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Finding the way : navigation in hypermedia

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Abstract

If navigation is recognized as a fundamental problem experienced by hypermedia users, then navigation merits further investigation. This review will identify observed navigational problems, suspected causes, and proposed solutions. To investigate the problem, it is necessary to examine methods used to sequence hypermedia components and to identify the various schemes used for navigation.

Information resulting from the review of literature will serve as the basis for a project evaluating current multimedia software packages designed to develop reading skills. The findings will also provide the media specialist or professional educator with a framework for evaluation and subsequent utilization of multimedia learning materials. Additionally, the information compiled can serve as a guide to professionals endeavoring to create their own hypermedia materials.

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I Introduction

Background

Present day hypermedia represents the embodiment of the vision of Vanevar Bush (cited in Tucker and Dempsey, 1991). Bush, a post World War II science advisor to President Roosevelt, envisioned a machine that could manage vast amounts of information. The memex, his name for the proposed machine, would use mechanical links to connect bits of information. Operation of the memex was based on the human mind's ability to make instant connections from one idea to another, i.e., to " . . . capture the anarchic brilliance of human imagination (Bukatman, 1994, p. 1)."

Although Bush's memex was intended to store and link mathematical information, in the 1960s his successor, Ted Nelson, expanded the idea to include literary applications (Tucker & Dempsey, 1991). Computing technology, which had become powerful enough to support high speeds and access to large amounts of information, further aided developmental work on information processing during the 1980s (Jonassen, 1989). Authoring tools once available only for large computers were adapted for use with microcomputers. In addition, the information databases were no longer limited to text but also included other media formats such as graphics, video, and sound (Tucker & Dempsey, 1991).

Both the computer industry and commerce were quick to recognize and adapt multimedia databases and hypermedia technology to their needs. Software engineers used the new technology to create networks of information and to control audio-visual devices. Commerce used hypermedia as a resource tool for linking and searching information, and as a presentation tool (Yang & Moore, 1995). Electronic encyclopedias and public kiosk systems are two representative commercial uses of hypermedia. Not surprisingly, educators noted the success with which industry and business were using hypermedia and glimpsed the potential for its use in education. Charney (cited in Welsh, 1995) goes so far as to credit hypertext with " . . . the potential to change fundamentally how we write, how we read, how we teach these skills, and even how we conceive of text itself" (p. 301).

Traditional technologies, i.e. text or video, limit knowledge representation to strict linear presentation. Hypermedia technology overcomes this limitation by making it possible to access information in a nonsequential manner. Knowledge can be represented in multiple ways and situations (Jacobson, Maouri, Mishra, & Kolar, 1995). For example, through the use of hypermedia technologies, an historical document like the Emancipation Proclamation can be seamlessly linked with an interpretive dramatization, with individual reactions, with historical precedents, or with glimpses of its ramifications for plantation life. Such an "enriched" knowledge presentation can be in text, audio, or visual formats. Using multiple formats motivates learners and provides better knowledge representations (Moore, Burton and Myers cited in Yang & Moore, 1995). Learning is also reinforced when multiple senses are stimulated by integrating related audio and video components (Thibodeau, 1997). For example, a textual description of life on a plantation might be made more meaningful by accompanying it with two video segments - one highlighting a day in the life of a young female slave and the other focusing on a day in the life of the plantation mistress.

When information is not presented linearly, the learner must actively explore and discover it (Thibodeau, 1997). This approach requires learners to forge links between new knowledge and the knowledge they already possess. Through the process of forging links, retention and understanding can be enhanced. Analytical skills needed to think critically about information can be developed by providing students with an easy means of connecting large bodies of information (Tucker & Dempsey,1991). Nelson, Parlumbo and Marsh, and Kumar (cited in Yang and Moore, 1995) saw hypermedia as a vehicle to support learner cognition by providing a means of actively involving the learner in finding information and constructing meaning. "Hypermedia allows nonsequential reading and thinking, thereby weakening the boundaries of unquestioned text and replacing isolated thought on a written surface with integration and multidimensional challenges" (Tucker & Dempsey, 1991, p. 17).

Although the literature abounds with the promise of hypermedia, the actual products based on it do not always meet expectations. It is critical to identify and address the areas in which hypermedia does not currently fulfill its potential in education. Numerous studies have cited "navigational problems," "wayfinding problems," or "lostness" as a fundamental problem for hypermedia users (Stanton and Barber, 1994; Tucker & Dempsey, 1991; and Yang & Moore, 1995). Navigation will be the focus of this literature review.

Problem Statement

If navigation is recognized as a fundamental problem experienced by hypermedia users, then navigation merits further investigation. This review will identify observed navigational problems, suspected causes, and proposed solutions. To investigate the problem, it is necessary to examine methods used to sequence hypermedia components and to identify the various schemes used for navigation.

Significance

Information resulting from the review of literature will serve as the basis for a project evaluating current multimedia software packages designed to develop reading skills. The findings will also provide the media specialist or professional educator with a framework for evaluation and subsequent utilization of multimedia learning materials. Additionally, the information compiled can serve as a guide to professionals endeavoring to create their own hypermedia materials.

Terminology

The phrase "reading a hypermedia document" often appears in the literature. However, the phrase "using a medium", introduced by personal computing, more nearly captures the nature of the interaction with a hypermedia document (Alsop, 1995). Hypermedia is based on signs with "text", which may actually be illustration, video, sound, music, and movie samples. These are structured in a multi-linear way so they can be accessed by depressing a key or clicking a mouse (Bukatman, 1994). Essentially an umbrella term, hypermedia, describes information contained in multiple formats, stored, linked, and accessed electronically via a computer (Babbit & Usnick, 1993; and Tucker & Dempsey, 1991). The use of data in multiple formats and non-linear sequencing are the two fundamental characteristics of hypermedia documents (Jonassen, 1989; Tucker & Dempsey, 1991; Yang & Moore, 1995).

Regardless of the format the information or database takes, the basic unit or segment of information is referred to as a node (Jonassen, 1989). Unlike conventional written material wherein verbal connectives unite units of information, links are the elements that serve this transitional function in hyper environments (Jonassen, 1989). There are various types of links as well as types of nodes and sometimes node type becomes the basis for the structural scheme of the document or program.

II Review of Literature

This review of literature centers around how hypermedia has been and is being used in education. Three questions form the focus of the information search: What are the navigational problems that have been observed? What are the causes of navigational problems? What are the solutions or suggestions proposed to address navigational problems?

Navigation

Problems

Reports of navigational problems, often described as being "lost in hyperspace," are an all too familiar experience for many readers of hypermedia documents (Heinich, Molenda, Russell, & Smaldino, 1996; Stanton & Baber, 1994; Tucker & Dempsey, 1991; and Yang & Moore, 1995). The complex hyperspace created by connecting vast amounts of information can leave readers puzzling over not only where they are, but also where they are to go, and how they are to get there (Yang & Moore, 1995). Hammond and Allison (cited in Stanton and Baber, 1994), see evidence of this in the reader's inability to locate desired information. Also cited in Stanton and Baber (1994) are Nielson's reports of readers experiencing disorientation within the available options. The problems can be summarized as uncertainty about what can or should be done and the resultant inability to formulate appropriate actions.

Causes and Solutions

Suspected causes of observed navigational problems can be classified in two ways: those due to the inherent nature of the medium itself and those resulting from flaws in design.

Kerr (cited in Locatis, Letourneau, & Banvard, 1990) attributes inherent navigational problems to the fragmented nature of hypermedia, and to its reliance on electronic technology. Concurring with this observation, Moulthrop (1995) views hypertext as ". . . an inherently disjunctive medium" (p. 56). The basic metaphor of navigation used to describe movement within a hyperdocument may itself be incorrect and misleading (Stanton & Baber, 1994). Or, since most hypermedia systems were designed to be used as authoring, resource, or presentation tools, they may not be suitable as instruments of instruction (Yang & Moore, 1995).

Flaw of design is the main reason most existing hypermedia systems fail for instructional purposes. They lack components critical to the instructional process (Yang & Moore, 1995). Anderson-Inman, Horney, Chen, and Lewin (1994) propose weaving learner supports into the hypermedia design. Comprehension can be enhanced by incorporating advanced organizers, definitions, and questions. Active reading skills can be promoted by including questions for thought and options for taking notes. Dr. S. C. Schatz, Professor of Instructional Technology at San Francisco State University (personal communication, March 8, 1997) suggests even using pencil and paper to take notes off screen can enhance the interaction.

Creating electronic spaces puts an emphasis on nodes and linkages. Many times the linkages appear to be made arbitrarily and result in unorganized and unstructured information collections (Stanton & Baber, 1994). Often unaware of the navigational problems associated with hypermedia use, designers provide inadequate information to facilitate going through the links. Unlike ordinary prose, where transitions and connections are made for the learner, in hypermedia the learner must make sense of the information gleaned. Confusion and disorientation result when students attempt to negotiate the maze of connections (Heinich, et al., 1996). Learners can be especially challenged when the information appears in an unstructured manner. In addition to causing disorientation of the user, lack of seqentiality may also cause the self-contained qualities of the text to be lost (Tucker & Dempsey, 1991).

Belief that it is the complexity of the space which causes students to become lost, spurs the search for better navigational aids (Stanton & Baber, 1994; and Yang & Moore, 1995). Tripp and Roby (cited in Yang & Moore, 1995), recognize that a great deal of cognitive effort and mental resources can be expended on navigation alone. Having to continuously make navigational decisions with the inherent process of making sense of the connections may result in cognitive overload. By providing clear and specific directions, the mental effort required to process instruction and make decisions can be reduced (Yang & Moore, 1995). Less mental effort is needed to process an instruction like "hit the return key" than is required to process "hit any key to continue".

Hyperdocuments currently available are relatively small in overall size, yet users appear unable to use the formats effectively (Stanton & Baber, 1994). An increase in size of the hyperdocument can be expected to produce increased disorientation. The challenge is to design a map simple enough to be easily recalled yet complex enough to depict multiple routes to and from an information segment. Further insights into the causes of and possible solutions to navigational problems emerge when methods of structuring hypermedia are analyzed.

Hypermedia Structure

Organization

Regardless of the size of information database, some type of organizational structure must be imposed. Boone and Jonassen (cited in Yang and Moore, 1995) identify three basic organizational schemes, i.e. unstructured, hierarchical, and networked. (see Figure 1). Random storage of information nodes typifies the unstructured scheme. This scenario gives learners maximum flexibility and maximum responsibility for learning. Electronic learning encyclopedias and dictionaries make use of random storage. Offering maximum structure to the knowledge base is the hierarchical arrangement with information nodes in a fixed tree-like sequence. Menu-driven systems represent the strictest of these hierarchical arrangements since they allow only one-step movements - upward or downward. In the networked organization, information nodes are connected or linked to other nodes based on relationships between them. This arrangement is favored for use in the computer industry and commerce. The complexity of a

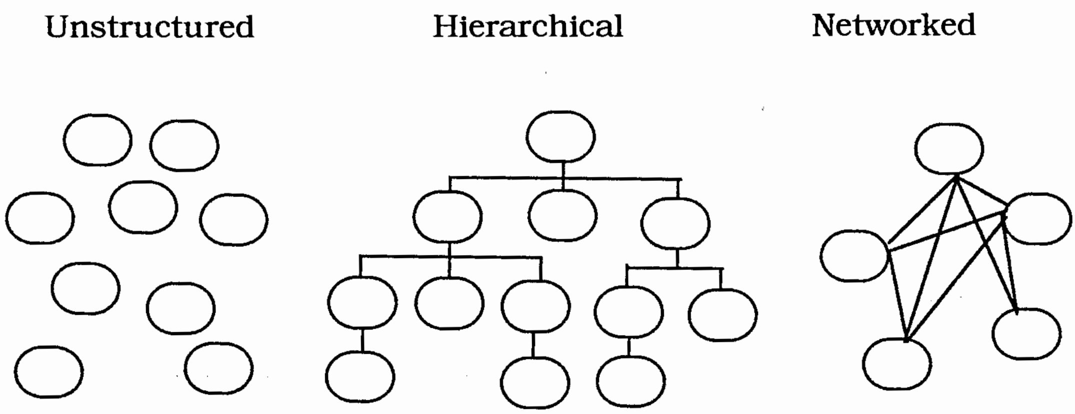

Figure 1. Basic organizations of hypermedia knowledge bases. (Yang & Moore, 1995, p.13)

Note. From "Designing Hypermedia Systems for Instruction," by C. Yang and D. M. Moore, 1995, Journal of Educational Technology Systems, (24)1, p.13.

particular structure depends upon the number of interrelationships between information nodes. By mixing hierarchical and network formats, most content used for instructional purposes can be accommodated.

Nodes or information units can be defined in ways which identify the type of information they contain (Stanton & Baber, 1994). Elements making up a unit of information have a common "theme". That theme describes the resultant node type. Examples of node types are positions on issues, attributes, examples, or implications (Jonassen, 1989). Other bases for node identification include media format (e.g., graphics, text, still images, moving images, or sound) and function of the information (e.g., principles, examples, applications, or questions) (Yang & Moore, 1995). Designation of the node type can be accomplished through choice of color, background, or shape. Regardless of the basis of organization, Locatis et al. (1990) caution against creating extremely large nodes since size could defeat hypermedia's purpose.

Connections

Unlike nodes in an unstructured organization, nodes of information networked or arranged hierarchically depend on links to connect them (Jonassen, 1989). Conklin (cited in Jonassen, 1989) identifies two methods used for linking nodes. The first is the referential method which connects a source in the node being viewed to a reference in a destination node. Referential links operate in both directions so the user can return to the original node after accessing the reference node. The pronunciation of a word within a passage would utilize a referential link.

The second method used for linking is organizational (Jonassen, 1989). Organizational linking is used to create hierarchical structures. A definition node, linked to nodes containing example, application, or implications would utilize the organizational method of linking.

The link itself can be either fixed or variable. A fixed link will remain the same in a hypertext whereas a variable link will change in response to a given context or conditions (Jacobson, Maouri, Mishra, and Kolar, 1995). Each link type is appropriate for certain purposes. For example, fixed links can be used to access information in the on-line help function of a word processing program. Variable links appropriately access information according to conceptual indices. These indices are derived from the analysis of expert knowledge in a particular domain.

Control

Accessing the information contained in a hypermedia program necessitates furnishing the user with a means of control. Control can be provided through the use of link indicators. Indicators signal the presence of additional information which the reader can elect to access or not. Indicating link locations to the reader is accomplished by one of two means: 1) The first is to embed the link in the text itself (Jonassen, 1989). Embedded link indicators take the form of highlighted text, change in cursor shape when it passes over the active link, or variations in the style of type itself (Jonassen, 1989; Locatis, et al., 1990; and Welsh, 1995). Type style is varied by bolding, italicizing, or underlining. 2) The second means is to insert an external graphic link indicator. Simple graphics or icons placed outside the text in margins or in the leading between lines of text alert the reader to the presence of a link. In addition to indicating the presence and location of links, variations in text type style or iconic representations can visually provide more specific information such as link type (Welsh, 1995).

Figure 2 shows an example of two link indication interfaces: visually differentiated links and undifferentiated links. In this example, visually differentiated links are shown as triangles, circles, stars or squares. Each shape, as explained in the accompanying legend, denotes a particular type of link. Use of the differentiated link indicator interface allows the user to filter or control both the amount and type of information accessed.

△☆□ Robins are commonly seen in urban yards. They often build their △○ nests close to where people live. If you can peek inside the nest, you might see three blue △○ eggs.

Legend: △ picture ☆ sound
○ video □ description

Differentiated link indicators

△△△ Robins are commonly seen in urban yards. They often build their △△ nests close to where people live. If you can peek inside the nest, you might see three blue △△ eggs.

Undifferentiated link indicators

Figure 2. Differentiated and undifferentiated link indicators.

Undifferentiated links in the example are all shown as triangles. No “cue” to the type of link is provided by the undifferentiated indicator. The user can see that a certain number of links are available at a given point; based on the indicator, the user cannot tell what types of information the links provide. Since a learner can only process small amounts of information at a time, it is important to provide some means for filtering the database size (Stanton & Baber, 1994). In his study on student perception of how interface design influenced performance, Welsh discovered that designs featuring differentiated link indicators were perceived more positively than designs with undifferentiated link indicators (Welsh, 1995).

Another method of giving the user filtering capability is by providing a menu which allows manual selection of the kind of link filtering desired (Welsh, 1995). By using the link interface menu, a user can alter the hyperdocument to show only certain types of links (see Figure 3).

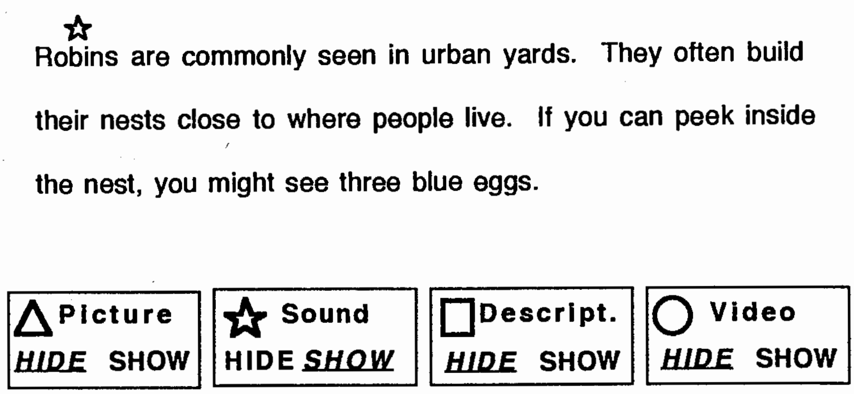

Figure 3. Menu bar providing manual filtering capability. Only sound links have been selected.

Furthermore, depending on the particular software, the selective linking can be configured for each individual screen (local configuration) or, it can be applied to the entire hyperdocument (global configuration). Nelson (cited in Welsh, 1995) found the type of link users selected was task dependent. It differed according to whether the user was browsing, searching for information, or studying. In the Nelson study, learners conducting an information locating task made use of the filtering links, whereas learners involved in a comprehension task did not exercise their option to hide or limit link indicators. Additionally, when manual link filtering tools were used in the locating task, users demonstrated increased efficiency. They accessed less information overall, spent more time reading the information they did access, perceived they viewed less irrelevant information, and had a stronger perception of efficiency.

Using the method of differentiating links for filtering hyperdocument information has been tried with some success; other approaches show promise as well. Calvani (cited in Tucker & Dempsey, 1995) proposes the design of levels of information with access. Level one opens a window containing brief information. Level two allows advancement into an interior scene. The third level features the appearance of a character's face with dialog. Levels suggested by S. C. Schatz (personal communication, March 8, 1997) take on a different character. Level one leads to a definition, level two links to a paragraph or short passage, and level three provides a link to an entire related document. Both level schemes give the user control of the database by effectively limiting the amount of information viewed and reducing the size of the hyperdocument.

Information about the structural arrangement of nodes and links is often depicted graphically using maps, diagrams, hypergraphs, or flow diagrams. These graphic supports, unnecessary when software was written in a linear fashion, become essential as software becomes less linear and increasingly complex (Smaldino & Smaldino, 1992). Maps are designed as navigational tools for locating information, reviewing where the user has been, and previewing destinations (Jonassen, 1989). The use of a spatial metaphor results from the concept of hypermedia as a mathematical "space" with links provided to facilitate moving through it (Stanton & Baber, 1994). Though useful for design purposes, the spatial metaphor may or may not prove useful to the user of the hyperdocument. Furthermore, use of hypermaps may even impede navigation for those lacking the spatial skills map interpretation requires (Jonassen, 1989).

Stanton and others (cited in Stanton & Baber, 1994) observed two groups of users performing information search and retrieval type tasks. One group was provided with a map and one group was not. On this particular task, the map group perceived less control, and developed inferior cognitive maps of the information found. However, Beard and Walker (cited in Stanton & Baber) found that performance on a spatial task was enhanced when a map window was provided. Still another study, conducted by Hammond and Allison (cited in Stanton & Baber), compared map and no map conditions on performance of a database inquire task and found no statistically significant difference between the groups.

Restricting movement within a hyperdocument is a final means of aiding the learner (Locatis, et al., 1990). Providing fewer options to users lessens their chance of becoming lost. Contents pages and index pages offer restricted options for movement within a document. Information on these pages can be in either text or graphical form.

Movement can also be restricted by reducing or even eliminating the need to navigate (Stanton & Baber, 1994). Using this design, a learner progresses through the tour one screen at a time. Each screen displays a "next" command which is activated by clicking a mouse or depressing a button. Information presented in this manner is necessarily arranged in a prescribed sequence so the learner is placed in a passive, not active, role. The guided tour approach can be a desirable method for modeling a process.

Incorporation of filtering capabilities in hypermedia programs provides the user a certain degree of control. Depending on the particular task undertaken, the user can "customize" the database to reveal only certain kinds and amounts of information. Or, the design can restrict a user's movement within the hyperdocument, thereby reducing the need for navigation. Purpose of the hypermedia application determines whether filtering or restricting movement is most appropriate.

III Summary and Conclusion

Although there appears to be a need for additional research, the literature to date identifies the navigational aspects of hypermedia as critical to its success as an educational medium. Hypermedia users experience uncertainty about what can or should be done at a particular point in the program. As a result of this uncertainty, the user may be unable to formulate appropriate actions. Suspected causes of these problems are either inherent to the medium or result from flaws in the design of the hyperdocument.

Problems resulting from flaws in design can be addressed. Hypermedia should be organized to facilitate access to the kinds and amounts of information the user is seeking. Additionally, it should provide the user with a means of controlling database size and information flow.

Whether evaluating commercially available software or creating one's own, certain features of the hypermedia program merit careful consideration. The following series of questions will give focus to these features and is recommended for use in hypermedia assessment.

Hypermedia Assessment Questions

1. What is the structure of the hyperdocument? Is it unstructured, hierarchical, networked or a combination of structures? Is the structure presented to the user?

2. Does the structure facilitate accomplishment of the user's intended purpose (e.g., locating information or reading for meaning)?

3. Is the task a spatial task? Are spatial maps provided?

4. Can components critical to the instructional process be identified (e.g., objectives, advanced organizers, or thought questions)?

5. Are directions clear and specific so navigation alone does not require a great deal of mental effort?

6. What provisions are provided to give the learner control? Are links clearly designated? Are they differentiated or undifferentiated?

7. What methods of filtering are provided?

8. Is the user's movement restricted? What is the method used? Is it appropriate to the task?

By utilizing these questions, educators considering implementing hypermedia learning environments will find they can quickly familiarize themselves with a hypermedia program. Strengths as well as weaknesses will be highlighted. Equipped with this information, the evaluator can better determine if the program will serve its intended purpose. Hypermedia written with care to incorporate sound principles of instructional and hypermedia design, can bring the product closer to realizing ". . . the potential to change fundamentally how we write, how we read, how we teach these skills, and even how we conceive of text itself" (Charney as cited in Welsh, 1995, p. 301).

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