ABSTRACT

USABILITY OF HYPERTEXT:
FACTORS AFFECTING THE CONSTRUCTION OF MEANING

by
Kathryn L. King

One type of hypertext application, information retrieval, has become increasingly popular and accessible due to the explosion of activity occurring on the World Wide Web. These hypertext documents are referred to as web sites. Readers can now access a multitude of web sites and retrieve a wide variety of information.

The uniqueness of a hypertext document centers around the concept that text is broken into an array of *non-sequential* text chunks, or nodes, which are connected through links. The hypertext reading can be considered an interactive experience requiring the reader to effectively *navigate* the document. The potentially complex link and node structure awaiting hypertext readers can lead them into becoming *lost in hyperspace*. Usable hypertext design will maximize document coherence and minimize readers' cognitive overhead, allowing readers to create an accurate mental model of the hypertext structure.

Usability testing is designed to determine how easily the functionality of a particular system can be used. In this case, the system under investigation is New Jersey Institute of Technology's web site. The usability of a hypertext document is affected by design elements which contribute to the content and structure of the hypertext. These design elements include good navigation aids, clear link labels, and consistent page layout.

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USABILITY OF HYPERTEXT: FACTORS AFFECTING THE CONSTRUCTION OF MEANING

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This thesis is dedicated to Mr. Christensen, my 3rd grade math teacher, who took time to teach geometry to me during several recesses. Cancer took his life when I was in the 7th grade—and I just wanted to thank him for heading me in the right direction way back then.

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CHAPTER 1

HYPERTEXT AS A COMMUNICATION MEDIUM

This chapter introduces the concept of hypertext and its application as a communication medium. Several features specific to hypertext are presented and followed by discussion including the advantages of a particular feature as well as an indication of potential pitfalls awaiting the hypertext reader. The early founders and implementers of hypertext are discussed and a review of specific applications of hypertext are presented. This chapter concludes with a discussion of how hypertext is currently used on the World Wide Web.

1.1 The Hypertext Vision

In the 1960s, Theodor H. Nelson coined the term hypertext to mean "...*nonsequential writing*—text that branches and allows choices to the readers...a series of text chunks connected by links..." (2). The reading of a hypertext document is considered an interactive experience. Each reader creates a unique path through the document by selecting links leading to blocks of text specific to that reader's needs.

The concepts and ideals of hypertext have been known for several decades; however, widespread interest in hypertext has corresponded with the recent arrival of supporting technology that is readily available and relatively inexpensive. Hypertext theorists of 20 years ago relied on extremely expensive, state-of-the-art mainframe computer systems to demonstrate hypertext's potential. The introduction of the workstation, followed by the personal computer, brings hypertext technology into the hands of not only scientists but also of business people, educators, and any other interested individuals.

1.2 Communicating with Hypertext

Hypertext can be viewed as a "computer-based medium for thinking and communication" (Conklin, 32). Thinking can proceed along several lines at once, creating and revising ideas on different levels and on different points in parallel, each idea related to, and affecting, the others. Traditional communication technologies, however, are typically serial, or linear, processes which can be inhibited by the limited range of human linguistic processing. For example, a listener must rely on the speaker's use of stresses, pauses, and intonations to follow parallel themes. A reader must rely on the writer's use of parenthetical comments, footnotes, bibliographic references, and sidebars to present information. These can strain against the linearity of traditional print material.

Hypertext allows the writer to present a vast array of information in a way that allow the readers to make their own decisions about which links to follow and which nodes to read or skim. Links and nodes are more fully discussed in sections 1.3.1 and 1.3.2, respectively. Hypertext can ease certain restrictions on writers and readers. When hypertext is used as a thinking or design tool, a meaningful relationship emerges between ideas in the mind and the nodes in a hypertext. The nodes can be arranged and linked in ways that reflect the thinking or design process. By using nodes and links, hypertext can more accurately represent, or model, the non-linear aspects of the thinking process.

Hypertext nodes generally represent a single concept or idea, while links between nodes represent the semantic interdependencies of these concepts or ideas.

1.3 Hypertext Features

Hypertext is recognized for its ability to link a vast array of information into a network of information. This idea of inter-textual references is not new, but hypertext allows these references, or links, to be machine-supported. Without the assistance of computers, readers have long been making use of print features for cross-referencing purposes such as tables of contents, indexes, footnotes, references, glossaries, figures and tables, and in some cases, hand-written annotations in the margins. Hypertext offers readers the following enhancements over traditional print technologies:

- References can be traced backward or forward. Through links, a reader can locate where the reference was cited within an article and writers can find out which documents contain references to their work.
- A hypertext system can automatically keep track of the "paper trail" that a reader creates while collecting references. Although document tracking would still be tedious, working with documents online would reduce physical efforts and waiting time to receive hard copy documents.
- Hypertext allows readers to add annotations as a separate node without worrying about squeezing notes in the margins, defacing original documents, or misplacing the comments on a *Post-it*™ note.

The network of information contained in a hypertext relies on the existence of links and nodes. Providing the reader access to all parts of the hypertext is also critical to the successful use of the hypertext. Links, nodes, and access are discussed individually in the next three sections.

1.3.1 Links

Hypertext usually exhibits two broad categories of linking: hierarchical and non-hierarchical. Hierarchical links reflect the organization of the hypertext and can be thought of in terms of a parent node with its children nodes or of a tree structure. The hypertext readers usually have a specific goal in mind, requiring them to interpret and ultimately select a link, or navigate, to their final destination—the node containing the desired information. In a strictly hierarchical hypertext organization, the reader can navigate up and down the structure, one layer at a time, selecting links to create a path to the final destination. One advantage of a hierarchical structure is the relatively simple command language required for navigation: from each node, the reader can go back one level or forward one level. This simplicity can reduce a reader's disorientation since a simple cognitive model of the hypertext is employed.

If the reader has a clear understanding of the desired information and is successful in interpreting the function of each link, then the reader would move in a single direction through the hypertext. If the reader selects a series of links by mistake, then links must be backtracked to some point in the hierarchy where the reader can begin navigating a new path through untried links and nodes. A strictly hierarchical structure places a great responsibility on the part of the writer, or developer, to create link names and organize nodes in such a way that will *work* for all readers. If the hypertext experiences many revisions or addition of links and nodes, then special care must be taken to update the names of the links to account for any "semantic shift" which may occur within the structure.

The second general type of linking refers to links that provide non-hierarchical, or cross-hierarchical, access to the hypertext. Non-hierarchical links are referred to as referential links and they can link any two nodes in the hypertext. The writer, or developer, can create referential links which criss-cross a hierarchical structure. In some cases, the reader can become the writer of the hypertext if the system allows the creation of new links to either existing information or new information also supplied by the reader. The ability to create links and nodes demonstrates a unique feature of hypertext which allows writer and reader to become one.

1.3.2 Nodes

Most hypertext is designed with the idea that each node contains a single concept or idea (Conklin, 35). The actual size and content of the node is up to the writer. Hypertext allows the writer to either break up or combine information into chunks or modules. The node contains text and graphics similar to the pages of a print document, with one exception—the links embedded within the content of the node will somehow be advertised to the reader.

Hypertext allows the nodes to be arranged in a way that models the expression of ideas. A reader's only clue to knowing what a node contains is by interpreting the name of the link leading to that node. Traditional text offers several cues to the reader about how information is broken up through the use of chapters, sections, and paragraphs. The construction of a book guides the reader through important pieces of information. In hypertext, the writer no longer controls the flow of the text. The reader must choose the links to pursue, which, in a sense, allows the reader to create a unique reading each time a new path is traveled. Again, as in the preceding discussion about links, the boundary between writer and reader blur. "In hypertext," Jay David Bolter explains, "readers cannot avoid writing the text itself, since every choice they make is an act of writing" (144). Hypertext places responsibility on both writer and reader to be aware of the hypertext structure—especially since the ability to navigate from node to node through links affects the flow of information.

1.3.3 Access

Hypertexts can be accessed by the reader in three ways: by selecting a link, conducting a search, or utilizing a graphical browser. The first method requires the reader to follow available links to view information stored at each node. The reader can move through the hypertext in any desired path, but each move is limited to the selection of links presented at each node visited.

The second method to access a hypertext is for the reader to perform a keyword search by applying standard database search and query techniques to locate specific nodes.

This usually involves boolean operations (e.g. and, or, and not) to activate a combination of keyword and full-string word searches. Using this technique, a hypertext could be filtered, presenting the reader with a manageable number of link and node options. Not all hypertext systems, however, provide its readers with the search and query capability for finding specific information.

The third technique for hypertext access allows the reader to navigate the document through use of a graphical browser. Successful use of a graphical browser relies on the highly developed visuospatial processing ability of the human visual system. Links and nodes can be viewed in two- or three- dimensional displays, creating a virtual spatial environment of the hypertext. Visually, readers can orient themselves within the hypertext just as they would if they were walking through a supermarket. As readers pass by a node of interest, they could select it and find themselves immediately at that location in the hypertext. As with the search and query features, not all hypertext systems are equipped with graphical browsers.

1.4 Hypertext Applications

Jeff Conklin, in his 1987 article summarizing the state of hypertext, points out that hypertext offers "exciting possibilities, particularly for new uses of the computer as a communications and thinking tool" (17). This potential is even greater today since workstations, and especially personal computers, continue to become more powerful and less expensive, offering an increasing number of computer users access to hypertext systems at work and at home. As computing technology evolves, so does the conception of possible hypertext applications.

Current development of hypertext applications can be grouped loosely into three general application schemes: macro-literary systems, problem exploration tools, and browsing systems (Jonassen, 30). Each of these applications is discussed below.

1.4.1 Macro-Literary Systems

The initial vision of the splendor of hypertext involved the notion of a macro-literary system where massive amounts of the world's information could be linked and accessed through a consistent interface. This concept was first discussed by Vannevar Bush in his article titled "As We May Think." Published in 1945, this landmark article established the significance of hypertext features such as labeled links and associative trails (or paths). As President Roosevelt's Science Advisor, Bush wanted to mechanize the burgeoning store of scientific literature. He called his machine a *memex* and created it, on paper at least, out of a large desk containing several viewing screens, microfilms readers, and photocells. Bush anticipated the need for more efficient methods of indexing and retrieving to handle vast quantities of information. In addition to acknowledging the importance of links and trails, Bush's *memex* system also allowed the reader to browse many forms of information including notes, photographs, and sketches, and even allowed the reader to become writer with the ability to add notes and create new links. The *memex* allowed the user to create associative links, which according to Bush, paralleled the association of ideas performed by the human mind.

The idea of a literary hypertext system takes on even grander proportions when reviewing Ted Nelson's goal for his *Xanadu* project. Nelson hopes to place the entire world's literary corpus online and provide access to all while maintaining copyright protection through an online royalty accounting system. Nelson began this quest almost 30 years ago and is still at work on the feasibility of such a system.

1.4.2 Problem Exploration Tools

The second category of hypertext applications includes tools for problem exploration. These tools allow the user to create and adapt hypertext to accommodate a large amount of unstructured information. These hypertexts can be the result of a collaborative effort and must provide mechanisms for filtering, organizing, and browsing data as the hypertext increases in complexity. These hypertext systems are typically created to meet the demands of a very specific project or organization. These systems can focus on problem solving and idea generation, software engineering, and textbook authoring.

In the early 1960s, Douglas Engelbart and his team at Stanford were the first to apply ideas that Bush outlined in 1945 to complex problem solving situations. Engelbart desired to augment the human intellect by increasing human capabilities to "approach a complex problem situation, gain comprehension to suit his particular needs, and to derive solutions to problems" (1). Engelbart lists the following outcomes as an indication of increased human capability:

- Comprehension is gained more quickly.
- Better comprehension is gained.

- A useful degree of comprehension is gained where the situation was previously seen as too complex.
- Solutions are produced more quickly.
- Better solutions are produced.
- Solutions are found where previously the human could find none.

Engelbart goes on to point out that complex problem situations can be experienced by many professionals including diplomats, executives, social scientists, life scientists, physical scientists, attorneys, and designers. He acknowledges the importance of developing a problem-solving approach that is a collaboration of the human "feel for a situation" and the use of "high-powered" technology.

Engelbart created a primarily hierarchical system containing text and video images. His system assumes that human capabilities are augmented through the use of artifacts, language, methodology, and training. Key elements of his system are based on the foundations of hypertext and include symbol manipulation and mental structuring The user can create non-hierarchical links, filter selected information from the database, and view windows displaying the document structure. The most current version of his system, known as Augment, also includes communication capabilities such as bulletin boards, electronic mail, and multi-user access (teleconferencing). In addition to his pioneering efforts in the field of hypertext, Engelbart is also well-known for the invention of the interface device known as the mouse (Jonassen, 65).

Each of these three original hypertext visionaries (Bush, Engelbart, and Nelson) share a common challenge endemic to highly conceptual ideas—the realization of their hypertext visions depend largely on the continued breakthroughs in computing technology. Implementation of new technology, such as macro-literary systems and problem exploration tools, also typically require a philosophical acceptance within the targeted community.

1.4.3 Browsing and Information Retrieval Systems

The third category of hypertext applications focuses on browsing and information retrieval capabilities. These types of systems have enjoyed the most exposure and commercial success. These systems are designed to give the reader easy access to large amounts of information and include online documentation and help systems, instructional systems, and information retrieval systems. These readers have very explicit and concrete goals and are looking for a specific piece of information in a manual, teaching module, or database environment.

According to Conklin, when considering a structured browsing system, "ease of learning and ease of use are paramount, and great care goes into crafting the interface" (26). Conklin also points out that writing, or adding new information and creating links, "is usually either not allowed to the casual user or is not particularly well supported [by the hypertext system]" (26).

1.5 Hypertext and the World Wide Web

Documents found on the World Wide Web (the Web) typically fall into the browsing and information retrieval category of hypertext applications. A popular development on the Web is the creation of a web site by companies, institutions, and even individuals. A web site generally gives the reader information about that particular company, institution, or individual. Current web sites range from a simple hypertext structure containing very few links to a complex hypertext structure containing several links and a deep hierarchical layout. New Jersey Institute of Technology's (NJIT's) web site contains hundreds of links which allow the reader to access, or navigate, several screens to look for specific information.

Searching the Web for information can play an important role in the development of a reader's critical thinking skills. A critical thinking model demonstrates how the reader must branch out and search for information related to, but existing beyond, the boundaries suggested by the starting point of an idea (Barat and Elliot, 3). Hypertext documents placed on the Web can allow readers access to a wide range of information about specific and ancillary topics of interest.

Web documents are created using an established markup language known as HTML (hypertext markup language). For a web site, the hypertext usually begins as an ordinary word-processed document. All of the formatting style you see in a web site is obtained through the use of markup tags in the original text instead of using the formatting features provided by your word processor. Specific tags indicate the function of a selected string of text and these functions include headings, paragraphs, bulleted or numbered lists, link anchors, and the use of italics, bolding, and underlining. In addition to saving the finished document in your particular word-processing format, you would also save it in a more universal, or generic, text format. It is this text file that is loaded onto the Web and available for reading by anyone with access to the Web through the use of a commercial Web browser, such as Netscape or Mosaic. The Web browser will interpret and display the format signaled by the tags. Software to simplify this markup procedure is currently enjoying a lot of attention from the online community.

In *Hypertext*, George P. Landow says the term *hypermedia* "...simply extends the notion of the text in hypertext by including visual information, sound, animation, and other forms of data" (4). Online encyclopedias and many web sites are a familiar example of the extension to hypermedia. James Martin's book titled *Hypermedia Documents and How to Create Them* refers to end-products created with hypertext and hypermedia as *hyperdocuments*. NJIT's web site displays text various graphics including still photographs but, at this point in time, does not include animation, sound, or video. Web sites can be referred to as hypertext, hypermedia, or even hyperdocuments. For simplicity, and consistency with Grice and Ridgway's definition, I will refer to NJIT's web site as hypertext because hypertext "...is a subset of hypermedia, limited to text and pictures, with simple navigation aids" (429). Hypertext, and its extension into multimedia, is already present in the workplace and will continue to make its mark in the area of electronic documents.

CHAPTER 2

HYPERTEXT AND COMPREHENSION

This chapter discusses the importance of several hypertext features which can positively and negatively impact a reader's comprehension. The significance of coherence and cognitive overhead are discussed in terms of hypertext features. A model which governs the process of making meaning from text is presented where the forces impacting the reader have been defined in terms of reading a hypertext instead of a print text. This chapter concludes with my representation of how hypertext, comprehension, and usability testing fit together.

2.1 Hypertext Design Considerations

In spite of a lack of empirical studies, a review of the literature addressing hypertext design reveals that one of the most commonly discussed design criteria for creating usable hypertext is providing the user with appropriate navigation aids (Alciere and Lewis, 71) (Bernhardt, 164) (Glover, 632) (Keyes, 18.12) (Lindstrom, 189) (Lynch) (Martin, 85) (Nielson, 133) (Thüring, Hannemann, and Haake, 64) (Weise, 27). Due to the non-linearity of hypertext documents, it is crucial that the user feel in control of the document and have a sense of orientation within the multiple pages. If the reader is not supported by cues taken from either traditionally linear texts, or from new hypertext designs, then the reader can become what is known as *lost in hyperspace*.

In a recent issue of a new publication, *Web Week*, correspondent Shoba Narayan interviewed several chief designers from firms specializing in web site design. Under the heading of "Most Important Issues to Consider When Designing a Site," each designer expressed concern with creating a usable interface between the reader and the hypertext on the screen. Specifically, Thomas Lakeman from Digital Planet Corporation stated that "things that jar you out of experiencing the medium and make you aware of its limitations are bad design. There is...a big reliance on the text on the Web" (43). The overall design philosophy of another designer, Geoff Katz with Organic Online, says that "form follows function...we design with the user experience in mind" (44). Whether the goal of the web site is to entertain, inform, or persuade, these designers point out that a web site is successful only if it provides the user a pleasant experience, which encourages the user to visit their site again.

2.2 A Mental Model of Hypertext

Specific interest in the role that electronic documents play in the interaction between users and technology is still in its infancy (Johnson, 195). A number of studies have been conducted to assess the readability of text (van Dijk and Kintsch, 45), but hypertext and hypermedia present new challenges to researchers concerned with the effectiveness of information transfer at the human-computer interface (Grice and Ridgway, 429). As part of a literate society, readers become familiar with established text structures. Readers depend on certain patterns to identify a text genre, anticipate its development, and integrate its parts. Reading comprehension studies confirm that understanding and learning occur most easily from texts with well-defined structures (van Dijk and Kintsch, 126). Effectiveness of traditional print has been rigorously studied resulting in time-tested cognitive and rhetorical theories. However, as Davida Charney points out, "we lack corresponding theories for how to deal with hypertexts—especially those that push the limits with complex linkages within and between a complex set of texts" (260).

As a hypertext structure grows in size, it becomes more difficult for a reader to construct a mental model of that structure. The hypertext is a network of information rather than a cohesive expository or narrative presentation. Figure 2.1 shows an example of a relatively simple hypertext structure. The capital letters represent the nodes, or destinations, which contain text (and audio, video, photographs, etc.). Each node can have any number of links embedded within its text. The lower case letters in Figure 2.1 represent these links.

The top half of Figure 2.1 shows two nodes; one named A and the other named C. Node A is connected to node C through a link named c. Since additional links anchored in A and C are shown, the reader begins to suspect that a network of links and nodes are at hand. *Reading* this hypertext requires the reader to navigate multiple links and nodes while constructing a mental model of the structure as shown in the bottom half of Figure 2.1. Document features that can help the reader construct an accurate mental model will lead to improved comprehension of that document.

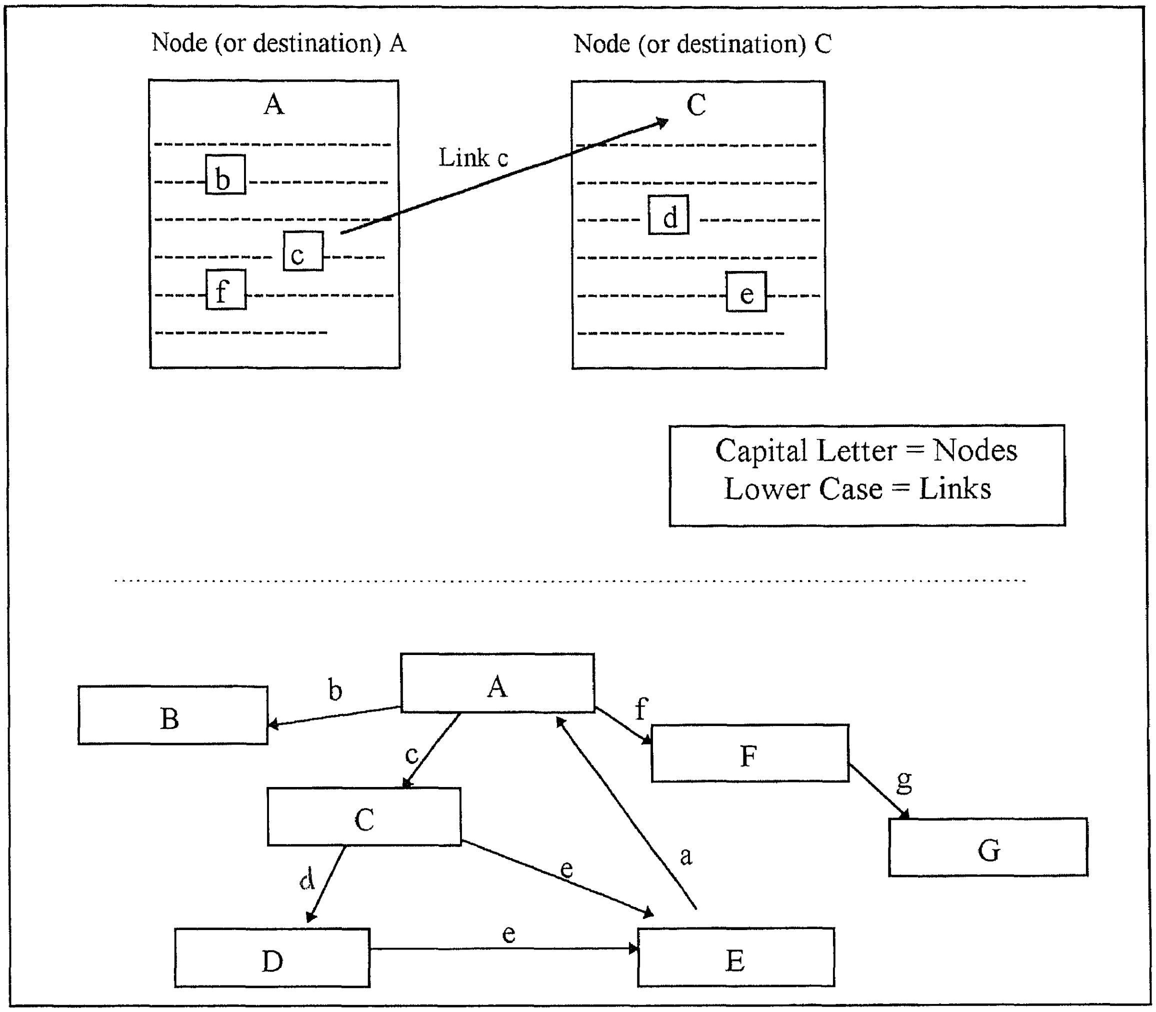


Figure 2.1 Simple Hypertext Structure

Readability is a term that has been used since the 1940s and it refers to the ease and speed of reading. In fact, readability formulas have been devised which measure the mental difficulty of reading material (Tinker, 4). Readability is an important contribution to comprehension since it reflects "the relative ease with which texts can be read and remembered" (van Dijk and Kintsch, 45). The readability of a hypertext can be increased if the factors that support construction of the reader's mental model are strengthened and the factors that impede this process are weakened. There are two factors which significantly affect this process: *coherence*, a positive influence, and *cognitive overhead*, a negative influence (Thüring, Hannemann, and Haake, 58).

2.3 Coherence

Empirical studies have shown that a reader's ability to comprehend a traditional print text depends on the degree of coherence found within that text (van Dijk and Kintsch, 149). Constructing a mental model relies on two types of coherence: *local* and *global*. In print text, local coherence is established through the relation between clauses and sentences. Global coherence is created through association of several clauses, sentences, paragraphs, and even chapters. During comprehension, the reader builds a hierarchical structure representing the main ideas of the text. Local and global coherence are strengthened when the document possesses a well-defined structure and provides rhetorical cues reflecting its structural properties (van Dijk and Kintsch, 188).

Extending the position of van Dijk and Kintsch to hypertext implies that writers will increase the readability of their hypertext by providing cues that increase local and global coherence. Within each node, writers can increase local and global coherence by employing many of the same guidelines applicable to print, such as meaningful clause and sentence structure, and aggregating sentences into paragraphs and sections. When considering the relationship between nodes and links, however, the hypertext writer must employ guidelines that go beyond those required for writing linear text. To increase local and global coherence of hypertext at the network level, writers must "provide cues in hypertext that parallel cues for both local and global coherence in traditional text" (Thüring, Hannemann, and Haake, 58).

2.3.1 Local Coherence at the Network Level

To increase local coherence at the network level, writers must recognize that the one of the main features of hypertext—the ability to chunk information—can also lead to destructive fragmentation. A *usable* hypertext must present linked pieces of information as a coherent whole rather than an aggregation lacking in interpretive context. To strengthen coherence, the writer can represent semantic relationships between nodes that indicate the relationship between the content of those nodes. In this case, the link between those two nodes can carry a label and that label should indicate the appropriate semantic relationship. Another option to facilitate construction of a mental representation of the hypertext is for the system to have the capability to display the previous node as well as the current node. When readers can see the information simultaneously, they can detect semantic relations between both sources more easily.

With respect to the Web, local coherence at the network level provides the reader with answers to questions such as: Where are the link anchors? Where will this link take me? Why should I select a particular link? Working within the available features of the hypertext markup language (HTML) which is used to create documents for the Web, writers have limited control over the use of fonts, sizing, and color to distinguish various items on the screen. Commercial browsers, such as Netscape and Mosaic, will display text and links within a document using their own convention for fonts, sizing, and color. This limits some of the format and style tools normally available to the print text writer used to establish local coherence.

The semantic relationship of a link can be revealed to the reader if the link anchor displays a meaningful phrase or bitmap (graphic) indicating the contents of the link destination thereby improving local coherence. The single window display provided by the commercial Web browser, however, precludes the reader from simultaneously viewing the node containing the link anchor and the node containing the link destination. This limitation removes an opportunity for readers to improve their visual context of the web site. This lack of support for local context makes the need for global coherence even more critical. The writer must consider readers' questions such as: What section am I looking at? How does this section fit with the remaining document?

2.3.2 Global Coherence at the Network Level

To increase global coherence at the network level, writers must implement cues to assist the reader in determining the major components of the hypertext and how these components create the overall structure. All nodes contributing to one of the main ideas presented in a hypertext should reside in close proximity to each other. This enables readers to identify important components and construct a mental representation of the hypertext structure. A coherent document structure reduces the mental effort of comprehension, but conveyance of that structure to the reader would further reduce the mental effort required. This can be accomplished through use of a graphical browser, or map, which can provide an overview of the major components and their relationships within the hypertext. A hypertext which allows the user to view only one node at a time may cause that user to become disoriented since no spatial event corresponds to the process of moving from node to node. In an effort to provide orientation, the user interface of a hypertext system can be designed to provide a graphical representation, or a map, of the hypertext structure. As each node is read and link is traveled, the representation of those nodes and links on the map can change to a different color. By referring to a map, a reader can spot quickly the parts of the hypertext already viewed and likewise, areas yet to be explored. A map provides contextual and spatial cues to supplement the reader's understanding of which nodes she or he is viewing and how they are related to the other nodes and links in the hypertext.

Use of a map, or graphical browser, can provide visual and tactile cues similar to the method a reader uses to locate a certain page in a book by remembering the location of that page with respect to the thickness of the book The physical limitations of the computer screen requires the browser layout to cope with the problem of hypertext complexity and hypertext size. As the hypertext structure becomes increasingly complex, even a map can only show part of the overall structure with each display on the screen. In this case, a hypertext can employ two types of map displays: a *global map* showing the entire hypertext structure and a *local map* presenting a view of the links and destinations radiating out from the node on which the reader is currently focused.

Navigation tools available to web site readers through commercial browsers include various arrangements of buttons or graphical representations of link anchors. The graphical browsers, or maps, mentioned above are limited to hypertext systems developed for specific applications and, as yet, have not been developed for use on the Web. In lieu of an overall map of the structure, a consistent set of graphic signs, or labels, can be developed to represent specific locations within the hypertext document. Labels can be developed to reference the top of the document (i.e. table of contents), the beginning of major sections (i.e. chapters), or the previously viewed node (i.e. page). These labels help readers navigate the global structure of the web site and determine their current location in a global context.

2.4 Cognitive Overhead

Creating, naming, and navigating multiple links offer challenges unique to writers and readers of hypertext. Conklin refers to the additional effort and concentration required to manage several paths at one time as "cognitive overhead" (40). Every effort additional to the reading process reduces the mental resources available for comprehension. There are three characteristics endemic to hypertext which can contribute to cognitive overhead: disorientation, inadequate navigation aids, and an unfamiliar user-interface.

The first two characteristics, disorientation and navigation, affect readers as they move from one piece of information, or node, to another. Readers experience disorientation when suddenly they do not know where they are, how they got there, or where they should go next. If no external orientation cues are given, then a considerable memory load can occur as the readers try to understand the overall document structure and keep track of their moves through that structure. Orientation cues should identify the readers' current position, indicate the path leading to that position, and present the different options for moving on from their current position. Empirical studies support the relationship that effective orientation contributes to increased comprehension (Dillon, McKnight, and Richardson, 172).

With the reader in mind, the hypertext writer must carefully consider how much information to place in a node and what to name the link to clearly indicate the node's contents. The reader experiences cognitive overhead when forced to process a large number of links and decide which links to follow and which ones to skip. The reader must interpret the name of each link and decide if the link leads to a desired destination or if it fall into the category of "side trips." If it looks like a side trip, then is the side trip worth taking? The cognitive overhead resulting from the distraction of this decision making does not affect the reader of print text in the same way because the print text writer has already made most of these decisions for the reader before publication.

The third hypertext characteristic likely to increase cognitive overhead involves the reader's ability to understand and use the user-interface. Hypertext can require the reader to move and resize multiple windows or scroll within windows: actions that are dependent on mouse-driven commands. Successful use of the user-interface employs the reader's current familiarity with hypertext systems. Lack of familiarity can increase a reader's cognitive overhead and ultimately reduce comprehension.

2.5 Constructing Negotiated Meaning from Hypertext

Comprehension of text can be characterized as the construction of a mental model that represents the objects and semantic relations described in that text (van Dijk and Kintsch, 44). In *The Construction of Negotiated Meaning*, Linda Flower discusses the components of a model she has created which demonstrates the complex process of discourse construction (Flower, 53). Her model encompasses readers and writers constructing meaning through the medium of print text. The effort spent on the construction of a mental model affects the document's readability. Figure 2.2 shows how Flower's model can be modified to reflect readers constructing meaning through the medium of hypertext.

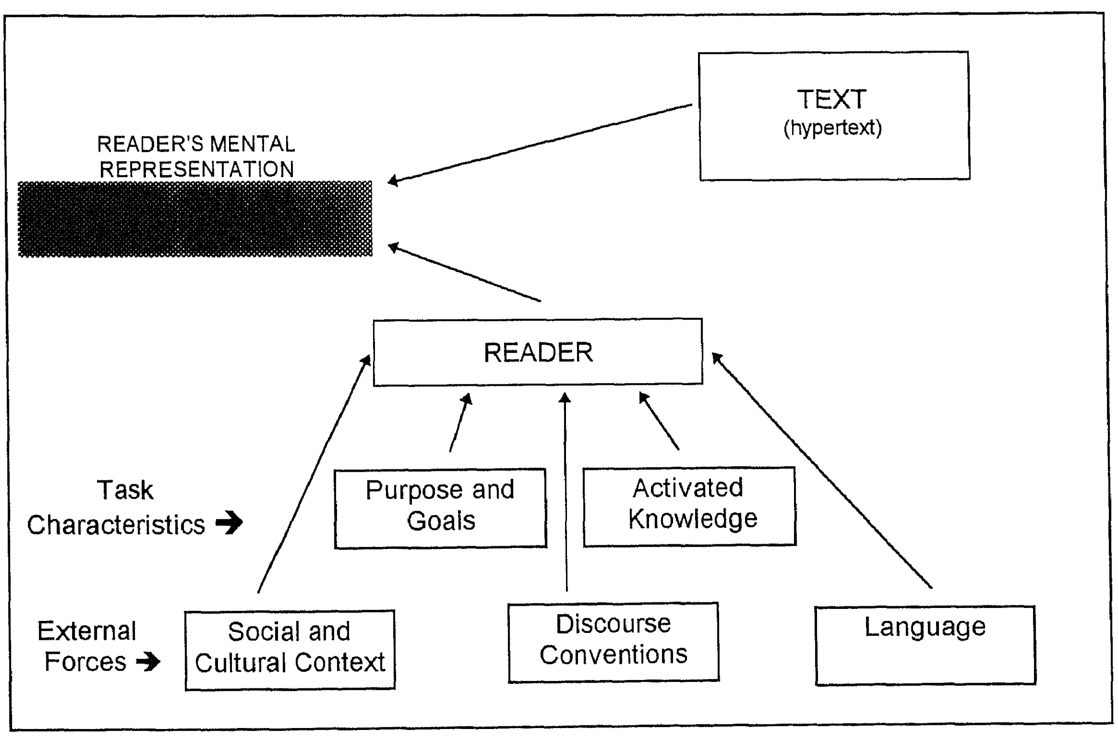


Figure 2.2 Linda Flower's Model of Discourse Construction—Modified

Flower defines the process of making meaning as "...an event that occurs in *the minds of individual thinkers whose cognition is embedded within and shaped by the social contexts and emotional realities.* Focusing on individual cognition acknowledges...the social or emotional dimensions of meaning" (89). Her model suggests that readers construct meaning within a range of contexts—contexts which can be considered forces external to the reader. These forces include social and cultural context, discourse conventions, and language. These external forces influence characteristics of the reading task at hand—characteristics which include purpose and goals, and activated knowledge. This model shows how external forces affect the reader's internal voice and guides meaning making. Ultimately, readers build socially shaped, individually formed meanings.

If we assume a hypertext medium, such as NJIT's web site, then the external forces and task characteristics affecting the reader's ability to construct meaning can be interpreted as listed below.

External Forces:

- **Social and cultural context** depends on the reader's background which includes the individual's experience within various personal, educational, and business communities. A person's attitude toward technology, and specifically the computer, can impact her or his effort in making meaning from hypertext.
- **Discourse conventions** provide a reader with a set of known, accepted, and quickly understood formats for written communication. If the discourse type is

hypertext, then the reader will automatically attempt to compare that hypertext format to other written text conventions. If the reader has a lot of experience reading hypertext, then he or she might compare it with other hypertext formats that have recently become familiar.

- **Language** affects the reader if unfamiliar words are used in the document. Web sites are particularly prone to containing language seen nowhere else except online. When document headings include language such as FAQ's, Cool Sites, or Click Here, the reader can easily feel left out.

Task Characteristics:

- **Purpose and goals** of any reader usually fall into two categories: reading for information and reading for deep understanding or learning. Hypertext supports the same categories of reading, however, the process will include navigation of links and nodes. This navigation can be enhanced or inhibited by the hypertext design.
- **Activated knowledge** refers to the talents and expertise that a reader brings to the reading task. Because hypertext is made up of text, this type of reading not only taps into a reader's resident knowledge just like reading print text would, but hypertext reading also requires a certain level of expertise with a personal computer, the Web, and web site design.

Further understanding about the significance of these factors and how they affect meaning making can be evaluated through usability testing. Thorough usability testing requires the development of several instruments and involves the analysis of a variety of measured data. Evaluation of each of the parameters listed above was helpful in determining specific usability problems with NJIT's web site.

2.6 Hypertext, Comprehension, and Usability Testing

This research includes a usability test designed to evaluate the significance of four hypertext design characteristics which can impact the reader's construction of negotiated meaning. Three of the design characteristics relate to global coherence and include useful navigation aids, clear names, or labels, for links, and clear graphical representations of links. The fourth design characteristic is the importance of good page layout, which can affect both local and global coherence of the hypertext for the reader. As discussed earlier in this chapter, comprehension increases as coherence is improved and cognitive overhead is reduced. Review of Figure 2.3 shows the relationship between hypertext, usability testing, hypertext design characteristics, coherence, cognitive overhead, mental model construction, and comprehension.

As Figure 2.3 indicates, increased document coherence and decreased cognitive overhead enable the reader to construct a higher quality mental model of the hypertext structure. A better mental model leads to increased comprehension which results in a usable document. Usability testing can point out specific document features which are inhibiting the readers' ability to make meaning from the hypertext. Usability testing of a hypertext document is discussed in detail in the next chapter.

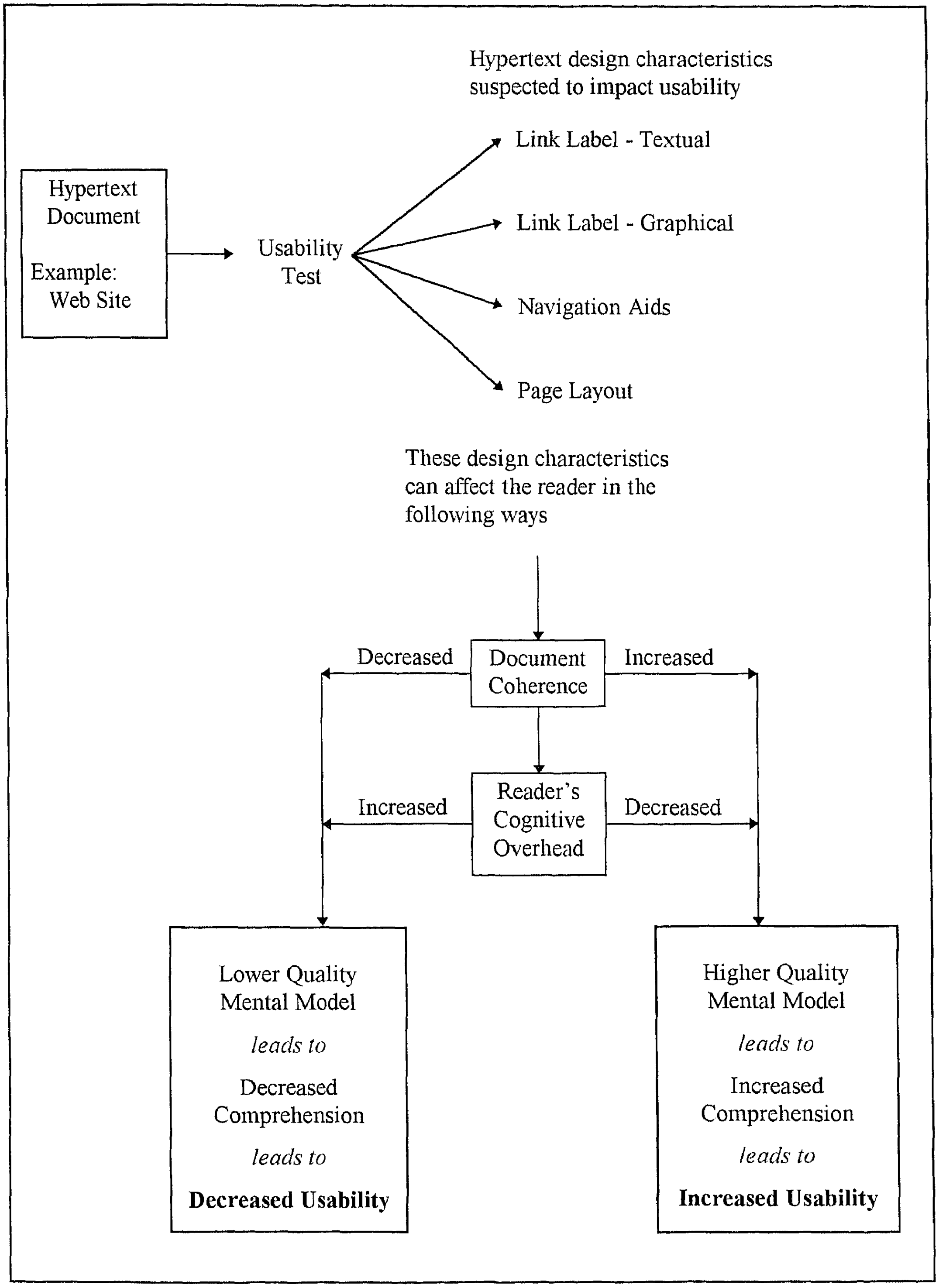


Figure 2.3 Relationship of Hypertext, Comprehension, and Usability Testing

CHAPTER 3

USABILITY TESTING APPLIED TO HYPERTEXT

This chapter begins with a discussion of what usability means followed by a review of the range of research domains and where usability fits into that range. The bulk of the chapter outlines the creation and administration of a usability test on NJIT's web site. This chapter concludes with a discussion of a triangulation method used to analyze the many different types of data collected during a typical usability test.

3.1 Usability Defined

Usability is a term that comes from computer interface design and was meant to cover studies on the ease with which a user could learn about or use a computer. Interest in the usability of written documents, especially hypertext, is a relatively new concept, gaining an audience since only the early 1980s (Johnson, 207). Usability factors have been defined for print and online documents and include: accuracy, completeness, pertinence, appearance, readability, clarity, task-orientation, task-supportiveness, and defined entry points (Grice and Ridgway, 432). Jakob Nielsen comments that "usability of hypertext systems really fits the general definition of computer system usability" and he goes on to list five attributes traditionally associated with the concept of usability (149).

- **Easy to learn**—users can quickly understand the link and node concept and can navigate to the desired information.
- **Efficient to use**—users want to find information quickly. They are able to orient themselves at any node and understand the location of that node within the hypertext structure.

- **Easy to remember**—users can transfer their knowledge of navigation from one hypertext to another.
- **Few errors**—users rarely follow a wrong link or if they do, then it is easy to backtrack until the correct path can be selected.
- **Pleasant to use**—users feel in control of the hypertext and can move about freely without feeling constrained by the system. Users would use the hypertext over alternative communication media.

To further understand the term *usability*, it is helpful to discuss the significance of a few other related terms such as *usefulness* and *utility*. A computer system is considered useful when it contributes to the users' achievement of some specific goal. As shown below, in Figure 3.1, usefulness can be broken into two distinct categories: *utility* and *usability*.

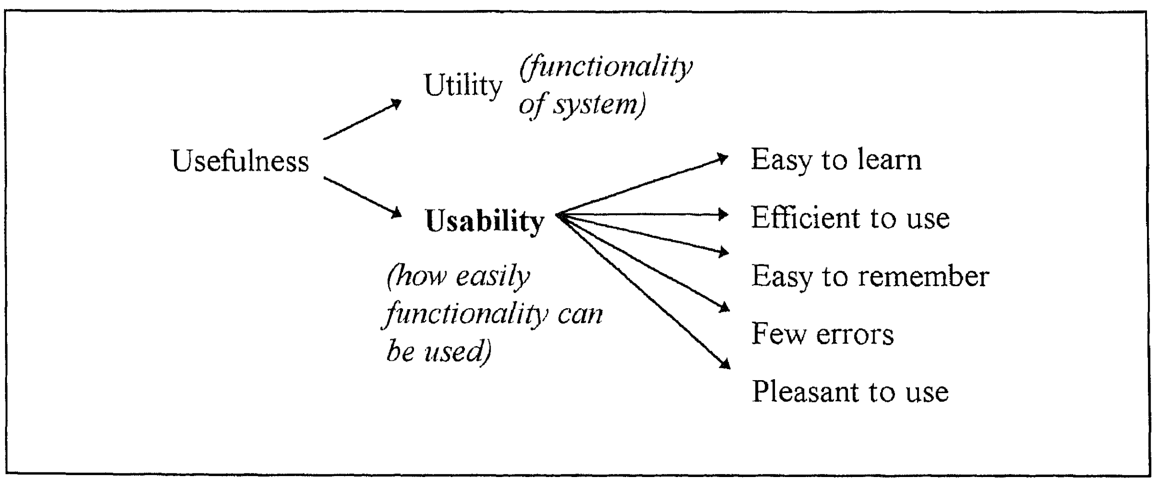


Figure 3.1 Nielsen's Definition of Usability

Utility refers to the functionality of a system—in other words, can the system in principle do what is required? The usability of a system has nothing to do with that system's functionality—it measures how well the users can use that functionality (Nielsen, 151).

Hypertexts must live up to the same standards of usability set for print documents. A web site must be accessible without requiring the user to stop working and read an online help or how-to tutorial. The hypertext reader wants to begin searching for desired information quickly and easily.

The usability of a hypertext system is affected by a combination of the technical features offered by the markup language and the design elements contributing to the content and structure of the hypertext. From the reader's perspective, the technical features and the design elements will be seen as a single interface. From the usability test evaluator's perspective, understanding the difference between the technical features of the hypertext system, in this case the markup language, and the design features, employed by the web site developer, are critical to the evaluation process. For example, a usability problem resulting from the technical limitations of the markup language relate to the functionality, or *utility*, of the system, where the usability problems resulting from some aspect of poor design will inhibit the use of that functionality, or the *usability*.

3.2 Research Domain for Usability Testing

Usability testing is considered an empirical method because specific types of observation data, such as the time required to complete a specific task and the number of wrong links selected, is carefully recorded (Dumas and Redish, 35). Data is also collected by using a protocol analysis in which the participants' comments are recorded as they *think aloud* while performing set tasks. The transcripts can be analyzed for similarities and differences from task to task among participants. Verbal data collected in this way "provide a rich source of information about human thinking" (Slatter, 21). The participants also contribute valuable data by completing pre- and post-task questionnaires and answering structured interview questions after completing all of the assigned tasks. Usability testing yields enough quantitative data to develop meaningful conclusions.

In *Composition Research*, Janice M. Lauer and J. William Asher present a taxonomy of research designs ranging from descriptive to experimental research. Figure 3.2 shows the individual research methods located within the descriptive and experimental regions. I have modified the diagram to show how usability testing fits into their taxonomy.

Usability testing exhibits more of the descriptive research characteristics of both a case study and a survey, as opposed to the more experimental research methods. This tendency toward descriptive research is typical for a situation where very little data is known about the research subject. In this case, the research subject is hypertext, which is an emerging, state-of-the-art, technology. At this point in time, there is limited literature available about hypertext as a writing and communication technology. A common thread throughout the limited literature is, in fact, a call for research on the usability of hypertext (Glover, 628; Grice and Ridgeway, 429).

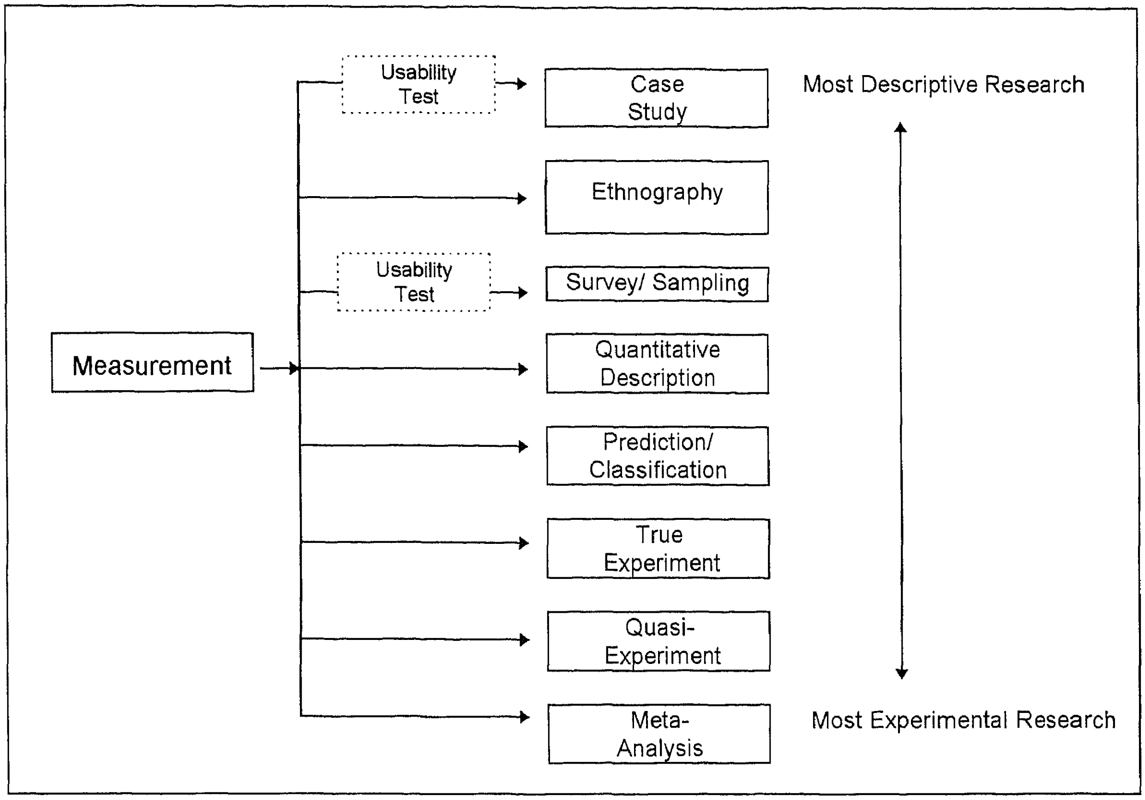


Figure 3.2 Lauer and Asher's Research Taxonomy—Modified

3.3 Scope of the Usability Test

The scope of this usability test was to determine if NJIT's web site, which consists of many pages and hundreds of links, is easy to use. I wanted to know if users of different experience levels could find the information they needed from the web site without getting lost in the links and without frustration. From discussions with an NJIT web site design team member, I learned that the primary focus of the redesigned web site was to add more information and boost the technological image of the campus. As is typical in many software development cycles, detailed discussion of usability did not occur up front in the process—it was just assumed that, by the end of the design process, appropriate navigation tools would be incorporated into the web site design.

3.4 Usability Test Design

In this section, I will discuss each of the components necessary to create an effective and meaningful usability test. The product for testing is, as stated earlier, NJIT's web site, located on the Web at http://www.njit.edu. The first page, or the *top*, of the web site, is shown as Document 1 in the Appendix. The first page of the web site sets the style for the entire hypertext: major links are displayed as photographic slides, and link names, or labels, are printed on the bottom edges of the slides. This section will explain how I chose a testing team, located a testing site, and selected suitable participants. I have also listed the steps I used to create the tasks for the participants, and I describe each of the instruments designed to capture various types of usability data. This section concludes with a discussion about the procedures I followed during the actual testing session.

3.4.1 Testing Team and Location

A usability test team typically includes a leader, briefer, data logger, camera operator, and a "help desk." For this research, I combined these responsibilities into one position called observer. Since the product for testing was NJIT's web site, the testing location had to provide certain amenities. I chose my home office for the testing site because it contains a personal computer, a modem, web browser software, access to an Internet service provider, a video camera, and a television monitor. The video camera was used to record the participant's actions on the computer screen and the participant's verbal comments.

3.4.2 Participant Selection

Usability test participants should be potential users of NJIT's web site and would include students, parents of students, faculty, and anyone else interested in academic institutions. NJIT's web site must be usable for individuals possessing different levels of expertise with the computer. The user's level of computer expertise can have a large impact on how they use the hypertext.

I created a matrix of user characteristics to develop specific profiles required for a meaningful usability test. Then I created a *User Profile (& Pre-Test) Questionnaire* (see Appendix, Document 2) to capture enough data to screen candidates and to group my candidates according to Novice, Intermediate, or Expert, as shown in Table 3.1. Dumas and Redish point out that if time or budgeting constraints limit the number of groups to be tested, then leave out the middle group, which in my case would be the Intermediate group.

I found that I had to modify my original candidate profile structure to account for a mix of varying levels of different kinds of computer experience. For example, if someone is a novice on the Web, one cannot assume that he or she is also a novice at other computer applications. When I eliminated the middle group (Intermediate) and rearranged the experience levels, I ended up with a smaller matrix where the profiles broke down into four types of candidates as shown in Table 3.2.

Table 3.1 Candidate Profiles

	Novice	Intermediate	Expert
PC experience, time	<6 months	6 mos - 2 years	>2 years
PC experience, freq.	< 1 time/week	a few times/week	every day
Web site navigation experience	<3 months	3 - 6 months	>6 months
Web site exposure	view <5 a week	1 - 5 a day	>5 a day

Table 3.2 Candidate Types

	Computer Novice	Computer Expert
Web Novice	**Type I**	**Type II**
Web Expert	**Type III**	**Type IV**

Type I: Avoid candidates in this group because they are not representative of most individuals viewing a web site. Most individuals accessing the Web possess some level of computing knowledge.

Type II: Ideal candidate possessing a good command of basic computing skills; someone who is ready to pursue information retrieval from the Web.

Type III: This is an unlikely combination of candidate attributes (except for any 12-year-old surfing the net) since Web experts have usually spent quite a few months on the computer using additional programs.

Type IV: This is also an ideal candidate that possesses good computing skills and is familiar with the Web and with several web site designs.

For the first run of my usability test, I planned to pursue a Type II or IV candidate, as defined above. I used the *User Profile (& Pre-Test) Questionnaire* to determine if the applicant fit my desired user profile and to determine which Type the user represented. My participant was a Type II in terms of expert computer skills and novice Web skills and was deemed an acceptable test participant.

3.4.3 Task and Scenario Creation

One of the essential components of a usability test is the creation of a set of tasks for the participant to perform. The tasks are presented, in a scenario format, to the participant. I created the tasks, and the resulting scenarios, in the process outlined below.

- **Become familiar with the product.** I visited NJIT's web site. I followed the available links throughout the hypertext to get a feel for the type of information that was available in the document and where that information was stored.

- **Brainstorm to develop tasks.** I generated tasks which would reflect real applications that someone accessing the web site might actually perform. I thought about the type of information an existing student, a new student, or just someone interested in an academic institution would be interested in searching for in NJIT's web site.

- **Select the tasks highlighting important characteristics of good usability.** An ideal task is one which will probe potential usability problems. I focused on four design elements considered important to hypertext usability: useful navigation aids, clear textual link labels, clear graphical link labels, and good page layout. I selected ten tasks which would highlight the participant's interpretation of at least two of the above design elements while performing each task. Some of the tasks appear to be repetitive in terms of which design elements are being tested. When I have more experience with this test design and gain confidence in capturing enough usability data, then I can consider reducing the number of tasks. Task reduction is discussed in the ***Direction for Further Research*** section in Chapter 4.

- **Reorder tasks for participant use.** I ordered the selected tasks in a way that would seem natural to the participant. I began with some general information retrieval tasks and moved to more detailed tasks requiring the participant to navigate through a deeper hierarchy of screens.

- **Create scenarios to encompass selected tasks.** A good scenario is brief, unambiguous, and written in the participant's words. I created scenarios to encompass each one of the ten tasks. The scenarios were designed to give the participant a reason and enough information to conduct each task.

The selected and ordered tasks and scenarios are listed below, in Table 3.3. Also shown in the table, are the four design elements considered important to good hypertext usability. A check mark indicates which elements the scenario is designed to test through the participant's actions. For example, Task #3 was designed to highlight the importance of navigation aids and clear textual link labels, whereas Task #9 was designed to test the importance of navigation aids and good page layout. As Table 3.3 shows, the importance of useful navigation aids are demonstrated in every task due to the linked structure of hypertext.

Table 3.3 Listing of Tasks and Scenarios

Tasks and Scenarios	Hypertext Design Elements: Navigation Aids	Textual Link Labels	Graphical Link Labels	Page Layout
1. Task: Find NJIT's mission statement. Scenario: You are writing an article about and NJIT and you want to include a few words from NJIT's mission statement.	✓	✓	✓	✓
2. Task: Find the phone number for the MS-Chemical Engineering department? Scenario: You are considering a Master's Degree in Chemical Engineering. Who, and at what number, can you call to find out information about the department?	✓	✓	✓	✓
3. Task: Find hours required for MS-PTC degree. Scenario: You may want a second Master's Degree in Professional and Technical Communication. How many hours are required for this degree?	✓	✓		
4. Task: Find out where to park. Scenario: You must pay your registration in person. You know how to get to NJIT, but where are you going to park your car? You want to park in a campus lot.	✓	✓		✓
5. Task: Locate the registrar's office. Scenario: The Bursar's office is in Cullimore Hall. Where is Cullimore Hall?	✓	✓		✓
6. Task: Find the reference librarian's phone number? Scenario: You have to look something up in the *New York Times Index*. How can you find out if the library has this reference?	✓	✓		
7. Task: Find Tau Beta Pi club information. Scenario: You would like to become a member of the Engineering Honor Society, Tau Beta Pi. Does NJIT sponsor a chapter?	✓	✓		
8. Task: Find AT&T on the list of Overseers. Scenario: You are an AT&T employee. You would like to know if any AT&T employees serve on the Board of Overseers.	✓	✓		
9. Task: Confirm that helpful links are missing. Scenario: Return to the top of NJIT's web site without using Netscape's Back button or Bookmark feature.	✓			✓
10. Task: Find "Center for Pre-College Programs." Scenario: Can you find this page?	✓	✓	✓	✓

3.4.4 Instrument Development

The following list describes each of the instruments developed to capture important usability test data.

- **User Profile (& Pre-Test) Questionnaire** documents background information for each participant. This allows computer expertise to factor into data analysis (see Appendix, Document 2).

- **Participation Logs** direct the action of the participant during the performance part of the usability test. A Participation Log contains one scenario per page, reminds the participant to think aloud during each task, and prompts the participants to write answers to four usability questions asked at the conclusion of each task (see Appendix, Document 4—only one page is shown for example purposes).

- **Observation Logs** are filled in by the observer, one page per each task. The Observation Log contains a written record of the participant's success at the task. Recorded data includes time to complete the task, number of steps and errors in completing the task, requests for assistance, and the number of expressions of frustration or delight. (see Appendix, Document 5).

- **Post-Test Questionnaire** assesses the participant's overall experience and impression of the product. The participant provides written answers recorded in a combination of Likert scale responses, yes or no answers, and open-ended responses (Babbie, 127) (see Appendix, Document 6).

- **Post-Test Interview** allows the observer to ask the participant any final questions. The first few questions were prepared by the observer before the test, but most of the questions will be generated spontaneously, during the testing session, by the observer.

These questions are usually the result of interesting behavior exhibited by the participant during the test. This is an opportunity to explore issues which can be unique to a given participant (see Appendix, Document 7).

This combination of data recording tools provided enough data to highlight, and even confirm, specific problems with the usability of NJIT's web site. The method of data analysis is discussed further in the ***Usability Test Results*** section in this chapter.

3.4.5 Testing Procedure

I developed a testing procedure containing nine steps as listed below. Following these steps ensures a consistent testing experience if multiple participants are used.

1. Participant arrives—make him or her feel comfortable.
2. Participant reads and signs the release form titled *Understanding Your Participation* (see Appendix, Document 3).
3. Orient participant. Describe the basic types of tasks to expect and familiarize the participant with the layout of the participation logs. Explain how to get help, remind participant to use a think aloud protocol, and ask participant to state the beginning and the ending of each task. Remind the participant that the product is being tested and not the participant.
4. Prepare video camera and get the *Observation Logs* ready for note taking.
5. Instruct participant to begin test.
6. Record participant actions and comments on *Observation Logs*.
7. Have participant fill out *Post-Test Questionnaire*.
8. Conduct *Post-Test Interview* with participant.
9. Thank participant for their contribution to the research project.

I followed this testing procedure to conduct my first, and only, session of usability testing. The resulting observation logs, participation logs, questionnaires, interviews, and the video tape, were evaluated to determined specific problems with the usability of NJIT's web site. The usability test data and results are discussed in the following section.

3.5 Triangulation Method for Usability Data Analysis

The goal of a usability test is to uncover problems rather than demonstrate the existence of a specific phenomenon (Dumas and Redish, 1993). This section reviews the types of measurement data available and outlines a method of analysis suitable for a small test population. Experience has shown that most major problems can be uncovered in a usability test with relatively few participants (Virzi, 457). As shown in Figure 3.3, Dumas and Redish suggest using a technique called *triangulation* for handling a great deal of data about a small number of participants.

Any problems with the product were pinpointed by fitting together three types of data shown at the corners of the triangle displayed in Figure 3.3. *Identified Problems* is shown at the top of the triangle and would include any problems with NJIT's web site already identified by the web site design team. Conversations with a team member revealed no type of early problem identification program. The two remaining corners of the triangle represent quantitative and qualitative data. *Quantitative Data* includes participant logs, observation logs, and questionnaires. *Qualitative Data* includes participant comments and reviewer observations. Usability test results based on this triangulation method for analyzing data are presented in Chapter 4.

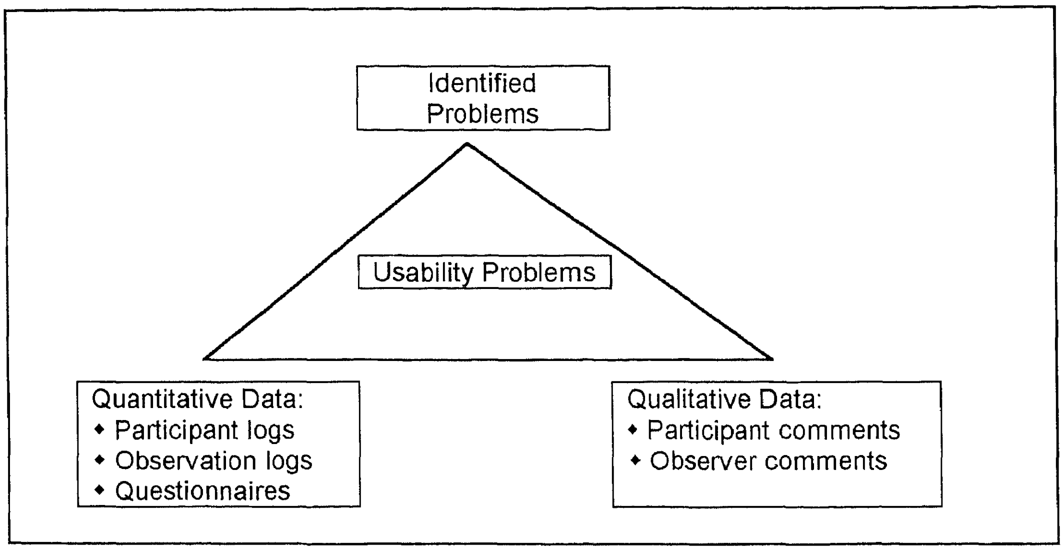


Figure 3.3 Dumas and Redish Triangulation Method

CHAPTER 4

USABILITY RESULTS AND CONCLUSIONS

This final chapter presents the usability test results and briefly outlines minor adjustments recommended for the test design. Conclusions and detailed recommendations for the improvement of NJIT's web site are discussed and include an assessment of solutions to disorientation, orientation cues, and navigation aids. The chapter concludes with a few suggestions for further research and some closing remarks with respect to the future potential of hypertext applications and the usability of those applications.

4.1 Usability Test Results

Triangulation of the test data highlighted four major usability problems with NJIT's web site. The usability problems centered around navigation difficulties, unclear textual link labels, ineffectual graphical link labels, and poor page layout. The specific problems are listed below, in the form of results, and supporting qualitative and quantitative evidence follows each stated result. Included with the evidence, is a discussion about which parameters from Flower's discourse construction model are affecting the participant's ability to construct negotiated meaning from the hypertext.

Result #1 The participant could not navigate to the top, or home, of the web site.

Evidence: By the third task, the participant was having trouble navigating within NJIT's web site structure. He had to rely on the navigation aids provided by the commercial

Web browser software, which exists outside of the hypertext design of NJIT's web site. By the ninth task, he declared "[You] should always be able to get home. Make it consistent to get home." In the *Post-Test Interview*, he commented that "you ought to always be able to go home and start over [by using] a button up in the corner."

Discussion: Two parameters from Flower's model come into play when analyzing the participant's ability to return to the top of NJIT's web site: social context and activated knowledge. The participant's lack of background with the Web and web sites contributed to his struggle when he was trying to figure out how to use a hypertext which did not supply all of the necessary navigation tools that a reader should have. His general computer expertise was evident when he quickly picked up on the availability of navigation aids outside of the hypertext design and when he discovered the importance of scrolling (see Result #3).

Result #2 The participant could not find the required links on all of the pages.

Evidence: The participant was not able to find links in two circumstances. In some cases, the links were clearly missing, but in other cases, the links were positioned in an unfamiliar location on the page. Task #9 illustrated both of these situations, prompting the participant to comment that the designers should "make it consistent to get home. There was symmetry [i.e. good page layout] for awhile, then it died on me."

Discussion: Flower's model illustrates how familiarity with discourse conventions can affect a reader's performance. During his brief exposure to the web site, the participant immediately began building a mental model of how the hypertext was structured. When he came across an inconsistency in the page layout, it totally disrupted his use of the document.

Result #3 The participant did not realize that the first page of NJIT's web site was meant to act as the table of contents.

Evidence: Since, without scrolling, only the top half of the table of contents page was visible to the participant when he initially accessed NJIT's web site, he never had a strong feeling for where the table of contents was located or that it was there as a reference tool. During Task #4 he remarked, "Didn't think to go back to the beginning [home]." And in the *Post-Test Interview*, he commented that "if you can always start over and see a table of contents [pause] because that's what we're used to seeing—those ought to be the two things [home button, table of contents] that every web site has. I forgot about the table of contents being there as a resource. A long table of contents would be okay [as opposed to only six main headings]."

Discussion: Flower's model points out that a reader's familiarity with certain discourse conventions affects his or her representation of a given text. As shown in the paragraph above, the participant obviously brought his familiarity with basic organizing principles of print text to this task, causing him to remark that he wanted to "...see a table of contents...because that's what we're used to seeing...."

Result #4 The participant had a difficult time interpreting and using the textual and graphical link labels.

Evidence: During the fourth and seventh task, the participant had trouble picking correct links due to the lack of meaningful labels. These links lead the reader through the hypertext structure to nodes containing information required to complete a specific task. During the fourth task, he actually had to ask for help because he was so disoriented and found the link labels meaningless. In the *Post-Test Interview*, he stated that a "consistent set of definitions or usage of words [would] help to find your way around." With respect to graphical headings, as opposed to textual, the participant commented that they "didn't do anything for me in terms of helping me find things." He also noted that, after spending 45 minutes browsing NJIT's web site, "I don't even know what the school colors are yet."

Discussion: Another factor affecting the reader, according to Flower's model, is the use of meaningful language. As the evidence given above reveals, the participant would have appreciated a set of clear and consistent labels (and more of them, see Result #3) to guide his search for specific information.

4.2 Modifications to the Usability Test Design

In the case of a newly designed usability test, Dumas and Redish recommend conducting a "test on the test." This was essentially what I was doing—"testing the test"—since I had just created the usability test for NJIT's web site and I had conducted the test with only one participant. Overall, the test yielded interesting, and in some cases, obvious results. Specifically, if I were going to observe additional participants in the future, I would make a few minor adjustments to the test design. These adjustments are listed below.

- **Problem**: Scenario #4 was misleading causing the participant to pursue an incorrect task. The participant thought he would have to register his car to park on campus and set off to look for instructions on how to register his car (these instructions are not included in the current version). All I wanted him to do was locate the campus map showing student and visitor parking lots.
- **Solution**: Rewrite Scenario #4 so that the participant performs the task of locating the campus map which displays the student and visitor lots.

- **Problem**: Scenario #6 was not clear enough to prompt the participant to look for the Reference Librarian's phone number. The participant forgot what he was looking for and felt lost once he got into the library's web site.
- **Solution**: As the test designer, I need to rephrase the scenario and review the library's web site options more carefully. The scenario needs to make clear the participant's desire for the Reference Librarian's phone number. Closer inspection of the library's web site may show me that I could have used different words (keywords, headings) in the scenario to help the participant recognize the proper path.

- **Problem**: The participant did not write any "extra" comments on the *Post-Test Questionnaire*. He started filling out the form continuing the think aloud protocol, but I told him he did not have to continue thinking out loud—that he could just fill out the form.

- **Solution**: The camera was still rolling, so I should have let him continue the think aloud protocol while he filled out the *Post-Test Questionnaire*. It would appear that the participant would much rather give his comments verbally than take the time to write them down. I will leave the camera rolling in the future.

4.3 Conclusions

The results of my usability test on NJIT's web site confirm my hypothesis that there are specific design criteria which do facilitate the user's successful interaction with the hypertext. Result #1 confirmed the general statements of several authors writing about hypertext that the user must be supplied with appropriate navigation aids to avoid becoming *lost in hyperspace*. Results #2 and #3 support my position that good page layout is necessary in aiding the user's ability to recognize document features, such as the availability of navigation aids and the table of contents. Result #4 confirms the importance of achieving document cohesion through the effective use of textual and graphical link labels. The usability test demonstrated the necessity for hypertext designers to consider, at the very least, these four document design criteria: existence of navigation aids, consistent page layout, representative textual link labels, and meaningful graphical link labels.

4.4 Recommendations Based on Results

The results, stated previously in this chapter, have been translated into recommendations and are listed below. These recommendations offer solutions to the usability problems identified for NJIT's web site through usability testing. Implementation of these recommendations will result in improved document coherence at the local and global level.

Aids to help the reader construct a mental model of the hypertext structure will also help reduce the reader's cognitive overhead. Improved coherence and reduced cognitive overhead leads to increased comprehension which ultimately leads to a more usable document. A well-designed hypertext document will "help the user understand how to interact with the document and allow the user to control the nature of that interaction" (Grice and Ridgway, 428).

Recommendation #1 Every page must display a link to the top of the web site. If a particular page is deep in the hypertext structure, then the designer should also consider displaying a link back to the top of a relevant subsection.

Recommendation #2 Every link of the same type (e.g. subsection headings) should look the same (e.g. look like slides in NJIT's web site) and be in the same position on every page (i.e. *back* links at the bottom, center, of each page). Consistency throughout the hypertext should be carefully maintained by the deliberate repeated use of design elements such as font type and size, location of particular kinds of information, and location of titles and navigation aids.

Recommendation #3 Redesign the top of the web site to convey a strong sense of a table of contents. The layout should allow for more than four slides (or main topics) to appear at a time on the screen. Right now, unless the readers know that they should scroll, they will miss the two bottom slides. The reader needs to know that all six slides comprise the table of contents for the web site.

Recommendation #4 Revise the content of the textual and graphical link labels to more clearly indicate specific information which can be found by following a particular path through the document. Enhance the display, or legibility, of link labels for easier reading.

4.4.1 Solutions to Disorientation

Hypertext offers the power to organize information in structures that seem complex when compared to traditional print layouts. Although a reader can become lost in a print text, there are typically only two options for orientation: search for the desired text before or after the reader's current location. As Conklin warns, "hypertext offers more degrees of freedom, more dimensions in which one can move, and hence a greater potential for the user [reader] to become lost or disoriented" (38). In addition to not knowing their current location, hypertext readers may also have no idea where the desired text is stored in the network.

There are three potential solutions to this problem of disorientation: two are technical, or systems-based, and one is design-based. The systems-based solutions include the use of a graphical browser and a query or search mechanism. These two functions were described in section 1.3.3 titled Hypertext Access. As pointed out in section 1.3.3, the markup language (HTML) used to create NJIT's web site does not have the capability for graphical browsing or keyword searching. In this case, the tools available to provide orientation for the reader fall into the design category. Since the structure of NJIT's web site is hierarchical, a strong sense of this structure must be apparent to the reader. This can be accomplished through a stronger representation of a table of contents at the *top* of the structure and the content of the vertical pathways must be indicated through the use of clear and representative link names.

4.4.2 Orientation Cues

Orientation cues can assist the reader in visualizing the hypertext structure. Color can be used in combination with a list of links resembling a traditional table of contents. A consistent variation of color can indicate which links have been selected and which ones have not. For example, upon initial viewing of a hypertext, the names of all of the links shown in the browser or the table of contents-like listing will be displayed in yellow. As each link is selected and subsequent nodes are viewed, those link names will change to green. Using these visual cues, the reader can tell at a glance which links, or paths, have been taken and which ones remain for exploration. Visual cues help readers keep track of their moves without any additional effort which reduces the memory load required for orientation.

4.4.3 Navigation

In addition to orientation cues, navigation aids can also reduce a reader's cognitive overhead. Beneficial navigation tools should assist the reader in determining *direction* and *distance* while moving within a hypertext structure. A consistent button bar or use of a graphical browser (discussed in section 1.3.3) can provide tools for the reader to consciously move forward or backward (up or down) through the hypertext. These tools also have options which allow readers to *jump* from their current location to other specified nodes, such as the *top*, or main page, of the hypertext. A button bar is a collection of relatively small icons representing links. In a web site, a button bar can be a part of every node. Icons in the bar can represent links to the main page, the top of a particular section, the previously viewed page, the next available page in the structure, or any other node that the button bar designer feels is relevant or important to the reader of the web site. Navigation aids provide the reader with a sense of direction and distance while moving through a hypertext. These tools can reduce cognitive overhead because by relying on simple and effective navigation facilities, readers can avoid awkward maneuvers and clumsy detours through the hypertext.

Hypertext readers need to be supported by local and global navigation aids. Local navigation involves the movement from one node to another through a selected link. Global navigation refers to movement that spans many nodes at one time. Local and global navigation closely parallel the concepts of local and global coherence outlined by Thüring, Hannemann, and Haake.

The Web offers a simple and effective form to create and display links between nodes. The writers have not been given any tools, however, to present any global context. Web browsers, such as Netscape or Mosaic, provide the following orientation information: the title of current document (node), the Universal Resource Locator (URL) or address of the current document, and the URL of a link destination. As hypermedia designer Paul Kahn points out, "none of these [orientation tools] support the user's mental model of how the current node fits into a larger collection" (67). One way to provide global orientation to the reader is to establish a graphic set of symbols, possibly a button bar, to guide the reader's navigation and tie the collection of nodes together as a whole. Kahn points out that even with the popularity of the Web, writers are still struggling against, rather than being supported by, the features of the currently employed markup language (HTML) used to create hypertext. Because global context is important to the usability of hypertext, Kahn acknowledges the effort of writers to "create global structure in a WWW collection largely through the application of inventive graphic design" (69).

4.5 Direction for Further Research

Two factors which can directly contribute to the usability of hypertext are coherence as a positive factor and cognitive overhead as a negative factor. Both factors can significantly affect the reader's construction of a mental representation of hypertext. As discussed previously (see section 2.6), a more accurate mental model leads to better comprehension, and increased comprehension leads to better usability. Usability testing of NJIT's web site points out the importance of good page layout, clear textual and graphical link labels, and the presence of navigation tools to increase comprehension and reduce the effort required for orientation and navigation.

There is no doubt that hypertext, and the usability of hypertext, are important issues to the technical communicator. Hypertext has been the topic of focus in several journals recently: *Technical Communication* (1Q91), *Technical Communication Quarterly* (Winter, 1995), and *Communications of the ACM* (August, 1995). Usability testing has been highlighted in *Technical Communication* (2Q92) and at the Society of Technical Communication's *42nd Annual Conference* (1995). As greater numbers of technical communicators move into the area of usability testing and user-interface design, they will play an important role in the initial shaping of those interfaces instead of analyzing interfaces after they have been designed and developed (Ridgeway, Grice, and Gould, 48).

4.5.1 More Participants

Future usability tests on hypertext should be conducted with more than one participant. With multiple participants, descriptive statistics would be possible and would include statistical values such as means, medians, ranges, and frequencies. Inferential statistics, including t-tests, are rarely appropriate for analysis of usability test data because usability tests yield meaningful results with relatively few participants. Therefore, in this case of fewer participants, it is appropriate to apply descriptive statistics to the data rather than inferential statistics.

If the cost of usability testing can be minimized then testing might be more easily incorporated into the product development cycle. Experiments designed to determine how many participants are required to provide meaningful data reveal that "(a) 80% of the usability problems are detected with four or five subjects, (b) additional subjects are less and less likely to reveal new information, and (c) the most severe usability problems are likely to have been detected in the first few subjects" (Tinker, 457). These test results can be said to demonstrate the law of diminishing returns with respect to large numbers of participants for usability testing programs.

4.5.2 Fewer Tasks

As I gain confidence in the usability testing of hypertext, I may be able to design a test which can yield the same results using with fewer tasks. Further testing may confirm the repetitive character of some of the tasks, allowing me to eliminate various tasks which results in a shorter testing time required for each participant. Further testing may also provide insight into the necessity of a diversified participant profile. Perhaps valuable information can be obtained from users with similar backgrounds, instead of pursuing diversified backgrounds. Any modifications to the testing process which can reduce testing and analysis time, and therefore reduce costs, will make usability testing that much more attractive to the designers and managers of hypertext projects.

4.5.3 Computer Tracking

Users' interactive behavior with a hypertext system can be monitored automatically by another computer system. This eliminates the need for an observer to collect data and the data can be collected unobtrusively, avoiding the observer's potential influence on the participant's working style. This method may allow greater quantities of data collection over longer periods of time. The computer software can accurately record the participant's every move, however, there will be no record of the participant's verbal comments or physical gestures—data which can contribute valuable information about the product's usability. Perhaps this data can be recovered, however, through a more carefully designed Post-Test Interview with the participant. Further study is required to determine if computer-logged data provides the same quality results as observer-logged data.

4.5.4 Legibility Research

Since usability is a function of cognitive overhead, the literature should be searched for more information on research into the legibility of print. In 1963, Miles Tinker developed several guidelines aimed at improving legibility. Legibility is a factor which fosters ease and speed of reading, or readability. These guidelines are based on 40 years of research and address font size and type, line length and indentation, spatial arrangement, and even the color of the print text versus the background color. In a section called *Illumination for Reading*, Tinker mentions visual field, reflective glare, and brightness ratio—factors which could also affect reading from a computer screen. Many of the issues affecting the print text reader and the hypertext reader are the same, however, due to the difference of the medium, the solutions may be quite different. Thomas Landauer, et. al., recognize the importance of getting "guidance in the construction of electronic text from knowledge of the effects of typography and layout, text organisation and heading structure" (84). Although literature exists on such topics, there appears to be no development of widely accepted guidelines for hypertext writing.

4.6 In Closing

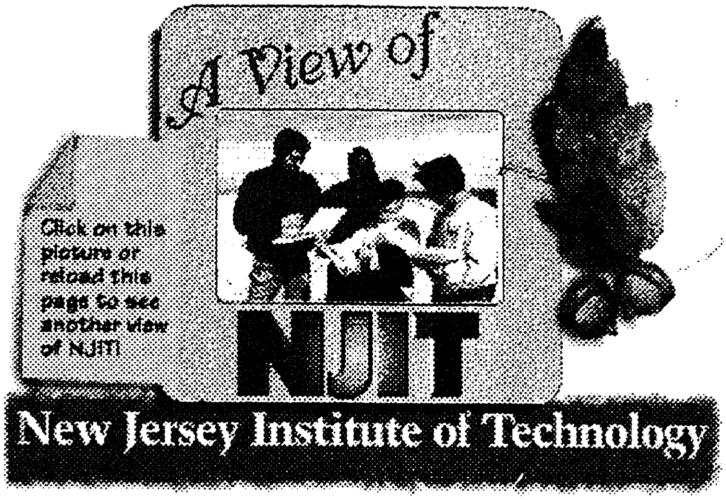
As more complex structures of hypertext appear, it becomes crucial to learn from practice in order to design appropriate hypertext components and interfaces. Valuable usability information can be obtained by watching readers in action, looking at the results of their work in a variety of environments, and by talking to them about what they are trying to accomplish (Marshall and Shipman, III, 1995). We need to establish collaborations between members of industry, academia, and professional societies to push forward the needed efforts to make hypertexts usable. Grice and Ridgeway claim that "there is a lot of ground to cover and a lot of work to be done" (436). As the hypertext vision converges with the identification of practical applications and the advancement of computing technology, guidelines for the development of usable hypertext will be established and may even become obvious to hypertext writers and readers.

APPENDIX

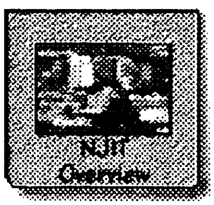
* The author is copywriting the usability testing procedure as modified for web site testing. The author is not copywriting New Jersey Institute of Technology's web site.

Document 1

Presenting



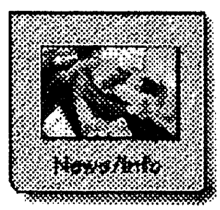
Select the slide below which represents the area you would like to visit.



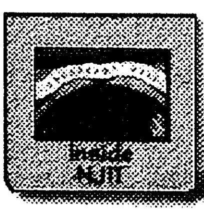
Click here for a general overview of the university and its history.

Here are descriptions of the schools and departments which comprise New Jersey Institute of Technology.

Here is complete information on how to apply to NJIT.

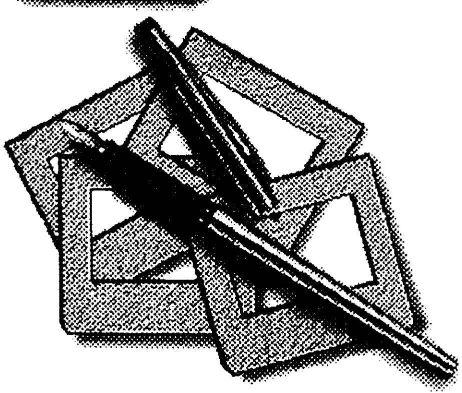


Keep up to date on what's happening at NJIT.



Included here are department home pages, introductions to faculty and staff, and other important pieces of information.

Here are some pointers to additional useful information on the internet.



Credits	Comments, questions? Send us mail!

DOCUMENT 2

USER PROFILE (& PRE-TEST) QUESTIONNAIRE

Name:

Address:

Phone:

Work Experience

1. Company Name:
2. Job Title:
3. How long have you been working at your current job?
   - ❑ less than 6 months
   - ❑ 6 months to 2 years
   - ❑ more than 2 years
4. Job Description:

Educational Background

1. Educational Degrees (and date):
2. Currently Enrolled in (degree and date):

Computer Experience

1. How long have you been using a personal computer?
   - ❑ I don't use one
   - ❑ less than 6 months
   - ❑ 6 months to 2 years
   - ❑ more than 2 years

DOCUMENT 2
(continued)

2. How often do you use a personal computer?

- ❑ I don't use one
- ❑ about once a week
- ❑ a few times a week
- ❑ every day

3. What type of programs do you regularly use? Check all that apply.

- ❑ word processing
- ❑ spreadsheet
- ❑ database
- ❑ programming languages
- ❑ games
- ❑ other:

4. How long have you been accessing the Internet?

- ❑ I am not using the Internet
- ❑ less than 3 months
- ❑ 3 to 6 months
- ❑ more than 6 months

5. If you have access to the Internet, how are you gaining access?

- ❑ web browser and local service provider
- ❑ online service such as CompuServe or America Online (circle one)
- ❑ other:

6. How many Home Pages do you read?

- ❑ None
- ❑ less than 5 a week
- ❑ 1 to 5 a day
- ❑ more than 5 each day

For Observer Use Only:

- ❑ Novice
- ❑ Intermediate
- ❑ Expert
- ❑ None, why:

Testing date and time:

DOCUMENT 3

UNDERSTANDING YOUR PARTICIPATION

Please read this page carefully.

NJIT's Professional and Technical Communication department is asking you to participate in evaluating NJIT's new Home Page. By participating in this evaluation, you will help us improve this and other University Home Page designs.

We will observe you and record information about how you work with the Home Page. We may also ask you to fill out questionnaires and answer interview questions.

We will videotape all or some of the interviews and your work. By signing this form, you give your permission to NJIT's Professional and Technical Communication department to use your voice, verbal statements, and videotaped pictures for the purpose of evaluating the Home Page and showing the results of these evaluations. We will not use your full name.

If you need a break, just tell us.

You may withdraw from the evaluation at any time.

If you have questions, you may ask now or at any time.

If you agree with these terms, please indicate your agreement by signing here:

Signature: ______________________________

Printed Name: ______________________________

Date: ______________________________

DOCUMENT 4

PARTICIPATION LOG

Scenario:
You are writing an article about NJIT and you want to include a few words from NJIT's mission statement.

Answer:

When you are finished:

Please state that you are finished.
Please fill out the post-task questionnaire.
Please wait for us to tell you when to begin the next task.

Post-task Questionnaire

	Very easy	Easy	Neither	Difficult	Very difficult
1. How easy or difficult was the task that you just completed?	1	2	3	4	5

2. Did you have to ask for assistance? ❑ No ❑ Yes
   If yes, why?

3. Please describe any problems that you encountered while completing this task:

4. We welcome any other comments you have about this task:

DOCUMENT 5

OBSERVATION LOG

Product Tested: ______________________

Participant #: ______________________

Observer: ______________________

Scenario #: ______________________

Task: ______________________

Code List

L - wrong link, path	F - frustration	B - body language
P - wrong page	H - happiness	V - verbal language
W - wrong answer	A - asked question	Q - quit, gave up

Starting Time:______________

Time	Code	Comments

Ending Time:______________

DOCUMENT 6

POST-TEST QUESTIONNAIRE

Please circle the number that best expresses how you feel about each statement. We welcome comments about each statement.

	Very easy	Easy	Neither	Difficult	Very Difficult
1. Overall, using the Home Page was Comments:	1	2	3	4	5
2. The descriptions of the main categories made using the Home Page Comments:	1	2	3	4	5
3. Deciding which link to click on was Comments:	1	2	3	4	5
4. Finding the right information was Comments:	1	2	3	4	5
5. The use of graphics as headings made using the Home Page Comments:	1	2	3	4	5
6. The use of graphics as part of the link made using the Home Page Comments:	1	2	3	4	5
7. Understanding the hierarchy of the screens during each task was Comments:	1	2	3	4	5

6. Would you recommend NJIT's Home Page as a source of information to your friends and co-workers? ❑ Yes ❑ No Please explain your answer:

7. Would you use this Home Page for information instead of the telephone?
   ❑ Yes ❑ No Please explain your answer:

8. If you could tell the designers one or two things to change about this Home Page, what would you say?

9. We welcome any other comments about NJIT's Home Page or about this testing process.

Thank-you for your assistance.

DOCUMENT 7

POST-TEST INTERVIEW

(Stay neutral)

What did you like about...the page layout?
(Not, did you like...)

When you were trying to ____________, you did _______________. Can you tell me what you were thinking at that point?

You were frowning (smiling) a lot when you were _________________. How were you feeling then? Why? (Not, you seemed upset (happy)...)

(Ask questions resulting from this particular session...)

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