AN INVESTIGATION INTO TEXT COMPREHENSIBILITY IN DYNAMIC ELECTRONIC TEXTS: HYPERTEXT AND HYPERMEDIA

BY

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A Thesis

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in Partial Fulfillment of the Requirements

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Department of Curriculum: Humanities and Social Sciences

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ABSTRACT

Text comprehensibility is a concept of prime concern because of the complexity of factors that influence the comprehensibility of text. In light of what is already known about comprehension processing, print text comprehensibility and the importance of ensuring an optimal match between reader and text, research into text comprehensibility within complex electronic environments is of immediate concern as the use of computer technology becomes more prevalent in today's classrooms.

In this study, the factors that lead to text comprehensibility in hypertext and hypermedia were identified using an integrative inquiry approach. Existing research regarding electronic text structure and text comprehensibility was analyzed and synthesized to provide new knowledge about text comprehensibility in electronic environments. The study focused on the following reader and text factors: readers' mental models for text representation, navigational issues of orientation and disorientation in hypertext and hypermedia, the role of strategic knowledge in complex electronic environments, the nature of support features available in these environments, and the issues related to individual reader differences and their effect on the support features.

This study found that the following 'outside-the-head' text factors influence text comprehensibility in hypertext and hypermedia: the use of print text authoring skills and tools; adjunct navigational aids; separate, movable, overlapping windows; the use of multilevel informational nodes including a combination of multimedia supports; the use of an intensive electronic environment; access to a variety of vocabulary and decoding options, inferential comprehension options, and comprehension monitoring options. The 'inside-the-head' reader factors which influence text comprehensibility in hypertext and hypermedia are prior knowledge of navigational strategies and metacognitive knowledge regarding the available support options.

This study confirms that readers: expect the same text structure in electronic mediums as is presented in well constructed print text; appreciate navigational features that signal familiar locations and help readers orient themselves in relation to the initial text; need strategic training prior to using hypertext and hypermedia; require multimedia support features which provide access to vocabulary and decoding options, inferential comprehension options and comprehension monitoring options.

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CHAPTER 1

An Investigation Into Text Comprehensibility In Dynamic Electronic Texts: Hypertext and Hypermedia

> *As readers and writers of electronic texts we will be pushed toward a more complex definition of what a text is and what successful readers and writers must know about to create them. (Reinking, 1994, p. 13).*

In an address to the National Reading Conference in San Diego, David Reinking (1994) focused on the increasingly fast-paced and irreversible movement inherent in the evolution from print media to electronic forms of communication. Reinking (1994) drew attention to the fundamental changes that are occurring in the way we express and share information, in the way corporate and private enterprises conduct their business, and in the way scholars, scientists and journalists, among others, exchange information using interactive electronic versions of text such as those provided by internet connections. As he observes, we are on the brink of a post-typographic era which is being ushered in by "the digital forces of the computer in all of its shape-shifting forms and uses" (Reinking,1994, p.2). Reinking believes that we, as educators and researchers, must re-evaluate our entire conception of literacy and every area of literacy research if we are to respond appropriately in the dawn of new technology.

One area of literacy which will need new research is the issue of text readability and comprehensibility because of the effect of electronic text on

meaning-making. Complex, dynamic electronic text has the potential to make text easier to understand. To discover a word meaning, for example, simply click on the word to have an automated voice give the definition. Click again to call up the concept. By means of electronics we can add to the information in the original text by making links to information at multiple levels and locations as well as access colour, graphics, speech, animation, video and photographs. Through self-selected options, hypertext and hypermedia have the potential to make text more comprehensible for individual readers.

Text readability is a concept that has been a concern since early times and the first recorded attempt at determining readability was made by monastic leaders (Klare, 1963). Academic interest in text readability re-surfaced in the '20s with increased automation, the need to re-educate workers and more students beginning to stay in school longer (Chall, 1988; Klare, 1963). The traditional approach to estimating text difficulty has been to apply readability formulas. The first readability formulas focused on a number of text factors as having an influence on text difficulty, but ultimately, these factors were reduced to two: sentence length and word frequency because these two factors consistently rated the highest on regression equations to predict comprehensibility (Zakaluk & Samuels, 1997).

One of the frequently used readability formulas to estimate text difficulty is the Fry Formula (1968) because it is easy to use. It involves selecting three 100-word selections (excluding proper nouns) from the beginning, middle, and

end of the text in question. The number of sentences are counted in each selection, estimating the number to the nearest tenth of a sentence. The average sentence count is then determined. Next, the number of syllables in each selection is counted and the average number of syllables is calculated. These two scores, which relate to sentence and word length, are then plotted on the Fry graph to obtain the estimated grade level of the text (Fry, 1968).

Marshall's (1979) discussion of readability and text comprehensibility, however, points out the problems associated with the use of readability formulas. She indicates that the formulas do not measure meaning. Many formula developers used the McCall-Crabbs Standard Test Lessons in Reading (Marshall; 1979: Stevens, 1980) which had comprehension criteria listed at the bottom of the lesson or page. The purpose of these criteria was to motivate readers. If, for example, students answered seven out of ten questions in Book B, they received instant feedback that their reading achievement level was a grade equivalent score on a range from 4.9 to 7.9 depending on the passage (McCall, Crabbs, 1926, 1950, 1961). These grade equivalents were not based on the performance of actual readers but rather on arbitrary indicators of comprehension performance established by the writers.

Marshall contends that since the comprehension of text is the process of extracting meaning, readability and comprehensibility are terms which cannot be used interchangeably. According to Marshall, it is more appropriate to determine the comprehensibility of texts rather than their readability.

Comprehensibility implies that, to estimate text difficulty, we cannot rely upon text factors alone but must also consider reader variables.

More recently, such an interactive text comprehensibility formula was developed by Zakaluk (1985). Zakaluk (1985) investigated qualitative or reader factors in addition to quantitative or text factors. The qualitative factors studied were the reader's prior knowledge of topic and word recognition automaticity. Based on an interactive model of text processing, Zakaluk (1985; 1988) categorized 'inside-and-outside-the-head' factors as independent variables and then tested students' comprehension as the dependent variable using informative passages of increasing difficulty. Students' comprehension scores were used as criterion variables in a regression equation to test which reader factors (prior knowledge of text topic and word recognition automaticity) and which text factors (conventional indices of readability and the use of adjunct comprehension aids) were the best predictors of text comprehensibility. Zakaluk's nomograph (1985), therefore, assesses a variety of factors beyond word frequency and sentence length and is designed to arrive at an optimal match between reader and text rather than estimating a general text difficulty level (Lipson & Wixson, 1991).

Zakaluk and Samuels (1997), however, later identified a myriad of other factors that influence text comprehensibility. For beginning readers, these factors include: familiarity with the story and with the underlying theme of the

story, the formality of the language, the complexity of the sentence patterns, the presence and nature of repetitions, the vocabulary, the format, and how well the illustrations complement the story. For older readers, a number of other factors influence reading ease. These include: text structure and whether the text is narrative or expository, the nature of the causal links - stated or inferred; the explicitness of the author's purpose, the reader's knowledge of text structure and facility in constructing links among the ideas in the text, and the reader's metacognitive knowledge and ability to use self-questioning while reading in order to monitor comprehension. Beyond mere sentence length and word complexity, these factors also have an important effect on how well a text is understood and remembered.

As we have come to understand the complexity of factors that influence the comprehensibility of text in print media, we are currently faced with a new dilemma or challenge. That is, to determine the effects of electronic media on text comprehensibility. If information acquisition will increasingly take place within electronic environments, as seems clear to many authorities (Leu, 1995), of principal concern is how the shift toward electronic reading and writing in schools will affect text comprehensibility and the way we teach struggling learners.

Statement of the Problem

A review of the literature demonstrates a definitive relationship between static print text structure and text comprehensibility which leads to reader

comprehension. Gourley (1984), in her study of basal readers, found that oversimplified basal texts were actually more, not less, difficult for beginning readers because such texts did not meet reader expectations for discourse structure. These texts: (1) eliminated connective devices such as pronouns, conjunctions, and articles that link ideas and (2) repeated words, phrases or sentences without considering structure. Research on the structure of expository text (Kintsch,1994; Kintsch & van Dyjk, 1978; Marshall & Glock, 1978-1979; Meyer, 1977; Meyer, Brandt & Bluth, 1980) shows that the structural relations among the ideas in text impacts text comprehensibility. Taylor and Samuels' (1983) study of recall for expository text revealed that when children aware of text structure were presented with normal and scrambled text, they recalled significantly more of the normal passage than the scrambled, while children unaware of text structure manifested no difference in recall. Marshall (1979) refers to one of her earlier studies which found that community college students remembered more information from sentences that were united by if-then relations than they recalled from sentences that were not cohesively related. Zakaluk and Samuels (1997) demonstrate the importance of text structure and causal links to text comprehensibility by listing seven different types of expository text structures which can be diagrammed with connecting arrows to link ideas therefore aid comprehension. McGee & Richgels (1985) developed strategies for teaching text structure to elementary students because "students who are knowledgeable about text structure have good recall for well organized text" (p.747).

Other studies focused particularly on story grammars as the structure for narrative text. The findings of these studies indicate that story grammars have a set of rules for taking apart the propositions of a story to create a hierarchy of key ideas which aid recall (Mandler & Johnson, 1977; Pearson & Camperell, 1994; Stein & Glenn, 1979). Whaley (1981) found that readers expect particular structural elements and sequences of elements in stories and that this holds true at the three different age groups studied: third, sixth, and eleventh grade students. As suggested by Zakaluk and Samuels (1997, p.16) when readers' expectations are met because there is "an interaction between the writer who uses the well-known narrative structure to tell the story, and the reader, who has certain expectations" about text structure, text comprehensibility is enhanced.

If text structure is an important element in the way we comprehend and remember what we read, the question then becomes what effect does electronically transmitted information have on text comprehensibility. Electronically transmitted text may provide not only intertextual links to provide background information but also nedia supports such as audio feedback and pictures.

Significance of the Study

Currently, researchers and educators in language and literacy development can draw on a rich history of transdisciplinary study leading to a reconceptualization of reading as a complex, constructive, multiple

contextualized process (Pearson & Stephens, 1994). As indicated, we now know that the comprehensibility of text is not dependent on a separate, isolated factor, but rather, on multiple factors which can be categorized as 'outside and inside-the-head' (Zakaluk, 1985, Zakaluk & Samuels,1988). Expanding on Zakaluk's (1985) concept, 'outside-the-head' factors are: readability level; text features such as print size and adjunct comprehension aids; text discourse which matches reader expectations; text which follows canonical structure schemas; social context, and teacher beliefs and expectations. 'Inside-the-head' factors (Zakaluk, 1985, Zakaluk & Samuels,1988) are accuracy and automaticity of word recognition, prior knowledge of text topic and structure, as well as affective and cognitive factors such as attitude, motivation, and awareness of how to store and retrieve information from one's schema (metacognition).

Throughout history, reading and writing has been shaped by the available technology (Reinking, 1994). The knowledge we have gained about language and literacy development, about readability and comprehensibility of text, and about the social construction of knowledge, has been gained through extensive study and experience with printed text. In the post-typographic era, however, static print may no longer dominate (Reinking, 1994).

For a very long time, the printed text or 'The Book' has been central to our conceptualization of literacy but this centrality is currently being challenged by 'The Electronic Text'. Reinking (1994) heralds evolving alterations to our

current conceptions of literacy necessitated by the substantial differences between printed and electronic texts. Electronic texts are literally interactive because of their malleability; may contain non-verbal elements not possible in printed texts; offer new textural structures at a variety of levels; expand the boundaries of freedom and control over text; and make possible changes in the pragmatics of written communications (Reinking, 1994). According to Reinking (1994), electronic texts may have a destabilizing effect on both our most basic assumptions about information processing and on teaching and learning because of the increasing liquidity of information no longer bound by printed words on a page.

Confronted with the new electronic technology, we have to deal with its impact on literacy. We are faced with a number of issues. For example, how will electronic reading and writing in schools change literacy and literacy development? How will the shift toward electronic reading and writing in schools affect the way we teach, especially the way we teach struggling learners? How comprehensible is electronic reading and writing?

The very characteristics of electronic texts which have the potential for increasing comprehensibility confront us with the need for new, perhaps different, inquiry into the comprehensibility of text. As Reinking (1994) asks, how are we to conceptualize comprehensibility of text or text difficulty levels and factors when readers can instantly: (1) access the pronunciation of a word; (2) click onto a graphic to illustrate the word's meaning; or, (3) link

onto an alternative text that provides additional background information on the topic as well as audio feedback? In light of the reality that electronic texts change which learning strategies make sense and are effective as well as change the options for instructional strategy modeling for supporting learners, how much of what we know about strategy instruction, based on printed texts, is relevant to teaching with electronic texts? The illustrations on the next two pages show what is now possible for learner support using electronic text. The first illustration is an example of non-linear electronic text known as hypertext. Clicking on underlined text provides access to further information at a lower level of text. The second illustration is an example of non-linear multimedia hypertext referred to as hypermedia.

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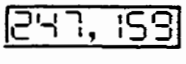

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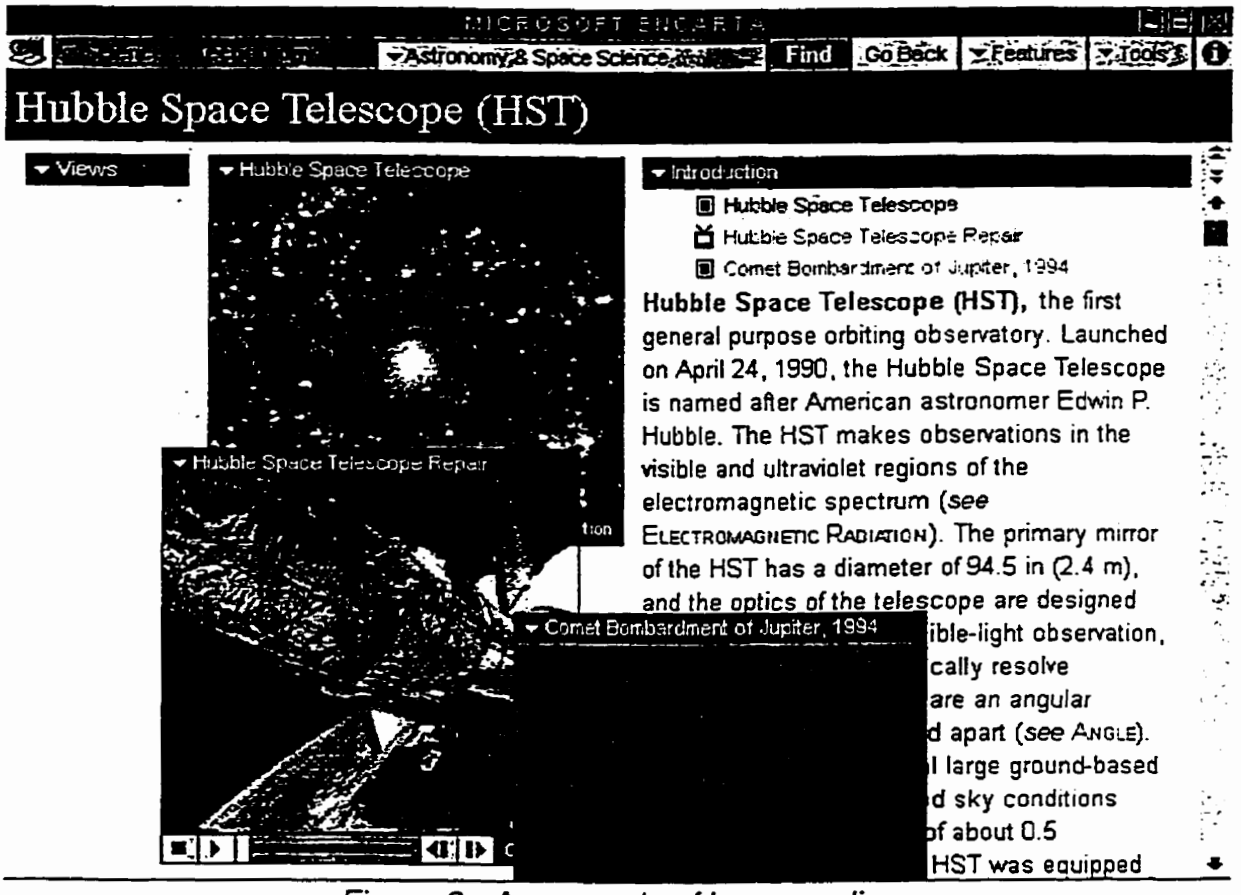


Figure 2. An example of hypermedia.

As we move into a post-typographic world, the research base on electronic text is thin. Much of the research has been conducted from the perspective of print-based in comparison to computer-based learning (Reinking, 1994). Leu (1995) reports that some studies related to text comprehensibility in dynamic, electronic environments (Fish & Feldman, 1987) have not demonstrated an advantage for using electronic text. Other studies (Reinking, 1988; Reinking & Schreiner, 1985) suggest comprehension gains when using electronic contexts in comparison to using traditional, static texts (Leu, 1995). New types of dynamic, electronic environments have since been considered as potentially supportive of readers' needs, and, consequently, are prompting new research. An example is Leu, Gallo and Hillinger's (1995) study of reading comprehension and the nature of 'considerate' text within the hypermedia environment.

An analysis of the findings of Leu, Gallo and Hillinger's (1995) study appear to indicate that Zakaluk's (1985) 'inside-and-outside-the-head factors' are as pertinent to texts in dynamic, complex, supportive electronic environments as they are to static printed texts. However, it appears that additional 'outside-the-head' factors in hypermedia environments may have to be taken into consideration. Leu et al (1995) believes that future research about the potential of dynamic electronic texts to support learning and meaning making need to be undertaken from a theoretical framework that is attentive to literacy research. The results of this research then need to be "related to central issues of literacy, software development, and instructional

practice" (Leu, 1995, p. 53).

Not only do we need theoretically-based research about the potential of dynamic, complex electronic text for enhancing comprehension, we also need theoretically-based research that will inform us about the crucial design factors of hypertext and hypermedia systems which make for more comprehensible text. We anticipate that this information will be of value to educational software developers as well as to educators.

In investigating the potential of hypertext and hypermedia for enhanced text comprehensibility, it is wise to keep in mind the following important findings:

(1) Zakaluk's (1985) 'inside- and-outside-the-head' predictor variables of text comprehensibility: word recognition automaticity, prior knowledge of text topic, readability level, and use of adjunct aids;

(2) Kintsch and van Dijk's (1978) model of text comprehension and production: the height of propositions in the structural hierarchy predicts and explains the comprehensibility of particular text segments while surface structures that violate canonical structure will decimate comprehension and recall;

(3) The effect of the reader's world knowledge, strategic knowledge, and schema for text structure as factors which influence text comprehensibility.

Accordingly, the purpose of this study is to investigate the nature of electronic text and its potential for making text more comprehensible.

The thesis of this investigation is that if hypertext and hypermedia have the potential for increasing the comprehensibility of text, the nature of electronic text structure has to be analyzed to establish the factors that lead to text comprehensibility within electronic environments. An integrative approach to this investigation using the existing research regarding electronic text structure and text comprehensibility will provide insight into this question.

Research Questions

The following questions have been developed: (1) from the knowledge gained through a review of some of the existing research on text comprehensibility and (2) in light of the destabilizing effect of the exponentially expanding use of electronic texts on our basic assumptions regarding literacy learning and text comprehensibility:

1. What are the similarities between static print text and electronic text which remain essential for text comprehensibility without being medium dependent?

2. What are the features which may make electronic texts more 'considerate' than static print text?

3. In what ways are informational nodes, a component of electronic text structure, instrumental in making hypertext and hypermedia text potentially more comprehensible?

4. Are there features within dynamic electronic environments which have the potential to make electronic texts less comprehensible?

5. Is there a difference between hypertext and hypermedia in text comprehensibility?

6. If there is a difference, does this difference hold true for both narrative and expository text?

7. Are there specific hypermedia environments which appear to have an optimal mix of multi-level support structures, audio, sound, color, graphics and animation which provide for text comprehensibility?

8. Would a text comprehensibility tool such as Zakaluk's (1985) nomograph be a useful tool for evaluating or developing electronic texts optimally responsive to reader needs?

The Research Methodology

The research methodology used in this study is described by Marsh (1991) as a form of integrative inquiry that searches out what is known from various studies which may be relevant to the issue in question. It necessitates the screening of the relevant existing studies and the synthesizing of the information in a useful and appropriate manner. The emphasis of the synthesis

is on the integration of diverse studies into a conceptual framework which offers new perspectives or which introduces new relationships or insights. According to Marsh (1991) there are four criteria for adequate knowledge generation from integrative research. These are:

(i) inclusivity, in which the research addresses significant variables

(ii) unequivocalness - there is an avoidance of equivocal meanings

(iii) practicality, in that it provides guidance

(iv) consensus, in that it is acceptable and relevant to researchers and practitioners.

Marsh (1991) cautions that there are technical and epistemological problems associated with integrative inquiry. He refers to Strike & Posner (1983) to emphasize the problem of lack of commensurability among concepts, conceptual frameworks, theories and disciplines that come from different sets of assumptions in the studies being reviewed and synthesized. Indeed, Leu (1995) speaks to this in discussing his own study of the nature of considerate text within a hypermedia environment. He indicates that "the lack of precision with central terms presents problems when interpreting studies since the exact nature of the electronic environment is seldom described with much theoretical precision" (Leu et al, 1995, p. 11). Marsh (1991) also refers to Rich (1983) to underscore the importance and difficulty of providing the reader of the synthesized research with an appropriate framework for the interpretation of the resulting integrated knowledge. In effect, as Marsh (1991) contends, these difficulties demonstrate the caution with which

investigators using this research methodology make claims, as well as how carefully these claims must be interpreted. Appropriate conceptual frameworks also serve to emphasize the gaps in knowledge which remain to be filled pertaining to the issue in question.

The general guidelines for conducting an integrative study (Marsh, 1991) involve the following:

1. Identification of the need for this particular knowledge, followed by a preliminary search of the literature to clarify the need. This allows for the setting of purpose and focus of the study as well as becoming aware of the constraints.

2. Conducting the search and retrieval of the existing studies. Some of the problems which may be encountered at this stage involve the failure: to uncover references on computerized databases that descriptors do not detect; to find unpublished works; and to conduct comprehensive searches of all information services and key researchers.

3. Selecting, screening and organizing studies. The central task at this stage is the review and analysis of the content of the retrieved studies. The researcher must be aware that judgments are sometimes difficult to make about the relevancy of some of the studies meeting the original purpose of the study.

4. Determining a conceptual framework which reflects the parameters of the study and fitting it to the information from the analysis. This process necessitates the systematic analysis of the data to produce appropriate categories as well as to conceptualize innovative groupings to arrive at new insights. In this study, Zakaluk's (1985) notion of 'inside-and-outside-the-head' factors for text comprehensibility as well as Kintsch and van Dyjk's (1978) model of comprehension processing will serve as the conceptual and theoretical framework.

5. Developing the synthesis and interpretation into a material product. In so doing, the researcher has to be concerned with the usefulness of the final product. Marsh (1991) indicates that the format is crucial in relation to the type of language used, the graphics, and the range and type of quantitative data included. He cautions that both integration and interpretation must be included in the final product.

Foreshadowing

The extensive literature review conducted prior to writing this proposal leads me to believe that the following issues and concerns will be identified in this study. The study of comprehension and by extension, text comprehensibility in hypermedia contexts poses a number of problems. One is the definition of comprehension and comprehensibility when carrying out comparisons of comprehension and text comprehensibility using printed text to comprehension and text comprehensibility using hypermedia (Leu, 1995).

Beginning at the same point, two readers, one in printed text and the other in a hypermedia environment, will likely have two very different experiences in the information encountered, in the sequence in which it is encountered and in the adjunct aids available (Leu, 1995).

Another potential problem to be identified is the lack of theoretical precision with which electronic environments have been described in previous studies (Leu, 1995). This makes the task of interpreting studies problematic when trying to compare the exact nature of the electronic environments used in the studies.

One of the characteristics of hypermedia texts is that they run along an extensive-intensive continuum (Leu, 1995). Comparing comprehension and text comprehensibility in the hypermedia environment to comprehension and text comprehensibility in static, printed text may be problematic because of this characteristic. The paths that students can explore in the hypermedia text have to be limited to ensure that students always return to the original text after exploring multi-level information so that the available information links support the goal of comprehending a specific text (Leu, 1995). Extensive hypermedia environments, on the other hand, broaden the range of communicative associations and links. This enables the readers to shift away from the initial text and explore the topic or issue in an extensive fashion (Leu, 1995).

Another challenge is the currently small number of studies on reading comprehension (Leu, 1995) and text comprehensibility within electronic environments. According to Leu, (1995), most of the work that has been done is limited in scope in terms of comparing different comprehension studies in hypermedia environments. For example, the Reinking (1988) study appears to have occurred in a limited, intensive hypertext environment in which students could move to only one level of additional information; moreover, the color, sound, animation, and movement of graphic elements are not available in hypertext as they are in hypermedia (Leu, 1995). The Higgins and Boone (1992) study of reading comprehension in electronic environments did use an intensive hypermedia environment but found no significant gains in reading comprehension for ninth-grade students (Leu, 1995).

However, it may be that readers need higher levels of strategic knowledge within complex electronic environments than they need when using printed text (Leu, 1995; Reinking & Bridwell-Bowles, 1991). Not only do students need declarative and procedural knowledge (Paris, Lipson & Wixson, 1994), which is knowing the what and how of strategies to be used for comprehension , but they also need conditional knowledge: knowing when and why a particular learning strategy needs to be used or communicative link accessed. The question is raised as to whether students in the Reinking (1988) and the Bridwell-Bowles (1992) studies were taught strategic knowledge prior to these experiments with dynamic electronic environments (Leu, 1995). According to Leu (1995), the possibility exists that

comprehension gains may have been limited in previous studies that employed more complex electronic environments because students may not have acquired sufficient strategic knowledge to fully exploit all the options available in the hypertext and hypermedia.

Previous studies have also not yet evaluated the way in which readers interact with the supportive elements within the complex electronic texts (Leu, 1995). For example, which supportive element is used by which reader in which location is a question of process may be difficult to access but is, nonetheless, central to the issue of developing more comprehensible texts (Leu, 1995). Other issues which have as yet to be explored are those related to individual differences and their effect on the use of the various supportive elements in the hypermedia environments (Leu, 1995).

Assumptions

This integrative study is based on two assumptions:

1. When the initial review of the literature was undertaken in the Fall of 1995, the research base was relatively thin (Leu, 1995). However, the exponential increase in use of dynamic electronic environments in every aspect of society, and education in particular, has resulted in extensive dialogue and projects centered on electronic environments. It is assumed that this flurry of activity will have caused increased research and publication of studies about comprehension and text comprehensibility which can be accessed for the purposes of this study.

2. When the initial review of the literature was undertaken, the researcher did not have the knowledge nor the access to hypermedia and internet environments to undertake an extensive search. Consequently, the initial review was limited. Currently, the investigator has access to internet capacities. It is assumed that this will enable her much greater access to and retrieval of the most recent studies concerning comprehension and text comprehensibility as well as an opportunity to communicate with other researchers in this field.

Overview of the Study

The purpose of this study is to investigate the existing literature on electronic environments, to analyze the data to determine the potential of electronic environments in making electronic texts comprehensible, and to discover which factors are crucial in making electronic texts comprehensible.

Chapter One delineates the nature of the problem. Chapter Two offers a review of the literature on text structure and factors that influence text comprehensibility undertaken prior to the integrative study. It includes, as a conceptual framework, Kintsch's theory of comprehension processing and Zakaluk and Samuel's theory that both 'inside-' and 'outside-the head' factors influence comprehensibility. A description of the selection, screening and organization of the existing studies is the central focus of Chapter Three. Chapter Four provides a systematic analysis and categorization of the data collected within a conceptual framework which reflects the parameters and

duration of the study. The emphasis of this chapter will be the integration of diverse studies into a conceptual framework which offers new perspectives or which introduce new relationships and insights. The content of Chapter Five includes a synthesis and interpretation of the research, implications for classroom practice and recommendations for future research.

Terms employed throughout this investigative study are defined in the section which follows.

Definition of Terms

Terms related to text comprehensibility:

considerate texts	texts having the characteristics of greater global coherence, greater local coherence, and more clearly identified structural elements such as headings and topic sentences (Leu, 1995).
intertextuality	"the construct that 'meaning derives from readers' transaction(s) with the text in which [they] apply their knowledge of literary and social convention to that text' (Beach et al., 1994 in Harris & Hodges, 1995, p.122).
semiotics	"the study of signs..... and sign systems which involves the analysis of how individuals within particular cultural contexts produce meaningful symbols, use symbols to communicate, interpret symbols, and systematically organize symbols into codes of meaning that are instrumental in social interactions" (Eco,1990 as explained by Labbo 1996, p.359).
text structure	the various patterns of ideas that are embedded in the organization of text. Common patterns of text structure are expository, cause-effect, comparison-contrast, problem-solution, description, and sequence (Harris & Hodges, 1995).

Terms related to electronic text environments

anchor	also sometimes known as a "button"; usually highlighted in a special way when the mouse is placed over it; an area within the content of a node which is the source or destination of a link; clicking a mouse on an anchor causes the link to be followed (http://www.w3.org/Terms.html).
authoring	the process of producing a document; a term which emphasizes that the writing of a document involves more that just writing (http://www.w3.org/Terms.html)
browser	provides the means of viewing the content of nodes and of navigating from one node to another; a program which allows a reader to read hypertext (http://www.w3.org/Terms.html).
button	an anchor which is the source of a link; usually represented on screen to look like a push button (http://www.w3.org/Terms.html).
check-up features	a support level in a dynamic electronic environment which is available to the user for help in monitoring on-going understanding of text (Leu, 1995).
close-up features	a support level in a dynamic electronic environment which is available to the user for help in making inferences and comprehending central ideas in electronic text (Leu, 1995).

digitized speech	a supportive feature within a dynamic electronic environment; electronic speech which will orally give the pronunciation of a word or its definition when one uses the mouse to click on the word; digitized speech is an electronic capacity of hypermedia environments to read those phrases, paragraphs or passages orally which the reader highlights with a click of the mouse.
electronic text	used interchangeably with the words hypermedia and hypertext as a superordinate term
extensive	in relation to the extensive - intensive continuum in hypermedia texts: the direction of meaning is directed away from the initial text by informational links to other, diverse topics (Leu, 1995).
intensive	on the extensive-intensive continuum in hypermedia texts: the direction of meaning is directed toward a specific text but the options are available for exploring multiple text and media sources to support the understanding of the text (Leu, 1995).
hypermedia	a dynamic non-linear electronic environment with links to information at multiple levels and multiple locations with access to multimedia media such as color, graphics, sound, speech, animation, video, and/or photographs (Leu, 1995).
hypertext	a single, textual electronic medium organized in a non-linear fashion with dynamic electronic links to information at multiple levels and multiple locations

link	provides a relationship between two anchors which is stored in the same or different database (http://www.w3.org/Terms.html).
multimedia	traditional text supported by multiple media sources based on choice to communicate the intended meaning: color graphics, sound, speech, animation, video, and/or photographs (Leu, 1995).
navigate	process of moving from one node to another through the hypertext web, usually by following links (http://www.w3.org/Terms.html).
node	a frame or card as in HyperCard or NoteCards; a unit of information within a document made up of a collection of nodes on related topics (http://www.w3.org/Terms.html).
non-verbal elements	a characteristic of electronic texts-includes icons, movies, animations, and sound (Reinking, 1994).
path	an ordered set of nodes or anchors which represent a sequence used by a reader or recommended to the reader by the author (http://www.w3.org/Terms.html).
post-typographic	a term meant to demarcate a shift in time to an era when static print will no longer dominate as the primary technology in shaping literacy (Reinking,1994)

representational literacy	a term coined by Chuck Kinzer and colleagues (The Cognition and Technology Group at Vanderbilt University) to refer to the ability to communicate ideas flexibly, using multimedia (Reinking, 1994).
surfing the net	refers to extensive exploration of the information available on the World Wide Web (WWW) and Internet (Leu, 1996).
web	the set of all the nodes interconnected by links (http://www.w3.org/Terms.html).

CHAPTER 2

Review of Related Literature

To understand all the factors involved in text processing and what makes text comprehensible, this review of the literature begins with Kintsch and van Dijk's (1978) explanation of the meaning of text processing. An overview of their model of text comprehension and production and how their model works is followed by a discussion of the history of reading research which has led us to an understanding of the interactive view of the reading process, of schema theory and of the role of metacognition in reading comprehension. Following a presentation of early readability formula development and formula limitations, Zakaluk's (1985) research on the effect of 'inside-and-outside-the-head' factors on text comprehensibility is explored. A brief discussion of hypertext and hypermedia environments provides the setting for the investigation.

The rapidity, the depth and the scope of technological changes challenge us to engage in research which is undertaken from a theoretical framework that is attentive to literacy research and to relate the results of this research "to central issues of literacy, software development, and instructional practice" (Leu, 1995, p.53). The work of both Kintsch and van Dijk (1978) and Zakaluk (1985) establishes the theoretical framework for the investigation of the variety of factors that must be considered in relation to text comprehensibility in electronic environments. The thesis of the investigation is that if hypertext

and hypermedia has the potential for increasing the comprehensibility of text, the nature of electronic text structure has to be analyzed to establish the factors that lead to text comprehensibility within electronic environments.

A Model of Text Comprehension and Production: What Makes a Text Comprehensible

The Meaning of Text Processing

Kintsch and van Dijk (1978) believe that the structure of text impacts on its comprehensibility because the text structure influences the storage and retrieval of information from the reader's memory during the reading process. These investigators hypothesize that: (1) the comprehension process can be decomposed into components and (2) several complex processes operate both in a parallel manner and interactively during the comprehension process. Working from these hypotheses, Kintsch and van Dijk (1978) conceptualized a model of text comprehension and production which describes the mental operations underlying what happens during the comprehension of text and in the protocol production of recall and summarization. According to their model, there are three sets of operations: (1) the meaning of the elements of a text become organized into a coherent whole (in essence, this is a process in which there is multiple processing of some elements and which results in differential retention); (2) the full meaning of a text is condensed into its gist which results in (3) the generation of new texts from what is remembered as a consequence of the comprehension process.

Kintsch and van Dijk (1978) based their model of text comprehension on the idea that the semantic structure of texts can be described at both the micro and macro level. The surface structure of a text, referred to as the microstructure, consists of a set of propositions which is ordered by various semantic relations among the propositions. The semantic relations can be either explicitly expressed in the surface structure or they can be inferred in the interpretation process by means of context-specific clues or general knowledge. The macrostructure is the global structure of the text which characterizes the discourse as a whole. Macrorules, best described as a set of specific semantic mapping rules, relate the micro and macro levels. Only when the respective sentences and propositions of a text are connected and the propositions are organized globally at the macrostructure level does the text become coherent (Kintsch & van Dijk, 1978) and thus, comprehensible.

According to Kintsch and van Dijk (1978) the process of comprehension involves the ways an individual constructs the semantic structure of a discourse or text base. The structure of this text base is dependent on its referential coherence. In other words, a text base consists of an established linear or hierarchical sequence of propositions in which coreferential expressions occur, with the first of these propositions having a specific cognitive status. This "cognitive status proposition" which is recalled two to three times more often than other propositions, functions as a superordinate proposition in the text-base structure. As well, a text-base can be explicit, featuring the propositions which are necessary to the coherence of the text; and it can be implicit in that

the listener or reader infers the propositions left implicit.

Thus, the propositions of a text base at the microstructure level must be connected relative to the topic of discourse to result in a meaningful whole. The notion within a discourse topic is made explicit by semantic macrostructures. As Kintsch and van Dijk (1978) explain, semantic mapping rules, with microstructural information as input and macrostructural information as output, are required in order to understand how a discourse topic is related to the respective propositions in the text base. These semantic mapping rules, or macrorules as they are called, allow for both the reduction and organization of the more detailed information of the microstructure of the text. The macrorules involve rules for deletion, generalization, and construction. The result is a reconstruction of the same facts but from a more global point of view. However, the basic constraint of macrorules is that no proposition which is an interpretation condition of a subsequent proposition may be deleted. The macrorules, whose operations are dependent on the reader's world knowledge and which are applied under the control of a schema, ensure that the macrostructure is connected and coherent.

The structure of a story, an argument or a research report are examples of conventional schematic structures of discourse (Kintsch & van Dijk, 1978). The structures of each genre of discourse are "specified by a set of characteristic categories and a set of rules of formation and transformation defining the canonical and possible ordering of the categories" (Kintsch & van

Dijk, 1978, p.366). The importance of these schematic structures of discourse is that they explain why language users are able to understand a discourse as a story and to judge whether a story or an argument is correct or not. They provide an explanation for why the summary of a story also has a narrative structure and why the abstract of a research paper or article conserves the global structure of the particular text (Kintsch & van Dijk, 1978). The schematic structures of discourse also play an important control function in the comprehension process.

How The Model Works

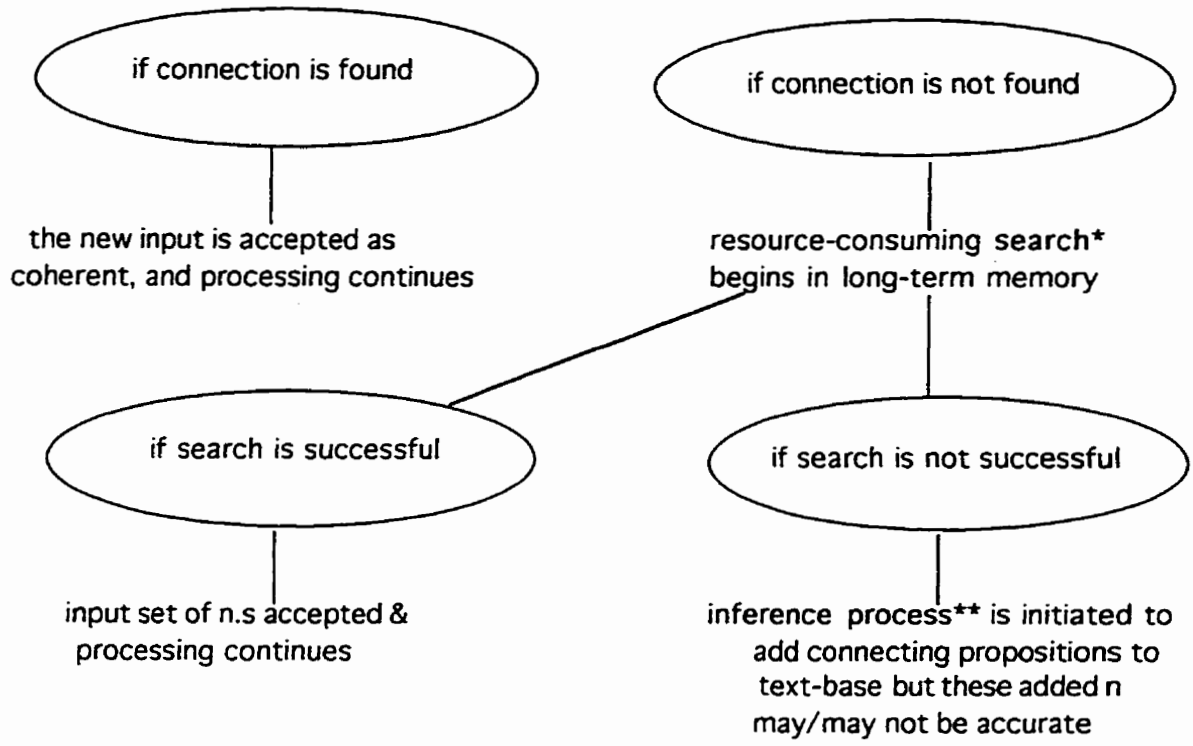
During the comprehension process, the formation of a coherent text base involves representing the meaning of the text by constructing a structured list of propositions. Each proposition must be composed of a *predicate* or relational concept and one or more *argument*. The *predicate* may be verbs, adjectives, adverbs, or sentence connectives and the *argument* fulfills different semantic functions such as that of agent, object, or goal. Each *predicate* determines the nature of the *argument* it may take depending on linguistic rules and the reader's world knowledge. The propositions are ordered in the text base according to the order of the propositional *predicates*.

Kintsch & van Dijk (1978) hypothesize that if, during text processing, a text base is found to be referentially coherent - if there is *argument* overlap among all of its propositions - it is accepted for further processing. If gaps

are found, however, inference processes are then initiated to close the gaps to make the text base coherent.

The second hypothesis made by Kintsch & van Dijk (1978) is that the check for referential coherence and the addition of inferences is determined by the capacity limitations of the reader's working memory. Text is processed sequentially from left to right in chunks of several propositions at a time in order of appearance. The first propositions (*n1*) are processed together in one cycle, then the next propositions (*n2*) are processed together in a cycle, then (*n3*), and (*n4*), continuing in this manner of constructing a network of coherent propositions until the whole text is processed. *The important aspect of this process is that the precise number of propositions (n.s) included in a processing chunk depends on the surface characteristics of the text: the sentence and phrase boundaries determine the chunking of a text in short-term memory.*

At this point, Kintsch & van Dijk (1978) make the assumption that part of the working memory is a short-term memory buffer of limited size (*s*) and that for every chunk of *n* propositions processed, a limited number of propositions (*s*) are selected and stored in the short-term memory buffer. As shown in the diagram on the following page, these (*s*) propositions are then available for connecting the new incoming chunk of propositions with the already processed material:



*long-term memory searches and * *inference processing add significant difficulty to the comprehension process (Kintsch & van Dijk, 1978, p. 368).

Thus, during each processing cycle, a number of propositions (*n*) are processed in chunks and a limited size number of propositions (*s*) are retained in the short-term buffer to be connected with the input set of the next cycle. As well, during each cycle, a number of the propositions being processed may be stored in long-term memory to be later reproduced as a recall or summary protocol. Each of these propositions has a reproduction probability of (*p*)

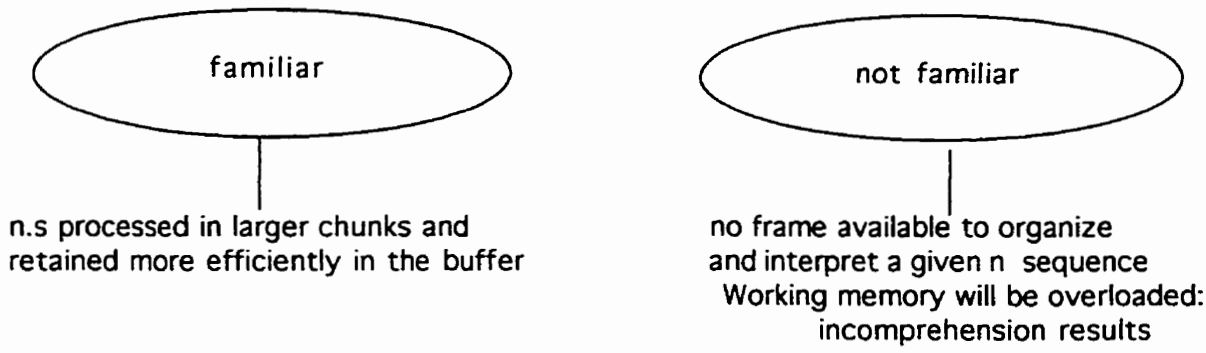
because it combines both storage and retrieval information (Kintsch & van Dijk, 1978). In other words, a proposition has a probability (p) for each time it has participated in a processing cycle.

Those propositions which participate in more than one processing cycle will have a higher reproduction probability; however, which propositions will be involved in multiple processing depends critically on the nature of the selection strategy employed. Propositions belonging to high levels of a text-base hierarchy are much better recalled than propositions low in the hierarchy (Kintsch, Kozminsky, Streby, McKoon, & Keenan, 1975; Meyers, 1975, 1977). If the selection strategy is such that higher-level propositions are selected, they will be processed more frequently than lower-level propositions, and hence, they will be better recalled.

As Kintsch and van Dijk (1978) indicate, a number of factors may influence the parameters of n, s, p which are dependent on reader and text characteristics. It has been shown that good and poor readers differ in their ability to hold text in short-term memory (Perfetti & Goldman, 1976). Kintsch and van Dijk (1978) contend that this may not necessarily be due to capacity differences but may, rather, be related to the observations made by Hunt, Lunneborg, and Lewis (1975) that persons having low verbal abilities will access information in short-term memory more slowly than persons with higher verbal abilities. Thus, in reading, the lower speed of operations have the same effect as decreasing the capacity of the buffer. On the other hand, the

difficulty of text also limits the capacity size available in the short-term buffer because of the resources that will necessarily be devoted to other aspects of processing during the reading of difficult text. The greater the automaticity of the perceptual decoding, syntactic-semantic analyses, and inference generation, the fewer the resource-consuming searches and the larger the capacity size of the buffer.

Similarly, the number of propositions within a processing chunk will vary, depending on familiarity, because a reader's prior knowledge determines to a large extent the meaning that is derived from text. As well, as the surface form of the text increases in complexity, the number of propositions in each processing chunk may be decreased (Kintsch & van Dijk, 1978). Familiarity is also an issue for the reproduction probability parameter (p) because the more familiar a text, the fewer resources will be required for other aspects of processing, thus the greater the probability for storage and retrieval:



Thus, comprehension is normally a fully automatic process making low demands on reader resources. Texts which make high demands on reader resources, however, will either result in an increase in the time required to read that particular text or result in low comprehension scores. As shown by Kintsch & van Dijk (1978) the factors related to this phenomena are the possible input size per cycle (*n*), the short-term memory capacity (*s*) and the nature of the selection strategy used. Therefore, a reader with a poor selection strategy and a small buffer, reading unfamiliar text, will have all kinds of problems with a text that would be highly readable for a good reader. In other words, the extent to which a text is comprehensible is considered the property of both the text and the text-reader interaction (Kintsch & Vipond,1978; Kintsch & van Dijk, 1978; Zakaluk,1985). At the same time, the role of reader schema must not be overlooked in text comprehension. The schema, which formally represents the reader's goals in reading a particular text, controls the process of determining which micropropositions or generalizations of micropropositions are relevant and which parts will form the gist of the text (Kintsch & van Dijk, 1978).

The Refined Model: A Construction-Integration Model

Walter Kintsch (1988, 1994) expanded on this concept of reader knowledge in discourse comprehension by designing a construction-integration model for text comprehension. The construction phase of this model consists of the construction of a text base using the basic process of proposition building described by Kintsch and van Dijk (1978). Essentially, a

text base is constructed from the linguistic input and the comprehender's knowledge base which is conceptualized as an associative network of concepts and propositional nodes. The integration phase involves integrating the text base into a coherent whole.

The construction process involves forming concepts and propositions directly corresponding to the linguistic input; elaborating each of these elements by selecting a small number of its most closely associated neighbours from the reader's general knowledge net; inferring certain additional propositions, and assigning connection strengths to all pairs of elements that have been created (Kintsch, 1994, p.956). As Kintsch (1994) explains it, this process results in "an initial, enriched but incoherent and possibly contradictory text base, which is then subjected to an integration process to form a coherent structure" (p.956).

According to Kintsch (1994), an associative net is constructed in each processing cycle described in Kintsch and van Dijk, (1978). It is at this point that the integration process takes over and activation is spread around until the system stabilizes. This integration process results in highly activated nodes in the associative net which constitute the discourse representation formed on each processing cycle. It includes information at the level of lexical nodes, text propositions, knowledge-based elaborations (inferences) as well as macropropositions (Kintsch, 1994) which form the gist of the text. The difference in the refined model is the expanded role of the reader's knowledge,

making the text base a richer structure by closely connecting the derivable propositions from the text to the propositions in the reader's general knowledge net (Kintsch, 1994).

Kintsch thus theorized that the organization of the microstructure of a text to facilitate the ordering of semantic relationships among ideas directly influences how well a reader constructs meaning and forms a coherent whole for the text. As well, the more familiar a topic, the more readable a text becomes. This is a much more extended view of text comprehensibility than early research suggests as described in the next section.

Historical Context of Current Insights Into Text Comprehensibility

Defining the Context

The terms 'readability' and 'comprehensibility' have been used almost interchangeably by Harris and Hodges (1981) in *A Dictionary of Reading and Related Terms* (Klare, 1988), but for the sake of clarity this paper draws a distinction between the terms. Readability is a more limited concept and represents more restricted and narrow views prevalent in the research of the 20s, 30s and 40s that conceived reading comprehension only as text-based. The term readability is used in reference to an approximate measure or estimate of the reading difficulty of a text and is reported in terms of grade level. Comprehensibility relates to the qualifying factors of a text which makes it easily understandable. A text which has a low readability level is not

necessarily comprehensible (Davison, 1988).

As suggested in Chapter 1, concern about the reading difficulty of text has been an issue for educators for a very long time. In the 1920's the search for a convenient objective method to assess text difficulty began in earnest (Chall, 1988; Zakaluk,1985; Zakaluk & Samuels, 1997). A series of historical events and social conditions have been cited as possible motivations for research into readability at that particular time. For example, in 1921, Thorndike published his *Teacher's Word Book* which ordered English language words according to frequency (Chall, 1988; Klare, 1963). With students beginning to stay in school longer, the school population began to change. More students continued into junior and senior high. The increased automation of the 1920s and the depression of the 1930s stimulated re-education and initiated a demand for informative texts which were easy to read (Zakaluk,1985). At the same time, there was a change in the instructional approach to teaching beginning reading from a focus on phonics to a focus on the teaching of sight words (Chall, 1988). The 1920s was an era of scientific thought with an emphasis on measurable objectives. Providing reading selections in published basal series at appropriate difficulty levels was deemed crucial so as not to overburden early readers. All of these factors led to the development of readability formulas to estimate text difficulty levels (Zakaluk & Samuels, 1997). According to Klare (1988), the history of readability is exhaustive. More detailed information may be found in Chall (1958), Klare (1963, 1974, 1984), and Harrison (1980). But still, only text and not reader

factors were considered in estimating text difficulty, in particular word and sentence length.

Shift in Research

The traditional view of reading until the the mid 1960s was that reading was a straight-forward perceptual process concerned with the printed words on a page. Thus, only text factors could influence comprehensibility. There was a shift in reading research, however, in the middle to late 1960s when the reading process came under scrutiny from various fields of inquiry (Pearson & Stephens, 1994). The initial thrust came from the field of linguistics with Noam Chomsky's revolutionary ideas in his 1957 and 1965 treatises regarding the nature of language development, language comprehension and language acquisition (Pearson & Stephens, 1994; Pearson & Camperell, 1994).

During the next decade, psycholinguists studied language acquisition and language comprehension from the perspective of the new linguistic theories. According to Pearson and Stephens (1994), the sentence comprehension studies of Miller (1962) and of several other researchers led to the derivational theory of complexity: the speed or difficulty a reader experiences in processing a sentence can be predicted by variations in the grammar of the sentence. According to this theory, simple active declarative sentences are understood more rapidly than passive, interrogative or negative sentences because they do not require as much cognitive processing energy in traveling the distance between the surface structure of the sentence to the underlying meaning

(Pearson & Camperell, 1994).

The psycholinguistic research into the implications of linguistic theories for language acquisition led to Brown's (1970) insight that oral language learning was rule-governed and that children were active learners who inferred language rules and tested them out (Pearson & Stephens, 1994). Psycholinguists were able to detail children's regular, stage-like process of language acquisition as they became proficient in the use of oral language in a relatively short period of time without direct instruction.

The work of psycholinguists in relation to oral language learning influenced reading experts to adopt a nativist approach to the study of reading and reading comprehension (Pearson & Stephens, 1994). Frank Smith (1971) argued that, rather than being taught to read, one learned to read as a result of belonging to a literate culture. Smith (1971) highlighted the idea that to be a skilled reader, one had to make use of prior knowledge and make informed predictions. The notion of prior knowledge and top-down influences is attributed to Bartlett (1932), the first psychologist to coin the term 'schema' to refer to the "active organization of past reactions, or past experience" (p.102) as a means of focusing on what he viewed as the constructive character of remembering (Anderson & Pearson, 1984). Smith (1971) believed that reading is a constructive process because readers make sense of the text based on what they already know (Pearson & Stephens, 1994). Similarly, Goodman and Goodman (1994) stressed that reading consists of processing

language and constructing meaning by means of an active transaction between the reader, the text and the writer.

Thus, psycholinguistic research led to the study of text comprehension from a cognitive psychology perspective in the 1970s. Prior knowledge of the topic was seen as helping readers actively construct meaning as they processed text. At the same time, research also demonstrated that the comprehensibility of narrative and informative text is influenced by the structure of the texts (Pearson & Stephens, 1994).

Story grammars. Narrative text - stories - have characters, a setting, a plot with a problem and ascending events, a climax and a resolution. The use of this organizational pattern enhances children's comprehension of stories (Mandler & Johnson, 1977; Meyer, Brandt & Bluth, 1980; Meyer, 1977; Stein & Glenn, 1979) because the story grammar offers a set of rules for taking apart the propositions of a story to create a hierarchy of key ideas which may be used as an aid to recall (Pearson & Camperell, 1994). Whaley (1981) used a story grammar to probe the extent to which good readers of different age groups expect structures in stories, and concluded that readers at grades three, six and eleven appear to have similar structural expectations. Thus, even at these differing levels, readers expect particular structural elements and sequences of elements in stories.

Mandler and Johnson (1977) showed that violations of story structure decreased comprehension and recall. Moreover, Meyer, Brandt, and Bluth (1980) cite a study by McDonald (1978) which found that the recall of poor comprehenders in the primary grades was facilitated by direct instruction of top-level structure of stories. Gordon (1980) emphasized that direct instruction in story grammar provides students with a generalized framework for storing and retrieving textual information (Pearson & Camperell, 1994). Thus, text comprehension is enhanced when readers' expectations are met because there is "an interaction between the writer who uses the well-known narrative structure to tell the story, and the reader who has certain expectations" (Zakaluk & Samuels, 1997) about the text structure.

Informative text. Similarly, research conducted with informative text (Kintsch & van Dyjk, 1978; Kintsch, 1994; Marshall & Glock, 1978-1979; Meyer, Brandt & Bluth, 1980; Meyer, 1977; Taylor & Samuels, 1983) shows that the structural relations among the ideas in text impact positively on the text comprehensibility (Pearson & Camperell, 1994; Pearson & Stephens, 1994; Zakaluk & Samuels, 1997). Informative text, however, is more complex. Zakaluk and Samuels (1997) list seven different types of informative text structures which can be diagrammed with connecting arrows to link related ideas. Taylor and Samuels (1983) studied text structure and its effect on the recall of ninth-graders, and found that seventy-two percent of the students in the study were identified as unfamiliar with organizational ideas in the expository text used.

Since the results of this study suggest that cognizance and use of text structure is a significant variable in recall, it appears that direct instruction in informational text structure is beneficial in making expository text more comprehensible. These ideas about text structure and their influence on text comprehensibility go far beyond the traditional conceptualization of readability that focused only on word and sentence level factors.

Schema theory. It was the schema theory postulates of the 1970's, however, who drove straight to the core of comprehension and, by extension, comprehensibility. Schema theory (Anderson, 1977, 1994; Anderson & Pearson, 1984; Rumelhart & Ortony, 1977) stems from the early work of Sir Frederick Bartlett (1932) and describes how knowledge is constructed and represented in memory. It explains how and where information is stored and how relations are established between one schema and another in memory - in short, how we make connections between ideas. Not only does this theory explain that we learn by making structural changes in our existing array of schemata depending on events and experiences, but it also explains the comprehension of text (Pearson & Stephens, 1994). Text comprehension occurs when the reader finds slots within particular schemata in which to place all the ideas encountered in the text. Thus, the reader must possess prior knowledge and construct a coherent model of the text (Pearson & Stephens, 1994) as described by Kintsch and van Dijk (1978) to ensure the comprehensibility of the material.

Metacognition and strategic knowledge. To better understand readers' knowledge of the reading and comprehension process, reading researchers have looked to the work of developmental psychologists in the area of metacognition (Garner, 1987; 1994). J.H. Flavell (1976; 1979; 1981) explains metacognition as the knowledge one has about one's own cognitive processes and products; essentially, it is knowing what one knows and knowing what variables or factors act in what way to affect the course and outcome of the knowing event (Garner, 1987; 1994). Flavell (1981) differentiates metacognition into metacognitive knowledge and metacognitive experiences and distinguishes between cognitive and metacognitive strategies. Metacognitive knowledge is highly interactive and includes statable information about the knowledge one has of oneself, of the tasks one faces, and of the strategies one employs. This metacognitive knowledge may be either declarative or procedural (Garner, 1987; 1994). Metacognitive experiences, on the other hand, occur before, during and after a complex cognitive activity such as reading or studying and frequently happen when one experiences a feeling of confusion about a cognitive activity (Garner, 1987; 1994). A cognitive strategy is employed to make cognitive gains. For example, in employing verbal rehearsal of material in preparation for a test, a metacognitive strategy in the form of a check-off list may be used to monitor if the cognitive strategy, in this case the verbal rehearsal, is effective (Garner, 1987; 1994).

Paris, Lipson, and Wixson (1994) point out that the key to reading

proficiency is self-controlled strategic behaviour which enables one to detect and repair comprehension difficulties. Metacognitive strategies or "awareness about the utility and appropriateness of various actions accompanies improvements in reading and may be a causal factor" (Paris, Lipson & Wixson,1994, p.789). Thus, the reader's strategic knowledge and behaviour during the reading and comprehension process influences text comprehensibility. Paris, Lipson and Wixson (1994) insist that declarative, procedural, and conditional knowledge are pragmatic ingredients to strategic behaviour. Declarative knowledge, or knowing *that*, is the knowledge that a story and an expository text, for example, each have a canonical structure that can be used as an aid to recall. Procedural knowledge, or knowing *how*, involves knowing how, for example, to skim through a text to find particular information within the canonical structure of the text; and conditional knowledge is knowing *when* and *why* to apply various actions, for example, when and why one would choose to skim the passage. Conditional knowledge allows for the adjustment of reading behaviour to changing task demands (Paris, Lipson, & Wixson, 1994).

With the research on metacognition, our notion of text comprehensibility moves even beyond the consideration of text structure, schema theory and the constructive processing of text to the realization that we, as educators, can facilitate comprehension by teaching learners strategic knowledge.

The role of 'context'. Sociolinguists put a final touch to our present understanding of comprehension, readability and comprehensibility because they led reading researchers, in the 1980s, to the reconceptualization of 'context' in relation to reading (Pearson & Stephens, 1994). Prior to this, 'context' for most people meant the printed words on a page and the use of surrounding words to help decode or infer meaning. Now, 'context' has been expanded to mean the instructional and non-instructional: the home, school and community contexts of literacy (Bloome & Greene, 1984; Pearson & Stephens, 1994) that affect the acquisition of language, and either provide, or fail to provide, experiences which contribute to understanding.

Sociolinguists heightened our awareness of reading comprehension as a process that also includes social and cultural influences on knowledge construction. The question and answer and recitation routines prevalent in mainstream cultural classrooms may have a deleterious effect on meaning-making for minority groups. As a result, the competitive atmosphere in many classrooms has begun to change (Pearson & Stephens, 1994) to one of cooperation where children are encouraged to engage in discussion and collaborate on activities to heighten understanding and learning from text. Forman and Cadzen (1994) describe a study of peer collaboration based on a Vygotskian perspective. Vygotsky's (1978) developmental theory explains that language plays a central role in development; development cannot be separated from its social contexts because children co-construct knowledge;

and, there exists a zone of proximal development which can be used to scaffold new learning. Forman and Cadzen (1994) show that children engaged in peer collaboration learn to use speech to guide the actions of their partner and, in turn, are guided by their partner's response. They thus scaffold each other's learning. As a result, peer collaboration and collaborative learning techniques are being used to facilitate the comprehensibility of informative text which may be a powerful strategy to enhance learning within the classroom context.

As indicated by Pearson and Stephens (1994), extensive research has caused a change in the traditional view of reading as a straight-forward perceptual process concerned with the printed words on a page to one of a "complex, orchestrated, constructive process" (p.35) through which readers construct meaning based on their previous experience and on the social context. Based on the premise that comprehensibility of text is dependent on more than narrowly-based readability indices and levels, Zakaluk (1985) developed a new approach to predicting text comprehensibility arguing that:

> Readability, however, is not an inherent property of text, alone, but the result of an interaction between a set of particular text characteristics and the information-processing characteristics of individual readers (Kintsch & Vipond, 1979). Text factors by themselves cannot determine readability. What readers already know and understand about the topic will also influence comprehensibility and recall (pp. 52-53).

From this premise, Zakaluk (1985) proposed the concept of 'inside-and outside-the-head' factors to describe the factors which impact on text comprehensibility.

Tracing The History Of Text Readability

Development of Readability Formulas: Use and Misuse

One of the first readability formulas was developed by Lively and Pressey (1923) followed by a number of other formulas developed in psychometric research: Vogel and Washburne (1928); Dale and Tyler (1934); Ojemann (1934) and Gray and Leary (1935). These experts developed a list of 44 factors that they could reliably count and which occurred with enough consistent frequency for statistical analysis (Klare, 1988; Zakaluk, 1985; Zakaluk & Samuels, 1997). The initial research focused on text factors such as sentence length and word frequency as indices of text difficulty level (Zakaluk,1985; Zakaluk & Samuels, 1997). A growing emphasis in the 1930s was to use a greater number of sentence and vocabulary factors as well as qualitative factors of expression in the development of readability formulas for predicting text difficulty levels. What is interesting to note in all of these earlier studies is that "the measure serving as a criterion was reading comprehension ability" (Zakaluk, 1985, p.29). Thus the original objective for developing formulas to predict text difficulty level was to ensure that the materials could be easily read and comprehended by the reader.

The years between the late 1930s to the late 1950s saw further refinement of readability formulas in an attempt to make them more "user efficient". As they became more refined, the formulas became very popular because they provided scores in terms of grade levels to match reading performance (Klare, 1988). Zakaluk (1985) compared four of the more known and used formulas: the Flesch (1948); the Dale-Chall (1948); the Spache (1953); and the Fry (1968).

Lipson and Wixson (1991) report that readability formulas are quite reliable as a rough check or estimate for ranking nonmanipulated texts for use with a general population. However, publishers began to misuse these formulas to reduce the readability levels of texts by simplifying the vocabulary and shortening the sentences (Davison, 1988). The result was more contrived texts with common, everyday words and shortened sentences to ensure low readability. However, these texts were not necessarily more comprehensible. In fact, the revision of text to lower the readability level frequently made the text more difficult to read because connectives were dropped and sentences shortened (Davison, 1988), making the text stilted and unnatural. Furthermore, rich, meaning-bearing words were also omitted (Zakaluk, 1985).

"Rewriting text to conform to a prescribed reading level may result in text that is more difficult to read" (Zakaluk, 1988, p.125). A case in point are primer stories in basal reading programs which have been oversimplified through the use of short sentences and high-frequency words. Gourley (1984)

conducted research which focused on the readability of beginning reading texts in light of the expectations of beginning readers based on the structures of children's natural discourse. She came to the conclusion that the language in basal stories is actually deviant because it does not follow the principles of natural discourse. For beginning readers, the effect on their understanding of print and their ability to predict upcoming words may be especially critical. Gourley's (1984) key findings indicated that children expect texts to use connective devices such as pronouns, conjunctions and articles to link ideas. Patterned repetition contributed to comprehensibility when full sentences were repeated at regular intervals in the story; but words, phrases or sentences repeated without consideration of discourse structure were a source of difficulty for beginning readers. Gourley (1984) found also that the miscues students made were substitutions of more natural language and that children's retellings demonstrated the natural use of connective devices. Thus, children's retellings showed that they expect a story to be written in the past tense and follow a straightforward sequence of events.

Limitations of Readability Formulas

Zakaluk (1985) contends that "in spite of the care and research that went into their development, readability formulas, in and of themselves, fail to define text comprehensibility" (p.38). Zakaluk (1985) and Zakaluk and Samuels (1988) cite inter-formula reliability, criterion validity and the consideration of only vocabulary load and sentence length as the limitations of readability formulas. In addition, the formulas fail to take into consideration other text

factors such as text organization, coherence, format and style of writing as well as reader factors (Lipson & Wixson, 1991; Zakaluk 1985; Zakaluk & Samuels, 1988). In essence, the use of readability formulas to reduce the readability levels of texts is atheoretical. The formulas do not determine the comprehensibility of reading passages.

Zakaluk (1985) reports that studies such as that conducted by McConnell (1982), for instance, indicate that different readability results can be obtained on the same text depending on the readability formula used. In addition, inadequately normed passages were employed as the criterion index of difficulty in formula development (Stevens, 1980). Marshall (1979) found that a poorly-organized and a well-organized text would have the same readability level using a readability formula. Taylor and Samuels (1983), on the other hand, showed that higher comprehension scores were obtained when reading well-organized text than when reading texts that were poorly-organized. Good readers were aware of text structure and used it as a retrieval aid.

Issues of Text Comprehensibility: Inside-and-Outside-The-Head Factors

Zakaluk (1985) categorized 'inside-and outside-the-head' factors to devise a system which could be used to predict text difficulty for individual readers. According to Lipson & Wixson, (1991), Zakaluk's (1985) *Nomograph*

for predicting text comprehensibility is an improvement over current methods of determining text difficulty because it is based on an interactive model of text processing; it assesses a variety of factors beyond word frequency and sentence length; and it is designed to arrive at an optimal match between individual reader and text rather than determining a general text reading difficulty level.

'Outside-the-head' Factors

Zakaluk (1985) and Zakaluk and Samuels (1988) studied conventional text readability levels and adjunct comprehension aids as 'outside-the-head' comprehensibility factors. As has been noted earlier, readability formulas can be reliable as a rough check or estimate for ranking nonmanipulated texts. Adjunct comprehension aids in text are titles, chapter headings, italics, bold-face type, pictures, tables, charts, advanced organizers, structured overviews, summaries, underlining of key ideas, instructional objectives, and interspersed questions (Zakaluk, 1985).

In the design of her nomograph, Zakaluk (1985) used two adjunct aids which a review of the literature suggested had the greatest impact on comprehensibility of text: interspersed questions and instructional objectives. Interspersed questions are effective in enhancing comprehension and recall because attentional behaviour and in-depth cognitive processing are required to respond to the questions as readers progress through the text. Interspersed questions increase the probability that readers will go back to reread and

reprocess information (Zakaluk, 1985). Interspersed questions, however, are more effective if the follow-up questions are identical to the criterion questions; and if questions interspersed throughout the text are in close proximity to the information required (Frase, 1967; Zakaluk, 1985; Zakaluk & Samuels,1988).

Instructional objectives or study goals presented at the beginning of the text, that stress learning expectations and reveal important information related to follow-up test questions also act as adjunct aids (Zakaluk, 1985). With these, also, effectiveness is conditional. Instructional objectives need to be explicitly stated (Lipson & Wixson, 1994; Zakaluk, 1985; Zakaluk & Samuels,1988); and they should direct students to focus on information to which they would not otherwise pay attention (Duell, 1974; Zakaluk, 1985; Zakaluk & Samuels,1988). Care also should be taken to limit objectives so as not to overwhelm students (Duchastel & Merrill, 1973; Zakaluk, 1985; Zakaluk & Samuels,1988).

'Inside-the-head' Factors

As 'inside-the-head' factors, Zakaluk (1985), Zakaluk and Samuels (1988), and Zakaluk and Samuels (1997) list background knowledge, and word recognition skills as cognitive factors that have a significant effect on text comprehensibility. Background knowledge is a necessary component because, as Kintsch (1994) explains, general knowledge about anything is what makes the construction of discourse representation possible. "The most important variable in learning with texts is a reader's prior knowledge" (Vacca &

Vacca, 1993, p. 13). Hence, the degree of familiarity with the text topic determines, in large part, the degree of comprehensibility of text for individual readers.

Zakaluk (1985) and Zakaluk and Samuels (1988) emphasize the important role that world knowledge plays in reading comprehension at various age levels. In particular, Zakaluk (1985) cites three studies, Dooling and Lachman (1971), Bransford and Johnson (1972), and Bransford and McCarell (1974) which have demonstrated that text may seem incomprehensible until background knowledge is brought to bear. "Well written texts signal to the reader what background knowledge must be activated to enhance processing" (Zakaluk & Samuels, 1988, p. 129). As discussed earlier, schema theory (Anderson, 1994; Anderson & Pearson, 1984; Tierney & Pearson, 1994) explains why the reader must possess prior knowledge to construct a coherent model of the text for comprehensibility of the material. As stressed by Kintsch and van Dijk (1978), a reader's schema controls the reader's ability to construct meaning from the text:

> "Just as general knowledge is needed to establish connection and coherence at the microstructural level, world knowledge is also required for the operation of macrorules... . (p.366). ...a reader's knowledge determines to a large extent the meaning that he or she derives from a text. If the knowledge base is lacking, the reader will not be able to derive the same meaning that a person with adequate knowledge, reading the same text, would obtain...if a topic is unfamiliar, there will be no frame available to organize and interpret a given proposition sequence (e.g., for the purpose of generalizing inferences from it)" (p. 371).

Word recognition skill, the second 'inside-the-head' factor used by Zakaluk (1985) in her nomograph, entails both accuracy and automaticity. Automaticity in word identification allows the reader to devote attention to comprehension rather than to the task of decoding (Samuels, 1994; Zakaluk 1985; Zakaluk & Samuels, 1988). Focused attention on decoding which results in word by word reading is an obstacle to comprehension because less 'attentional energy' is left to devote to comprehension (Samuels, 1994; Zakaluk & Samuels, 1988). According to Juel (1990), early decoding skill accurately predicts reading comprehension. In a 1988 study on early decoding and comprehension, Juel found there was a .88 probability that a child whose comprehension level was in the bottom quartile on a standardized test at the end of grade one, would still be a poor reader at the end of grade 4 because of decoding difficulties (Juel 1990). Lesgold and Resnick (1982) demonstrated that speed [or automaticity] of word recognition in grade one was an excellent predictor of a child's reading comprehension in the next grade.

Zakaluk's Research

Zakaluk, in 1985, undertook a text comprehensibility study which investigated the relative influence of text-specific and reader-specific factors on the comprehensibility of text. Her purpose was to develop a regression equation and corresponding nomograph as a tool for predicting text comprehensibility. The nomograph would have a high degree of accuracy because it would account for essential reader and text factors and at the same time it would not be a complicated or time-consuming tool to use. The

inside-the-head cognitive factors examined as predictor variables for comprehension were prior knowledge and word recognition skill; outside-the-head text factors measured as comprehension predictor variables consisted of the use of adjunct aids, the reading difficulty level of the reading passages, and the effect of different content area topics.

The study. Zakaluk's (1985) research explored which inside-the-head and outside-the-head variables accounted for the most variance on a regression equation to predict text comprehensibility. To determine which independent inside-the-head variables could be omitted from the full regression model without biasing the predictive power of the equation, two measures of prior knowledge for text topic were used to assess subject background knowledge and two measures of word recognition skill - accuracy and automaticity - were used to assess word recognition skill. The first prior knowledge measure was a word association procedure based on Noble's M measure of prior knowledge (Noble, 1952) and the second was a student self-evaluation report (Taylor & Beach, 1984) in which subjects, after reading the passage, indicated on a Likert-type scale of 1 to 5 how much they had known about the topic before they read it. To assess word recognition skill, subjects were instructed to read aloud a 157 word expository passage, following the traditional pattern of an Informal Reading Inventory (IRI). The oral reading performance was audio-taped and scored for both word recognition accuracy, using a percentage score, and for automaticity by measuring in seconds the rate at which the passage was read. Basically, the intent was to determine the

relationship between reading comprehension and each of the following inside-the-head variables: (1) word recognition accuracy, (2) word recognition automaticity, (3) prior knowledge of text topic according to the Noble's M measure, and (4) prior knowledge of text topic as measured by student self-reports.

Similarly, Zakaluk (1985) investigated the following outside-the-head variables to establish the effect of each variable on text comprehensibility: (1) reading difficulty level as measured by the Fry Readability Formula (Fry,1968), (2) adjunct aids: the inclusion or absence of interspersed question and their placement, and the inclusion or absence of instructional objectives; and (3) content area topic: social studies as one and science-health as another.

Zakaluk (1985) selected passages from classroom-based texts in different content area subjects, social studies and science-health. She chose one passage in each of the two content areas, that met the criterion of difficulty for each of the grade levels four to seven as measured by the Fry formula for a total of eight reading passages varying in length from 300 to 435 words. To control for the outside-the-head factors, the adjunct aids of instructional objectives and interspersed questions, four separate versions for each of the eight passages were prepared, totaling thirty-two reading passages, thus enabling Zakaluk (1985) to account for four possible adjunct aid conditions. One version offered both instructional objectives and interspersed questions; one contained instructional objectives but no

interspersed questions; a third version contained no instructional objectives and interspersed questions; and the last version contained no instructional objectives and no interspersed questions.

To obtain reading comprehension levels which reflected the performance of the general population, Zakaluk (1985) considered the factors of setting and socio-economic status. Consequently, subjects at the grade 5 level were selected from six schools: two city schools: one from the inner city in which both native and immigrant students were enrolled and one from a middle-class neighbourhood; two suburban schools: one from a low-cost housing neighbourhood and one from an area of owner-occupied homes; and two rural schools, both of which were located in a prosperous agricultural area. All the subjects in the study were fifth grade students as representative of upper elementary grade students with a final sample of 253 complete data sets.

Reading comprehension of the assigned texts was measured by a range of fifteen to twenty open-ended, short-answer questions across the passages. Zakaluk (1985), in formulating the comprehension questions, ensured that the range in the level of questions measured both comprehension and memory for text. Questions were text explicit, and test and scripturally implicit. Each of the 253 subjects was assigned passages with different adjunct conditions in each of the content area topics in random order. Thus, the inside-the-head reader factors of prior knowledge of topic and word recognition automaticity served as covariates; the content area topic, reading difficulty level and adjunct

aid conditions were the independent or predictor variables, and reading comprehension performance served as the dependent or criterion variable.

Zakaluk's (1985) data analysis and interpretation of the results of the study was two-fold. First, Zakaluk (1985) identified the relationship between the designated inside- and outside-the-head predictor variables and the criterion variable of reading comprehension performance. Next, she determined which of the predictor variables related the most significantly to reading comprehension so she could enter these into a regression equation to estimate text comprehensibility levels.

Zakaluk's (1985) findings. The data analysis and interpretation of reader predictor variables revealed a high correlation between word recognition accuracy and word recognition automaticity (rate of reading) which suggested that the two variables, in essence, measured similar behaviour. However, when determining the relationship between these two variables and reading comprehension performance, Zakaluk (1985) found that word recognition accuracy did not have a significant relationship to reading comprehension while word recognition automaticity was significantly related to reading comprehension performance. Similarly, prior knowledge measured by student self-reports revealed a non-significant relationship to reading comprehension but prior knowledge as measured by Noble's M technique was significantly related to reading comprehension performance. Consequently, the two predictor variable of word recognition automaticity and prior knowledge

measured by Noble's M technique were the significant inside-the-head predictor variables which were entered into the regression equation to estimate text comprehensibility.

The analysis for reading comprehension and outside-the-head relationship demonstrated that both difficulty level and the use of adjunct aids were significantly related to comprehension. For content area topic, however, further analysis was necessary because the results showed only a tentative significant relationship with reading comprehension at the .05 level with significance on some of the trials and not on others.

Zakaluk (1985) found no three-way relationship among the three conditions of content area, difficulty level, and adjunct aids. She did find, however, a significant relationship between difficulty level and content area topic; a non-significant relationship between content area topic and adjunct aids; and, a non-significant relationship between adjunct aids and difficulty level. Further analysis revealed, as well, that reading comprehension performance was greatly enhanced when any of the instructional aids were present, be they instructional objectives, interspersed questions, or both questions and objectives. Zakaluk (1985) found that the use of either instructional objectives or interspersed questions or both objectives and questions, reflected a higher reading comprehension performance than the non-use of instructional aids and that it did not appear to make a significant difference which adjunct aid or combination of adjunct aids was present to increase comprehension

performance.

Three outside-the-head predictor variables, however, were too many factors to plot on a nomograph. Yet, Zakaluk (1985) could not arbitrarily dismiss the tentative significant relationship of content area topic with reading comprehension performance. Consequently, she undertook a series of stepwise regression analysis: one regression analysis for each content area at each difficulty level, and a second analysis that consisted of entering the main effects automaticity, prior knowledge and adjunct aids first on the regression equation for the purpose of controlling for interactions amongst the variables. The results of the analyses showed that automaticity and prior knowledge consistently predicted comprehension performance while adjunct aids added predictive value only for the science-health content areas. The inclusion of adjunct aids, however, did have a positive impact on the comprehension of social studies materials. Aside from that finding it had previously been established that there was a significant relationship between adjunct aids and reading comprehension performance. It was thus definitively established that the three main effects of automaticity, prior knowledge and adjunct aids were predictor variables that had to be considered when determining text comprehensibility for individual readers.

At this point, Zakaluk (1985) had sufficient data to make the decision to combine difficulty level and content area performance. Her data showed that despite the overall significant differences in comprehension performance across

the content areas, there were inconsistencies in the differences when performance was examined across trials. She concluded from this finding that the differences may have been a result of the differences in the difficulty of the test items used to measure performance on each passage rather than difficulty with the content area passage itself.

In the third set of regression analysis, Zakaluk (1985) pooled the content area performances with difficulty level so that the main effects of automaticity, prior knowledge, difficulty level and adjunct aids were entered into the regression equation. Zakaluk's (1985) results revealed that the combination of automaticity, prior knowledge, and difficulty accounted significantly in predicting text comprehensibility but the presence of adjunct aids did not appear to increase consistently the predictive power of the regression equation. Adjuncts aids, however, had been shown to have a significant relationship with reading comprehension performance and since a nomograph could be built to accommodate for either the presence or absence of adjunct aids, Zakaluk (1985) retained adjunct aids as a variable for predicting text comprehensibility.

Further analysis of the data and cross-validation was then undertaken to definitively establish the inside- and outside-the-head factors to construct the overall regression equation and corresponding nomograph. This final analysis revealed that the two inside-the-head variables of word recognition automaticity and prior knowledge of text as measured by Noble's M word

association measure and the two outside-the-head predictor variables of difficulty level as measured by the Fry formula and the presence or absence of adjunct aids were found to be the predictor variables which accounted the most for predicting text comprehensibility.

Summary and Conclusions

This literature review shows that comprehensibility of text is not dependent on separate, isolated text factors as traditionally accepted in the application of readability formulas. Multiple factors influence text difficulty. These can be categorized as 'outside- and inside-the-head' (Zakaluk, 1985). According to Zakaluk's (1985) theory, current research suggests that the following 'outside-the-head' factors in addition to readability level and adjunct comprehension aids also affect text comprehensibility: text discourse which matches reader expectations, text which follows canonical structure schemas, and social context. 'Inside-the-head' factors (Zakaluk, 1985) are automaticity of word recognition, prior knowledge of text topic and of text structure, as well as cognitive factors and awareness of strategies of how to store and retrieve information from one's schema (metacognition). Therefore in determining the best reader-text match for text comprehensibility, we need to keep in mind the following important findings:

(a) Zakaluk's (1985) 'inside-and-outside-the-head' predictor variables of text comprehensibility: word recognition automaticity, prior knowledge of text topic, difficulty level and presence of adjunct aids;

(b) Kintsch and van Dijk's (1978) model of text comprehension processing and production: the height of propositions in the structural hierarchy predicts and explains the comprehensibility of particular text segments while surface structures that violate canonical structure will decrease comprehension and recall;

(c) The effect of the reader's world knowledge, strategic knowledge and schema for text structure are factors which influence text comprehensibility.

We are, however, approaching a new millennium in which information technology is predicted to play a major role in literacy. How electronic texts fit into the complex view of text comprehensibility remains to be examined.

The Role of Electronic Texts Examined

For the print-based mind, 'the book' is central to our conception of literacy. This centrality is being challenged by "The Electronic Text". Reinking (1994), argues that the "differences between printed and electronic texts are substantial enough to alter current conceptions of literacy" (p.9). Electronic texts are literally interactive because of their malleability, may contain non-verbal elements not possible in printed texts, offer new textual structures at a variety of levels, expand the boundaries of freedom and control over text, and make possible, changes in the pragmatics of written communications (Reinking

1994). These dynamic characteristics, not endemic to printed text, may have even more potential to increase the comprehensibility of text.

Significant Characteristics of Electronic Text

As was discussed earlier, reading is an interactive, constructive process because of the reader's active role in constructing meaning. In the case of the printed text, the print is inert and fixed on the page, unresponsive to individual reader needs (Reinking 1994) while electronic texts are, in themselves, truly interactive in the literal sense, because of their malleability. They can be programmed to monitor a reader's performance and to adjust the textual presentation according to what the reader is doing or not doing (Reinking 1994). Electronic text can be programmed to respond immediately to the particular needs of any reader at any point during the reading experience (Leu, 1995).

An example of the current technology's interactivity is Peter Reitsma's (1988) study on computer-based speech feedback for beginning readers. This study suggests that "increases in reading efficiency depend largely on the amount of independent practice and self-propelled reading activity" (p.220) offered by the opportunity to self-select at will, the computer-based speech feedback option. Currently, the opportunity for independent, self-propelled reading by self-selection of options to make text more comprehensible has been rapidly advanced with the development of dynamic electronic

environments. Reinking (1988) and Reinking and Rickman (1990) studied the effects of computer-mediated texts on comprehension. Their findings indicate that options for self-selection to obtain information at multilevels of electronic text and the computer's capability to sense and adjust text to readers' difficulties can effect increases in comprehension during independent reading (Reinking, 1994).

Zakaluk (1985) identified adjunct comprehension aids as significant factors for text comprehensibility. The non-verbal elements of electronic texts such as images, animation, and sound have the potential to serve as powerful adjunct comprehension aids. These non-verbal elements can compete equally with the written prose (Reinking 1994), and may possibly make an equal contribution to the comprehensibility of text because of the flexibility with which the ideas may be communicated within a multimedia context.

The cognitive psychology perspective of the 1970s demonstrated that comprehensibility of texts was influenced by the structural organization of the text and the relations among the ideas. Much has been written about the importance of teaching text structure as a comprehension strategy (McGee & Richgels, 1985) for printed text which is linear and hierarchical in structure (Leu, 1995) because of its inert, fixed nature. However, electronic texts such as hypertext and hypermedia offer non-linear access to separate but inter-connected nodes of text (Reinking, 1994), linking information at multiple levels and multiple locations (Leu, 1995) reminiscent of the "complexity of our thinking

and the interrelatedness of our ideas" (Reinking 1994, p.14) as explained by schema theory. As Jay Bolter (1991) emphasizes, "When technology provided us with printed books and photographs, our minds were repositories of fixed texts and still images. When the contemporary technology is electronic, our minds become pulsing networks of ideas" (Reinking 1994, p.14).

Potential of Electronic Text

The structural organization of electronic texts such as hypertext and hypermedia offers students the opportunity to determine their own unique path through an elaborate network of textual environments in such a way that it is possible that no two readers will experience the same information in the same sequence (Leu, 1995). Not only does the potential exist for electronic texts to be more comprehensible because their structural organization is non-linear, multi-level textual information, but the potential also exists that students, by their own unique choice of path, may make the text more comprehensible for themselves.

Hypertext, hypermedia, and internet applications continually manifest the exponential expansion of freedom of access to textual information and global sharing of ideas (Reinking 1994). In fact, internet communications and e-mail discussion groups have been compared to 'virtual communities' which, as Reinking (1994) points out, "function much like the marketplace in ancient Athens where citizens met to talk, gossip, argue" (p.17) and debate ideas. At the same time, these dynamic, electronic environments manifest the capability

to monitor the strategies used by a reader and to present or control options accordingly (Reinking 1994). These characteristics may be additional factors that increase text comprehensibility. Vygotsky's theory of the social construction of knowledge and the need for scaffolding within the learner's zone of proximal development [for comprehensibility] may never be more evident than in the knowledge constructed through the freedom of access and control of information, and the networking provided by these dynamic, interactive applications. Let us imagine for a moment, a classroom community of peer reading and writing collaborators using electronic texts to guide and scaffold each others' construction of knowledge and then sharing this knowledge with another classroom community of peer collaborators a continent away, enabling these two communities to co-construct new knowledge: a virtual ever-growing web, schema-driven within a social constructivist context.

Recent studies of computers in classrooms (Dickinson, 1986; Genishi, 1988; Mehan, 1989) have highlighted the rich social interactions that occur when children use computers (DeGroff, 1990) and the learning that occurs between children as a result. Mehan (1989) found that the increased verbal interactions related to computer use was an important vehicle for understanding, facilitated the opportunity for students to hear other points of view, and led to cognitive conflicts which force students to examine their understandings and readjust their thinking to resolve the conflict (Forman & Cadzen, 1994). Collaborative work at the computer leads to considerable talk

for planning, self-monitoring, peer support, and response (Dickinson, 1986) and creates a new social environment for cooperative learning. Within this new social environment, children, in keeping with Vygotskian theory, "can move each other along in their zones of proximal development" (Genishi, 1988).

Kay Gore (1991) in her description of Stanley Pogrow's Higher Order Thinking Skills (HOTS) program, refers to Pogrow's use of computers for developing thinking skills even though he views "sophisticated conversation between adult and child as the most under-used and powerful 'technology' that teachers have at their disposal" (p. 157). Pogrow insists that computers have the ability to help build an intellectually challenging environment for using language to develop thinking skills (Gore, 1991). According to Gore (1991), recent brain research on the impact and the potential of the computer concludes that the "computer interacts with the brain in ways that we do not fully understand, constructing unique pathways for learning" (p. 157).

Dr. Jane Healy (1990), however, insists that it is precisely because we do not yet fully understand how the computer interacts with young children's brains that society must control "its own infatuation with 'progress' when planning for its young. Unproven technologies and changing modes of living may offer lively visions, but they can also be detrimental to the development of the young plastic brain" (p.345). Moreover, computer technology is seductive and the danger exists, in educational practice, for embracing this technology from an activity-based perspective rather than from an instructional objectives

standpoint. Studies have shown, also, that "instructional outcomes tend not to be fully realized" (Reinking & Pickle, 1993, p.263) when computer-based activities are used in the classroom. Rather, the computer remains an entity unto itself, or the technology is adapted to maintain existing educational practice rather than instigating change (Reinking & Pickle, 1993).

With this caution in mind, it appears timely that research of electronic text in terms of text comprehensibility be undertaken. Electronic texts, especially dynamic, supportive electronic texts such as hypermedia, appear to have the potential to offer more considerate, responsive texts. Similarly, from the transactional sociopsycholinguistic perspective, a wider electronic environment appears to have the potential to facilitate enhanced learning because of its capabilities for greater freedom of access to textual information, and global sharing of ideas. We clearly need research and sound theory, however, to give direction to educational practice if this innovative and promising technology is to enhance text comprehensibility in the optimum sense, as we enter a different technological era.

This research must emanate from a theoretical framework that is attentive to current text comprehensibility research. In their search for expository text factors which lend themselves to greater comprehensibility, Armbruster (1984) and Anderson & Armbruster(1984) focused on coherence, unity, audience appropriateness and adjunct instructional aids as features of text that render it more 'considerate' to individual readers (Leu, 1995; Lipson

& Wixson, 1991). Kintsch and van Dijk's (1978) model of text comprehension and production demonstrates both the role of text structure at the micro and macro levels of text and the role of the reader's prior knowledge for text comprehensibility. Zakaluk's (1985) research identified the four factors with the most predicative power for enhancing text comprehensibility as word recognition automaticity, the reader's prior knowledge, text difficulty level and the presence of adjunct aids. If hypertext and hypermedia have the potential for increasing the comprehensibility of text, an analysis of the nature of electronic text structure has to be undertaken from this theoretical framework to establish those factors that lead to text comprehensibility within the electronic text environment.

CHAPTER 3

Literacy and Electronic Texts Examined: The Selection, Screening and Organization of Existing Studies

"The medium is the message."
-Marshall McLuhan

Computer technology appears to be rapidly becoming "the medium" as society relentlessly pushes for technology use in today's classrooms. The concern for electronic literacy acquisition is legitimate because the Internet is "the world's largest library, shopping mall, business market, museum, university, [and] health information provider" according to Stephen Leahey (1998), president of the Manitoba Corporation for Enabling Technologies. Clearly, this and future generations of students will have a new work environment imposed on them by the pervasive influence of an electronic information technology which can facilitate the immediate global sharing of ideas, data and tools.

Text comprehensibility in electronic text environments is of immediate concern in light of what we already know about comprehension processing as studied by Kintsch (1994) and Kintsch and van Dijk (1978), and about text comprehensibility as demonstrated by Zakaluk (1985). The purpose of this study is to investigate the nature of electronic text structure and its potential for increasing the comprehensibility of text. This investigation involves an integrative study of the existing research regarding electronic text structure and text comprehensibility.

The studies chosen for this integrative study have been selected and organized to present an indepth review of factors that need to be considered when contemplating which technological design features can offer the optimal in text comprehensibility. Following a brief discussion of existing computer use in classrooms, design concepts of electronic text, hypertext and hypermedia, are defined. A discussion of a reader's "mental representation for text" examines the influence of prior knowledge for text structure on the accurate ordering of chunks of information and how this reader factor impacts on hypertext design systems. Issues related to the hypertext/hypermedia environments in relation to orientation and disorientation are presented followed by a discussion of problems associated with the study of comprehension in hypertext and hypermedia environments. An examination of existing studies on this topic is then undertaken to determine the factors for designing potentially considerate text within hypertext and hypermedia environments.

Issues Related to Electronic Texts

Computer Technology Use in Classrooms

Research conducted by Becker (1990) and Reinking and Bridwell-Bowles (1991) has consistently identified computer use as a highly motivating instructional activity in schools (Reinking & Watkins, 1996). A recent study by Tierney, Kieffer, Whalin, Desai, Moss, Harris, and Hopper (1997) demonstrates that although students indicate using hypertext environments is more demanding, they also believe that using hypertext is worth the effort because

the experience is "more interesting, more enjoyable, more exciting, or better than more conventional assignments" (http://www.readingonline.org/research/impact/index.html).

Yet, Reinking and Watkins (1996) in citing the work of Reinking and Bridwell-Bowles (1991), Roblyer, Castine, and King (1988), and Becker (1992), report that conventional experimental research fails to support classroom computer-based activities consistently over non-computer based literacy activities. Moreover, the limited number of comparative studies of hypertext versus printed text have failed to show any advantage for hypertext, except in those cases where powerful search tools were available in hypertext but not in the print text condition (Chignell & Valdez, 199-).

A few qualitative and ethnographic studies such as those of Dickinson, (1986), McGee (1987), Mehan (1989), and Riel (1989) which focused on literacy and computer use have shown some advantages for computer use in the classroom by investigating the influence of factors pertinent to a particular environment over time (Reinking & Watkins, 1996). Reinking and Watkins (1996) point out, however, that despite the potential promise of computer technology to transform literacy learning, the existing research clearly demonstrates that innovative computer-based activities in classrooms does not necessarily achieve this promise especially if the use of computer technology is not fundamentally supported by clear pedagogical goals for its use in the classroom. Most often, computer technology is used in a way that

maintains the status quo (Reinking & Watkins, 1996).

David Reinking (1994) insists, however, that the substantial differences between printed and electronic texts challenges society, and educators in particular, to alter our current conceptions of literacy. He cites the malleability of electronic technology which permits it to be literally interactive, the non-verbal elements that can be activated but are not possible in printed text, the text structures accessible at a variety of levels, the expanded boundaries of freedom and control over text; and the possibility for change in the pragmatics of written communications (Reinking, 1994). These differences have the potential to expand our notion of literacy. Ultimately, these dynamic characteristics, not endemic to printed text, may have the potential to increase text comprehensibility.

Hypertext and Hypermedia Defined

Hypertext and hypermedia within electronic text environments are methods of creating, organizing and disseminating on-line, non-linear textual information. They allow for the dynamic, interactive presentation of electronic text by means of easily accessible multi-level linked nodes containing either a single concept or chunk of information. The network of interconnected nodes is created by links which connect related nodes either within one document or between documents (Mohageg, 1992). The terms hypertext and hypermedia tend to be used loosely in place of each other (Hypertext Terms: http://www.w3.org/Terms.html).

The identifying difference between hypertext and hypermedia, however, is that the latter method of electronic text presentation has an added characteristic. Each interconnected node in hypermedia "may contain animation, graphics, audio (digitized or synthesized), video, executable computer programs, or other forms of information" (Mohageg, 1992, p.352). The chief advantages of hypermedia come from its flexibility in storing and retrieving information, and in the variety of forms, that are linked to many other pieces of information at various multilevels (Valdez & Chignell, 1988).

According to Mohageg's (1992) discussion of hypertext linking structures, nodes are connected by either organizational or relational links. Organizational links can organize nodes using either an alphabetical or functional organizational scheme, or they can arrange nodes using a more popular hierarchical organization. In a hierarchical organizational pattern, nodes are organized in a general to specific manner which allows the reader to traverse the nodes to progressively more specific topics (Mohageg, 1992).

Mohageg (1992) explains that relational links, on the other hand, link nodes using either reader- or author-determined dimensions, with no attention to an organized node location system. Currently, there exists no universal automated method for establishing relational links; most relational links are determined according to relationships of interest to the author or the reader. Most often links are established by the author, although some hypertext

systems allow for reader configurability (Mohageg, 1992). Conklin (1987) reports that relational linking is advocated as the essence of hypertext environments because most relational linking is relevant to task performance and flexibility (Mohageg, 1992).

Readers' Models of Text Representation for Print Text and Hypertext

As Dillon (1991) states, "hypertext is often described as a liberating technology, freeing readers and authors from the constraints of 'linear' paper document formats" (p.913). Dillon (1991) contends, however, that there is little documented evidence to support the notion that readers are limited by the linear format of printed text or that readers read printed text in a linear, start-to finish fashion. To support his argument, he cites reader interactions when reading a newspaper or book. Reader expectations for the format and content for each document type determine how the reader will interact with the document. For example, readers may skim the headlines of the first section of a newspaper before focusing on the story or editorial of interest; or readers may use the table of contents or index of a book to identify the sections most relevant at the moment, turn to that section of the book, and scan the graphics, captions, charts, diagrams, headings, and key words before engaging in active reading of the content, perhaps using the glossary or diagrams to support meaning-making during the active reading activity.

The work of Kintsch and van Dijk (1978) demonstrates that readers acquire mental representations, better known as schemata or superstructures,

for organizing the global meaning (or gist) of a text based on experience with text types using canonical text structures. Therefore, what is known about mental representation for discourse can inform hypertext and hypermedia design with the intention of optimum text comprehensibility.

According to Dillon (1991), previous studies of electronic journal possibilities identified limited structure, poor image quality and restricted manipulation facilities as constraints for user acceptance of hypertext systems. Research by Gould, Alfaro, Barnes, Finn, Grischowsky and Minuto (1987) demonstrated that reading from computer screens is between 20 to 30 percent slower than reading from printed text because screens tend to have a poorer image quality compared to paper texts (Dillon, 1991). According to Haas and Hayes (1985) there is also evidence that the size of the screen may account for some of the differences in reading time between printed text and electronic text (Reinking, 1988). Moreover, "much work in this area of electronic text has shown that when text is presented on-screen many of the findings from the paper domain cease to hold" (Dillon, 1991, p.919).

In an attempt to identify the ways that hypertext systems could support formats that are not possible in static print formats, Dillon (1991) undertook experimental work to identify the extent to which readers had an internalized superstructural mental representation of a typical academic article and examined how this mental representation might be affected by the screen presentation in a hypertext environment. He conducted two separate but

related experiments. The first examined whether readers were able to use acquired schemata for text structure to form whole articles out of isolated chunks of printed text. For comparative purposes, the second study used a computer screen as well as a paper presentation condition. Subjects were professional investigators experienced in the reading of academic research.

In the first study, for each academic field, two articles, not previously read by the 12 subjects were chosen from the same journal. The articles were approximately matched according to conformity to the style of an experimental report, length and number of paragraphs, and existing figures and tables. The articles were cut up so that every second paragraph was removed, where possible, with adjustments made to ensure comparability between texts. Every second table and figure, as well, was removed from each text. As an aid to physical manipulation, the selected paragraphs, headings, tables and figures were pasted on individual cards (Dillon,1991).

Dillon (1991) used a repeated measures design which is an experimental design where the same experimental group of subjects is exposed to more than one treatment. Each subject was asked to assemble both texts, one with headings and one without headings. By counterbalancing the order of the texts and the presence or absence of heading, he ensured that any systematic order effects would be avoided. The experiment was run with each individual subject in an experimental room where the subject, as quickly as possible, assembled in order of sequence a randomly ordered text and then, in another

area of the room, wrote a brief summary of what the s/he thought the article was about. This exercise was then repeated with the second printed text.

In analyzing the results of this first experiment, Dillon (1991) looked at accuracy of placement, speed of task performance, error types and awareness of text content. In terms of accuracy, Dillon (1991) found that no subject showed a high degree of absolute accuracy but that all subjects were clearly imposing a structure on each text in the form of Introduction/Method/ Results/Discussion - a form familiar to professional researchers. As well, Dillon (1991) found no significant difference when assessing the effects of headings using a related samples t-test. Based on the analysis of this first experimental data, Dillon (1991) concluded that readers can predict the location of isolated paragraphs in their correct general sections with high levels of accuracy.

As to speed of task performance, Dillon (1991) found that, estimated in number of seconds, each of the recorded times to complete the "no headings" condition was slightly faster than the recorded times in the "headings present" condition. This was an expected difference, however, because the "headings present" condition always involved slightly more pieces of text than the "no headings" condition (Dillon,1991).

In examining the error types, Dillon (1991) found three basic types of errors in data collected: the placement of secondary headings which was the most obvious problem; the placement of figures and tables; and the distinction

between Introduction and Discussion sections for paragraph placement. Dillon (1991) concluded that, because primary headings are relatively standard in academic articles, they were easily placed; secondary headings, however, reflect the author's determination of the section's content and are thus unique to the article, making them harder to place with accuracy. Figures and tables also were problematic in terms of absolute accuracy placement but they were generally placed in the correct section. Confusion between the Introduction and Discussion paragraphs was common. Dillon (1991) describes this as understandable because both Introduction and Discussion sections contain general text with reference to other related work which is a form not typical of the Results and Methods sections. In other words, the subjects in the experiment more easily identified isolated paragraphs as belonging to either Introduction or Discussion sections; however, they less easily distinguished between the two sections as to placement of the paragraphs (Dillon,1991).

Upon completion of each condition, each subject was required to write a brief summary of the content of each text. It is interesting to note that ten of the twelve subjects reported they had not read the text for comprehension and therefore had little memory for the text and could not write much (Dillon, 1991). Yet, all subjects were able to report the subject matter of the text accurately, determine the text was an experimental paper, identify the design or analysis and give its broad aims. Nonetheless, the written summaries were mostly a listing of key words or short phrases without a grasp of the argument of the text demonstrating that, indeed, the subjects had not read

for comprehension (Dillon, 1991). However, Dillon (1991) was successful in clearly demonstrating that experienced readers do possess a schemata for a text's structure which allows the reader to predict the location of paragraphs within the text accurately.

In the second experiment, Dillon's (1992) aim was to determine if the ability of readers to use their mental representation of text structure to predict the location of information was transferable to information within an on-screen text environment. The eight subjects engaged in this second experiment were familiar with Apple Macintosh computers and were experienced in using academic journals. The criteria for journal article selection and modification were similar to the first experiment except that no figures, tables or headings were used. Twenty paragraphs from each text were presented in random order which was consistent with the presentation in the first experiment. Dillon (1991) again employed a repeated measures design. This time, he counterbalanced the text and the order of presentation (paper presentation and screen presentation) to avoid systematic ordering effects (Dillon,1991).

Subjects were given time to become familiar with both the task, using sample texts, and with the HyperCard software on the Apple Macintosh Plus computer. Paragraphs in the hypertext condition were presented as black text on a white background. In this condition, the number of each paragraph was visible in the top right corner of the screen and a "button" was situated in

the lower centre screen. Subjects clicked on the "button" using a mouse to access the next page. After reading the first series of paragraphs, each subject identified, as quickly as possible, the probable location of each paragraph in relation to the major sections of Introduction, Method, Results and Discussion by writing I, M, R, or D on the answer sheet provided. There was a rest period of about two minutes before engaging in the paper condition trial (Dillon, 1991).

In the paper condition, paragraphs were presented on twenty sheets of paper printed from the HyperCard stack and stapled at the top left corner. They contained identical information to the paragraphs on screen and were of similar size to the screen. The only difference between the screen and paper conditions was the omitted "button" in the paper condition. In using the paper condition, subjects followed the same directions as presented in the hypertext trial (Dillon, 1991).

Dillon (1991) examined the results of this second experiment in terms of speed, accuracy and error types. He found the mean performance time, measured in seconds, to be faster in the paper-presented text condition than in the screen-presented text. This finding concurs with Gould, Alfaro, Barnes, Finn, Grischowsky and Minuto's (1987) research which demonstrated reading from print text was 20 to 30% faster than reading from screen text. When it came to accuracy, however, the mean number of errors per subject was similar for both paper and screen conditions and overall accuracy levels were

similar to those for the first experiment. Similarly, Dillon's (1991) analysis of error types indicated that the subjects had the greatest difficulty in distinguishing between the Introduction and Discussion sections with an error margin of 40%. Difficulty with Results-Discussion distinctions fell in the 30% range. Seventeen percent of the errors were related to distinguishing between the Method and Discussion sections (Dillon,1991).

The results of these two experiments led Dillon (1991) to concur with earlier findings demonstrated by Walter Kintsch (1988, 1994) and Kintsch & van Dijk (1978). Readers "experienced in the use of a certain text type possess a superstructure or model of that text which enables them to predict with high levels of accuracy where information is located" (Dillon, 1991, p.922). Dillon (1991) points to the high degree of accuracy (80% rate) shown by all subjects in rapid scanning of available text and deducing the most likely placement of paragraphs. Moreover, the findings of the second experiment clearly demonstrated that this mental representation of text held true for on-screen text (Dillon,1991).

Dillon (1991) contends that, given this embedded mental representation for text held by experienced readers, the broad structure of print versions of text should be retained in hypertext construction in order to support the reader's ability to navigate in hypertext environments. To support this conclusion, he cites Edwards and Hardman (1989) who report that navigation is a major problem for hypertext users. According to Dillon (1991):

> Experienced readers of this [academic] text type know its broad structure, where particular details will be found and how different sections relate to each other. Rendering such knowledge redundant in some misguided quest for new ["unique and innovative electronic"] forms seems less a liberation than an abuse of technological advancement and should be avoided (p. 923).

Orientation - Disorientation in Hypertext and Hypermedia Environments

With the absence of any kind of lexical or linear ordering in hypertext and hypermedia environments, the potential exists for two very different outcomes when using electronic text in either environment. On the one hand, non-linear environments may serve to deepen a reader's understanding of the concepts embedded in the electronic text by offering multiple levels of exploration of specific and related concepts, forcing the reader into more active information processing in ways that link up with the reader's prior knowledge (Beishuizen, Stoutjesdijk, & Van Putten, 1994). On the other hand, the potential for user disorientation is a major concern with electronic texts using highly flexible and complex network structures (Byles, 1988; Conklin,1987; Edwards & Hardman,1989; Kuhn & Steitz,1989; Jin & Reeves, 1992). Therefore, a second very different outcome relates to the cognitive load placed on the novice user of hypertext and hypermedia (Beishuizen, Stoutjesdijk, & Van Putten, 1994; Jih & Reeves,1992) especially in light of Kintsch and van Dijk's (1978) explanation of the working memory and the capacity of the short-term memory buffer for processing chunks of information. Novice users of hypertext and hypermedia electronic texts, navigating through multilevel content in a largely unrestrained exploration "may become confused and lose track of what is going on, what

they can do and /or where they are located in the program" (Jin & Reeves, 1992, p. 40). The abundance of options which increase the cognitive load places the user at high risk of confusion and disorientation in hypertext and hypermedia environments and limits the learner from benefiting fully from the learning opportunities offered in these environments (Jin & Reeves, 1992).

According to Beishuizen, Stoutjesdijk and Van Putten (1994), to avoid disorientation, novice users of hypertext and hypermedia will need the author's suggestions for following a reading order; they will need some other content structuring or strategic clues for establishing and using criteria for selection and for determining their path through the complex electronic environment.

Valdez, Chignell and Glenn (1988) identify two general categories in providing a solution to the problem of disorientation in hypermedia. One category includes maps or browsers which can be created to allow the reader to determine his/her location within the overall network or regions of the hypermedia environment. The other category involves the tags, markers or milestones that "represent familiar locations, much as lighthouse signals location in the middle of a foggy night" (p. 318).

Jin and Reeves (1992) emphasize that literate people do not become easily disoriented in print text despite the variety of texts they may read. They argue, however, that the structure of screen displays of highly interactive

electronic texts are different from that of print text. Readers in hypertext and hypermedia environments are confronted with unique navigation aids embedded in the text and, therefore, considerable learning is required of novice users to enable them to use these aids in ways that will overcome navigational difficulties. Moreover, in an 1987 study of computer-mediated text, Kunz, Schott, and Hovekamp (1987) found that users who received training in the use of computer-mediated text were able to read faster and comprehend more information than subjects who received no training (Reinking, 1988).

Chignell and Valdez (199-) conducted a study at the University of Toronto, which focused on comparisons between printed and electronic text with particular attention on the navigational strategies used by readers for hypertext and for printed books. Their findings indicate that readers used considerable non-linear behaviour with printed books and used linear navigation in hypertext. According to Chignell and Valdez (199-), these findings suggest that "there may not be as sharp a difference between books and electronic text as has previously been believed" (p.18). Using their classification of navigational tools as either "booklike" or "hypertext like", Chignell and Valdez (199-) observed a 60% (booklike) to 40% (hypertext like) difference of frequency use of navigation functions across all three of the study's treatment conditions. When they ran a follow-up study at the University of Southern California, Chignell and Valdez (199-) found the same pattern of navigational behaviour with booklike navigational functions being used more frequently.

Another finding in the Chignell and Valdez (199-) study was that "next page was one of the fastest selected actions, while hypertext links were generally selected [at a] considerably slower [rate]" (p.19). This finding suggests that readers bring a "fairly stable navigation model" to the reading task in electronic environments and that "this navigation model has a strong linear component to it even when the documentation is presented as hypertext" (p.19). These findings support Dillon's (1991) study of the mental representation of text which showed that readers bring a superstructure or model of text to the reading task as previously demonstrated by Kintsch and van Dijk (1978) and that this mental representation of text holds true for on-screen text.

According to Chignell and Valdez (199-), their investigation on navigational strategies suggests that hypertext design should "include rather than preclude booklike navigation (e.g., the table of contents is particularly important)" (p.24) and that "hypertext authoring requires many of the skills and tools that are currently employed in authoring printed text" (p.24). This recommendation parallels Dillon's (1991) contention that the broad structures of printed text should be retained to support readers in their use of navigational functions in hypertext environment to minimize disorientation in hypertext environments.

Jin and Reeves (1992) present the following factors as contributors to learning outcomes in hypertext and hypermedia environments: (1) individual

learner differences related to learning styles and prior knowledge, (2) cognitive loading related to the instructional content, the structure of the program and the response strategies available, and (3) an internalized mental model which dictates a user's expectations about the effects of actions such as navigation, planning of actions and interpretation of feedback.

Zakaluk (1985) demonstrated that both reader "inside-the head" factors and text "outside-the-head' factors must be considered if a text is to be reader-friendly. It appears from the discussion of the electronic text orientation/disorientation issue that this holds true for hypertext and hypermedia texts as well.

The Problems Associated with Studying the Potential of Hypermedia for Text Comprehensibility

The study of comprehension in hypermedia contexts poses a number of problems (Leu, Gallo & Hillinger, 1995). One is the definition of comprehension itself when conducting comparison studies of comprehension using printed text to comprehension using hypermedia (Leu et al, 1995). Beginning at the same point, two readers, one in printed text and the other in hypermedia environment, will likely have two very different experiences related to: the information encountered, the sequence in which it is encountered and the comprehension aids available because information and media links are almost limitless in true hypermedia environments (Leu et al, 1995).

Another problem is the lack of theoretical precision with which electronic environments have been described in previous studies. This makes the task of interpreting studies (Leu et al, 1995) problematic when trying to compare the exact nature of the electronic environments used in the studies.

Because hypermedia texts run along an extensive-intensive continuum (Leu et al, 1995), this also poses a challenge. A pure hypertext or hypermedia environment is the optimal example of an extensive environment where initial text is the starting point for constructing meaning. A myriad of links lead away from the initial text to links of other, diverse topics, offering each reader the option to follow a unique path and read a uniquely varied set of topics. Extensive hypertext and hypermedia environments broaden the range of links and permit readers to pursue various topics or issues in an extensive exploration of a broad area of information (Leu et al, 1995).

Previous studies have also not yet evaluated the way in which readers interact with the supportive elements within complex electronic texts (Leu et al, 1995). For example, which supportive element is used by which reader in which location is a question of process which is central to the issue of developing more comprehensible texts (Leu et al, 1995). Other issues which have as yet to be explored are those related to individual differences and their effect on the use of the various supportive elements in the hypermedia environments (Leu et al, 1995).

Another challenge is the currently small number of studies on reading comprehension for electronic text (Leu et al, 1995). According to Leu (in press), Kamil and Lane (in press) report that during the period of 1990-1995, only twelve out of 437 investigations concerning literacy technology have appeared in the four major journals of reading and writing research. Consequently, the number of investigations regarding text comprehensibility within electronic environments is difficult to find. Only a few studies such as the following: Reinking (1988), Mulcahy-Ernt and Collins (1993), and Higgins and Boone (1992) have presented empirical data on reading comprehension using electronic forms of text presentation (Leu et al, 1995). Existing studies of comprehension using electronic text, however, appear to have occurred in limited, electronic environments (Leu et al, 1995). According to Leu and his colleagues, most of the work that has been done is limited in scope. These limitations make comparisons of comprehension in hypermedia environments difficult.

Nonetheless, these studies can be useful in informing this integrative study and, consequently, the respective Reinking (1988) and Higgins and Boone (1992) studies of comprehension in hypertext and hypermedia have been selected for more intensive analysis and discussion. The discussion of these earlier studies is followed by an overview of the design elements found in later studies to be most supportive in hypertext/hypermedia environments. These studies are Anderson-Inman and Horney (1993), Anderson-Inman, Horney, Chen and Lewin (1994), Horney and Anderson-Inman (1994, 1995);

Horney, Anderson-Inman and Chen (1995); and Anderson-Inman and Horney (in press); and the Leu, Hillinger, Loseby, Balcom, Dinkin, Eckels, Johnson, Mathews, and Raegler (in press) study. The Leu, Gallo, and Hillinger (1995) study is examined in depth because it specifically investigated and presents empirical data on the issue of elements in hypermedia design which have the potential to make electronic text "considerate" text.

Studies on Reading Comprehension Within Electronic Text Environments

The Reinking (1988) study

Leu and his colleagues (1995) cite the Reinking (1988) study as one of the best studies to date of reading comprehension within an intensive hypertext environment. Reinking's (1988) investigation had three objectives: (1) to replicate his earlier finding that comprehension increases when readers' options for obtaining information from text are controlled or expanded using computer-mediated texts; (2) to discover if the type of textual presentation affected readers' preferences, reading time and estimations of their own learning; and (3) to find out if the factors of reader preferences, estimation of learning and reading time contribute to comprehension differences when textual presentation is varied.

The subjects in Reinking's (1988) study were a heterogeneous group of thirty-three, grade 5 and 6 students in an urban elementary school. From the pre-study data collected about the subjects, Reinking (1988) reasonably

assumed that the subjects were proficient in using the Apple IIe computers employed in the study; and because of their extensive familiarity with computers, the performance of the students on the computer-based tasks would not be greatly influenced by the novelty of using computers.

The materials used in this study were adapted from the Reinking and Schreiner (1985) study. Four of the six passages used in the earlier study were used for treatment conditions in the Reinking (1988) study. The remaining two passages were used as training selections to teach the subjects how to interact with the computer versions of the passages as well as to provide them with the opportunity to familiarize themselves with selection options during the reading activity. The four 140-180 word passages, each followed by a 6-item multiple-choice comprehension test, were presented to the subjects under four treatment conditions:

1) the off-line condition: passages on printed pages with no options for assistance available;
2) text-only condition: passages on computer with no options for assistance available;
3) select-options condition: passages on the computer with choice of several options for assistance with comprehension;
4) all-options condition: passages on the computer with the requirement that all options for assistance be viewed after reading the passages and before continuing with the process (Reinking, 1988).

The study used a two-factor, repeated-measures design to test for differences across the treatment conditions on the following four dependent measures: comprehension score, reading time, passage preference and estimation of learning. All subjects read one passage under each of the four treatment conditions. Subjects were unaware that their performance was being timed by means of a subroutine which was activated when they pressed a key to either access the text or to continue after reading the passages. Two questions were displayed on the screen after a subject had finished reading a passage. The first question asked how much the subject liked the passage and the second question asked the subject to estimate how much he or she had learned from the passage. Subjects indicated their responses by selecting a number from 1 to 5 (ranging 'from not at all/nothing' to 'very much'). Subjects were not required to achieve a criterion score for comprehension of a passage before continuing the process (Reinking, 1988).

As to options for assistance in the select-options condition, these were: a request for an easier, less technical version of the passage; a definition of difficult words or phrases; important background information; and the main idea of each paragraph in the passage. In the all-options conditions, subjects were required to view all the information in all the options before choosing to review any of them. In both of these options conditions, subjects could view the information in each of the options for as long as they wanted before attempting the six-item multiple-choice comprehension test which followed each

of the passages (Reinking, 1988).

Reinking (1988) analyzed the data in four steps:

(1) a repeated-measures analysis of variance (ANOVA) to test for differences between means on the comprehension tests under the four treatment conditions;

(2) ANOVA using three separate designs to test for differences between means for reading time, passage preference and estimation of learning;

(3) regression procedures to test for a relation between identified factors and comprehension scores;

(4) regression weights from the third analysis to adjust scores on the comprehension test and to make a comparison of these results with the results of the original ANOVA using unadjusted scores.

In terms of comprehension, Reinking (1988) found that comprehension scores were higher in the computer treatment conditions which provided either the optional or mandatory assistance with no statistical difference in comprehension between these two conditions. As well, he found no statistical difference in comprehension between the unassisted treatment conditions presented on printed pages and on the computer. Good readers outperformed poor readers across all treatment conditions (Reinking, 1988).

The analysis of reading time showed that reading time was longer in the

computer treatment conditions providing assistance. Moreover, reading time was longer in the treatment condition which required subjects to view all options than in the select-options condition. These differences in reading time were true across levels of reading ability and there was no statistical difference in reading time between good and poor readers (Reinking, 1988).

As to passage preference and estimation of learning, Reinking's results demonstrated no statistically significant main effect for the treatment conditions nor for reading ability. As well, he found no significant interaction effect. There was no variance in the subjects' passage preferences by treatment conditions or by ability level and no variance in the subjects' estimation of learning by treatment conditions or by ability level. Reinking also found, at a .05 level of significance, that reading time and comprehension scores were unrelated. He also found identical patterns of differences in comprehension between the adjusted and unadjusted comprehension scores. Thus, comprehension differences could not be accounted for by variations in reading time, preference for text or estimation of learning (Reinking, 1988).

Overall, the results of the Reinking study of computer-mediated text and comprehension differences supports his earlier finding that when a computer is used to control a reader's processing of text or to expand the reader's options for acquiring information from text, comprehension increases. The results of this study also supports previous findings that reading time is longer for computer-mediated text than reading time for printed text but with one

condition: the reading time was longer for computer-displayed text only when readers had options for assistance and not when text was displayed on computer without options for assistance. As well, Reinking did not find evidence that the mode of text presentation or reading ability had an effect on readers' passage preference or estimation of learning. Reinking states, however, that further research which controls for factors such as narrative vs expository text types, length of text and the readers' experience with computers, must be undertaken to clarify this finding.

Reinking (1988) points out that increased reading time, by itself, did not account for increases in comprehension when using computer-mediated text with options for assistance. He states that deeper or more efficient cognitive processing is more likely to be the source of the increases in comprehension and he points to other studies (Daniel & Reinking, 1987; Duchastel, 1986; Reinking, 1987; Reinking & Schreiner, 1985) to support this interpretation.

Reinking notes that his study raises a number of questions for further research. To what degree do each of the options for assistance contribute to increases in comprehension? How does computer assistance affect the time devoted to processing various aspects of text? How does reader control as opposed to computer control relate to the comprehension of computer-mediated text? Reinking also points out that when text is displayed on computer screens in a similar manner to its presentation in static print, no consistent differences in reading comprehension have been found. He

emphasizes, however, that when electronic text is used purposefully to foster more active processing of text, computers may increase comprehension during independent reading. Anderson-Inman and Horney (in press) also emphasize this point that when students approach seriously the task of reading computer supported text and purposefully use the self-select options to assist their understanding, they demonstrate superior comprehension of the texts they read. One question that might be added is, to what degree does students' "know how" in regard to using computer-mediated texts impact on overall comprehension of text?

While the Reinking (1988) study makes a valuable contribution to our growing understanding of the role of computers in enhancing comprehension, Leu and his colleagues (1995) note limitations in the findings in terms of studying the potential of electronic environments for developing more considerate text: (1) the rewritten passage, as one of the support options, may have been a more considerate text raising the possibility that comprehension was enhanced by the text itself rather than because the computer created a more considerate environment for comprehension (Leu et al, 1995); (2) there is no data given describing which support options were accessed by students or how often they were accessed (Leu et al, 1995); (3) the electronic environment used in the study had limited capabilities for providing support options - the several support options moved only one level beyond the initial text and they were textual in nature with several monochromatic graphics (Leu et al, 1995). In addition, the color, sound,

animation, and movement of graphic elements, features of the hypermedia environment, are not available in hypertext environments (Leu et al,1995). Higgins and Boone (1992) developed more complex technology to support computer learning.

The Higgins and Boone Study

Higgins and Boone (1992) adapted a Canadian history text within an intensive hypermedia environment to study the effect of hypermedia study guides on three sub-groups of forty-nine, grade nine students. The subgroups consisted of remedial students, regular students and students diagnosed as having learning disabilities. The hypermedia authoring system used by Higgins and Boone to adapt the print text permitted them to use three hypermedia functions to a third level support option:

(1) the note function containing either a graphic, a text or a combination of both;
(2) the replacement function which, when activated, replaced a selected text in the first level window with a clarifying segment of text or related graphic;
(3) the inquiry function which controlled students' movement through interspersed multiple-choice questions; before the students could move on to the next page of the study guide, the correct answer was reinforced by text and graphics directly related to the question; if the answer was incorrect, the student was rerouted to the

appropriate segment of text and prompted to try the question again after reading the text (Higgins and Boone 1992).

There were nine to thirteen screens in the hypermedia study guides, each containing eight multiple-choice questions presented on the same screen as the text to which they related. The screens consisted of either text alone with word or graphic enhancements; text and multiple-choice questions with word or graphic enhancements; or, a graphic alone with word enhancements. The enhancements offered definitions, graphics, and clarifications of vocabulary.

Higgins and Boone (1992) found, for all students combined, that the hypermedia study guide method was more effective than the lecture only or the combined lecture/hypermedia study guide methods. When they broke the results down to educational sub-groups, however, they found the hypermedia study guide to be only slightly more advantageous to the students with learning disabilities; and hypermedia study guide to be most effective for the remedial students because of the reinforcement the guide provided. For regular students, Higgins and Boone (1992) found no significant gains. These findings were similar to a 1990 Higgins and Boone study which demonstrated that regular students performed equally well using any of the three conditions: the lecture alone, the lecture/hypertext combined or the hypertext alone methods. Their findings are also similar to the results of a study by Mulcahy-Ernt and Collins (1993) which used an intensive hypertext passage from a science text and found no significant advantage in terms of increases in comprehension

among college students using the hypertext passage (Leu et al., 1995).

The question is raised, however, as to whether students were taught strategic knowledge for using dynamic, complex electronic environments prior to the hypertext/hypermedia experiments. According to Leu, Gallo and Hillinger (1995), the possibility exists that comprehension gains may have been limited in previous studies using complex electronic environments, because students may not have acquired sufficient strategic knowledge to exploit fully all the options available in hypertext and hypermedia environments. It may be that readers may need higher levels of strategic knowledge within complex electronic environments than is needed when using printed text (Leu, 1995; Reinking & Bridwell-Bowles, 1991). Not only do students need declarative and procedural knowledge (Paris, Lipson & Wixson, 1994), which is knowing the what and how of strategies to be used for comprehension, but they also need conditional knowledge: knowing when and why a particular strategy needs to be used.

The Higgins and Boone (1992) study focused on whether the hypermedia environment enhanced greater comprehension but did not evaluate the way the subjects used the various supportive elements available to them nor did it address the effect of individual differences on the use of the support options (Leu et al, 1995). As well, even though Higgins and Boone (1992) describe their study as being within a hypermedia environment, the features most characteristic of hypermedia such as audio, speech, video, animation, do not appear to have been part of the enhancements used in the study.

Nevertheless, interest has grown in the effects of using hypermedia to enhance the comprehensibility of low-achievers.

The Anderson-Inman, Horney, Chen, and Lewin (1993, 1994, 1995) studies

Recent work by Anderson-Inman and Horney (1993), Anderson-Inman, Horney, Chen and Lewin (1994), Horney and Anderson-Inman (1994, 1995) and Horney, Anderson-Inman and Chen (1995) has investigated hypertext literacy for "at-risk readers". "At-risk readers" are described as readers with severe literacy deficits for a variety of reasons including, but not limited to, hearing impairment, visual impairment, learning disability, cognitive or physical disability, and limited experience with the English language (Anderson-Inman and Horney, in press). According to Anderson-Inman and Horney, supporting the development of literacy skills for these at-risk readers has to go beyond teaching them basic reading and writing skills. Literacy development for these students must focus more on supporting them in the use of reading and writing skills to learn new information. Hence, Anderson-Inman and her colleagues (1993, 1994, 1995) at the University of Oregon have been developing what they call "supported text" which is "text that has been electronically enhanced in ways that are designed to improve and facilitate the reading experience" (Anderson-Inman & Horney, in press, p.6) and thereby, to promote comprehension. The supported text was developed through Anderson-Inman and her colleagues' work in two projects, the ElectroText Project (Anderson-Inman, Horney, Chen and Lewin, 1994; Horney & Anderson-Inman, 1994) and Project LITERACY (Horney & Anderson-Inman, 1995), a project developed for

readers with hearing impairments.

In reviewing transcripts of electronic monitoring of "at-risk reader" interactions with supported text, Horney and Anderson-Inman (1994) found six distinctly different interaction patterns:

(1) skimming - moving through the text too quickly for reading and studying;

(2) checking - checking things out as they moved through the text but not reading or responding;

(3) reading - reading the text but with little or no use of support options;

(4) responding - reading the text and using one or more of the support options, be they interactive or writing;

(5) studying - reading the text and using resources in an integrated manner;

(6) reviewing - moving through the text which had already been read and rereading pages and/or revisiting resources (Anderson-Inman & Horney, in press).

Horney and Anderson-Inman (1994) conducted a detailed analysis of these at-risk reader interactions with supported text and concluded that the 'studying' interaction was used more frequently than other interactions; readers in supported text environments used different interactions at different times; readers in supported text environments were different in terms of when

in the reading process they engaged with various interactions; and, reader interactions appeared to vary depending on the resources available and the experience each reader had with electronic reading environments (Anderson-Inman & Horney, in press).

As a result of their work, Anderson-Inman and her colleagues, (1993, 1994, 1995) have reached conclusions concerning the essential components of supported text for "at-risk readers" (Anderson-Inman and Horney, in press). These essential components of supported text are:

(1) the presentation of text - the main body of the text containing the author's message and the system in which the text is presented, in this case, the electronic environment. In hypertext and hypermedia environments, the presentation of the text is such that it is not possible to duplicate it in print-based text;

(2) keys - parts of text identified as "keys, such as individual words, phrases, sentences, paragraphs or sections of text, which readers might find problematic;

(3) resources that readers can access to help them understand the text marked as keys.

Anderson-Inman and Horney (in press) have categorized these resources for supported text into eight categories:

(1) translational resources which substitute for the key but do not explain it; they translate segments of text into another form of expression such

as American Sign Language, for example, or from written to spoken language;

(2) illustrative resources which provide examples, comparisons, illustrations and visualizations;

(3) summarizing resources that give overviews, summaries, outlines and/or abbreviations of the information in the initial text to illustrate the structure of the text;

(4) instructional resources that provide a range of resources such as directions and reminders to focus reader attention; questions to help readers monitor their comprehension; mentors accessed via telecommunications software to provide on-line assistance; activities to practice skills, and to construct meaning; instructional presentations providing computer-assisted instruction regarding certain concepts, vocabulary and facts; and intelligent tutoring systems (ITS) which monitor reader activities, ask specific questions and make appropriate recommendations to the reader;

(5) collaborative resources which provide tools to support collaboration among readers either via synchronous on-line discussions or asynchronous discussions via network software such as the World Wide Web and Listservs;

(6) supplementary resources (multimedia) that provide information related to the initial text and take the form of explanations, side bars, enrichment, historical references, and references to other parts of the text;

(7) notational resources that provide writing or drawing tools to be used by readers as they read and study the text; and

(8) generalized resources that provide databases, encyclopedias, dictionaries, reference lists, CD-ROMS, web sites, which may support any

number of texts rather than just one (Anderson-Inman and Horney, in press).

The Leu, Hillinger, Loseby, Balcom, Dinkin, Eckels, Johnson, Mathews and Raegler (in press) Study

Another study which can inform this integrative study of text comprehensibility in dynamic electronic environments is the Leu, Hillinger, Loseby, Balcom, Dinkin, Eckels, Johnson, Mathews and Raegler study (in press) of classroom-centered design principles for the design of multimedia software responsive to both teacher and student needs. In this study, Leu and his colleagues (in press) used an alternative approach to designing responsive electronic text by first identifying teachers' instructional needs and then investigating the design principles which emerged when teachers, instead of technical experts, made the final decisions about software design.

The project took place in an urban K-6 elementary school which had a diverse population and which was well known for its inclusive programming. The school had older technology and none of the teachers had any familiarity with multimedia technology. Nonetheless, the 6 grade six teachers agreed to participate in the project. Although each teacher implemented the social studies curriculum in different ways, all the teachers regularly developed thematically organized units of study by integrating social studies, language arts and literature selections. It was the expectation of each teacher that the students must explore a variety of information resources, construct their own meaning from the information and communicate that meaning to their peers

(Leu et al, in press) as part of their classroom and text-based learning journey.

There were three phases to the project process. The first phase focused on the initial software development process where it was determined that social studies would be the curricular focus for software development, teachers would collaborate to design the software they wanted for their classroom, the multimedia developer would develop the software according to teacher specifications, and teachers would evaluate and make revisions to the software over the course of the year to meet their instructional needs (Leu et al, in press). During this phase, teachers made decisions about the basic interface; they developed a list of key concepts in several categories for each of the civilizations selected for study; for each civilization, they identified three myths to be used as literature selections; and they provided a large set of resources for developing the content information, the literature and the graphics for the software. The second phase involved four revision sessions over the year where teachers had the opportunity to recommend changes. The third phase was the final revision conference which occurred during the summer following the school year and after the completed version of the software was used in two classrooms during the latter part of the school year (Leu et al, in press).

Three design principles evolved as a result of the project:

(1) a clear focus on the curricular content which was integral to the instructional program;

(2) support options that permitted both teachers and students to construct their own meaning from the content information and to communicate that meaning to peers and to their teachers;

(3) features which would allow teachers to monitor student activity within the structure of the program as well as students' understanding of the content (Leu et al, in press).

As to the first design principle, it was important to the teachers in the project that the content of the software match the information that students were required to learn in terms of the social studies curriculum. Consequently, the teachers developed a master list of key concepts important to the instructional program (Leu et al, in press). The second design principle focused on support options which permitted students to construct meaning and to communicate that meaning to other (Leu et al, in press). These features included the following:

(1) an interactive timeline - the main window of the program which contained maps of various time periods, geographical regions, and icons for accessing information about a particular time and location. Navigation occurred by sliding a box in the interactive timeline or by clicking buttons and clicking on the icons accessed a graphic or a video with a text window containing additional information. As well, a button accessed a "student pack" which opened a tool kit to permit students to communicate with others about the information they encountered (Leu et al, in press);

(2) interviews - an icon of a microphone, when clicked, accessed an

interview with a historical or mythical figure pertinent to the era and geographical location displayed on the initial map window. Questions on the bottom of the interview window, when clicked, generated a video response and an overlapping window on the side contained a graphic image of the figure as well as textual information about the figure (Leu et al, in press);

(3) dictionary items - for challenging vocabulary words; clicking on these provided the meaning; a click on a speaker icon provided the pronunciation; and students had the option to construct their own meaning for any word and thus, add vocabulary items to the dictionary. This entry would prompt the word to appear in red to indicate that it contained a vocabulary definition and the student's initials appeared at the bottom of the window (Leu et al, in press);

(4) notepad - a central feature to the program accessed by clicking on the "student pack" button; a writing space to permit meaning-making from the program and to send messages to others about the constructed meaning or discoveries, to write a "sticky" before posting it, to write on the bulletin board, or to write an assignment for the teacher (Leu et al, in press);

(5) publishing on the bulletin board - a feature to permit students to publish their work on the bulletin board for all to read; written work was sent to the bulletin board by clicking on the "publish" button located at the top of the notepad (Leu et al, in press);

(6) the hand-in option - a copy of the student's work could be sent to the teacher by clicking on the "hand-in" button at the top of the notepad (Leu et al, in press);

(7) the read option - users could read email sent to their mailbox by clicking on the "read" button at the top of the notepad (Leu et al, in press);

(8) the send option - clicking on the "send" button at the top of the notepad allowed the student to send an email message to another student (Leu et al, in press);

(9) the sticky option - a post-it note that could be placed on any window to post information anywhere in the program for other students (Leu et al, in press);

(10) the shoot option - permitted readers to add an image to the information they sent to others (Leu et al, in press).

The third design principle was the record keeping feature which permitted teachers to keep track of the students' time, to monitor their comprehension of the material, to monitor the information they shared with their peers and to send them email messages about their work.

The principal focus of the Leu et al (in press) study was to investigate which features teachers would choose to incorporate in the design of educational software if given the opportunity to so. They found that the design features teacher-subjects incorporated in the software closely matched the teaching and learning reality in their classrooms. Based on this observation, they conclude that software publishers must be very attentive to the specific content needs of teachers if multimedia software is to be fully integrated into the curriculum. In other words, common design principles of classroom

instruction must be incorporated into software design so that the software can be consistent with and easily become part of classroom instructional programs:

> Design principles must be developed inductively out of the nature of teacher's instructional needs, not imposed upon teachers by technical experts unfamiliar with the reality of classroom contexts. (Leu et al, in press)

The Leu, Gallo and Hillinger (1995) Study of Reading Comprehension in Hypermedia

This particular study is central to this investigation because it is the study which most clearly details the essentials to comprehension and to designing considerate text within the hypermedia context.

The study. Leu, Gallo and Hillinger (1995), studied the potential of hypermedia for developing more considerate, expository texts by comparing comprehension of a passage from a social studies textbook with comprehension of the same passage converted into hypermedia. Two other dimensions were studied: the frequency with which students used the available interactive hypermedia features, and how readers of different ability levels compared in their use of these interactive features. Leu et al (1995) based their study on the premise that hypermedia environments may possibly provide the ultimate in texts that are 'considerate' [and comprehensible] to individual readers because hypermedia contexts can be designed to "continually respond to the unique needs of each reader to support ongoing comprehension" (p.10).

For the purpose of comparing comprehension in the hypermedia environment to comprehension in static, printed text, Leu and his colleagues determined that the paths that students could explore in the hypermedia text had to be limited so that students always returned to the original text after exploring multi-level information. In this way, the available information links would support the goal of comprehending a specific text. As well, Leu and his colleagues (1995) had to contend with another design issue - the potential for disorientation in hypermedia. They circumvented this problem by using "separate, movable, and overlapping windows for each level of support" to help readers "see at any time where they were in relation to the initial text"(p. 25).

Sixty sixth-grade students, twenty-four girls and thirty-six boys, were randomly selected from seven classrooms in a suburban middle school which was recognized as having an ethnically and economically diverse population. Each student was very familiar with the graphic user interface of the Macintosh LCII (13-inch color monitor and sound), the computers used in the study, because they spent up to two hours a week on these computers as part of their instructional program and they spent additional time using the machines for writing reports or for completing other independent projects. Prior to the study, the selected students were provided with training to develop the declarative, procedural and conditional knowledge related to strategy use for intensive hypermedia passages. As well, the students were required to demonstrate their acquisition of these three types of strategic knowledge for

each of the supportive features in the design before beginning the experimental study (Leu et al, 1995).

The task involved reading a passage from a sixth-grade social studies textbook in any of four condition:

(1) the original passage in the textbook - traditional static text;

(2) the original passage on a computer monitor - used to control for any potential effects in the intensive hypermedia condition which might be due to heightened interest from working on a computer;

(3) the original passage on a computer monitor with the addition of the color graphics used in the hypermedia condition but without the interactive capabilities - to control for any potential effects in the intensive hypermedia version which might be due to the additional color graphics commonly found in hypermedia;

(4) the original passage in the intensive hypermedia environment with color graphics and interactive hypermedia options (Leu et al,1995).

The original textbook passage selected for this study (mean-grade level readability score=7.73) was a 577 word passage which fit several criteria: it represented expository text frequently used in classrooms; it appeared at the end of the textbook thus, minimizing the likelihood of having been previously read by the students; it appeared to be 'considerate' according to Armbruster's (1984) criteria for considerate text; and, it discussed topics that were likely to be somewhat unfamiliar to students (Leu et al, 1995). A map

and two end-of-passage review questions were included in the original textbook passage condition. The second treatment condition, the original textbook passage on computer monitor, included the map and the two review questions. The only interactive features built into this condition were the left and right arrows which, when 'clicked', turned the pages forward or backward (Leu et al, 1995).

Leu and his colleagues (1995) describe the third treatment condition as the presentation of the original passage on a computer monitor with the color graphics used in the fourth condition, the intensive hypermedia environment. These color graphics, some of which had accompanying captions, were not used at lower levels to ensure that the treatment condition would remain outside the defining criteria of hypermedia environments. The only interactive features built into this condition were the left and right arrows which, when 'clicked', turned the pages forward or backward (Leu et al, 1995).

The fourth treatment condition, the intensive hypermedia version, "contained the text and map from the textbook passage, several additional color graphics and captions, and access to a number of supportive, interactive features" (Leu et al, p.22) for readers to use in their explorations of the text. A series of eleven screens, each with a map or illustration, constituted the text portion of this treatment condition. Beck et al.'s (1991) two-stage strategy for revision of inconsiderate text guided the development of the interactive features for this version of the passage. Although the original text was not

revised as per Beck et al (1991), decisions about the interactive features were rooted in Anderson and Pearson's (1984) and Just and Carpenter's (1987) theoretical insights of cognitive processing for reading comprehension. As well, Leu et al (1995) developed the content of each interactive feature based on their expectations of the needs of a variety of different readers as they interacted with the text. Consequently, the following interactive features were incorporated in the design of the intensive hypermedia version:

(1) Vocabulary support - clicking on a bold print word in the initial text provided readers with digitized speech pronunciation, a textual definition, additional information about the concept and sometimes a graphic element (Leu et al, 1995);

(2) Extended vocabulary support - clicking on a "more about" button provided readers with additional textual information and frequently with an additional graphic element about a particular concept (Leu et al, 1995);

(3) Decoding support - clicking on any bold print words provided readers with digitized speech pronunciations of the words (Leu et al, 1995);

(4) Inferential support - clicking on a magnifying glass icon labelled Close Up accessed assistance for understanding the meaning of textual units, either at the sentence level or above, which contained particularly dense information. This assistance provided background information, sometimes additional graphic elements and, at two locations, it provided animation with explanations. Close up buttons on the initial map provided illustrations of life in a particular location accompanied by brief textual information describing the scene at that location (Leu et al, 1995);

(5) Comprehension monitoring support - "Check-up" and "End Question" experiences to help readers monitor their own comprehension. Clicking on the check-up icon at the end of the first section allowed readers to engage in an interactive simulation where the reader dragged the names of island groups to locations on a map. A correct placement resulted in a spoken positive comment but an incorrect label placement resulted in a move back to the original placement, in which case the reader could make another try at a correct placement. After reading the second section, readers could try the second check-up which allowed readers to move the names of island formations to an illustration. If the name placement was correct, a spoken positive comment was heard but the label would return to its original placement if the reader placed it incorrectly. A "hint" button was also available to provide additional cues to help readers when they were incorrect in their placements. The two review questions came at the end of the entire passage. A "click for the answer" button provided the answer to each question so readers could compare their answer with the appropriate one (Leu et al, 1995).

Students in the study were randomly assigned to groups of four. Each group of four consisted of one student from each of the four quartiles on the total reading percentile scores obtained from the Metropolitan Achievement Test. Each of these four students was then randomly assigned to one of the reading treatment conditions which resulted in a randomized sample of fifteen students in each of the four treatment groups. The median total reading

percentile scores for each of the groups were not significantly different when compared using the Kruskal-Wallis one-way analysis of variance (Leu et al, 1995).

The students were told that the task required them to read the passage and, after which, to retell all the information they could remember from the reading. An observer recorded the time when each student began reading, the length of the reading time and the time when each indicated s/he had finished reading. After reading the passage, each student completed a free recall task which was taped and later transcribed for analysis (Leu et al, 1995).

The free recall was analyzed in two ways. The first way was a text-based analysis in which Leu and his colleagues (1995) parsed content units from the text and compared these to the parsed content units of the recall data using gist criteria. The scoring decisions of two independent scorers were compared for half of the protocols to establish reliability, and agreement was reached on 90% of the decisions. Discussion and agreement resolved the differences.

The second method of recall analysis was the reader-based analysis in which Leu and his colleagues (1995) parsed units from the reader recalls and compared these units to the information in the text. Again, the scoring decisions of two independent raters were compared for half of the protocols to establish reliability. Agreement was reached on 94% of the decisions and

discussion and agreement resolved the differences (Leu et al, 1995). After the retelling, the students were required to answer three questions on a 10-point Lickert scale related to their interest level for the content of the passage. As well, the readers' interactions within the intensive hypermedia environment were video-taped and a constant-comparative analysis was conducted to develop the following categories of interactions: vocabulary interactions, close-up interactions, check-up interactions, end questions interactions and rereading interactions (Leu et al, 1995).

The results. The results of this study indicated a significant increase in recall - twice as many reader-based and twice as many text-based content units- in the intensive hypermedia condition compared to the recall of reader-based and text-based content units by students who read the original textbook passage. It was also found that students in the intensive hypermedia environment spent significantly more time reading the passage and demonstrated significantly more interest in the passage than did their peers reading the textbook passage (Leu et al, 1995).

Leu and his colleagues conducted several analyses of covariance using the four treatment conditions as the independent variable, the text-based and reader-based recall scores as separate dependent variables and the total reading time and total interest scores as separate and then combined covariates to evaluate the possibilities that the differences in mean recall scores were due to the greater interest and greater time spent (or both) in

reading the intensive hypermedia passage (Leu et al, 1995). The result of these analyses of covariance revealed that:

(1) when both the separate and combined effects of greater total reading time and total interest scores were controlled by treating each as a covariate, the increased recall of both reader-based and text-based content units of intensive hypermedia material was sustained (Leu et al, 1995);

(2) most of the content units recalled by the readers in the intensive hypermedia treatment condition came from the initial text which appeared in the highest level of the intensive hypermedia passage (Leu et al, 1995).

Leu and his colleagues (1995) conducted a frequency and a time analysis on the video-tape data to determine the nature of text interactions within the intensive hypermedia environment. Principally, they wanted to know the differences in frequency and length of time that students used each interaction type; if there was an interaction between reading achievement level and the frequency and length of time spent using the interaction types; and lastly, they wanted to know if students who varied in reading achievement level also varied in the frequency and length of time with which they interacted with the different support options (Leu et al, 1995).

The results of the frequency and the time analyses revealed no significant effect for reading ability level but a significant effect was found for interaction type in terms of frequency. Students in each ability group employed various interaction types with the same overall frequency but used a significantly

greater number of check-up interactions, on average, than any other type of interaction (Leu et al, 1995). There was, however, a significant interaction between type of support feature and ability level. Low ability readers used more close-up interactions, fewer check-up and fewer rereading interactions than readers in the average and high ability levels. Vocabulary and end-question interactions were used with relatively similar frequency among all ability levels. The mean time students spent with support features revealed no significant difference among reading ability levels in the overall time spent interacting with various support features but more of this overall time was spent with rereading and check-up support options and less time was spent in close-up, vocabulary and end-question features (Leu et al, 1995).

Leu and his colleagues (1995) undertook an analysis of rereading and check-up interactions to determine the nature of these experiences. The rereading analysis demonstrated that many, shorter rereadings of the initial text were prompted by the check-up support option and fewer, longer rereadings were prompted by the end-questions support option. The rereadings were fewer and longer, as well, when they were initiated within the initial text. The analysis of interactions with the check-up option indicated that most of the students engaged in check-up interactions; more of the check-up options happened during the first check-up opportunity; and many of the check-up interactions prompted the rereading of the map (Leu et al, 1995).

Comprehension and text interactions in intensive hypermedia. As Leu and his colleagues (1995) indicate, it is possible that gains in comprehension were attributable to the various levels of additional information available in the hypermedia passage. On the other hand, access to various levels of information is characteristic of hypermedia environments and the nature of the Leu, Gallo and Hillinger (1995) study was to determine the potential of intensive hypermedia as considerate text, responsive to the needs of readers as they attempt to comprehend expository passages.

Furthermore, Leu et al (1995) conclude that certain aspects of the study suggest that comprehension gains are more likely due to students' ability to access information at the appropriate moments rather than due to the additional information available at the lower levels of the hypermedia environment. The first aspect is that the scoring of the free recall included only those content units which appeared in the initial text; secondly, the analysis of the content units demonstrated that most of the content units recalled by the readers came from the target passage; thirdly, most of the interactions with support options in the intensive hypermedia environment were with the check-up feature which allowed the students to monitor their comprehension of the initial text rather than to access information not available in the target passage. Fourthly, the use of the check-up feature prompted many rereading experiences with the original text (Leu et al, 1995).

It is important to note, as well, that no easier version of the original text

was available to prompt comprehension gains so it is reasonable to conclude that the significant comprehension gains found in this investigation are more likely to be due to the intensive hypermedia's dynamic ability to respond to individual readers' needs (Leu et al, 1995). This may suggest, in addition, that the strategic knowledge the students acquired during the training sessions is a factor in the increase in comprehension for the hypermedia context. The students were equipped to more fully exploit the supportive context that was available in the hypermedia environment (Leu et al, 1995). Moreover, the design of the hypermedia environment circumvented the navigational problem of potential disorientation. The intensive hypermedia environment designed by Leu and his colleagues ensured that the readers always knew where they were in terms of the meaning and structure of the first-level text, and their use of lower levels of information only served to increase their ability to comprehend the information in the original passage (Leu et al, 1995).

Results of the study also indicated that each student averaged twenty-four separate interactions with the support options available within the intensive hypermedia context. Not only did students use significantly more check-up interactions which frequently prompted rereading of the passage, but students spent significantly more time on check-up and rereading interactions (Leu et al, 1995). Leu et al suggest cautious interpretation of check-up interactions as being the cause of greater comprehension, however, because causal relationship between comprehension gains and time and frequency of use of a particular support options was not the focus of this study. However, the

frequency of use of check-up interactions as an aid to monitoring ongoing comprehension may indicate the usefulness of this particular feature in the development of more comprehensible text (Leu et al, 1995).

Another finding of Leu et al's study was that students of differing ability levels used the supportive elements of the hypermedia passage with approximately the same frequency but there was a significant difference in types of support options accessed. Low achievers tended to use more close-up support features, while average and high achievers gravitated more to the check-up and rereading options. This finding appears to suggest that "intensive hypermedia contains the potential for providing students with the ultimate in considerate texts" (p.51) because of its capability to respond to the unique needs of each reader who actively seeks to construct meaning.

Summary

The findings of existing studies appear to indicate that Kintsch and van Dijk's (1978) theory of comprehension processing and Zakaluk's (1985) 'inside-and-outside-the-head factors' are theories as relevant to texts in dynamic, complex, supportive electronic environments as they are to static printed texts. However, additional factors have to be taken into consideration. Additional 'outside-the-head' factors in hypermedia environments are the extent to which color, sound, speech, graphics, animation, and video are availabie; the number of multi-level supportive structures which can be accessed; the types of supportive elements, such as close-up and check-up features available for

specific hypermedia texts; and the navigational issue of orientation and disorientation in complex multi-level electronic environments.

Additional 'inside-the-head factors' is the strategic knowledge which the reader has internalized. Declarative knowledge, the 'what', procedural knowledge, the 'how', and conditional knowledge, the 'why and when' appear to be factors necessary for optimum comprehensibility of textual material in the hypermedia context. Knowing what strategy to use, how to access it, when and why the strategy should be accessed appear to influence the degree of comprehension gains in the hypermedia environment. The reader's mental representation and prior knowledge of canonical text structures appear to be "inside-the-head" factors that must be considered as factors for designing considerate text in hypertext and hypermedia environments.

Existing studies related to electronic texts, particularly Leu et al's (1995) study, have demonstrated the potential of dynamic electronic environments to enhance comprehension and have pointed to a number of the support options which are most likely to effect comprehension gains. The factors most likely to effect comprehension gains are also those factors which are most likely to render a complex, multi-level electronic text a "considerate" text. These factors are discussed in the following chapter in relation to the theoretical framework established for text comprehensibility.

CHAPTER 4

Data Analysis Using Text Comprehensibility As A Theoretical Framework

> *"...literacy has become a deictic term; its meaning continually changing, dependent upon the technological context in which it occurs" (Leu, 1997, p.62)*

The purpose of this integrative study was to: investigate the existing literature on reading comprehension in electronic environments; analyze the resultant data to determine technology's potential for making texts comprehensible; and discover which factors in electronic text structure enhance text comprehensibility. In essence, the goal was to determine, through a literature review of the research carried out on text comprehensibility within electronic environments, what multilevel support options in hypertext/hypermedia design systems are most supportive of the reader and most likely to render an electronic text comprehensible. This integrative study is grounded in Kintsch and van Dijk's (1978) theory of comprehension processing and Zakaluk's (1985) theory of reader and text factors that influence text comprehensibility. This chapter synthesizes and integrates diverse studies related to research into electronic text into the conceptual framework of Kintsch and van Dijk (1978), Zakaluk (1985) and Zakaluk and Samuels (1988, 1997) to offer new perspectives and insights on text comprehensibility in dynamic electronic environments.

The studies chosen for this integrative study were selected and

organized to present an indepth review of factors to consider when contemplating which technological design features can offer the optimal in text comprehensibility. Within this context, this chapter synthesizes and integrates findings regarding:

(1) readers' models for text representation both in paper-based and hypertext documentation;

(2) orientation/disorientation in hypertext and hypermedia environments;

(3) the role of strategic knowledge in technological environments;

(4) the nature of support features available in these environments; as well as

(5) issues related to individual differences.

Studies of computer-based learning such as those of Becker (1990), Reinking (1988), Reinking and Bridwell-Bowles (1991), Reinking and Watkins (1996), and Tierney, Kieffer, Whalin, Desai, Moss, Harris and Hopper (1997) reviewed in Chapter 3 have demonstrated that computer-based instructional activities are highly motivating. Although a limited number of qualitative and ethnographic studies (Dickson, 1986; McGee, 1989; Riel, 1989) have shown advantages for computer-based activities in the classroom in terms of engagement on task and creating shared interest, Becker (1992), Reinking and Bridwell-Bowles (1991), Reinking and Watkins (1996), and Roblyer, Castine, and King (1988) report that conventional experimental research has, to date, failed to demonstrate that computer-based classroom activities achieve the

technological promise of transforming literacy learning. Moreover, Chignell and Valdez (199-) indicate that comparative studies of hypertext versus print text have not shown an advantage for hypertext, except when powerful search tools were available in hypertext.

Yet the promise for transformed and enhanced literacy with the rapid and continuous appearance of new technologies for information sharing and communication is intuitively apparent. As Leu (no date) indicates, the literacy of the past is not the literacy of today, nor will it be the literacy of tomorrow. Current technology is expanding our conceptualization of literacy to include both the visual and communicative arts (Flood and Lapp, 1998) in which electronic technology plays a major role. Consequently, research on the structure of hypertext and hypermedia for enhancing comprehension is essential if electronic technology is to be meaningfully integrated into the curriculum.

Based on the initial analysis of the findings of existing studies focusing on reading comprehension and electronic technology, both Kintsch and van Dijk's (1978) and Zakaluk's (1985) theories for comprehension processing and text comprehensibility are as relevant to texts in dynamic, complex, electronic environments as they are to static print versions of text but with consideration of additional factors. While all the studies selected for analysis inform this integrative study, in particular, the Leu, Gallo and Hillinger's (1995) study of reading comprehension and the nature of considerate text in responsive,

multimedia environments, such as hypermedia, has been most informative because of its relevance to the purpose of this study. Leu and his colleagues (1995): (1) demonstrated the potential of dynamic electronic environments to enhance comprehension; and (2) pointed out a number of support options which facilitate comprehension and transform a complex, multi-level electronic text into a "considerate" text.

Issues Related To The Design Of Electronic Systems

The Readers' Models For Text Representation And Navigation In Hypertext and Hypermedia Environments

Dillon (1991) conducted experiments using both print and hypertext versions of documentation to determine to what extent readers' mental models for text can inform hypertext and hypermedia design. The work of Kintsch and van Dijk (1978) has shown that readers acquire mental representations for organizing the global meaning of a text and Zakaluk (1985) has demonstrated the role of prior knowledge as a factor for text comprehensibility. As a result of his experiments, Dillon (1991) found that, based on the mental representations for text structure acquired by experienced readers, the broad structure of print texts should be retained to support readers using hypertext, and by extension, hypermedia versions. In Dillon's (1991) opinion, rendering readers' already internalized mental models for text structure redundant for the sake of designing unique and innovative electronic forms of documentation would be an abuse.

Dillon's conclusions regarding the retention of the broad structure of printed text when designing hypertext/hypermedia environments is supported by the studies conducted by Chignell and Valdez (199-) at the University of Toronto and duplicated at the University of Southern California. As a result of their repeated experiments, Chignell and Valdez (199-) concluded that there may not be as great a difference in the way readers navigate print text and hypertext based on their findings that:

(1) readers used considerable non-linear behaviour with printed books;

(2) readers used linear navigation in hypertext with the "next page" support feature selected the most frequently;

(3) readers used "booklike" navigational functions more frequently (60% of the time) than "hypertext like" navigational functions (only 40% of the time) across all treatment conditions.

Consequently, Chignell and Valdez (199-) report that readers bring a stable navigational model with a strong linear component to the reading task even when the text is presented in hypertext. Dillon's (1991) recommendation that the broad structures of print text be retained for hypertext versions of documentation, therefore, must be considered as one of the design features essential to text comprehensibility. As Dillon (1991) indicates, hypertext navigation will be supported if readers can make use of the text structure mental representations that they already possess. Similarly, Chignell and Valdez (199-), based on their study on readers' navigational strategies, state that:

(1) Hypertext design should include booklike navigation features -The Table of Contents being particularly important;

(2) Many of the skills and tools currently employed in authoring printed text are required in authoring hypertext.

The Role Of Strategic Knowledge In Hypertext And Hypermedia Environments

As suggested earlier, research into reading comprehension within dynamic electronic environments (Fish & Feldman, 1987; Higgins & Boone, 1990, 1992; Mulcahy-Ernt & Collins 1993) has generally found no significant comprehension differences when comparing computer and paper presented text. As well, the limited number of comparative studies of hypertext and print text have not shown any significant advantages for hypertext (Chignell & Valdez, 199-). Investigations by Daniel and Reinking (1987), Duchastels (1986), Reinking (1988) and Reinking and Rickman (1990), however, have demonstrated contradictory findings. Their research shows enhanced comprehension performance with computer-presented texts.

These contradictory findings may be explained by the degree of strategic knowledge internalized by readers prior to their participation in the investigations using dynamic, electronic texts. Paris, Lipson and Wixson (1994) have shown that students need declarative, procedural and conditional strategic knowledge for increased comprehension. Kunz, Schott and Hovekamp (1987) found that readers who had received strategic training in the use of computer-mediated text exhibited both increased reading speed and

increased comprehension. Jin and Reeves (1992) contend that novice hypertext users require training to use the unique navigation aids embedded in dynamic, electronic text environments. Anderson-Inman and Horney (in press) indicate that readers who purposefully use the support options of computer-mediated text demonstrate superior comprehension. The issue appears to be that readers require strategic knowledge about what support options are available, how to access and use the support options, and when and why to use them. As well, prior knowledge of navigational strategies as described by Chignell and Valdez (199-) minimizes the potential for disorientation in hypertext and hypermedia environments.

Leu, Gallo and Hillinger (1995) considered the role of internalized strategic knowledge for using hypertext and hypermedia in their investigation of hypermedia's potential for developing more considerate text. To ensure readers' minimal disorientation and maximum strategic knowledge acquisition for accessing support features in their hypermedia investigation, they considered the following three notions. Two are technological design features and one is a pre-reading strategy applied to hypermedia:

(1) the provision of separate, movable, overlapping windows for each level of support so readers are able, at any time, to orient or re-orient themselves in relation to the initial text;

(2) the use of an intensive hypermedia environment so that readers always return to the original text after multi-level exploration;

3) pre-teaching of declarative, procedural and conditional strategy

training prior to the reading of hypermedia texts and subsequent monitoring to establish whether readers are metacognitively aware of each of the support features in the hypermedia environment.

In other words, the design of the hypermedia in the Leu, Gallo and Hillinger (1995) study was such that it enhanced comprehension by minimizing the potential for disorientation. Students were also trained in the strategic use of the program support options. As Zakaluk and Samuels (1997) emphasize, when readers' expectations are met because of an interaction between an author who has used familiar authoring structures and a reader, who has certain expectations about the text structure, comprehensibility is enhanced.

The Nature Of Support Features Available In Hypertext And Hypermedia Environments

A limited number of studies have investigated support features in hypertext and hypermedia. Anderson-Inman et al (1993, 1994, 1995) focused on the needs of severely "at-risk" readers, those readers with intensive needs in relation to non-at-risk readers. Leu et al (1995) considered the needs of a variety of different readers for interacting with hypertext and hypermedia, and Leu et al (1997) studied hypermedia support options to meet the needs of both the classroom teacher and the students. Anderson-Inman and Horney (in press) categorized the support options in their "at-risk readers using hypertext" studies as:

(1) translational resources for transforming segments of text into another form of expression;

(2) illustrative resources: examples, comparisons, illustrations and visualizations;

(3) summarizing resources: overviews, summaries, and outlines to illustrate the structure of the initial text;

(4) instructional resources: directions and reminders; questions for comprehension monitoring; mentor access; skills practice; instructional presentations; and tutoring systems;

(5) collaborative resources: providing on-line collaboration;

(6) supplementary resources: multimedia providing information related to the initial text;

(7) notational resources: writing and drawing study tools; and

(8) generalized resources: databases, and other types of on-line references able to support any text.

Leu et al's (1997) investigation of support features grounded in the needs of teachers and students resulted in the following "constructivist-communicative design elements" (p.2). Their hypermedia design features provided:

(1) an interactive timeline: the main window featuring several navigational icons;

(2) an interview feature: in the form of (a) a graphic, (b) textual information, (c) video, and (d) questions that provided further

information;

(3) a dictionary feature: for vocabulary support;

(4) a notepad feature: writing space for study notes, for sending messages or posting "sticky notes" and for writing assignments;

(5) bulletin board and publish feature: for publishing student work;

(6) 'hand-in feature': to send work to the teacher;

(7) read feature: to read an email message;

(8) send feature: to send an email message;

(9) stickies feature: a post-it note that could be placed on any window;

(10) shoot feature: to allow students to add images to their information; and

(11) a teacher record-keeping feature: a record folder for teachers.

The intent of the design features in the Leu et al (1997) study was to permit students to construct their own meaning, to communicate that meaning to others, and to allow teachers to monitor the meaning-making of the students.

The Leu, Gallo and Hillinger (1995) study of comprehension and considerate text in hypermedia involved five basic support options in an intensive hypermedia environment. These included:

(1) vocabulary support: textual definition, speech pronunciation and additional information about the word sometimes accompanied by a graphic;

(2) extended vocabulary support: essentially a "more about" feature;

(3) decoding support: digitized speech pronunciations;

(4) inferential support: 'close-up' assistance for understanding dense textual information; some contained graphics, animation, and or illustrations; and

(5) comprehension monitoring support: 'check-up' feature which offered an interactive simulation with corrective feedback; 'hint' buttons for additional clues; and 'end questions' with responses for monitoring understanding.

Of these investigations, only the Leu, Gallo and Hillinger (1995) study actually focused on the nature of considerate text in hypermedia for a variety of readers. The Anderson-Inman et al (1993, 1994, 1995) and Leu et al (1997) investigations, however, present commonalities with the Leu et al (1995) study in terms of the various support features which have the potential for increasing text comprehensibility in hypertext and hypermedia. These can be categorized as:

(1) vocabulary/decoding support (Leu et al., 1995): dictionary feature (Leu et al., 1997); translational resources, generalized resources (Anderson-Inman, in press);

(2) inferential support (Leu et al., 1995): interview feature (Leu et al., 1997); illustrative resources, instructional resources, supplementary resources (Anderson-Inman, in press); and

(3) comprehension monitoring support (Leu et al., 1995): illustrative and

instructional resources (Anderson-Inman, in press).

The Leu et al (1995) study of the nature of considerate text in hypermedia did not have the communicative features described in the Anderson-Inman et al (1993, 1994, 1995) and Leu et al (1997) studies. These communicative features, however, are related to the process of studying which, as Beishuizen, Stoutjesdijk and van Putten (1994) say, is a process different from that of reading and comprehending. According to Beishuizen, Stoutjesdijk and van Putten (1994), comprehension is the process of understanding the text. Studying, on the other hand, goes beyond comprehension to include the process in which the reader's goal is to acquire textual information to perform a follow-up task such as writing a test or perhaps giving an oral presentation. In keeping with the focus of this investigation, to analyze existing studies to determine the factors in hypertext/hypermedia environments which have the potential for enhancing the comprehensibility of text, the support features in the Leu et al (1995) study appear most relevant.

There is one feature not used in the Leu et al (1995) study. This feature relates to the need for a support feature that can serve as a browser, such as (1) a table of contents as noted by Chignell and Valdez (199-) and Valdez, Chignell and Glenn (1988); (2) the summarizing resource (Anderson-Inman et al, in press) which features an outline of the text and, (3) an interactive timeline feature (Leu et al,1997) which is a main window featuring several navigational icons. Valdez, Chignell and Glenn (1988) contend that dynamic, electronic

environments should include browsers to allow the reader to determine his/her location in the overall network of nodes in the hypertext/hypermedia environment. Chignell and Valdez (199-) and Dillon (1991) have shown that readers bring a mental representation for text which has a navigation model with a strong linear component and therefore, booklike navigational features such as "next page" and "table of contents" should be included as design features in hypermedia programs.

Individual Differences And Their Effect On The Use Of Support Features

The Horney and Anderson-Inman (1994) investigation looked at the issue of supportive features used by "at-risk" readers and found six distinctly different interaction patterns: skimming, checking, reading, responding, studying, and reviewing (Anderson-Inman, in press). Of these six patterns, studying was the most frequently used interaction with readers reading the text and using the support options in an integrated manner. This study, however, did not investigate support feature use in particular locations. Similarly, the Leu et al (1997) study did not investigate which hypertext/hypermedia support features were used because the purpose of their study was to determine which support features should be included in a hypermedia design if teachers had the final choice.

The Leu, Gallo and Hillinger (1995) study did, nevertheless, examine the issue of support option use in various locations by readers of varying ability. They found five interaction patterns: (1) vocabulary interactions using

vocabulary and decoding support options, (2) close-up interactions using inferential support options, (3) check-up and (4) end questions interactions using comprehension monitoring support options, and (5) rereading interactions, primarily generated by the use of check-up interactions.

When Leu, Gallo and Hillinger (1995) analyzed the interaction patterns, they found that check-ups using the comprehension monitoring support option was the most frequent interaction overall, across ability groups. As well, vocabulary and end-question interactions occurred with similar frequency among all ability levels. In terms of which support options were used by which readers, however, Leu et al (1995) found that low ability readers had more close-up interactions using the inferential support options, while average and high-ability readers used more comprehension monitoring support features for check-up interactions. Leu et al (1995) also found, across all reading ability levels, that more overall time was spent with check-up support options that prompted short rereadings of the initial text. Although Leu et al (1995) recommend a cautious interpretation of check-up interactions as being the cause of enhanced comprehension, the frequency of check-up interactions as part of the comprehension monitoring support options indicates the importance of this particular support option in developing more comprehensible text. Leu et al's (1995) findings also demonstrate that the comprehension gains in the hypermedia context were more likely due to each reader's ability to access information at the appropriate moment for each of their individual needs rather than due to additional information at the lower levels of the

intensive hypermedia environment.

Synthesis of Factors Which Have The Potential For Enhancing Text Comprehensibility

Kintsch and van Dijk (1978) conceptualized a model of text comprehension and production based on their belief that the structure of text impacts on its comprehensibility because of its influence on the storage and retrieval of information from the reader's memory during the reading process. Their model of text comprehension describe the mental operations which occur during the comprehension and recall of text: (1) the meaning of the elements in a text become organized in a coherent whole through a process of the multiple processing of some elements and differential retention; (2) the full meaning of the text is condensed into its gist; and (3) new texts are generated by the reader from what is remembered. According to Kintsch and van Dijk (1978), when the respective sentences and propositions in a text are referentially connected and the propositions are organized globally at the macrostructure level according to conventional schematic structures of discourse, only then does the text become coherent and comprehensible.

Dillon (1991) has shown that experienced readers bring a mental representation of text structures to the hypertext environment, and therefore, he recommends that the broad structure of print texts should be retained to support readers when using dynamic, electronic environments. Consequently,

an essential and underlying factor for comprehensible text in hypertext and hypermedia, using Kintsch and van Dijk's (1978) model for comprehension processing as a theoretical framework, is the adherence to conventional schematic structures of discourse for the main textual information window in dynamic electronic environments.

Furthermore, Beishuizen, Stoutjesdijk, and van Putten (1994) report that the author's suggestion for following a reading order and a type of content structuring for establishing and using criteria for selection and determination of reading path are needed structures in hypertext and hypermedia designs. Chignell and Valdez (199-) recommend that hypertext design, [and by extensions, hypermedia], include booklike navigation features, and in particular, a next page feature and a table of contents which can be used, as pointed out by Valdez, Chignell and Green (1988), as a navigation browser. This table of contents could be in the form of a main window featuring several navigational icons and landmarks. The next page feature in the form of a bar across the bottom of the page would serve to inform the readers, by means of highlighting, which page they are currently reading and which pages they have previously visited.

As Kintsch and van Dijk (1978) state, structure of text impacts on text comprehensibility and, as Jin and Reeves (1992) point out, the abundance of options increases the reader's cognitive load. Consequently, hypertext and hypermedia design principles such as used by Leu et al (1995) must also be

considered as factors for text comprehensibility in hypertext and hypermedia. Leu et al (1995) structured their hypermedia documentation so that each multilevel window was a separate, movable and overlapping window. Moreover, the hypermedia documentation was within an intensive environment to ensure that readers always returned to the initial text after multilevel exploration. Therefore, not only did the readers in the Leu et al (1995) study always know where they were in relation to the initial text, but the exploration of lower level information empowered the readers to increase their comprehension of the information in the initial passage. Separate, movable and overlapping windows are design features that must be considered as fundamental to minimize cognitive loading and capitalize on multilevel structures that permit readers to remain oriented.

Zakaluk (1985) demonstrated that "inside-and-outside-the-head" predictor variables of text comprehensibility were word recognition automaticity, prior knowledge of text topic, readability level and adjunct aids. Based on the analysis of the studies selected to inform this investigation, the following support options, as additional "outside-the-head" factors (Zakaluk, 1985), can serve not only as adjunct aids for text comprehensibility but also have the potential to increase comprehension. These are:

(1) vocabulary and decoding support options that include dictionary definitions, translational features with digitized or synthesized speech; and additional information and graphics for particular vocabulary that is content specific;

(2) inferential support options that provide intensive assistance for understanding dense textual information and which would include graphics, animation, video and/or illustrations as well as the opportunity to access third level vocabulary and decoding supports for particular words found in the second level textual information provided by the inferential support options;

(3) comprehension monitoring support options that provide interactive check-up features with corrective feedback, end questions with respective responses for comprehension monitoring, as well as illustrative, graphic, video options and instructional resources such as direction and hint buttons.

As to the "inside-the-head" factors of word recognition automaticity and prior knowledge of text topic (Zakaluk,1985), prior strategic knowledge for using hypertext and hypermedia must be considered as an additional essential factor for text comprehensibility in dynamic electronic environments. As a result of their findings, Leu et al. (1995) concluded that the strategic knowledge acquired by the readers in their study was a factor in the increase in comprehension for the hypermedia documentation because the students were empowered to more fully exploit the support options that were available to them for enhancing their understanding of the presented information.

Discussion

Kintsch and van Dijk's (1978) discussion of the working memory and the capacity of the short-term memory buffer for processing chunks of information explains the process of efficient cognitive processing for paper-bound textual

information. Reinking (1988), based on his experimental findings, concluded that when a computer is used to control a reader's processing of text or to expand the reader's options for acquiring information from text, comprehension increases. Reinking (1988) hypothesizes that the source of this increased comprehension is likely deeper and more efficient cognitive processing brought about through the reader's use of computer-mediated text with support options.

Zakaluk (1985) demonstrated the "inside- and outside-the-head" factors which were predictor variables for the comprehensibility of paper-bound text. Jin and Reeves (1992) indicate that cognitive loading related to the instructional content, the structure of the program and the support options available is a factor which contributes to positive learning outcomes in hypertext and hypermedia environment. Other factors which contribute to learning outcomes in hypertext and hypermedia environments, according to Jin and Reeves (1992) are individual reader differences in terms of learning styles and prior knowledge as well as users' internalized mental models. Therefore, hypertext and hypermedia design must be grounded in Kintsch and van Dijk's (1978) theory of comprehension processing and Zakaluk's (1985) theory of reader and text factors that enhance text comprehensibility.

Of the studies selected for this integrative study regarding factors that enhance text comprehensibility in dynamic electronic environments, it was found that only the Leu, Gallo, and Hillinger (1995) research focused directly on the

nature of considerate text in hypermedia. Nonetheless, other studies (Anderson et al 1993, 1994, 1995, in press; Chignell and Valdez, 199-; Dillon 1991; Higgins and Boone, 1992; Leu et al., 1997; Reinking, 1988; Valdez, Chignell and Glenn, 1988) informed this study by virtue of the different perspectives of their research. Because of these studies, the issues of mental representation of text and navigational strategies, disorientation and orientation in complex electronic environments and the resultant cognitive loading, and the need for conventional authoring structures and prior strategic knowledge for hypertext and hypermedia environments were more fully explored. As a result, a variety of design features are identified as essential features for developing considerate text in complex dynamic environments.

CHAPTER 5

Summary, Conclusions, Implications, and Recommendations

> *For the first time in our history, we are unable to accurately anticipate the literacy abilities expected at the time of graduation for children who will enter school this year. (Leu, 1998).*

Reinking (1994) drew attention to the exponentially rapid and fundamental changes that are presently occurring in the way we communicate, in the way business is conducted and in the way information is shared as a result of the current fast-paced, irreversible technological evolution that is taking place as we move from static print to electronic forms of communication. He emphasized the immediate need for a re-evaluation of the way that we, as educators, conceptualize literacy and literacy research if we are to respond appropriately to students' literacy needs in the dawning of this post-typographic era.

The purpose of this study has been to investigate the nature of electronic text and its potential for increasing text comprehensibility using an integrative inquiry approach. The thesis of the investigation was that if hypertext and hypermedia have the potential for increasing the comprehensibility of text, the nature of electronic text structure must be analyzed in order to identify the factors that lead to text comprehensibility within electronic environments.

An integrative approach to this investigation used the existing research regarding electronic text structure and text comprehensibility to provide insight. The investigation was guided by the work of both Kintsch and van Dijk (1978) and Zakaluk (1985). These two bodies of research established the theoretical framework for examining the variety of factors to consider in relation to comprehensibility in electronic texts. These factors include text structure and its role in comprehension processing (Kintsch & van Dijk, 1978) and the inside- and outside-the-head factors which are predictor variables for text comprehensibility: word recognition automaticity and prior knowledge of text topic as inside-the-head, reader factors; and, conventional indices of readability and the use of adjunct comprehension aids as outside-the-head, text factors (Zakaluk, 1985).

The studies chosen for this integrative study focused on the following qualitative reader and text factors: (1) readers' models for text representation both in paper-based and hypertext documentation (Dillon, 1991); (2) navigational issues of orientation/disorientation in hypertext and hypermedia environments (Chignell & Valdez, 199-; Leu, Gallo & Hillinger, 1995; Valdez, Chignell & Glenn, 1988); (3) the role of strategic knowledge in dynamic electronic environments (Jin & Reeves, 1992; Kunz, Schott & Hovekamp,1987; Leu, Gallo & Hillinger, 1995); (4) the nature of support features available in hypertext and hypermedia environments (Anderson et al 1993, 1994, 1995, in press; Chignell and Valdez, 199-; Leu et al., 1997; Leu, Gallo, and Hillinger, 1995); and (5) issues related to individual differences

(Anderson et al, in press; Leu, Gallo, and Hillinger, 1995).

Summary of Findings

Readers' mental representation for text structure. Dillon (1991) found that experienced readers possess internalized mental representations for text structure using print text. Furthermore, he found that these mental representations are transferred to electronic forms of text in hypertext environments. Based on these findings, Dillon (1991) recommended that the broad structure of print text should be retained when designing hypertext and hypermedia environments. This recommendation is supported by the findings of Chignell and Valdez (199-) which demonstrated that readers bring a stable navigational model with a strong linear component to the reading task even when the text is presented in hypertext. Chignell and Valdez (199-), therefore, recommend that booklike navigation features, in particular the 'table of contents' and 'next page', should be included in hypertext design and that print text authoring skills and tools should be employed in authoring hypertext and, by extension, hypermedia environments.

Navigational features or adjunct aids. As to navigation issues, Beishuizen, Stoutjesdijk and Van Putten (1994) recommend that novice users of hypertext and hypermedia heed an author's suggestions for following a reading order. Novice users also require some content structuring or strategic clues for establishing and using criteria for selecting and for determining a path through the complex electronic environment (Beishuizen, Stoutjesdijk, and Van

Putten, 1994). These navigational features will prevent the reader from becoming disoriented as a result of the cognitive load placed on the reader by the abundance of options available (Jin & Reeves, 1992). This content structuring feature may fall into the two general categories identified by Valdez, Chignell and, Glenn (1988) as (1) a map or browser which allows the reader to determine his/her location within the overall network or regions of the hypermedia environment, and (2) the use of tags or markers that signal familiar locations. As well, using separate, movable and overlapping windows for each level of support can also help readers to orient themselves in relation to the initial text at any time (Leu et al, 1995).

Furthermore, in terms of comprehension of a specific topic within hypertext or hypermedia, especially for younger students, consideration must be given to the intensive-extensive continuum of the hypermedia environment. Limiting the paths that students can explore in the hypermedia text will ensure that students always return to the original text after exploring multi-level information. In this way, the available links support the goal of comprehending a specific text (Leu et al, 1995).

Strategic Knowledge. A limited number of studies (Chignell & Valdez, 199-; Kunz, Schott & Hovekamp, 1987; Jin & Reeves, 1992; Leu, Gallo & Hillinger, 1995) considered the issue of strategic knowledge that is internalized by readers prior to reading dynamic, electronic texts. It appears that: (1) readers who have strategic training prior to the use of computer-mediated

texts exhibit increased reading speed and increased comprehension (Kunz, Schott & Hovekamp, 1987); (2) novice hypertext users require specific training in the use of unique navigation aids embedded in dynamic, electronic text environments (Jin & Reeves, 1992); (3) prior knowledge of navigational strategies minimizes the potential for disorientation in hypertext and hypermedia environments (Chignell & Valdez, 199-); and (4) comprehension is enhanced and disorientation minimized when design features, such as a browser or main window with navigation icons are included, and when readers possess the strategic knowledge about what support options are available, how to access and use them and when and why they should be accessed (Leu, Gallo, & Hillinger, 1995).

Supportive features. As to studies related to the nature of support features available in hypertext and hypermedia environments (Anderson-Inman et al, 1993, 1994, 1995; Anderson-Inman & Horney, in press; Leu et al, 1997; Leu et al, 1995), only the Leu et al (1995) study actually focused on the nature of considerate text in hypermedia. Nonetheless, there were commonalities among the studies cited above in terms of support features that have the potential for increasing text comprehensibility. These can be categorized as: (1) a variety of vocabulary and decoding support features including dictionary and translational features; (2) a variety of inferential support features such as assistance for understanding dense textual information, and illustrative resources such as graphics, animation and illustrations; (3) a variety of comprehension monitoring support features including illustrative and

instructional resources such as interactive simulations with corrective feedback, buttons to access additional clues and end questions with responses for monitoring understanding; and (4) a browser such as a table of contents, an outline of the text or a main window featuring navigational icons.

Individual Differences. In terms of individual differences and their effect on the use of support features, only the Leu, Gallo, and Hillinger (1995) study examined the issue of support options in various locations. This study demonstrated five interaction patterns according to frequency of use by ability levels: (1) check-up interactions using the comprehension monitoring support option which was the most frequent interaction overall with more interaction time across all ability groups; (2) vocabulary interactions using vocabulary and decoding support options, (3) end-question interactions using comprehension monitoring support options which occurred with similar frequency among all ability levels; (4) close-up interactions using inferential support options which were used more frequently by low ability readers whereas average and high-ability readers used more comprehension monitoring support features for check-up interactions; and (5) rereading interactions prompted by the use of check-up interactions. Although cautious interpretation should be made of the frequency of check-up interactions using comprehension monitoring support options in relation to comprehension gains (Leu, 1995), the frequency of check-up interactions as an aid to monitoring ongoing comprehension appears to indicate the importance of check-up features in developing more comprehensible text. It appears, as well, that

comprehension gains in a hypermedia context are likely due to each reader's ability to access information at the appropriate moment for each of their individual needs, rather than due to additional information at lower levels of an intensive hypermedia context (Leu et al, 1995).

Based on this analysis of the findings of existing studies focusing on electronic technology and text comprehensibility, both Kintsch and van Dijk's (1978) and Zakaluk's (1985) theories for comprehension processing and text comprehensibility are as relevant to texts in dynamic, complex, electronic environments as they are to static print versions of text but with consideration of additional factors.

Conclusions Based on Research Findings

Eight Major Questions for Study

First. Given all that we know about predictor variables that influence the comprehensibility of printed text, and the role of text structure and mental representation for text, there are similarities between print and electronic text which remain essential for text comprehensibility without being medium dependent. Currently, we have gained significant knowledge in relation to reading and comprehensibility of text: (1) Reading is a complex, constructive, interactive, multiple contextualized process (Pearson & Stephens, 1994); and, (2) The comprehensibility of text is dependent on multiple factors which can be categorized as 'outside- and inside-the-head' factors (Zakaluk, 1985; Zakaluk & Samuels, 1988). Qualitative text factors are: readability level; text features

such as print size and adjunct comprehension aids; text discourse which matches reader expectations; and text which follows canonical structure schemas. Reader factors are: accuracy and automaticity of word recognition, prior knowledge of text topic and text structure, and affective and cognitive factors such as attitude, motivation and metacognition. This study of the existing research regarding text structure and text comprehensibility has uncovered no data that would lead to minimizing, in electronic environments, the importance of the role of reader and text factors shown by Zakaluk (1985) to be predictor variables of text comprehensibility and to minimizing the role of text structure as demonstrated by Kintsch and van Dijk (1978).

On the contrary, Dillon (1991), Chignell and Valdez (199-), and Leu, Gallo, & Hillinger (1995) have clearly demonstrated: (1) that readers possess a stable navigational model with a linear component for hypertext; (2) that readers transfer their mental representation for print text to hypertext; (3) that broad structures of print text should be retained for texts in hypertext; (4) that prior knowledge for navigating in hypermedia as well as strategic knowledge regarding support options play an important role in text comprehensibility. Because reading and writing will become even more crucial to one's ability to succeed in a technological era (Leu, no date), the comprehensibility factors demonstrated by Zakaluk (1985) and the role of text structure in comprehension processing as demonstrated by Kintsch and van Dijk (1978) remain pertinent to comprehension and text comprehensibility in hypertext and hypermedia environments, just as they are for print text.

Second. There are additional factors in hypertext and hypermedia that may render electronic texts more 'considerate' than print text. These factors are design features in electronic text that allow each reader to access information at the appropriate moment for each of their individual needs. Leu, Gallo and Hillinger (1995), in their analysis of the frequency and time students spent interacting with hypermedia support options, concluded that comprehension gains were more likely due to the ability to access multilevel options which matched individual needs than to additional information at lower levels of the intensive hypermedia context used in their study. These design features include audio, sound, color, graphics, animation, and nodes of information in a variety of combinations at multilevels which can be accessed as required to support comprehension of the initial text. These support options tap into a variety of learning styles (Dunn & Dunn, 1978) and learning needs such as those of the auditory learner, the visual learner and the kinesthetic learner. As well, they provide immediate feedback as frequently as required, all within the control of the reader. The support options which enhance comprehension include vocabulary, textual definitions, decoding, and translational options; inferential comprehension support options which provide additional background information; and comprehension monitoring support options which allow a reader to check-up on his/her comprehension of the initial text. Interactive simulations using a combination of text, audio, colour, graphic, and/or animation built into these support options meet individual needs more closely than can print text alone, thus making hypertext and hypermedia

more 'considerate' than print text.

Third. Informational nodes are instrumental in making hypertext and hypermedia potentially more considerate because they can provide additional background information that may not be part of a reader's prior knowledge of the text topic. Zakaluk (1985) identified prior knowledge of text topic as a predictor variable for text comprehensibility. If the reader is deficient in his/her prior knowledge of the text topic, the informational node is accessible at will with information about the topic to fill in the knowledge gap. These nodes augment the textual information by providing additional graphic elements and/or animation to enhance meaning.

Fourth. There are features within dynamic electronic environments that have the potential to make electronic texts less considerate. The nature of the extensive-intensive continuum of hypertext and hypermedia is such that the potential for user disorientation is a major concern when using electronic environments with highly flexible and complex network structures (Jin & Reeves, 1992). For example, the abundance of options in an extensive hypermedia environment increases the cognitive load of users of hypertext and hypermedia, and places a user, especially a novice user, at high risk. Confusion and disorientation may result (Beishuizen, Stoutjesdijk, & van Putten, 1994; Jin & Reeves 1992). This can be a major concern in light of Kintsch and van Dijk's (1978) explanation of the working memory and the capacity of the short-term memory buffer for processing chunks of information. The abundance of

options may prevent the learner from benefiting fully from the learning opportunities because of the increased cognitive load. Leu, Gallo, and Hillinger (1995), however, circumvented this problem by ensuring that users internalized the strategic knowledge necessary for knowing the what, how, why and when of support option access. They also limited the paths readers could follow so that students always returned to the initial text after a multilevel exploration of support options. Leu, Gallo, and Hillinger (1995) also provided separate, movable and overlapping windows for each level of support to help readers orient themselves in relation to the initial text.

Fifth. In terms of differences between hypertext and hypermedia, a difference exists in relation to the support options each offers. Both environments use multilevel nodes which provide additional information beyond the initial text to enhance comprehension. The difference lies in the multimedia features of the hypermedia environment. Hypertext is textual in nature with additional informational nodes at various levels. Hypermedia, on the other hand, is not constrained to text. Hypermedia offers audio, digitized or synthesized speech, illustrations, graphics, animation, and even video beyond the hypertext.

Sixth. The difference between hypertext and hypermedia is especially important for the comprehensibility of expository text because, in expository text, information tends to be more dense and complex. The addition of audio and visual multi-level, self-select options serve as comprehension aids.

Furthermore, although both hypertext and hypermedia are both considerate text by virtue of the accessibility of informational nodes, hypermedia has the potential to be more responsive to individual learning needs and hence, more comprehensible for many learners, because of the addition of the audio and visual options.

Seventh. In examining the mix of multilevel support structures such as audio, color, graphics, illustrations, animation and video in hypermedia environments, it appears that the optimal for text comprehensibility is the inclusion of all of these support options to ensure that auditory, visual and kinesthetic learning needs are met. On the other hand, the optimal mix of these features is not as much an issue as the issue of path limitations to prevent extensive explorations within the hypertext or hypermedia environments. Readers are more likely to acquire greater comprehension of a specific text if the paths are limited to ensure a return to the initial text after each multilevel exploration. Multilevel explorations, however, must offer access to an optimal mix of the following: (1) vocabulary support options, (2) inferential support options, and, (3) comprehension monitoring support options.

Eighth. In terms of the question of whether a nomograph similar to Zakaluk's (1985) would be useful to evaluate electronic texts that are optimally responsive to reader needs, it is not possible, within the parameters of this investigation, to offer a definitive answer. A similar nomograph for evaluating

hypertext and hypermedia environments for text comprehensibility could conceivably retain the variables established by Zakaluk (1985) with some modification regarding the nature of the variables. Word recognition automaticity and passage difficulty level would remain as constant variables but the instructional adjunct aids could focus on other than the inclusion of interspersed questions and the placement instructional objectives. In addition to prior knowledge of text topic, other types of knowledge, including knowledge of metacognitive strategies for navigating in the electronic medium, could be factored in. Because a hypertext or hypermedia environment is so different from print text in regard to malleability and interactivity, the multilevel informational nodes are powerful instructional adjunct aids; and prior and strategic knowledge of navigation aids and support option use may hold priority over prior knowledge of text topic. As important as prior knowledge of text topic is for print text, dynamic electronic texts can compensate because the multilevel informational nodes containing auditory and visual supports and interactive simulations can provide background information. Prior knowledge of navigation in hypertext and hypermedia and strategic knowledge of support options is essential for comprehensibility in hypertext and hypermedia.

Practical Implications Related to Text Comprehensibility in Hypertext and Hypermedia

In light of the findings of this investigation, it appears that the following 'outside-the-head' (Zakaluk, 1985) design features play a role in making

hypertext and hypermedia more comprehensible:

(1) retention of the broad structures of print text which include:

- a 'next page' feature in the form of a bar across the bottom of the page to inform the readers, by means of highlighting, which page they are currently reading and which pages they have previously visited; and
- booklike navigation features such as an outline of the text, a table of contents, or a main window with navigational icons which can be used as a guide for access to support options;

(2) use of a browser or map to allow the reader to determine his/her location in the overall network or regions of the hypertext or hypermedia environment;

(3) use of separate, movable, and overlapping windows for each level of support to help with orientation;

(4) use of print text authoring skills and tools for authoring hypertext and hypermedia environments;

(5) use of multilevel informational nodes which include a combination of audio, digitized or synthesized speech, graphics, illustrations, animation and video;

(6) use of an intensive hypertext and hypermedia environment if the goal is comprehension of a specific text to ensure that the available informational nodes support that goal;

(7) a balance in the following comprehension enhancing support features:

- a variety of vocabulary and decoding support features including dictionary and translational features;
- a variety of inferential support features such as additional background information and assistance to facilitate the understanding of dense textual information through illustrative resources such as graphics, animation and illustrations; and,
- a variety of comprehension monitoring support features or 'check-ups' including illustrative and instructional resources such as interactive simulations with corrective feedback, buttons to access additional clues, and end questions with responses for monitoring understanding.

'Inside-the-head' (Zakaluk, 1985) factors that must be considered for text comprehensibility in hypertext and hypermedia environments are the following. Readers must:

(1) acquire prior knowledge of navigational strategies to minimize the potential for disorientation in hypertext and hypermedia;

(2) possess strategic knowledge about what support options are available, how to access and use them and when and why they should be used.

Limitations Of This Investigation

The thesis of this investigation was that if hypertext and hypermedia have the potential for increasing the comprehensibility of text, the factors that lead to text comprehensibility within dynamic electronic text environments need to be established based on an analysis of the nature of electronic text structure. This analysis was undertaken within a theoretical framework that was attentive to existing literacy research. As was initially foreshadowed, the study of text comprehensibility in hypermedia context posed a number of problems: First, there was an element of difficulty in defining comprehension and comprehensibility when making comparisons of comprehension and text comprehensibility for print text and for hypertext and hypermedia. Second, only a limited number of studies related to text comprehensibility and the nature of considerate text for dynamic, electronic environments exists. In fact, only the Leu, Gallo, Hillinger (1995) study, among all the studies selected for investigation, specifically focused on the potential for hypermedia to be optimally considerate text. Third, the existing studies related to electronic environments lack precision in defining hypertext and hypermedia environments. These two environments are different in the nature of their support options, yet the terms for different design concepts, hypertext and hypermedia, tend to be used interchangeably. Fourth, it is difficult to compare comprehension for the dynamic electronic environments used in existing studies when there is little indication of the placement of each environment on the intensive-extensive continuum of hypertext and hypermedia.

Recommendations For Further Study

First, because this investigation was exploratory in nature and because of the limitations related to current studies for studying the nature of electronic text structure and its potential for text comprehensibility, further research should be undertaken to verify the results of this investigation, especially as new research related to electronic environments becomes available for comparison purposes.

Second, as technology becomes increasingly more prevalent in today's classrooms, there may be value in evaluating the comprehensibility of dynamic, complex electronic texts for their responsiveness to reader needs. An investigation focusing primarily on developing an instrument for evaluating comprehensibility for complex electronic environments should be undertaken. Currently, the attractive nature of computers and their ability to hold a user's interest may mask the degree of learning that is actually taking place. If the electronic text is assumed to be comprehensible but no evaluation tool exists for establishing the optimal match between reader and text, we may be short-changing our students. Just as it is possible for a reader to read print text fluently and accurately and still not understand the text because of limitations in one or the other of the variables for text comprehensibility, so it can be for text comprehensibility in dynamic electronic environments. Even though a reader may benefit from enhanced comprehension in hypertext and hypermedia because of the variety and combinations of support options, if there is a limitation in one or another of the variables for text comprehensibility in the

dynamic electronic environment, there will not exist the optimal match between the individual reader and the text as conceptualized by Zakaluk (1985).

Zakaluk (1985) developed a nomograph for evaluating text comprehensibility of print text which used passage difficulty level, adjunct instructional aids, word recognition automaticity and prior knowledge of text topic as the four predictor variables for text comprehensibility. This nomograph is particularly useful for print text because it is an interactive text comprehensibility formula that is attentive to the interactive nature of text processing and takes into account qualitative reader and text factors. The scope of this study was such that an in-depth study of the usefulness of Zakaluk's (1985) nomograph for hypertext and hypermedia could not be realistically undertaken. Nonetheless, the question of a similar nomograph or the development of a weighted checklist for evaluating the comprehensibility of specific electronic environments for an optimal match with individual readers is worthy of research.

Based on the findings of this study, a weighted checklist would need to incorporate the 'inside- and outside-the-head' features as shown in the table on the following page. It must be emphasized, however, that for an optimal match between reader and text, the features in the table are in addition to, and not meant to supersede, the 'inside- and outside-the-head' factors shown by Zakaluk (1985) to be predictor variables for text comprehensibility.

outside-the-head	inside-the-head
Use of Print Text Authoring Skills and Tools Adjunct Aids (navigational features): map or browser for orientation an outline or table of contents or a main window & navigational icons a browser or map tags or markers Separate, Movable, Overlapping Windows Use of Multilevel Informational Nodes With: audio digitized or synthesized speech graphics illustrations animation video Use of an Intensive Environment Variety of Vocabulary and Decoding Options: pronunciations dictionary and translational options Variety of Inferential Options (close-ups): addtional background information enhanced by illustrative resources Comprehension Monitoring Features (check-ups): interactive simulations corrective feedback end questions with responses buttons for accessing additional information	Prior Knowledge of Navigational Strategies Strategic Knowledge of: what support options are available how to access them how to use them when and why to use them

Epilogue

Of all the studies selected for this integrative study regarding factors that enhance text comprehensibility in complex electronic environments, only the Leu, Gallo, and Hillinger (1995) study focused directly on the nature of considerate text in hypermedia. Other studies (Anderson et al 1993, 1994, 1995, in press; Chignell and Valdez, 199-; Dillon 1991; Higgins and Boone, 1992; Leu et al, 1997; Reinking, 1988; Valdez, Chignell, and Glenn, 1988), nevertheless, informed this investigation but from different perspectives. Findings from these studies on a variety of "inside- and outside-the-head" variables that influence text comprehensibility provide answers to the questions which fueled this study, and identify essential features for enhancing the comprehensibility of text in complex, dynamic environments.

In terms of the development of electronic texts, this study confirms that readers: (1) expect the same text structure in electronic mediums as is presented in well constructed printed text; (2) appreciate such navigational features or adjunct aids as tags or markers that signal familiar locations, a table of contents, next page features, and movable, overlapping windows that help readers orient themselves in relation to the initial text; (3) need strategic training prior to using complex, dynamic environments; (4) require such support features as vocabulary/decoding/dictionary options, close-up and check-up features as options for comprehension monitoring, and translational, graphic and illustrative resources for providing additional background information to support comprehension of dense expository text.

As Leu (no date) reminds us, students of fifteen years ago had no need for word processing technologies; ten years ago, knowledge of 'navigation' through hypermedia technologies was irrelevant; and five years ago, students did not conduct searches on the internet, or use e-mail for communication. Each of these technologies, however, are currently forcing educators and students, and researchers as well, to continually create new envisionments for their use and, as a result, to adapt to ever-changing definitions of literacy (Leu, no date).

It is apparent that there are immediate and imperative consequences for focusing on the instructional application of electronic technologies in today's classrooms, especially when most of the existing research and instructional practices appear to assume that the literacy needs of today will remain the same as the literacy needs of tomorrow (Leu, no date). The reality is, however, that because of the rapid acquisition and communication of information in today's world of global competition and information-based economies, reading and writing proficiency will be more critical than ever to our children's future success in the world of work (Leu, no date).

Based on a rich history of transdisciplinary study, we have gained significant knowledge of the importance of text structure and 'considerate' text in facilitating comprehension and recall when using print material. As we approach a post-typographic era where static print may no longer dominate,

the knowledge we already possess about literacy development, about readability and comprehensibility of text, and about the social construction of knowledge that has been gained through extensive study and experience with print text begins to assume increasing importance. Poised, as we are, on the brink of a new era in deictic literacy (Leu, 1997), it is imperative to consider the impact that electronic technology has on literacy development and the potential of dynamic, interactive, electronic environments for enhancing comprehensibility within a theoretical framework informed by literacy research.

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IMAGE EVALUATION
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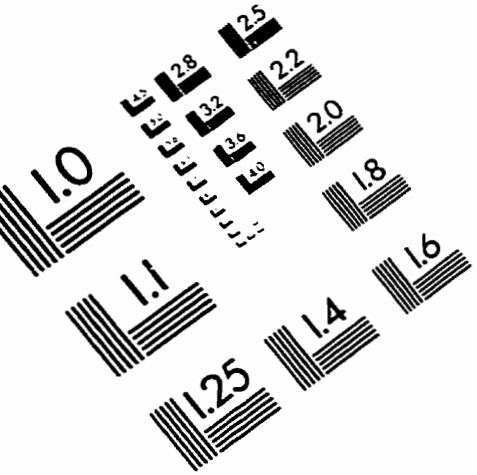

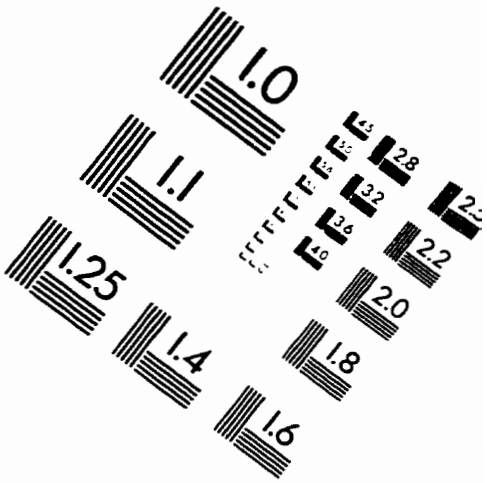

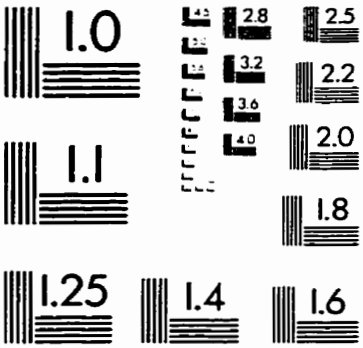

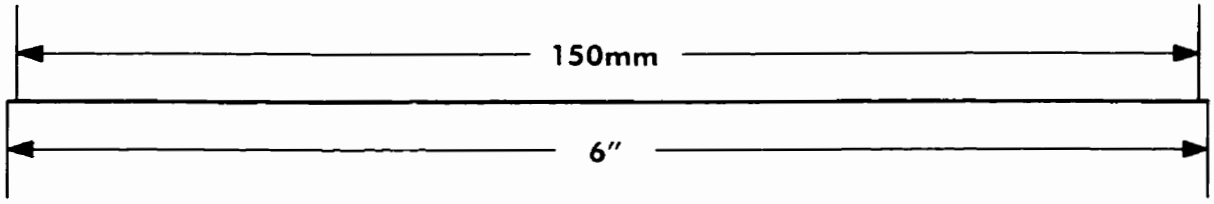

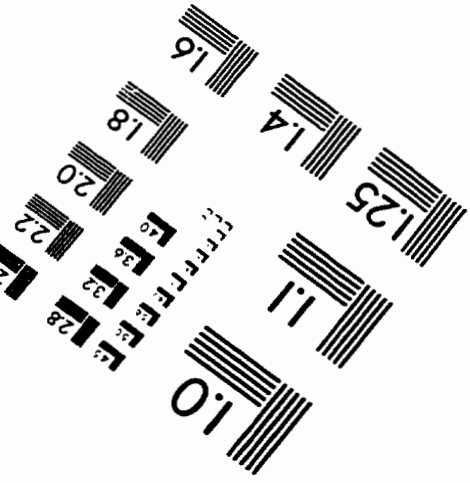

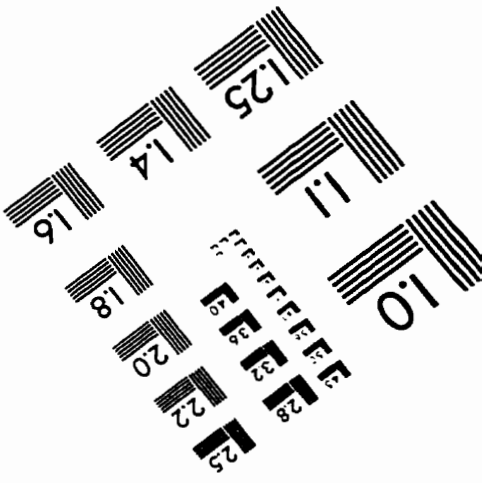

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