productive? This last question merits special consideration.

3. How Can We Best Introduce New Users to Electronic Text Environments?

Lochovsky and Tsichritzis (1981) suggest that providing users with a paradigm for an effective search strategy may help produce better searches and more satisfied users of electronic text. Such paradigms might be especially valuable if they could be tailored explicitly for various audiences and various searching styles, as described by the research suggested above.

The problem, as we have already noted, is that simply providing a model or a paradigm for how to use electronic text may not be the best thing to do under some circumstances. For those who cannot easily develop their own understandings of how electronic text is organized, we need to use information about typical search strategies and typical ways users structure text to create models of problem definition, information search, and incorporation of new information with old that will work. On the other hand, individuals who are capable of developing a personal representation of the electronic environment should be permitted and encouraged to come up with their own models. For these latter we need ways to encourage a diversity of approaches so as to capitalize on the propensity of individuals to conceptualize structures of information in various ways — spatially, via relationships and connections, or using other metaphors. Interfaces that the user could customize so as to approach the text in these different ways would be helpful here, but we need much further work on interface design before this sort of modification by individuals can become a practical reality.

The challenge is not simply to recreate in electronic text what has been done in print, but to capitalize on what electronic text can do best — provide rapid access to lots of information, and help to organize and structure the way in which the user interacts with the text. Doing this will require us to not only reconceptualize how the text itself is structured, but also to think more deeply about how it is to be understood and used by the reader.

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