Running Head: Exploring online reading comprehension

Exploring the online reading comprehension strategies used by sixth-grade skilled readers to search for and locate information on the Internet

Julie Coiro

University of Connecticut

Elizabeth Dobler

Emporia State University

Abstract

The purpose of this qualitative study was to explore the nature of reading comprehension processes while reading on the Internet. Eleven sixth-grade students with the highest combination of standardized reading scores, reading report card grades, and Internet reading experiences were selected from a population of 150 sixth-graders in three different middle schools in central and northeastern United States. These eleven skilled readers were then asked to meet individually with a researcher and complete two separate reading tasks: First, students read within one multilayered website in search of answers to seven literal and inferential level comprehension questions. Later, in a second session, participants used the Yahooligans search engine to locate answers to two open-ended questions related to the sixth grade curriculum. Students answered specific questions about their strategy use in a follow-up interview after each reading session. Qualitative analysis evolved through four distinct phases, each of which involved reviewing data from think-aloud protocols, field observations, and semi-structured interviews to provide insights into the nature of online reading comprehension. Findings suggested that successful Internet reading experiences appeared to simultaneously require both similar and more complex applications of (1) prior knowledge sources; (2) inferential reasoning strategies; and (3) self-regulated reading processes. The authors suggest that reading Internet text prompts a process of self-directed text construction that may explain the additional complexities of online reading comprehension. Implications for literacy theory, future research, classroom instruction, and assessment are discussed.

A great deal is known about the comprehension strategies that skilled readers use as they read within traditional text environments (National Institute of Child Health and Human Development. [NICHD], 2000; Pressley, 2000). Research has confirmed that proficient readers actively construct meaning using a small set of powerful reading comprehension strategies in printed text environments (e.g. Pressley & Afflerbach, 1995; RAND Reading Study Group [RRSG], 2002). However, much less is known about how students use comprehension strategies within electronic environments such as the Internet (Author, 2004a; Leu, 2000; Reinking, 1998). Little empirical evidence has been gathered, particularly among adolescents, to support claims that printed and digital texts are distinctly different media requiring different cognitive processes (e.g., Reinking, 1992; Salomon, 1979/1994) and that new types of strategic knowledge are necessary to effectively locate, comprehend, and use informational text found on the Internet (e.g., Author, 2003a; International Reading Association (IRA), 2001).

Ironically, the lack of a research-based understanding of the strategies needed to successfully read and understand information on the Internet coincides with an increase in the importance of the Internet in our daily lives. The Internet has become an important context for teaching and learning (U.S. Department of Education, 2005; Web-Based Education Commission, 2000) and information gathering is perhaps the most widely used application of the Internet (Hill, Reeves, Grant, & Wang, 2000). Nearly 75% of all households reported they had Internet access in 2004 (Neilson/NETRatings, 2004) and 94% of online teens use the Internet for school-related research (Lenhart, Simon, & Graziano, 2001). Similarly, 93% of K-12 classrooms in the United States now have at least one computer connected to the Internet (National Center for Education Statistics [NCES], 2003a) and in 1999, 66% of public school teachers reported using computers or the Internet for instruction during class time (NCES, 1999).

Despite this increased use of information and communication technologies in school and at home, little is known about the reading patterns and cognitive processes readers use in nonlinear digital texts (Balcytiene, 1999). Moreover, increasing numbers of researchers suggest that it is important, in an age of information, to identify the information seeking strategies that we use while reading on the Internet to better inform both research and practice (e.g., Alexander & Jetton, 2000; Goldman, 1997; Leu, 2002). This study, then, observed students while reading on the Internet and used qualitative methods to explore what some (Author, 2003a; Author, 2004a) suggest are new types of reading strategies necessary to learn within this interactive, informationally rich, and relatively new text environment.

Theoretical Framework

Our study was informed by three different theoretical perspectives associated with literacy, technology, and learning, respectively. The first perspective views reading as an active, constructive, meaning-making process (RRSG, 2002). According to this perspective, readers actively construct meaning as they interact with text (see also Kintsch, 1998; NICHD, 2000). Expert readers use a range of strategic cognitive processes that include asking questions, drawing connections, and making inferences (Pressley & Afflerbach, 1995). In addition, readers use their existing knowledge to more clearly understand new ideas encountered within texts (Anderson & Pearson, 1984; Beck, Perfetti, & McKeown, 1982), to make predictions about what might come next (Duke & Pearson, 2002; Pearson, Roehler, Dole, & Duffy, 1992), and to reason strategically when they encounter barriers to comprehension (Baker & Brown, 1984; Paris, Lipson & Wixson, 1983). Using informational texts, in particular, requires readers to attend to structural text features, interpret their intended meanings, and evaluate the relevancy of certain text portions in

relation to the task (Dreher, 2002; Goldman & Rakestraw, 2000). It would make sense, then, that these strategies would also play a role in online reading comprehension.

A second theoretical perspective is that of new literacies (Author, 2004). The construct "new literacies" means many things to many people. Some define new literacies as social practices (Street, 1999) or new Discourses (Gee, 2003) that emerge with new technologies. Others see new literacies as new semiotic or cultural contexts (Cope & Kalantzis, 2000; Kress, 2004; New London Group, 1996) made possible by new technologies. While each of these perspectives lends important insights to studies of everyday literacies (and related notions of identity, gender, and positionality) from a more social and linguistic point of view (e.g., Chandler-Olcott & Maher, 2003; Guzzetti & Gamboa, 2004), we also believe that not enough attention is paid to the equally important issue of how adolescents develop and demonstrate the literacies needed to read and use online informational texts in formal school and work settings. The questions we seek to answer focus particularly on school contexts and require a point of view that includes cognitive as well as social and linguistic perspectives. Consequently, our study draws from theoretical work that argues the nature of literacy is rapidly changing as new technologies emerge (Alexander & Jetton, 2000; Lankshear & Knobel, 2004; Reinking, 1998). According to this new literacies perspective, reading comprehension becomes an important issue to study (Author, 2003a) since new comprehension skills, strategies, and dispositions may be required to generate questions, locate, evaluate, synthesize, and communicate information on the Internet (Author, 2004). Similarly, this perspective posits that traditional reading skills are necessary, but not sufficient, to read and learn from information on the Internet.

A third perspective that informed our study was the theory of cognitive flexibility (Spiro, Feltovich, Jacobson, and Coulson, 1991). According to this perspective, open networked

information spaces such as the Internet require readers to draw from and integrate multiple knowledge structures while adapting to the rapid changes from one reading situation to the next (Spiro, Coulson, Feltovich, & Anderson, 2004). Internet readers are called upon to not only construct meaning from text, but to also construct meaning through flexible and purposeful choices of relevant hyperlinks, icons, and interactive diagrams. Thus, reading in Internet contexts requires the ability to flexibly reassemble preexisting knowledge with new knowledge applications customized to each new reading situation (Spiro, 2004). More importantly, cognitive flexibility theory posits that older notions of knowledge domains used to interpret and predict the meaning of printed text (e.g., Anderson, 1994; Stein & Trabasso, 1982) no longer sufficiently explain the knowledge domains required of readers in web-based contexts. In fact, Spiro (2004) argues, learning strategies that work in simple domains are exactly opposite of those best for dealing with complex domains such as the Internet. Thus, as reading teachers and researchers, it is imperative that we identify appropriate knowledge domains and differentiate between effective and ineffective comprehension practices in online reading environments.

Guided by these three overlapping perspectives, we sought to explore the nature of reading comprehension strategies prompted by Internet texts and to begin to describe how skilled readers employed these strategies while reading within two different online reading contexts.

Previous Research

To fully appreciate the complexity of reading on the Internet, it is important to understand four distinct bodies of research as well as how each builds on the other to frame the present study. We begin with a brief description of the cognitive processes involved in comprehending printed text. Then, we outline differences between narrative and informational text and how these differences impact information seeking and comprehension. Third, we highlight differences

between printed informational text and closed hypertext systems and finally we explore theories that suggest reading informational text within open-ended Internet environments adds complexities beyond reading in closed hypertext systems. It is the complexities of this last area, strategic reading within informational text sources on the Internet, in which we are most interested, and regrettably, the area in which little research has been done (Kamil & Intrator, 1998; Leu, 2002).

Comprehension of printed text

Previous research suggests that reader and text characteristics play a central role in reading comprehension (RRSG, 2002). Expert readers use a range of strategic processes when comprehending printed text (e.g., Paris, et al., 1991; Pressley & Afflerbach, 1995) such as previewing the text, setting goals, making predictions, monitoring understanding, asking questions, drawing connections, and interpreting text (Duke & Pearson, 2002; Pressley, 2000). While these strategies are central to the comprehension of narrative texts (Graesser, Golding, & Long, 1991), they change and become more challenging as readers increasingly encounter informational text during their progress through the elementary grades (e.g., Biancarosa & Snow, 2004; Dreher, 2002).

Informational text is distinctly different from narrative text in terms of structure and intent (e.g., Armbruster, 1984; Duke, 2000). Because of these differences, the processes and strategies readers employ as they interact with informational texts also differ from those they employ while reading narrative texts (e.g., Guthrie and Mosenthal, 1987). Studies of how textual differences influence comprehension indicate that both children and adults have more difficulty reading informational text than reading narrative text (e.g., Biancarosa & Snow, 2004; Zabrucky & Ratner, 1992). The difficulty posed by informational texts becomes even more challenging when

readers must define a specific task, search for information, and select the resources themselves (e.g., Dreher, 2002).

Skilled readers employ a range of integrative processes to aid their comprehension of text (e.g., Pressley, 2000; Pressley & Afflerbach, 1995). Four key elements appear central to informational text comprehension processes: (a) prior knowledge; (b) inferential reasoning; (c) self-regulation; and (d) affective variables related to efficacy and motivation.

Prior knowledge. Readers of information text activate two distinct areas of prior knowledge as they construct meaning: (a) prior knowledge of the topic (e.g., Alexander, Kulikowich, & Schulze, 1994; Means & Voss, 1985) and (b) prior knowledge of text structure (Englert & Hiebert, 1984; Meyer et al, 1980). Readers who draw on both are most able to mentally organize and remember the ideas gained from information text t (e.g., Weaver and Kintsch, 1991).

Inferential reasoning. Inferential reasoning refers to the ability to read between the lines while making connections not explicitly stated in the text (Bartlett, 1932/1995; Beck, 1989). Inferential reasoning is considered a central component of skilled reading (Garnham & Oakhill, 1996). Readers with sufficient prior knowledge tend to make many more inferences compared to less knowledgeable readers in order to facilitate their comprehension of informational text (Kintsch & Vipond, 1979; Voss, Vesonder, & Spilich, 1980).

Self-regulation. Metacognition, in the context of reading comprehension, involves the conscious and strategic use of evaluation and self-regulation (e.g., Paris, et al., 1991). Hacker (1998) has proposed the term *self-regulated reading* to highlight the importance of *both* self-questioning and repair processes. In keeping with Hacker's perspective, we will use the term "self-regulation" in this study to represent the dual metacognitive processes of evaluation and regulation that may occur while reading on the Internet. Skilled readers of printed text are

consciously aware of effective information-seeking processes and regulate their use of these processes by adopting alternative strategies when others do not work (Paris et al., 1983). In contrast, less skilled readers do not naturally monitor their use of effective strategies and are unsure of alternative strategies that work best when the comprehension cycle breaks down (Paris et al., 1983).

Affective variables related to efficacy and motivation. Contemporary perspectives of reading comprehension suggest that motivational variables (e.g., beliefs, values, needs, and goals) intersect with cognitive reading processes to enhance achievement (Baker & Wigfield, 1999; Guthrie & Wigfield, 1997). This work (e.g., Chapman & Tunmer, 1995; Guthrie & Alvermann, 1999; Horner & Shewry, 2002; McKenna, Kear, & Ellsworth, 1995) suggests that a reader's goals, beliefs, and attitudes toward reading can influence how he or she employs cognitive reading strategies while reading informational texts.

In summary, informational texts present additional challenges to readers familiar with narrative texts. Comprehension in print-based information environments is dependant upon a reader's interest and ability to simultaneously connect and apply his/her prior knowledge of topic and text structure with inferential reasoning and self-regulated reading abilities; all in an effort to locate, understand, and use information effectively.

Comprehension of informational hypertext text as compared to printed informational text

Much like the body of research that indicates informational text is distinctly different from narrative text, many have argued that informational hypertext is distinctly different from printed informational text in ways that prompt readers to employ unique cognitive processes and strategies (e.g., Landow, 1994; Reinking, 1997; Snyder, 1996). Hypertext describes "a kind of

informational environment in which textual materials and ideas are linked to one another in multiple ways" (Burbules & Callister, 2000, p. 43). Links embedded within hypertext systems are constructed so that readers must select a target location (rather than just turning the page) in order to move through the text (Rouet & Levonen, 1996). Consequently, compared to print-based texts, hypertexts require readers to take a much more active role in determining the quality and coherence of the texts they read (Burbules & Callister, 2000).

Second, while both print and hypertext environments typically provide supportive navigational features (i.e. a table of contents or network map), the actual content of hypertext is hidden beneath multiple layers of information not viewable with traditional previewing procedures such as rapidly leafing through the pages of a book. Moreover, compared to print-based text, hypertexts often provide link labels with *less* semantic clarity and *fewer* surrounding context cues to guide the reader's anticipation about where a certain hyperlink may lead (Foltz, 1996; Otter & Johnson, 2000). As a result, readers are regularly required to infer associative relationships among links before and after link selection while simultaneously attending to their physical location with the hypertext system (Balcytiene, 1999; Yang, 1997).

A third difference is that contemporary hypertexts often incorporate "hyperlinked icons" (e.g., navigation buttons and dynamic image maps) to provide a visual representation of a hyperlink, rather than a textual one. Consequently, hypertext readers are expected to integrate processes for decoding and interpreting images and pictures into their repertoire of effective comprehension strategies (Kinzer & Leander, 2003).

Studies of how informational hypertext differences influence comprehension are inconclusive. Some argue that interactions with hypertext (and hypermedia) promote comprehension, critical literacy, and choice (e.g., Burbules & Callister, 2000; Myers, Hammett, &

McKillop, 1998; Reinking, 1997). However, others found that the textual features of closed hypertext systems present processing challenges associated with cognitive overload, disorientation, distraction, and frustration (e.g., Balcytiene, 1999; Foltz, 1996; Tripp & Roby, 1990).

Comprehension of Internet text as compared to informational hypertext

While considering the difficulties that closed hypertext systems present to readers, many have recently argued that Internet texts present additional challenges beyond those in hypertext systems that may impact reading comprehension in online environments (e.g. Author, 2003a; Author, 2004a; RAND, 202; Spires & Estes, 2002). For this study, in order to later describe the comprehension challenges presented by informational texts in different electronic reading environments, the term *hypertext* refers to information texts (as opposed to narrative hypertexts) found within a closed hypertext system such as a CD-ROM encyclopedia or library database. *Internet text*, on the other hand, refers to information (hypertext and otherwise) found within the open networked system of the Internet.

A closed hypertext environment is typically bound within the confines of a static system with one organizational structure (Plat, 2004). Users typically enter into the system from the same starting point and, by design, a hypertext system does not usually contain outside advertisements, links that change from one day to the next, or pathways to information that is completely outside the realm of its intended purpose. Finally, search tools in hypertext systems use familiar keyword functions and typically provide the reader with a finite and relatively constant set of results.

In contrast, Internet texts are part of a complex open-ended information system (see Hill & Hannafin, 1999) that changes daily in structure, form, and content (Zakon, 2005). Readers may

enter into the "middle" of an Internet text from countless origins, and, often, they encounter distracting advertisements, inconsistent text structures, broken links, and access to an infinite amount of information completely unrelated to their intended reading purpose (Neilson, 2002). Moreover, multi-modal Internet texts are combined in complex ways (Kress & van Leeuwin, 2001) and are often intermingled with hidden social, economic, and political agendas not typically incorporated into hypertext learning systems (e.g., Cope & Kalantzis, 2000; Leu & Kinzer, 2000). Finally, Internet search tools employ a range of diverse methods beyond keyword searches and confront the reader with an infinite and rapidly changing set of results (Broch, 2000).

Although there is very little work currently published in this area, a few studies have considered issues of reading Internet text. Hill and Hannafin (1997) explored the cognitive strategies used by adult learners on the Internet and found that metacognitive strategies, prior knowledge of subject and Internet text systems, and perceived self-efficacy influenced their ability to interact with and learn from Internet text. Others have explored the nature of Internet search strategies among students in K-12 classrooms and found numerous obstacles to information seeking with open Internet text environments. Readers on the Internet experienced challenges associated with (a) ineffective and inefficient search processes (e.g., Bilal, 2001; Eagleton, 2003; Schacter, Chung, & Dorr, 1998), (b) cognitive overload and disorientation (Fidel, Davies, Douglass, Holder, Hopkins, & Kushner, et al., 1999); (c) a tendency to drift from one search question to another (Lyons, Hoffman, Krajcik, & Soloway, 1997), and (d) an inability to know how to use the information once it has been located (Wallace, Kupperman, Krajcik, & Soloway, 2000).

Findings such as these have prompted calls for more research that explores the strategic reading processes students employ as they navigate, use, and comprehend Internet text (e.g.,

Author, 2004; Dreher, 2002; Windschitl, 2000). Unfortunately, most studies to date are framed in issues related to hypertext design and/or or information science. Few studies have considered these online cognitive processes as critical aspects of reading comprehension (e.g., RRSG, 2002). Consequently, the purpose of this study is to explore the reading comprehension strategies of skilled sixth grade readers prompted by Internet search engines and informational websites, and further, to begin to describe how readers employed these strategies in each context. The tasks we designed focused on three aspects of comprehension deemed important from a new literacies perspective (e.g., locating, evaluating, and synthesizing) (Author, 2004) in two online reading contexts commonly used for Internet research tasks in school classrooms (Lenhart et al., 2001). To explore these issues, we conducted a qualitative study of reading strategies used across these contexts guided by two related questions:

(1) What characterizes the reading process as skilled readers search for and locate information on the Internet?

(2) What informs the choices that skilled readers make while reading for information on the Internet?

Method

Context for this research

As literacy educators, each of us brings to this study experience with navigating and learning from digital texts in closed hypertext learning environments (e.g., multimedia CD-ROMs) as well as from texts encountered within open Internet search environments and multi-level informational websites. As mentioned earlier, we came to this study with a primary interest in how best to develop the informational and academic literacies required in school settings (Educational Testing Service [ETS], 2003; Author, 2004) as opposed to the narrative personal

literacies that adolescents often demonstrate in communities of practice beyond academic settings (e.g., Chandler-Olcott & Maher, 2003; Guzzetti & Gamboa, 2004). Consequently, our tasks required participants to locate, evaluate, and synthesize content area information within informational websites and search engines (typical school and work practices) as opposed to asking students to communicate using Instant Messenger and weblogs, for example, which tend to reflect the Internet technologies and tasks students engage with outside of the school day (Lenhart, Rainie, & Lewis, 2001).

Participant Selection Procedures

Considerations for participation. Our sample selection for this study was guided by four decisions; each based on different, but important, considerations. First, we chose to conduct an in-depth analysis with fewer participants rather than a broader analysis with a larger number of participants. Qualitative researchers suggest when we know relatively little about a phenomenon, as is the case with online reading strategies, exploring a small number of cases to provide a more focused analysis is more likely to provide clearer directions for future research (e.g., Stake, 1995; Yin, 1989). However, we also sought to examine preliminary patterns across readers to explore any group commonalities that may prompt important research questions to investigate further with larger samples. Thus, we felt a purposeful selection of eleven informants allowed us a small enough group to observe individual differences while also being large enough to explore preliminary patterns across the group of informants as a whole.

Second, skilled readers are more likely to demonstrate a wider range of appropriate strategies when asked to complete reading tasks (e.g., Pearson et al.,1992). Moreover, readers demonstrate more knowledge about how to successfully read and navigate Internet contexts when they have more experience using the Internet (Bilal, 2001; Author, 2005). In contrast,

inexperienced hypertext readers and novice Internet searchers tend to be unfamiliar with the conventions and capabilities of hypermedia technology and Internet search engines (Eagleton, 2003; Kumbruck, 1998) and less apt to successfully locate information on the Internet (Bilal, 2001; Yang, 2001). Moreover, less skilled readers tend to have difficulty narrowing the scope of their research questions; they tend to make hasty (and less strategic) reading decisions that cause them to bypass useful information; and are often unaware of how to synthesize information from multiple sources (Author, 2004b; Eagleton, Guinee, & Langlais, 2003). Thus, to explore what characterizes successful Internet reading, we sought to limit our sample to skilled readers in traditional print contexts who *also* demonstrated prior experience reading websites and using Internet search engines.

Third, we selected sixth-grade readers because expository text comprehension is a vital component of success in middle school (e.g., Biancarosa & Snow, 2004) and many middle school students are being assigned tasks in school to search for and read information on the Internet (Becker, 2000). Our sample came from sixth-grade classrooms in two schools in Connecticut and one in Kansas that were in close proximity to each researcher's university. All three schools had populations that were largely white and from middle to high socio-economic levels. Thus, this may limit our results to similar adolescent populations.

A final consideration for selecting participants was informed by previous work in reading comprehension that suggests different types of readers may possess different levels of strategic knowledge (Paris et al., 1983) and different abilities to describe their strategic knowledge (Pressley & Afflerbach, 1995). The latter is especially important since we employed verbal protocol analysis. For this reason, potential informants were asked to indicate their comfort level

when asked to explain out loud to someone else what he or she was thinking while searching and reading on the Internet.

Data sources and procedures. Data sources used to select the most skilled and experienced Internet readers from our population of 150 sixth-grade students included the following: (1) the teacher's informal recommendation about the student's reading ability and amount of experience with searching and reading on the Internet; (2) scores on a district-adopted standardized reading test; (3) sixth grade reading report card grades; (4) a student questionnaire of ability and experience ratings with searching and reading on the Internet (see Appendix A); and (5) an almost identical parent questionnaire of their child's ability and experience with searching and reading on the Internet.

First, teachers in six classrooms were asked to identify students they considered as (a) skilled in traditional reading and (b) experienced in finding information on the Internet. Each teacher identified between three and eight students that fit this criteria. Below we provide a sample description of two students. Space does not permit such an in-depth description of all students, but descriptions are fairly representative of the eleven participants in our study.

Bill: Bill prefers science fiction and fantasy genres, but does not usually read for pleasure. He reads to research topics of interest and school projects and frequently requests to use the Internet to search for information. Bill likes to read on the Internet and reports spending 1 to 3 hours a week searching for information online. He considers himself a very good reader of books and to be very good at knowing where to go on the Internet.

Marie: Marie is a very perceptive reader who chooses classical literature to read for enjoyment. She has an exceptional vocabulary and high levels of prior knowledge about many topics. Marie likes to read on the Internet, but prefers email and chat, which she reports spending 3 hours per week. She considers herself a very good reader of books and to be very good at knowing where to go on the Internet.

Teachers were then asked to indicate each student's most recent standardized reading scores and reading report card grades. Finally, teachers were asked to send a packet of

information home with each student identified as matching the criteria. This packet contained a letter describing our study, two short and almost identical questionnaires (one for parents and one for the student; see Appendix A) and a form seeking parental permission for each child's possible participation. Signed permissions and questionnaires were collected from thirteen students. Two students were excluded because of their lower standardized test scores. Thus, our final sample included four boys and seven girls. Pseudonyms have been used for presentation of all student data.

On the questionnaire, all eleven participants and their parents indicated they were very good at understanding what they read in printed books. Likewise, all of the participants and their parents believed they were at least somewhat skilled at how to figure out where to go on the Internet and could use a search engine to find what they wanted. Questionnaire results indicated all participants had experience using e-mail, playing computer games, and browsing webpages, with most students spending 1-3 hours a week on these activities (See Table XX for details about individual participants). Use of the Internet varied among the locations of home, school, or a parent's office, although the most common location was school. Finally, all eleven students in our sample reported they were "very comfortable" or "sort of comfortable" with think-aloud procedures, which are an important component of the data collection procedures for this project.

In summary, we sought to purposefully select those sixth-graders with the highest combination of standardized reading scores, report card scores, and Internet reading experiences as indicated on student, teacher, and parent questionnaires.

INSERT TABLE 1 ABOUT HERE

Data Collection

Once students were selected, verbal protocols, interviews, and field observations were the principal methods used to collect data. During the two reading sessions, data were gathered during tape-recorded interviews using a think-aloud protocol (Pressley & Afflerbach, 1995) as an effective way to "get inside the minds" of Internet readers in order to better understand their reading processes. Spires and Estes (2002) recommend the think-aloud protocol be used "to help uncover potential cognitive processes inherent in Web-based reading environments…" (p. 123). A pre- and post-reading interview was also conducted with each student (see Appendix B) to capture metacognitive thought processes not revealed during the actual reading activity (see Baker, 2002). Data were collected during two interviews with each participant on two different days.

Both online reading sessions were also video recorded at one research site. However, this data was not analyzed because a mismatch between the scanning rates of each computer monitor and the video camera made it difficult to clearly see any meaningful transitions from one screen to another. Finally, computerized log file data was not collected in this exploratory study for two reasons. First, schools would not allow the required software to be installed on the computers used in the study. Second, extensive a priori programming would have been required to capture online data within reading tasks that did not limit where students could search and read. Because the nature of our research questions focused more on the quality of students' strategic thinking rather than the quantitative totals of page clicks and time spent at each website, we concluded that verbal protocol and strategy interviews would generate enough process data to inform our initial exploration of the cognitive strategies employed while reading online.

Session 1: Reading in a website context. The audiotaped interview began with a brief pre-reading interview to determine participants' level of prior knowledge about tigers, the topic of the

reading task. Next, participants were asked to read within one multilayered website, *5 Tigers: The Tiger Information Center* (http://www.savethetigerfund.org/index.htm), and think aloud while searching for answers to seven literal or inferential comprehension questions. The 5Tigers website was selected after a thorough search by both researchers for a well organized informational website that featured a range of web-based features and was designed with younger readers in mind. The 5 Tigers website contained many photographs, embedded hyperlinks, interactive diagrams, multimedia clips, and informational text passages ranging in length from one paragraph to several pages. Three teachers with experience at the middle school level determined the text was appropriate for skilled sixth-grade readers and the subject overlapped with a range of topics (e.g., endangered animals and habitats) commonly found in the sixth-grade curriculum. Information on the site was organized into eight different sections, all clearly visible from the homepage (see Figure 1), and the website provided a local search-engine.

INSERT FIGURE 1 ABOUT HERE

Each participant was given a typed sheet to refer to as they completed the task, with the following assignment:

> Use information provided from 5 Tigers: The Tiger Information Center to answer the following questions: (1) Describe the habitat of the Bengal tiger; (2) What causes the white color in tigers?; (3) According to the narrator of the video "Tigers a Vanishing Species", how does the loss of timber indirectly affect the survival of tigers?; (4) What are the names of the three people who maintain this website and why was it created?; (5) How many pounds did each new cub weigh that was born at the Minnesota Zoo in 1999?; (6) How might a teacher using this website help students join a letter writing campaign to help save tigers?; and (7) What parts of the tiger are used for traditional Chinese medicine?

The questions were designed to encourage students to remain within the pages of one

informational website while locating specific facts found in very different locations (e.g., varying levels away from the homepage) and in multiple media forms (e.g., text, hypertext, dynamic images, and video) within the site. Participants could work through the questions in any order they preferred and were given the option of moving to another question if they had difficulty locating the answer. Participants verbally reported each answer to the researcher. During the tasks, students were encouraged to first make a determination if the answer they located was correct. If asked, the researcher would confirm or disconfirm the correctness of a response.

Students were asked to think-aloud during this reading task because verbal protocols are thought to offer valid and reliable insights into a reader's thinking and actions, especially if conducted during a task (Pressley & Afflerbach, 1995). The researchers followed a combination of concurrent and retrospective procedures (Afflerbach, 2000). At the beginning of each task, students were asked to "tell me what you are thinking and what you are doing as you look for information on the Internet". This provided access to information about how readers constructed meaning and responded to a range of Internet texts. In addition, since readers tended to naturally share their thinking just before or after they clicked on a link or scrolled a page, these opportunities appeared to represent a natural stopping point from which to find out more about what informed these reading decisions (which was the focus of our second research questions). Often, readers naturally shared their thinking at these decisions points and, occasionally, we asked students to further explain "Why are you clicking there" or "Where do you think that's going to take you?" to learn more in particular about what informed these reading decisions. While we recognize these procedures may have interrupted the flow of reading or prompted participants to use particular processes over others (Pressley & Hilden, 2004), our readers appeared quite capable

of thinking aloud while making decisions. Moreover, we were careful not to place judgment on reader comments in any way that might appear to value one thought over another.

Immediately after the reading session, further insights about each student's use of particular strategies students were gained in a post-reading interview (see Appendix B). Open-ended questions such as "what worked best for you today" or "what do you think good readers do when they read on the Internet" also provided a more natural opportunity for students to reflect on their strategy use outside of the prompted think-aloud session. Data from researcher field notes and post-reading interviews were compared to the data from think-aloud protocols as a way to confirm or disconfirm patterns and conclusions. Table 2 displays a synopsis of numerical data collected from the website reading task in Session 1.

INSERT TABLE 2 ABOUT HERE

Session 2. Reading in a search engine context. In the second interview, on a different day, participants were asked to select a search question from two open-ended questions developed from the sixth-grade science curriculum: (1) What can make a hurricane lose its power? and (2) What is the difference between a landfill and a dump? The first question asked students to locate a particular fact while the later was designed to elicit some form of synthesis from at least two different sources since no search results pointed directly to an answer. Topics were chosen based on the likelihood students would have some prior knowledge from the previous grades' curriculum, but these specific topics had not yet been covered in the current curriculum, so the answers to questions would likely not be readily apparent.

Participants used *Yahooligans!* (http://www.yahooligans.com) a children's search-engine and directory designed for children ages 7-12 (see Figure 2) to search for an answer to these two

questions. When this study was conducted, this engine provided five different ways of accessing the same information within its directory of websites. Users could: (a) use the open search box to type in search terms of their choice; (b) browse by subject hierarchies such as "Around the World", "Sports & Recreation", and "Science & Nature"; (c) select from a variety of "popular" children's categories found on the left hand side of the homepage, such as games, animals, science, music, and news; (d) browse a list of answers to questions previous readers posed to the "Ask Earl" service; or (e) compose an original message using the "Ask Earl" service that would be answered within 24 hours and posted back to the search engine's growing list of frequently asked questions.

INSERT FIGURE 2 ABOUT HERE

Similar to the first reading session, both researchers used a standardized protocol at the beginning of this open-ended reading task. Participants were asked to "tell me out loud what you are thinking while you look for information that might help answer each question". Occasionally, during the session, participants were asked to explain how they selected search terms, how they skimmed through search results, how they decided which site to visit, and how they attempted to locate relevant information within each web site. Both researchers also kept field notes and gained further insights about the strategies students used in the post-reading interview (see Appendix A). Again, data from the field notes and interviews was compared to the data collected from the think-aloud protocols as a way to confirm or disconfirm patterns and conclusions. Table 3 displays descriptive data from the search engine reading task.

INSERT TABLE 3 ABOUT HERE

Member Checking. Participants at the Kansas site returned for a third session where the researcher and group discussed the Internet reading process in general and those strategies used by the participants. Initial observations and conclusions were presented to the group to a) check for accuracy and b) seek confirmation and further illumination of strategy use by individual participants and the group as a whole. The session was audio taped, transcribed, and analyzed for the confirmation or disconfirmation of initial patterns and conclusions identified in the think-aloud and interview transcripts.

Data Analysis

Data analysis followed a grounded theory model (Glaser & Straus, 1967; Glaser, 1992), which seeks to identify concepts that emerge from the data and compare these concepts to established ideas. Our purpose was to develop an understanding of (a) the nature of online reading, and more specifically, the reading processes Internet readers used to search for and locate information; and (b) the rationale behind the choices our participants made during their Internet reading experience. Our analysis evolved through four distinct phases, each of which involved reviewing data from think-aloud protocols, field observations and semi-structured interviews to provide insights in these two areas.

Phase One

During the first phase, an overall sense of the data was gained from a general review (Tesch, 1990) of questionnaires, transcripts, interviews, and field notes. These various data sources were read to gain an understanding of the nature of online reading. Notes were made regarding general impressions and initial ideas about common patterns and possible themes. Next, we applied Stake's (1995) direct interpretation approach to draw meaning from the think-

aloud data by looking at each unit of analysis and then making comparisons among and between tasks and participants. Within the think aloud protocols and interviews, the unit of analysis was identified as a propositional cluster, or a cluster of propositions focused on the same or similar ideas (see Van Dijk & Kintsch, 1983). For the purposes of this study, a propositional cluster was defined as a reading decision and an accompanying explanation. For example, a propositional cluster from one participant included the following: "I am going to click on this link because I think it will help find information about tiger habitats". Some propositional clusters contained 2-3 sentences such as, "I am not sure where to go next. I think I will go back. When I was reading the other webpage, I think there was something there that I might have missed. I want to read it again." Clusters within the think aloud transcripts were identified. Occasionally one cluster overlapped with another when two reading decisions appeared to occur simultaneously.

Phase Two

During the second phase of analysis, we followed Glaser's (1992; 1998) grounded theory procedures. First, each researcher scanned a common transcript to a) get a general sense of the data; b) assign tentative labels to propositions; and c) look for patterns across these propositions. Then, each researcher applied constant comparison analysis across cases (Merriam, 1988) to scan a second transcript, looking for propositional patterns that compared or contrasted with the first transcript. Individually, and then together, we tentatively coded patterns between the first two transcripts using categories that emerged from our note taking during and after the interviews. We discussed these patterns and compared them to theories of reading comprehension and Internet text that might inform our formal coding process. For example, in this phase, we initially noted a high frequency of propositional clusters that contained inferential predictions, or evidence that a reader makes, confirms, or adjusts a substantiated guess about what will come next before

clicking on a particular link. This tentative pattern appeared consistent with the notion that "web-based information is highly abstract because detail about its description is concealed until activated" (Dede & Polumbo, 1991, as cited in Bilal, 2001, p. 661). Guided by this theory, we focused our attention on coding these inferential predictions, and when possible, included the readers' inference of where that prediction would lead.

As this category emerged with high frequency of mention, we classified it as a core category, or theme. Then, data in subsequent transcripts were compared to initial data to see if these tentative patterns continued to emerge as a constant theme across all transcripts. As Glaser (1992) recommends, during this pass through the data, we ceased coding any propositions that did not relate to the core category of inferential predictions or to particular properties of these predictions. Appendix C outlines the coding scheme, definition, and examples of each theme that emerged from our data as we applied this process to each phase of our analysis. The two researchers coded 27% of the think-aloud protocols (N=3) for inferential predictions and agreed on 92% of the codes. Disagreements were resolved in discussion, and one of the researchers then coded the remaining protocols for this theme. After completing our focused coding of inferential predictions, we returned to the data in two subsequent phases to explore the emergence of other patterns.

Phase 3

During phase three, we returned to an emerging theme related to our research question about the reasons behind the choices Internet readers made during each reading task. We noticed participants using various types of prior knowledge to guide their decisions (see also Trabasso & Bouchard, 2002). Collaboratively, while referring to one transcript, we identified four types of prior knowledge being activated while reading on the Internet (See coding scheme in Appendix

C). Each researcher then coded three more transcripts for these different types of prior knowledge and agreed on 90% of the codes. Disagreements were resolved in discussion, and one of the researchers then coded the remaining protocols for this theme.

Phase 4

The fourth and final phase of data analysis was informed by a tentative pattern among our participants in relation to our first research question about Internet reading processes used by students. When we made comparisons between the cases, we found evidence of readers following a loose structure of steps that seemed to reoccur during their reading process. We were reminded of the work by other researchers who outlined cognitive models of information seeking in printed informational texts (e.g., Guthrie & Mosenthal, 1987; Mosenthal & Kirsch, 1991). Thus, we decided to investigate whether or not similar processes were taking place among skilled readers as they read informational text in Internet contexts (e.g., websites and search engines). Through comparison and discussion, we reached agreement that the transcripts contained preliminary evidence of students using a recursive pattern of four self-regulatory comprehension strategies including mental planning, predicting, monitoring, and evaluating. The two researchers coded 36% of the think-aloud protocols (N=4) for this loose pattern of strategy use in the information gathering process and agreed on 85% of the codes. Overlaps between the strategies employed in this cyclical process made coding for this theme more challenging than previous phases. Nevertheless, most disagreements were resolved in discussion, and one of the researchers then coded the remaining protocols for this theme.

Findings

In this study, we explored two research questions: (1) What characterizes the reading process as skilled readers search for and locate information on the Internet? and (2) What informs

the choices that skilled readers make as they search for and locate information on the Internet? An analysis of the data from think-aloud protocols, observations and post-reading interviews revealed several patterns of cognitive strategy use suggesting that, in some ways, reading on the Internet looks the same as reading printed text and in other ways, reading on the Internet is uniquely more complex. More specifically, the skilled readers in our study shared insights that suggested successful Internet reading experiences appeared to simultaneously require both similar and more complex applications of (1) prior knowledge sources; (2) inferential reasoning strategies; and (3) self-regulated reading processes (see Table 4). Examples of each will be discussed in turn. For each pattern, we begin with examples that illustrate similarities between the comprehension of printed text and Internet text. Then, we continue with examples that illustrate what appear to be complexities of comprehending Internet text beyond those required for comprehending printed text. Finally, since we found the comprehension process to be much more complex than could be represented by separate thematic descriptions, we conclude our findings with an illustration of a richer and more complete reading episode to illustrate how each of these patterns simultaneously played itself out during online reading.

INSERT TABLE 4 ABOUT HERE

Prior Knowledge Sources

A first theme that emerged from our data suggested that reading comprehension on the Internet appeared to require both established and new sources of prior knowledge combined in unique and complex ways. We found that skilled readers relied on four major sources of prior knowledge as they read for information on the Internet: two sources that are established in the

research literature and grounded primarily in knowledge gained from broad reading and other world experiences, and two that we believe account for new areas of knowledge gained from experience reading on the Internet. We have identified these four sources as (1) prior knowledge of the topic; (2) prior knowledge of printed, informational text structures; (3) prior knowledge of informational website structures; and (4) prior knowledge of web-based search engines. Think-aloud protocols from each participant reflected a reliance on these four sources. We briefly define these four categories of prior knowledge and provide examples to illustrate how students drew upon them while reading on the Internet.

Familiar knowledge sources used to comprehend Internet text

Prior knowledge of the topic. For many years, we have known that readers rely on domain specific information and key vocabulary as they read printed texts (Anderson & Pearson, 1984; Beck, et al., 1982). We found this also to be the case when reading on the Internet. For instance, Jessica explained how her understanding of vocabulary helped locate information online.

> Jessica: (while trying to answer the question, "How many pounds did each tiger cub weigh when it was born?"): I'll probably go here (pointing to the hyperlink "Breeding log"), because the breeding log is what would have the cubs, to see if there's anything there.
> Researcher: What do you think a breeding log is?
> Jessica: Where they were born, the tiger cubs, and it keeps track of them.

Jessica's previous background knowledge of the separate vocabulary items "breeding" and "log" guided her toward making a navigational decision to click on the link for breeding log. Similarly, below, Carrie applied her topical background knowledge and vocabulary skills as she searched for an answer to "What causes the white color in tigers?". She justified her choice of the hyperlink "Appearance" with this reasonable prediction:

> Carrie: Well, their [the tigers'] appearance is the color, so that [the hyperlink "Appearance"] might help us…It's probably going to give us an article of

> more specific information, on the color of a tiger, since it's under 'Appearance' so it will probably talk about the way tigers look.

More generally, Veronica explained in one interview session:

> Veronica: Use your vocabulary to figure out if words would have anything to do with the question whatsoever. We were doing a study earlier with you on Yahooligans and using that, we kind of eliminated certain links by using that process.

Prior knowledge of printed informational text structures. This second source of prior knowledge includes the knowledge of organizational and structural features of informational text such as signal words, bold-faced or italicized typography and paragraph headings, index, and table of contents (see Armbruster, 1984; Goldman & Rakestraw, 2000). The skilled readers in our study integrated their understanding of these informational features and structures as they read within websites on the Internet.

Marina, for example, drew from her prior knowledge of printed informational text structure as she searched for information about dumps and landfills. As she skimmed a particular website, she expected to find certain textual features to support her reading based on her experiences with printed informational text: "Maybe we should scan the page to see if there are any headings that might show where that would be." Later, when asked in the post-reading interview how she decided what link to follow when she is looking for information on the Internet, she explained, "You kind of think of what topic it would be related to…what page it would be under; it's kind of like a table of contents, what a chapter would be on under a certain topic." In both instances, Marina used her knowledge of the hierarchical way informational text is typically organized in books to guide her reading decisions in web-based contexts.

In a follow-up interview with another student, Bill more clearly explained how his structural knowledge of textbooks supported his ability to infer the most likely place to locate particular levels of information on the websites he visited:

Bill: Textbooks are divided into units, and then into chapters, and then to lessons and sections. So you could see on the website that we visited that we started out with just the homepage and then you'd pick something on the side and that was basically your unit, and then you had like five choices there, and that was a chapter, and then you went in there and picked from like ten or so there and that was like a lesson or a section. So it was similar to a book.

New knowledge sources used to comprehend Internet text

Prior knowledge of informational website structures. The skilled readers in our study also drew from their prior knowledge of informational website structures to guide their reading on the Internet. This particular knowledge included how to recognize and negotiate hierarchical and non-linear hyperlinks, navigational icons, interactive multimedia, and browser toolbars (see also Bilal, 2001; Eagleton, 2003). Our data suggested that readers appeared to possess important sources of knowledge about the structure and organization of informational websites that informed the decisions they made during online comprehension. For example, Chad alluded to his familiarity with website structures and his understanding of the varied purposes of different hyperlinks in relation to their location on a webpage:

Researcher: Is there a difference between the links down here [pointing to the list of links down the left hand side of the screen] and the links, let's say in the page itself?

Chad: Yeah, these [links in the left frame] are a little bit broader…but once you get to the page, see it will bring you to a page that will be more in-depth so you can actually find what you need easier.

Guided by his understanding of this website's underlying structure, Chad made purposeful and effective choices about where, what, and how to read.

In a different session, Alison relied on her prior knowledge of website structures to identify important starting points within the 5Tigers website. Each time she started to answer a new question, she returned to the homepage to begin her search. When asked why, she replied, "Because that [the homepage] is pretty much the general site and it has general information on it."

Alison's new source of background knowledge enabled her to navigate multiple levels from the homepage to locate specific information for one reading purpose and then efficiently return to a logical starting place to complete her next reading task.

Prior knowledge of web-based search engines. This type of knowledge involved understanding the processes for browsing, selecting appropriate search engines, formulating keyword searches, negotiating subject hierarchies, and evaluating annotated search results (see, for example, Bilal, 2001; Eagleton, 2003; Henry, in press). Equipped with these experiences, the readers in our study strategically narrowed down the amount of information required to read in order to efficiently access relevant information without being overwhelmed:

> Veronica: So now, for this one, 'what is the difference between a landfill and a dump?' I'll type in landfill because I learned that it's better to search all of Yahooligans! instead of restricting it to just [the category] Science and Nature.
>
> Chad: Well, if using the search engine, then read all, like the top five or ten or something of the sites to decide which is best and then click on the best one. And if none of them work, then you can keep going down, but not too far…if they don't work, most of the other ones won't work and you should try a different search.

These students' insights demonstrated how experience with the workings of search engines fostered reading efficiency and comprehension of the search results they received.

In summary, the patterns that emerged in relation to this first theme suggested readers drew from four sources of prior knowledge: knowledge of the topic, knowledge of printed informational text structures, knowledge of informational website structures, and knowledge of web-based search engines. These four knowledge sources, two old and two new, provided the readers in our study a foundation from which to inform each of their Internet reading choices.

Inferential Reasoning Strategies

A second theme that emerged from our data suggested that reading comprehension on the Internet required similar and more complex dimensions of inferential reasoning compared to the comprehension of printed, informational texts. Inferential reasoning refers to the ability to read between the lines while making connections not explicitly stated in the text (Beck, 1989). "A prediction is a special kind of an inference [whereby] background knowledge is used to make a guess about what is going to happen in the text" (Keatley, 1999). When analyzing the data across all eleven students and two different tasks (reading within multi-level websites and using search engines), we observed skilled readers regularly, and without exception, actively applying a range of inferential reasoning strategies, especially forward, predictive inferences, as they searched for information on the Internet. Some dimensions of these strategies appeared to be similar to those employed while reading traditional, printed text and others appeared to be unique to Internet reading contexts.

Similarities to inferential reasoning applied to printed text

The interactive and associative nature of Internet text seemed to encourage students to regularly make, confirm, and adjust inferences using strategies and structures similar to those skilled readers use in printed texts (e.g., see Duke & Pearson, 2002; Rumelhart, 1977). While each tasks' comprehension questions were not deliberately designed to elicit the use of any particular strategy or cueing system, the readers in our study made conventional types of forward inferences to inform their online reading decisions aided by their ability to use (a) literal matching skills, (b) structural cues, and (c) context cues.

In terms of literal matching skills, many students described their attempts to match words they located on the Tiger website to words on the printed question sheet in order to make an

inference about which link may be most relevant for their purpose (since they could not see the resulting information until the link was selected). For instance, after scanning through the labels of various hyperlinks in a webpage's topical list to locate an answer to the question "How might a teacher using this website help students join a letter writing campaign to help save tigers?, Bill relied on literal matching skills to inform his inference about which link may be most appropriate to follow:

Bill:	Okay, and now [I'm going to click on] "Letter writing campaign" (clicked on the hyperlink)
Researcher:	Now before you go on to the next one, why did you pick that one again?
Bill:	Because it [the hyperlink] had 'Letter writing campaign' and it [the printed question] asked 'Letter writing campaign'
Researcher:	So it had the words in the question [on the paper], and the same words on the screen, so you picked that one.
Bill:	Yeah, that's what I was looking for.

Second, during both tasks, readers made inferences based on structural cues in the text. For example, while scanning a page of text to locate an answer to the question, "What parts of the tiger are used for traditional Chinese medicine?" one student explained, "Now, I'm just going to read the subtitles and a little information about it to see which one to choose…and I'm going to look here [pointing to a certain link] for what tiger parts are used for". Another student suggested "Maybe we should scan the page to see if there are any headings that might show where that would be." Several other students described their process of scanning the text on a webpage for headings and bold-faced words, predicting that these might lead to important details about tigers.

Third, similar to making inferences while reading printed texts, we found evidence that skilled readers of Internet text relied on context cues embedded in the text surrounding a link, rather than the link itself, when they were available (e.g., link annotations and related captions) to predict, *before* they clicked, where that link may lead. Chad, for example, predicted the hyperlink "Multimedia" was the best link to follow to answer the question 'According to the narrator of the

video *Tigers a Vanishing Species*, how does the loss of timber indirectly affect the survival of tigers?', because, "it said under the caption that it has slide shows and pictures and stuff". In another example, while looking for the answer to the question "What is the habitat of the Bengal tiger?", Jessica explained, "I'll probably go to 'Tiger Basics' because it says after the link "tiger facts, physical characteristics", and that kind of stuff….I think it might show their habitat, I guess." Here, Jessica's inferential connection between keywords in the description after the hyperlink (e.g., "tiger facts") and keywords in the question (e.g., "habitat" and "tiger") appeared to inform her decision to select that hyperlink rather than another.

In addition to using context cues to guide their inferences within informational websites, the skilled readers in our study relied on context cues while reading an annotated list of search results. Readers often relied on the text annotation after each hyperlinked search result to infer which link would bring them *closer to* or *further away* from a relevant answer. For example, while searching for information about what makes a hurricane lose its power, Veronica inferred a connection between her reading goal and the description *surrounding* the link (rather than the link name itself):

> Veronica: I'm going to choose 'Weather for hurricanes and tycoons' (clicked on link), and now I'm going to read the list of sites and information about them to see if they're good. And this looks like a good site, cuz it says [after the hyperlink] 'See how hurricanes are formed' and it might have information on hurricanes losing their power.

Similarly, many readers elaborated on their use of the information surrounding a hyperlink to help decide what links would *not* be worthwhile:

> Carrie: (sifting through search engine results for information about the difference between a landfill and a dump): I read the little description…like what it said about them; so for that link, it [the annotation] said the Boston Tea Party, I knew that wouldn't have anything to do with the dump I was looking for. And then some of them [other annotations] were talking more about ways to recycle, and I knew that wasn't what I wanted to look for either.

Thus, the skilled readers in our study often made conventional types of predictions and inferred connections between various context cues, their background knowledge, and their reading purpose (see Rumelhart, 1977) as they read in two different Internet text environments. In turn, their use of these strategies appeared to foster their ability to navigate relevant and efficient pathways through Internet text while consciously steering clear of those that seemed to detract from their reading goal.

Unique complexities of inferential reasoning required in Internet contexts

As we deliberated about the amount of predictions our participants made while reading Internet text, we began to look more closely at the nature of the inferences themselves. From our analysis, two themes emerged to suggest that Internet texts may prompt different patterns of activation and a more complex use of inferential reasoning strategies compared to those that research suggests are required for reading printed informational text.

A high incidence of forward inferential reasoning. The first theme suggested that the nature of Internet text appeared to prompt a high incidence of forward inferential reasoning (e.g., predictions) beyond the level typically involved in the comprehension of printed informational text. Previous research shows that forward inferences play a large role in the comprehension of narrative text (e.g., Graesser, Singer, & Trabasso, 1994; Murray, Klin, & Myers, 1983). However, forward inferences (e.g., predictions) are generally considered to play a much smaller role in the comprehension of informational texts as compared to backward inferences, or those intended to fill a gap in the cohesion of a text (Leon, Escudero & van den Broek, 2000; Singer, Harkness, & Stewart, 1997). In addition, when readers do generate forward inferences, some studies show that they typically occurred only for informational retrieval purposes *after* reading (e.g., Potts et al., 1988; Singer & Ferreira, 1983).

In contrast, in our reading of the data, we found evidence to suggest that the skilled readers in our study appeared to make forward inferences (e.g., predictions) within Internet text each time they were confronted with one or more hyperlinks on a given page. At first, we wondered if the nature of verbal protocol may have prompted the high incidence of these predictions, and at times, it did. Yet, as we looked closely at the transcripts, we found our informants were often volunteering these predictions as a natural part of their thinking process rather than responding to any prompting to make a prediction about where a particular link may lead. Exemplars provided in the previous section about prior knowledge sources are illustrative of the types of predictive inferences our participants regularly made to guide their comprehension of Internet text. Other examples included the following:

Jessica: (while searching for information about how a hurricane loses its power): I think I'm going to go to "American Red Cross Hurricane" because it says "What to do when a hurricane warning is issued" and it might have something on what might cause it to stop.

Veronica: (while reflecting on an inference made about a link she followed for information about the difference between a landfill and a dump): I thought that it might say something about what a landfill is, and what a dump is, and how they're different and stuff…but I guess not.

Further, data from the follow-up interviews revealed that skilled readers considered their ability to make forward inferences an important component of online reading comprehension. When we asked Alison, for instance, what she would tell students about how to read well on the Internet, she replied:

Alison: Well, I guess I would look at the link to see what would be likely.
Researcher: Okay, so you look at the link. Do you think before you click, or click before you think?
Alison: I guess I think a bit before I click.

Similarly, Matthew described the strategy he would use to teach others how to read well on the Internet: "You kinda just have to use common sense…you just kinda' think you know

which one would fit or seems like it's the right one. There are some [hyperlinks] that fit and some that don't fit". Here, we would argue, Matthew's mention of "some [hyperlinks] that fit" and "some that don't fit" suggested that while he was reading, he not only made predictive inferences about the links he ultimately selected, but he also made inferences about the relevance (or fit) of at least some of the other links on the pages he visited. Another student's comments appear to support this argument as well:

> Marina: [skimming a website for information about what would make a hurricane lose its power] Well, we can eliminate already that we don't want the facts of it [referring to one link], and we don't want to protect buildings from it [a second link], and we're not talking about warnings [a third link], so we have three left. And since this one [a fourth link] has more of the context of the power of the storm, it's connecting the words with the question, so this one [link] would probably be better to look at.

Thus, as we conjure up images of the hundreds or even thousands of hyperlinks a typical reader passes over while conducting a forty-minute search through multiple websites and lists of search engine results, our data hints at the likelihood that strategic readers of Internet text may indeed make *many* forward predictive inferences as they construct an efficient and relevant path through Internet text.

A multi-layered inferential reading process. A second pattern that emerged from our analysis suggested that the skilled readers in our study engaged in a multi-layered inferential reading process that occurred across the three-dimensional spaces of Internet text. That is, we observed skilled readers combining their use of traditionally conceived inferential reasoning strategies with a new understanding that the relevant information may be "hidden" beneath several layers of links on a website as opposed to within one visible layer of information in a printed book. For example, one student's use of the word "underneath" as part of her reading plan implied her understanding that reading on the Internet involves anticipating what may appear

across multiple levels of information. Before she clicked the mouse, this reader predicted what she would find at not just one level, but *two* levels beneath a particular hyperlink:

> Carrie: I'm going to click there [on the link for the National Hurricane Center] because it sounds pretty basic, and I'll see if it has another title *underneath* it [on the next page] that might take me to a center about hurricanes and just stuff about it.

Likewise, in the post-interview, another student used the term "multi-step link" to express her understanding that the Internet is organized a bit differently than many printed informational texts and may require more of a multi-level, problem-solving approach to reading comprehension:

> Marina: If you would go over to one of the encyclopedias and just open up the page, generally they would have a picture and the name of the species, various specific but general information that you would be able to find the name of the species, the scientific name, what kind of region they live in and stuff like that - whereas this [information on the Internet] is more of a multi-step link.

When thinking about the differences, printed text environments (e.g., textbooks, magazines, and novels) allow readers to quickly flip and scan through all of the available pages in a book, getting the general gist of the text and then using this knowledge to anticipate the comprehensibility and relevance of the information bound within that text (e.g., van Oosterdorp & Goldman, 1999). In contrast, these data suggested that Internet reading environments (e.g., multi-level websites and search engine interfaces) do not provide these same affordances. Instead, comprehending Internet texts required readers to anticipate their understanding through multiple layers that were almost always hidden from view. As a result, compared to the literature on reading in printed text environments, Internet reading seemed to demand many more attempts to infer, predict, and evaluate reading choices (e.g., hyperlinks followed) while anticipating the relevance of information in an open information space multiple levels beyond a visible link. In addition, comprehending Internet text appeared to require readers to orient themselves in a new

and dynamic three-dimensional space that extended beyond the traditionally conceived boundaries of static books to figure out how to get back to where they "were".

As we describe the types of inferences our participants used to comprehend Internet text, it is important to note that, in the current study, we did not actually observe our students reading any printed texts other than the question sheet. Thus, we are obviously cautious in how we interpret the unique patterns and complexities that emerged from our data. However, the notion that Internet text comprehension may be characterized by a high quantity of forward, or predictive, inferences *during* the comprehension of informational text and not just for retrieval purposes introduces the possibility of a unique complexity to how skilled readers process Internet text compared to printed informational text. Further, our finding that some skilled readers were actively engaged in making forward inferences about information that laid multiple layers away from their current location in the text suggests we should further explore the idea that online comprehension may pose additional complexities associated with inferential reasoning.

Self-regulated reading strategies

A third theme that emerged from our data suggested that the skilled readers in our study regularly employed a range of self-regulated reading strategies as they read within and across search engine and website contexts. As indicated earlier, self-regulated reading refers to the dual metacognitive processes of evaluation and regulation that occur during reading (Hacker, 1998). Similar to patterns within the two previous themes, some of these self-regulated reading strategies appeared to be similar to those traditionally conceived in print-based reading contexts while others appeared to be more complex.

Similarities to self-regulated information seeking processes in printed contexts

Use of independent fix-up strategies. Data from think-aloud protocols revealed many instances where skilled readers used traditional types of self-regulatory reading strategies such as goal setting, rereading, monitoring, and comprehension repair (e.g., Baker, 2002; Horner & Shewry, 2002) as they read within search engines and across websites on the Internet. At times, it seemed as if our informants employed these as independent fix-up strategies (e.g., Baker, 2002; Duke & Pearson, 2002) when they were confused or realized they were not where they wanted to be. For example, when one student realized her Internet search turned up little relevant information for answering the question about the difference between a landfill and a dump, she demonstrated her use of a rereading fix-up strategy:

> Carrie: I'm going to try [searching for] landfill again.
> Researcher: Okay, and how come you're going to do that?
> Carrie: I'm going to see if I didn't read something that maybe I should have.

Similarly, in the 5Tigers website reading task, Andrew used a rapid "back and forth" constructive thought process to actively scan, monitor, and then pursue several fix-up strategies right in a row:

> Andrew: How many pounds did each new cub weigh? [reading from the question sheet about the weight of three cubs that were born at the Minnesota Zoo]… I'm going to go "How Big is a Tiger" [clicked on the hyperlink on the 5Tigers site] and uh…it doesn't have anything about cubs [monitored his understanding and the relevancy of information], so I'm going to go back [used a fix up strategy] and I'm going to go to "Cubs" [clicked on the hyperlink] and I'm going to read this… and I'm going to look for "Minnesota Zoo" [scanned the page for this phrase which was a second fix-up strategy] and there's nothing here so I better look somewhere else [began the plan for a third fix-up strategy].

Use of a self-regulated reading process. More often, however, as we looked at the patterns across our data, we found these fix-up strategies not only being used as a series of isolated strategies, but more as connected components of a self-regulated reading process that seemed to parallel dimensions of self-regulated, information-seeking models derived from research in print-based text (e.g., Brown, 2003; Guthrie & Dreher, 1990; Mosenthal & Kirsch, 1991). The eleven

sixth-grade skilled readers in our study demonstrated to varying degrees a recursive cycle of choice-making behaviors (see Figure 3) while reading for information within a multi-layered web site as well as when using a search engine to skim and scan search results. Although this process often occurred very quickly, four cognitive strategies appeared to underlie most of the behaviors we observed. Typically, each time a student was faced with a new webpage that contained a new series of links to choose from and new information to read or interact with, this cycle began again. For the sake of illustration, we have attempted first, to represent this cycle by isolating each strategy and elaborating on the thinking process involved with a series of questions we have inferred the reader is asking while reading on the Internet. Afterwards, we follow up with examples of this recursive cycle as it played out in two web-based reading contexts.

INSERT FIGURE 3 ABOUT HERE

Strategy 1. Plan: Fromwithin the homepage of a website or a search engine, a reader is immediately faced with multiple choices upon which to think and act. The reader begins thinking and acting in ways that address the following questions: What do I need to find out? Where should I begin? Where do I want to go? What do I need to do first?

Strategy 2. Predict: Having set a purpose and developed a mental plan, the reader almost simultaneously makes a prediction or draws an inference about where this plan's current choice will lead. Given that we asked readers to think out loud as they were reading, this strategy was revealed in think-alouds such as (a) I think this hyperlink will lead…. ; (b) I am hoping this will take me …. ; (c) If I click here, I'd expect to find…

Strategy 3. Monitor: Having selected a link with an anticipated result, the reader monitors the choice that has been made. Thinking at this stage is often characterized by pauses, headshakes, page scrolls, and thinking sounds (e.g., um, hmm, ah). The reader seems to wonder: Is this where I expected to be? What pertinent information stands out on this page? Should I skim or read more carefully? Does this make sense?

Strategy 4. Evaluate: Given his/her prior knowledge and the information available, the reader actively evaluates the relevance of the choice: Does this choice bring me closer or further away from my goal? Is this a likely and appropriate place for the information I need? Should I move to a deeper level, select a related topic, revert back to an earlier location, or start all over again? This complex thinking easily blends in with the monitoring process described in the previous stage, but here, given the interactive nature of Internet text, the reader must make an active decision as part of the comprehension process. Once a decision is made, the reader is again faced with multiple choices and the cycle repeats with an updated goal. This cyclical dimension of the online reading process is revealed in think-alouds such as, " Now, I'm just thinking about the question and where to find it, and see if it's there, and if it's not, I'm thinking about where I can go next if it's not there."

We found evidence of this self-regulated reading process as revealed through student think-alouds, first while reading within a website and second, while using the Yahooligans search engine. In these next two examples, we have highlighted our coding of the four stages in this process, as described above, by inserting a one-word label for each within brackets. The bracketed label precedes the thinking that represented each stage in the process.

In the first example, while reading with a website, Andrew began at the homepage for the 5Tigers website (http://www.savethetigerfund.org/index.htm). Over the course of the next six

minutes, Andrew, a very skilled reader and experienced Internet gamer, cycled through this recursive information-seeking process no less than seven times, thinking aloud as he navigated within the website while answering the first three comprehension questions. Andrew indicated he would start with the first task: "Describe the habitat of the Bengal Tiger". He began talking while skimming the homepage:

Andrew: [**PLAN 1**] I'm just going to read the introduction now…Or skim it…to see if … I'm going to look at all the subtitles to see any good links. (clicked on "All About Tigers", skimmed quickly, then clicked on "Research") … [**PREDICT**] I'm going to look for something that might be related to habitat or something or just general information… [**MONITOR**] (skimmed the page)…And ah, …[**EVALUATE**] … this doesn't really seem to be anything so I'm going to go back (clicks the "Back" button)… [**PLAN 2**] and I'm going to go to 'General Information' (clicked on hyperlink)…[**MONITOR based on prior PREDICTION and EVALUATE**] …ah… there's nothing here, I'll go back (clicked the "Back" button) …(**PLAN 3 and PREDICT**) maybe I can find some information on the different tigers and their habitat…hmmm (Clicked on "Siberian Tigers", quickly skimmed the page)…[**MONITOR**]… hmmm… [**EVALUATE**] I'm going back now (clicked the "Back" button)…[**PLAN 4**] I'm just going to check everything now because [**PREDICT**] I don't know what to do … [**MONITOR** and **EVALUATE**] (skimmed links and eventually clicked on "Tigers in Trouble") …[**PLAN 5**] Now I'm going to go to 'Descriptions of Habitat Loss" (clicked on hyperlink) so… [**MONITOR**] ok, uh, the habitat is like, they live in forests, in forest-y areas. [**EVALUATE**] yup yup, there's some other places that'll tell you some more that you may come across. [**PLAN 6**] And now I'm going to the second question, 'What causes the white color in tigers?' and um…I'm going to …think that I should go to the place that has the features of a tiger and all about tigers (clicked on "All About Tigers") …and I'm going to go to Tiger Basics (clicked on "Tiger Basics") [**PREDICT**] because it seems like it'd be there. [**MONITOR**] And it has physical characteristics somewhere around here (recalled from a previous viewing of this page as he skimmed and then more closely read the section about white tigers, read the introduction and skimmed the rest). Um…[**EVALUATE**] ok…well it says it's caused when most of its parents have the gene.

Researcher: Yup…you are right, so that's number two, good.

Andrew: [**PLAN 7**] Ok, going to Adventures (clicked on "Adventures") and uh, I'm going to look for the slide show now (began to look for the answer to next question).

Similar to the strategies revealed while reading within a website, skilled readers employed this self-regulated reading process as they read for information within a list of search results from the Yahooligans search engine:

> Andrew: (reading from a list of search results generated from using the keyword "Hurricanes" in the Yahooligans search window): [**PLAN 1**] I'm going to go to "Hurricanes FAQ" (clicked) and then "What is a hurricane, typhoon, tropical cyclone?" (clicked) and skim it for [**PREDICT**] how it loses power…[**MONITOR and EVALUATE]** didn't find anything there…[**PLAN 2**] I'm going to go back (clicked Back button)…I'm going to go to "Once the eye has been formed and maintained" because [**PREDICT**] it may be the only one that's good because it [the question sheet] says about losing power and it [the hyperlink] says maintain…[**MONITOR and EVALUATE**] um I didn't find anything so I'm going to back again…and [**PLAN 3**] I'm going to try a search in here and [**PREDICT**] see if there's anything…I'm going to search for "hurricanes losing power' (keyed this phrased into the search box and clicked Search)…[**MONITOR and EVALUATE**] maybe not…[**PLAN 4**] maybe I'll go to 'Hurricane Research' (clicked) …[**MONITOR AND EVALUATE**] ummm…there's not much about hurricanes so… [**PLAN 5**] now I'm going to go under "Weather Info" …[**PREDICT**] I'm just looking under the subtitles or something about losing power…[**MONITOR and EVALUATE**] and there's nothing here either.

These exemplars suggested the reading of each page within a website and a search engine interface required the efficient reader to rapidly make many higher-level reading decisions in order to effectively construct meaning and locate appropriate information. Andrew's thinking in both contexts illustrated the self-regulated cycle of planning, predicting, monitoring, and evaluating commonly used by the Internet readers in this study.

Indeed, this reading process shares certain commonalities with previously defined models of information seeking in printed text. Mosenthal & Kirsch (1991), for example, proposed a model of document processing that included goal identification, searching, locating, and verifying strategies; Brown's (2003) information search model included the components of searching, navigating, locating, and extracting; and Guthrie & Dreher's (1990) cognitive model of text search included processes such as goal formation, category selection, information extraction,

integration, and recycling. However, two patterns emerged from our data that suggested the nature of Internet text and Internet reading tasks may demand a richer and more complex self-regulated process of reading for information beyond that required with printed text.

Unique complexities of self-regulated information seeking processes on the Internet

Cognitive reading strategies intertwined with physical reading actions. As we looked more closely at the nature of the strategies used as our skilled readers constructed meaning from Internet text, it appeared that the set of self-regulatory cognitive reading processes we observed (e.g., planning, predicting, monitoring, and evaluating) was intertwined with an associated set of physical reading actions unique to electronic reading environments (e.g., typing, clicking, scrolling, and dragging). This set of physical reading actions introduced new technical reading skills required to navigate open information spaces on the Internet above and beyond those required to navigate within the pages of a printed book.

To illustrate, we return to the excerpt from Andrew's search process within the Yahooligans search interface described in the previous section. Inspired by Rowe's (2002) attempt to capture talk and activity together in one transcript, we matched up each "proposition" from Andrew's continuous think-aloud passage (in bold-faced text) with its associated set of physical reading actions (in italics) and cognitive reading strategies (in regular text) to characterize how skilled readers dynamically wove together complex reading, thinking, and navigating strategies as they read on the Internet (see Table 5). As you read vertically across three lines of text, the speaker's thoughts and actions are aligned horizontally to represent their temporal relationship to each other.

It is important to note that the individual segments of Andrew's think-aloud protocol represented connected propositions in the flow of one long thought process (hence, the use of

ellipses before and after each phrase). At first, we hesitated to isolate each proposition, thinking it may take away from the richness of the data in its more holistic form. However, after much consideration, we felt that this format more clearly illustrated the sheer number of physical actions and multiple cycles of high-level cognitive strategies skilled readers employed, even when prompted with short segments of Internet text.

Insert Table 5 about here

Our informant's verbal protocol suggested that the self-regulated Internet comprehension process integrated multiple dimensions of complex thinking. In other words, web-based physical reading actions appeared to interact with conventional printed text strategies (e.g., monitoring and repairing meaning) and new Internet text comprehension strategies (e.g., querying search engines, evaluating search results, gleaning relevant information from multiple media formats; conceptualizing the multilayered relations between passages of Internet text) in ways that illustrated important and uniquely more complex aspects of online self-regulated reading.

Rapid cycles of self-regulated reading within short text passages. A second complexity of online self-regulated reading reflected a difference we observed between reading in multilayered websites and reading in Internet search environments. Specifically, it appeared that the readers in our study cycled through the self-regulated process of reading choices much more quickly when reading through lists of search results than they did while reading within hyperlinked text passages found on informational websites. In this first example, Vanessa began at the Yahooligans! homepage as she searched for the answer to the question "What makes a hurricane

lose its power?". Notice, in this case, how quickly she moved through the processes of planning, predicting, monitoring, and evaluating.

Veronica: [**PLAN 1 and PREDICT**] I'm going to search under "Science and Nature" (clicked on the category 'Science and Nature' from the Yahooligans homepage) [**MONITOR and EVALUATE**] and [**PLAN 2**] I'm going to put in hurricanes (typed in the search term "hurricanes" and clicked "Go"). [**MONITOR**] And now I'm going to read the sites and information about them to see which one is the best [**EVALUATE**] And this looks like a good site, cuz it says "See how hurricanes are formed". [**PREDICT]** And it might have information on hurricanes losing their power [**MONITOR and EVALUATE**] (chooses a link]. [**PLAN 3**] and I'm going to look at the links [**PREDICT and MONITOR**] … and … hmm ….well… unless these are tornadoes… [**EVALUATE**] I think these are different science related things, not really hurricanes, so [**PLAN 4 – fix up strategy**] I'm going to go back…

Researcher: So, we're back at that list again?

Veronica: Mm-hmm and [**PLAN 5**] I'm going to skim the information again…and I'm going to go to this link [**PREDICT**] cuz' I think it will have information about hurricanes.

Among the skilled readers in our study, it appeared that each and every click within a search engine reading context required readers to cycle through this multifaceted, complex comprehension process.

Similarly, Andrew's reflections in the previous example (see Table 2) provided evidence that planning, predicting, monitoring, and rapid evaluation within search engines seemed to characterize a whole portion of the reading process separate from our current notion of reading comprehension within longer informational passages. In this "searching and navigating" phase of Internet reading, Andrew rapidly skimmed and scanned as he toggled back and forth between a list of search results and several homepage locations. In this phase, he was engaged in very little close reading of long text passages on a particular website, yet he was still actively moving through all four stages of thinking. This suggested that the nature of Internet text may be such that even small amounts of text, (in this case, a list of search results), presented a challenging reading context that required additional skills and strategies to efficiently locate relevant

information with success. For these reasons, although elements of the information seeking process we observed in this study somewhat paralleled those used by readers of printed informational texts, reading to locate information on the Internet appeared to be more complex. New reading contexts (e.g., Internet search engines) and new reading tasks (e.g., manually scrolling and clicking through short and disparate text passages in dynamic, open information spaces) may prompt new dimensions of thinking about how readers actively regulate their understanding of Internet text.

Representing the integrated complexities of online reading comprehension

As we bring our findings to a close, it is important to note that although we analyzed and coded each of the themes that emerged in separate passes through the data, the thinking processes and strategies we observed did *not* take place in isolation. Instead, our data suggested skilled and experienced Internet readers were actively engaged in an overwhelmingly complex and integrated reading comprehension process as they searched for and located information on the Internet. To synthesize this complex process, we draw from a final example.

We captured Marina's thoughts as she searched for information within a website (see Table 6) and coded them across the three main patterns of online reading comprehension observed in our study. Her thoughts reflected the simultaneous use of (a) inferential reasoning; (b) four different sources of prior knowledge; and (c) self-regulated cognitive strategies intertwined with physical reading actions as she evaluated her progress within a recursive Internet reading plan. The left hand side of the figure contains Marina's verbal thoughts, with the various reading processes underlined and coded immediately following the presence of each to demonstrate how rapidly she negotiated this complex array of comprehension processes. The coding scheme is outlined in the right side of the figure.

In this example, Marina explained her thinking midway through the search process, just after linking to a page with no relevant information. She described what she expected to find as she searched within the Tiger website, revealing the interwoven complexity of the thought processes used to actively read within an informational website. Marina let the listener in on the internal metacognitive struggle she encountered when reading on the Internet. She grappled with which choices to make, constantly relying on her prior knowledge about tigers, what she knew about informational text, her knowledge of how to physically move through Internet reading spaces, and her ability to monitor and regulate her online reading for a particular purpose.

Insert Table 6 about here

Discussion

This study represents a qualitative investigation into the cognitive reading comprehension strategies used by skilled adolescent readers as they searched for and located information on the Internet. We sought to explore the nature of the online reading process, and further, to examine what informed the choices that skilled readers made as they read on the Internet. The findings suggested that the processes and choices made as skilled readers comprehend Internet text are both similar to and more complex than what previous research suggests is required to comprehend printed informational text. In this final section, we briefly summarize the similarities and then focus our attention on interpreting the additional complexities of reading online. We close by discussing the implications of these findings for theory, research, and practice.

Similar to reading printed informational text we found that skilled readers appeared to draw upon their knowledge of the topic and printed informational text structures (Means & Voss, 1985; Weaver & Kintsch, 1991) to guide their reading decisions and pathways through informational websites and online search environments. We also found that skilled Internet readers often used inferential reasoning strategies informed by their use of literal matching skills, structural cues, and context cues (e.g., Goldman & Rakestraw, 2000; Rumelhart, 1977) as they chose what and where to read on the Internet. Third, the skilled readers in our study frequently used traditional self-regulated reading processes such as goal setting, predicting, monitoring, and evaluating the relevancy of online information for a particular reading purpose (Duke & Pearson, 2002; Mosenthal & Kirsch, 1991).

In addition to these more conventional reading comprehension processes, we found that skilled readers often used what appeared to be new, more complex dimensions of reading comprehension as they actively searched for and located information on the Internet. We found readers typically drew from two additional sources of prior knowledge to inform their reading decisions, including their knowledge of informational website structures and knowledge of web-based search engines. We also found that Internet text appeared to prompt a high incidence of forward inferential reasoning across multiple layers of Internet text. Third, we observed readers often engaged in a cognitive self-regulated reading process that was intertwined with new physical reading actions unique to web-based reading contexts. Moreover, this complex cycle of self-regulated reading often occurred rapidly within extremely short text passages. In this next section, we turn our attention toward interpreting what might explain these additional complexities of online reading.

Interpreting the additional complexities of online reading comprehension

Some time ago, Tierney & Pearson (1983) suggested that reading is essentially a composing process. They suggested that readers composed texts through their construction of an internal representation of meaning. We found that conceptualizing reading comprehension as a composing process seems to capture much of what we discovered in this study. However, instead of viewing reading as only an internal, metaphorical composing process, it appeared that online readers also constructed the external texts that they read through the many choices they made about which links to follow while reading on the Internet. This difference seemed to produce many of the new complexities to online reading comprehension that we found.

Many others, of course, have noted that hypertext environments require readers to make choices and construct the texts they read within a closed hypertext system (e.g., Landow, 1994; Reinking, 1997). Our study, however, looked carefully at the nature of the comprehension process as readers made these choices within an open information system that presented a far greater range of choices and many more possibilities for getting lost or distracted along the way. Our findings suggest that the greater complexities in online reading comprehension may result largely from a process of *self-directed text construction*; that is, the process Internet readers use to comprehend what they read as they search for and locate information most relevant to their reading needs.

On one level, we observed skilled readers engaged in an ongoing "self-directed" process of planning what and where they would read next as a result of an inference about what would best fit with their interpretation of a certain text's meaning. In addition, as online readers constructed their internal understanding of the text, they also constructed their own external texts. Each decision about which resource was most relevant involved constructing the next element in

the text they built. Those readers who comprehended Internet text were able to anticipate and monitor the relevancy of each new text unit and decide whether to continue to add that text to their *own* text (i.e., by following deeper links within a page) or to exclude any additional text that they anticipated would elaborate on a certain point (i.e., by clicking the back button as a fix-up strategy). At the end of the reading session, each reader had constructed not only his or her own understanding of a certain text, but had also constructed an original external text that was different from that of any other reader. Thus, the product of their online reading included (a) a set of new internal understandings different from anyone else, and (b) a unique pathway through open Internet spaces that physically represented an external representation of the texts most applicable to their needs.

As we mapped these complex dimensions of online comprehension onto the patterns of cognitive strategy use outlined in our findings, we began to see how the notion of self-directed text construction might provide a common thread. That is, if this self-construction of Internet text frequently necessitates additional sources of prior knowledge, a high incidence of forward inferential reasoning, and new dimensions of self-regulated reading, this commonality may serve to explain the complexities that emerged in our study.

Additional sources of prior knowledge introduce additional complexities to Internet text comprehension. Our findings suggested that Internet texts required skilled readers to activate and negotiate meaning within at least four sets of prior knowledge. Similar to research in printed text comprehension, we found that prior knowledge of the topic and prior knowledge of printed, informational text structures played a critical role in online comprehension. Topical knowledge (e.g.,. vocabulary) appeared to influence the entire reading experience by enabling readers to construct a rich and relevant external text within which to locate an answer. It also mediated a

reader's ability to generate effective search terms, pare down search engine results, and infer from vocabulary items that appeared as hyperlinks within a website. A reader's knowledge of printed informational texts appeared to provide a schematic context that supported meaning construction and fostered the efficient construction of relevant texts within informational websites.

In addition to these two prior knowledge sources supported by research in printed text environments, proficient online readers relied on two additional areas of prior knowledge. First, their prior knowledge of web-based search engines appeared to support their ability to query search engines, employ electronic search tools within websites, and comprehend small units of text found within listings of search results that had few conventional context clues. Second, prior knowledge of informational website structures guided readers to efficiently navigate disparate collections of multi-level website texts in search of particular pieces of information. Further, skilled and experienced Internet readers drew from their knowledge of website structures to understand that they may have to read several levels deep within a website to locate the information they needed. In our study, a reader's ability to negotiate within all four of these prior knowledge sources appeared to be crucial in the chain of meaning and text construction that began from a search engine. Consequently, having to draw from at least four different knowledge sources, especially two that appear to flexibly accommodate the rapidly changing features of websites and search engines, made the Internet reading process more complex than that of comprehending printed text.

A high incidence of multi-level forward inferential reasoning introduces additional complexities to Internet text comprehension. Our findings indicated that links seldom contained sufficient information to inform the reader about all that they would find at any location. The absence of traditional context clues at links prompted a high incidence of forward, or predictive,

inferences among our readers during online comprehension. Since the texts they were intending to read were not yet available to scan using traditional previewing strategies, strategic online readers were left with no choice but first, to anticipate the possible directions their own text could take and, then, to select what they considered would best fit within the external text they were constructing before continuing on with their internal meaning construction. Thus, inferences appeared to operate a bit differently on the Internet, compared to the reading of information text in a book, where backward inferences about content dominate (e.g., Olson, Mack, & Duffy, 1981). Moreover, in our study, readers' forward inferences occasionally involved complex predictions about what lay not one, but two levels beneath a particular hyperlink.

These differences suggested that while making and monitoring *forward* inferences about "what happens next" may be considered *optional* for comprehending printed informational text (Singer & Ferreira, 1983), forward inferences (e.g., predictions) appeared to be extremely important to comprehending Internet text. With printed texts, readers can make predictions and then simply continue reading the static text previously constructed by the author, even if they are having trouble comprehending its meaning. The external text itself does not change from one reader to the next. On the Internet, inaccurate predictions about upcoming text may cause readers to get physically lost or disoriented while they construct their texts within multiple layers of tangential information far away from a more relevant text. Readers who do not strategically plan and anticipate where they are headed within open Internet spaces may end up constructing a disjointed collection of random texts as opposed to a systematic compilation of carefully chosen texts from which to sift out a relevant point. Thus, an increased need to make forward inferences about *text* appeared to compound an already complex process of making bridging inferences about *content* in a manner that prompted additional complexities to the process of reading online.

New dimensions of self-regulated reading introduce additional complexities to Internet text comprehension. Finally, if we assume that forward inferential reasoning about the text being constructed is central to the process of online comprehension, it is reasonable to argue that this planning and prediction process might prompt the need for online readers to more frequently monitor and evaluate the choices they make against the information they find. This notion is consistent with previous research that suggests the cycle of selecting relevant passages and evaluating one's reading goal achievement is *compulsory* in hypertext reading while it may or may not be observed in linear text (van Oostendorp & de Mul, 1986). As with previous findings, we recognize the large body of literature that confirms skilled readers of printed text regularly make connections and monitor their understanding of what they read within one text (e.g., Baker, 2002) and across multiple printed texts (Hartman, 1995). Current conceptions of self-regulated reading in printed text, however, do not reflect the intricacies of rapidly integrating a *physical* process of clicking the mouse, dragging scroll bars, rolling over dynamic images, and navigating pop-up menus that intertwined with a *cognitive* process of planning, predicting, monitoring, and evaluating one's pathway through open Internet text spaces (as opposed to multiple printed texts or closed hypertext systems). In addition, this self-regulated cycle often occurred across much shorter and disparate units of Internet text than the continuous text passages typically included in printed text comprehension tasks.

Similarly, our findings suggest that research in closed informational hypertext systems may not adequately capture the greater complexity of self-directed text construction that takes place while reading on the Internet. Skilled hypertext readers do plan and monitor choices about where to go in a particular text and in what sequence to move (Rouet & Levonen, 1996). However, the hypertext reader's external text composition is limited to a finite collection of texts

previously constructed by the author within a static and closed hypertext system (see for example, Azevedo & Cromley, 2004). With fewer deviations outside of the hypertext system, readers focus their energies on a specific and limited collection of texts. In contrast, online readers construct their own text spaces within a rapidly changing, open information system that contains an infinite number of potentially distracting reading pathways. Skilled Internet readers must be able to regulate their movement between a) newer online search and evaluation processes that typically occur very rapidly across hundreds of short Internet texts and b) less spontaneous, more traditional self-regulation strategies within longer text passages that require more time and effort. These complexities, then, introduce a new metacognitive regulatory strategy required to combat the motivation of efficiency and spontaneity in order to ultimately slow down and read clearly.

What is the significance of these complexities?

First, our analysis suggests that reading on the Internet may prompt a process of self-directed text construction characterized by multiple complexities beyond those previously defined by research in printed text comprehension (e.g., Duke & Pearson, 2000; Pressley & Afflerbach, 1995) or hypertext studies in closed environments (Foltz, 1996; Salomon, 1978/1994). The patterns emerging from our data suggest that the quality of the external text that each online reader constructs appeared to be influenced by his or her ability to (a) flexibly draw from at least four knowledge sources, (b) regularly make forward inferences, and (c) self-regulate the relevancy and efficiency of one's self-directed pathways through Internet text. Thus, our findings contribute to the limited body of research in this area and provide a beginning framework for further investigation into what may prompt much of the greater complexity that defines reading comprehension on the Internet.

Second, and perhaps more importantly, the significance of these complexities lies in the potential challenges they may present to lower achieving readers who are less apt to make inferences (e.g., Voss et al., 1980) or actively monitor and repair their understanding (e.g., Paris et al., 1983) while reading. Our findings suggest that the comprehension strategies required to efficiently locate information and respond to Internet comprehension tasks are precisely the same strategies that most challenge our weakest adolescent readers (Biancarosa & Snow, 2004). Although the current study did not compare the Internet reading performance of skilled readers to their less-skilled peers, preliminary work from a more recent project revealed differences in terms of accuracy and efficiency between skilled and less-skilled Internet readers (Author, 2004b). Data from this work also suggested that higher achieving sixth grade readers with Internet reading experience are aware of and demonstrate strategic online reading processes to a higher degree than their less-skilled peers with Internet reading experience. Consequently, the greater complexities of online comprehension may lead to even greater gaps in reading performance between higher achieving and lower achieving readers. If so, we need to invest more research and energy in studies that help a) broaden current theories of reading comprehension by considering the demands of reading online followed by b) more studies that investigate how to support all readers in these more challenging comprehension environments. (e.g. Dalton & Palinscar, 2004).

Implications for theory and research

We examine the implications of our findings for current theory and research within the three lenses that framed our study; that is the perspectives of (1) comprehension as constructive meaning making (e.g., RRSG, 2002); (2) new literacies (Author, 2004a), and (3) cognitive

flexibility (e.g., Spiro et al., 2004). We believe our findings can help set the agenda for future work associated with each of these perspectives.

Online reading comprehension as constructive meaning making. The RAND Reading Study Group (2002) defined comprehension as a process of active meaning construction involving the reader, task, text, and context. Some have previously argued that conventional understandings of these four elements are not always sufficient in electronic and networked environments (e.g., Author, 2003a; Author, 2004a; Kymes, 2005). Findings from this study are consistent with this notion. They highlight specific ways in which the literacy community can begin to consider how the complexities of Internet text may influence current notions of readers, tasks, and texts. For instance, we found that online reading demands *active self-regulated readers* who can readily retrieve information from at least four prior knowledge sources, flexibly integrate their use of cognitive reading strategies alongside physical reading strategies, and regularly make forward inferences across a range of three-dimensional Internet spaces. We also found that online reading prompts *new tasks* such as querying Internet search engines, sifting through lists of disparate search results, and navigating multi-level informational websites. Third, online reading tasks introduce *new texts* such as interactive diagrams, real-time videos, and external texts constructed by each reader as he or she chooses where to read next.

Indeed, this study provides a place from which to begin, but much more research is needed to sufficiently broaden our understanding of online reading comprehension. Future studies should continue to explore how these emerging patterns play out with larger groups of adolescents from more diverse populations. For example, how do these Internet reading processes compare with those employed by lower achieving readers or by those with little online reading experience? Answer to these questions will be crucial if we are to truly conceptualize our understanding of

online reading comprehension. Future research should also focus on a broader range of online reading tasks. Our study was limited to two imposed search-and-locate tasks within one informational website and one children's search engine and we recognize that our interpretations of effective strategy use may not automatically apply to more open-ended online reading texts and tasks. Thus, future studies should investigate the role of inferential reasoning and self-regulation when adolescents are asked, for example, to generate their own search tasks, use self-selected search engines, or respond to tasks that prompt a more focused interaction with narrative Internet texts (as opposed to informational websites).

Finally, given our notion that Internet text prompts a process of self-directed text construction, we encourage researchers to revisit the question of how reading interacts with writing (e.g., Tierney & Pearson, 1984) in global Internet contexts. Surely, there is much to learn about the reciprocal relationship between reading, writing, and the new forms of communicating on the Internet not only as a post-reading response (e.g., Brookes, 1988) but also as an integral part of online reading comprehension as a social activity (RRSG, 2002).

Online reading comprehension as a set of new literacies. Findings from our study also have implications for theory and research associated with Author's (2004) perspective of new literacies. The notion that Internet text introduces additional complexities to the process of online reading comprehension contributes to an emerging body of work that argues new technologies are transforming the nature of reading, writing, and communicating (Author, 2004a; Lankshear & Knobel, 2003; Reinking, McKenna, Labbo, & Kieffer, 1998).

However, we need to be cautious in how we interpret these findings for at least three reasons. First, as mentioned earlier, we did not actually observe our students reading printed texts. Thus, we can only interpret our observations of Internet text comprehension by comparing them

to previous research on printed text comprehension instead of to any printed text comprehension patterns that emerged from our study. Second, given the complex combinations of traditional and new comprehension strategies we observed among our participants, it may be that these strategies do not represent fundamentally *new* literacies as much as more complex versions of traditionally conceived printed text literacies.

Third, we framed our study around a model of new literacies that contains five functions (Author, 2004a), yet, to keep our study manageable, we only used tasks that explored particular dimensions of three of these functions: locate, critically evaluate for relevancy, and synthesize. In our initial exploration, we did not invite students to identify their own problems (our tasks were more controlled) nor did we ask students to use online communication tools (e.g., email, weblogs, Instant messaging) as part of the reading process. Moreover, students were asked only to evaluate the relevancy of information to their task and to locate information about the author's purpose for creating the site (initial steps in the critical evaluation process) as opposed to higher-level requests to discuss the accuracy of information or the legitimacy of the site itself. It was troublesome, to say the least, that no student in our study appeared concerned about these issues when the task did not prompt them to be. Nevertheless, these higher-level considerations of author purpose, stance, and credibility play an increasingly important role in online reading comprehension (Author, 2003b; Kalantzis & Cope, 2000), and should surely be integrated into future studies in this area. Finally, we asked students to locate and synthesize information from only two different website sources, rather than from multiple locations across multiple media formats. We suspect requests to employ higher-level critical evaluation and synthesis strategies may prompt additional strategies that can further inform our emerging understanding of online reading comprehension.

Thus, these patterns only hint at the complexity that is likely to be found in future studies that examine how readers negotiate unique combinations of all five dimensions of a new literacies perspective. We are in need of an active, broad based set of studies to further define our understanding of how reading comprehension changes on the Internet and the extent to which reading comprehension might (or might not) differ when it takes place online. More tightly controlled experiments are needed to evaluate questions such as: What additional complexities emerge when a wider range of online reading comprehension tasks are studied? Which foundational reading strategies play a critical role within each new online text environment? What precisely is different or more complex about reading Internet text and for whom do these differences matter most? In addition, we encourage other researchers to use our findings as a springboard for exploring the nature of online reading from other contemporary points of view in ways that address notions of identity, gender, stance, positionality, and socio-semiotic perspectives (see for example, Author, in process). Studies such as these can help *all* of us better understand the unique challenges that dynamic Internet texts and online reading tasks may pose for readers and literacy instruction

Further, much greater attention should be paid to research studies that can inform large-scale assessment and policy. Important questions include: How can we identify individual strengths and weaknesses with regards to online reading comprehension? How can we anticipate who will be successful and who will need more support? What is the relationship between scores on standardized measures of printed text comprehension and measures on Internet text comprehension? What predicts performance on particular Internet reading comprehension tasks over and above general reading ability and prior knowledge?

Preliminary work in this area can inform future efforts to validly and reliably discriminate between students who can and cannot successfully locate, evaluate, synthesize, and communicate information using the Internet (e.g., Author, 2005; ETS, 2003; Quellmalz & Kozma, 2003). However, the federal government continues to request research that focuses on the traditional literacies of our past (No Child Left Behind Act, 2001; Institute of Educational Sciences, 2002) with no consideration of the complex reading strategies that will characterize the new literacies of our future (e.g., Leu, 2005; Partnership for 21st Century Skills, 2004). Clearly, the research community needs to look beyond traditional measures of literacy to consider new ways of measuring online reading comprehension. The resulting information may be used to help determine who demonstrates which types of literacies, who does not, what impact each has on their ability to comprehend and learn from Internet text, and how these abilities change over time.

Online reading comprehension as cognitive flexibility. Findings from our study also prompt ideas that support and extend the theory of cognitive flexibility (Spiro et al, 1994) as applied to reading comprehension (Spiro, 2004) in at least two ways. First, in order to make sense of what they read on the Internet, strategic online readers appeared to employ a process of flexible text and knowledge integration informed by a "fluidly changeable" (Spiro, 2004, p. 655) set of reading strategies while activating at least four sources of prior knowledge. Likewise, readers appeared to understand how to balance and negotiate the self-regulatory skills required for navigating search engines and skimming across multiple texts with more traditional self-regulatory processes required to read closely and critically within one text. Marina's thoughts seemed to capture how readers confidently drew from their past experiences with printed text and Internet text, while also expressing the need to be more flexible and open to alternative ways of approaching the task when reading online as compared to reading in a book:

> Marina: [When reading on the Internet], sometimes you have to think about what kind of question you have, and instead of reading the whole page or just reading the first sentence, you have to figure out how you're going to read the page. Because if you read every single page that you open up a link for, you're just going to be on there forever. So sometimes if you have a more general question you can read the first sentence of each paragraph, and there's different ways to read than just right down the page.

Could it be that this particular student's ability to adapt her reading strategies to the unique contexts and tasks of the Internet represents the sort of "cognitive flexibility" that Spiro and his colleagues (1991) described as critical to being successful in rapidly changing, ill-structured environments? Other scholars have recently described the need for learners to be resilient, strategically flexible, and self-directed (e.g., Carr & Claxton, 2002; Guthrie & Alvermann, 1999), especially as they prepare for the challenges associated with rapidly changing texts and emerging technologies (Johnston, 2005; Kalantzis, Cope, & Harvey, 2003). Consequently, much more work is needed to clarify the role that cognitive flexibility and additional reader attributes play in strategic online reading comprehension as readers struggle to synthesize diverse text models into a cohesive representation of what has been read.

A second tenant of cognitive flexibility theory suggests that interactions with ill-structured environments facilitate deeper levels of processing and the meaningful construction of knowledge (see also Jonassen, 1996; Kintsch & Kintsch, 2005). In our study, we found that skilled readers who struggled to make sense of complex Internet texts were actively engaged in high levels of inferential reasoning and self-regulation. These findings appear to be consistent with Spiro et al's (2004) notion that rapidly emerging technologies may actually prepare readers to assemble knowledge in a more situation specific manner. However, important questions remain: How do complex Internet texts impact the comprehension and engagement of lower achieving readers? How might issues of cognitive flexibility and navigational efficiency further complicate Internet

text comprehension for online readers who lack automatic decoding skills in printed text environments? Do all readers have the cognitive capabilities to process Internet text? What role might interest and motivation play in one's ability to flexibly adapt his/her strategy use to online reading contexts? Indeed, in terms of theory and research, this study raises more questions perhaps, than provides solid answers.

Finally, our findings challenge current notions of effective teacher education and professional development. Spiro (2004) argued our most important challenge is in preparing students and teachers to welcome the complexities associated with a world increasingly defined by change. A single reading methods course or a few weeks over the summer spent integrating technology into classroom lesson plans is not nearly enough to prepare new and veteran teachers for the complexities of reading on the Internet. We can begin by exploring ways of communicating more flexible strategy use to students who have limited Internet experience or who are quickly frustrated by the reading inconsistencies from one click to the next (see for example, Author 2005). We also need to identify ongoing support strategies for educators responsible for developing a curriculum framed around reading contexts that often look different from one day to the next, and certainly from one year to the next. Thus, we are left wondering how the notion of *flexible reading strategies* might be applied to a broader notion of a *flexible literacy curriculum* that grows and evolves with the Internet texts our students encounter in their daily lives.

In conclusion, having the skills and strategies to comprehend and respond to information on the Internet is likely to play a central role in our students' success in an information age. Although our study was limited to a small number of skilled adolescent readers, it provides important initial insights into the comprehension strategies skilled readers use as they seek

information on the Internet. Further, the emerging patterns shed light on a series of issues and related questions for future explorations into the nature of online reading comprehension.

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Appendix A

Student Questionnaire about Reading on the Internet

1. Do you like to read on the Internet? (circle one answer) Yes Sort of No
2. Please rank the following six activities in order of use from 1 – 6. Write a "1" beside the Internet activity you do the MOST, a "2" beside the activity you do second most, and so on, ending by writing a "6" beside the Internet activity you do the LEAST.

   ____ Playing interactive games on the Internet

   ____ Searching for a topic using a search engine

   ____ Reading certain websites to learn more about a topic

   ____ Using email, Instant messenger or chat rooms

   ____ Browsing or exploring lots of different web pages

   ____ Downloading music or software games
3. Find the activity you rated as **"1"** in question #2 and guess how much time you spend doing that activity in one week

   Less than 1 hour Between 1 and 3 hours More than 3 hours
4. Find the activity you rated as **"2"** in question #2 and guess how much time you spend doing that activity in one week.

   Less than 1 hour Between 1 and 3 hours More than 3 hours
5. How good are you at understanding what you read in books (stories, textbooks)? (circle one answer)

   Very good Just okay Not so good
6. How good are you at figuring out where to go on the Internet to find what you want? (circle one answer)

   Very good Just okay Not so good
7. How good are you at using a search engine to find what you want? (circle one answer)

   Very good Just okay Not so good
8. When reading on the Internet, you are usually at . . . (circle one answer)

   School Home Friend's house Parent's office
9. How comfortable would you be in explaining out loud to someone else what you are thinking while you are searching and reading on the Internet? (circle one answer)

   Very comfortable Sort of comfortable Not at all comfortable
10. Name two of your favorite Internet sites.
11. How do you find something you are searching for on the Internet?
12. What else would you like to tell me about how you use the Internet?

Appendix B

Pre-Reading Interview Questions

1. On a scale of 1-5 (5 being the highest and 1 being the lowest)
   - how much do you know about this topic?
   - how much does this topic interest you?
2. In your opinion, what do good readers do when they are reading for information on the Internet?

Post-Reading Interview Questions

1. On a scale of 1-5 (5 being the highest and 1 being the lowest)
   - how much did you enjoy the task you did today?
   - how successful were you at completing the task you did today?
2. In your opinion, what do good readers do when they are reading for information on the Internet?
3. If your teacher asked you to give advice to other students about how to read on the Internet… What would you tell the students about the things that happen in your mind when you read on the Internet?
4. As you were searching on the Internet today, what worked best for you to find the answer?
5. As you were reading from the three websites about XXX, what worked best for you to find the answer?
6. What kinds of things are helpful to know when you are reading on the Internet and trying to figure out what to read next? Are some of these more useful than others?
7. Do you ever find yourself making predictions as you read on the Internet? If so, when?

Appendix C

Coding scheme aligned with phases of data analysis after a general review of the data in Phase 1

Phase 2: RQ1 - What characterizes the reading process as skilled readers search for and locate information on the Internet?	
CATEGORY/CODE	DEFINITION / EXAMPLES
Inferential prediction (IP)	Reader makes, confirms, or adjusts a substantiated guess about what will come next, usually prior to clicking on a particular link. • *I'm going to try [the link] 'managing tigers in zoos' because it might tell about tigers in zoos, which I'm looking for.* (IP) • *I'm going on this site [about hurricanes]…it's National Geographic, so it probably has lots of information and it's very accurate. It might have how they lose their power because it's the science behind them. (IP)*
Phase 2: RQ2 - What informs the choices skilled readers make while reading on the Internet?	
CATEGORY/CODE	DEFINITION / EXAMPLE
Inferential prediction informed by literal matching (IP-LM)	Uses the words in the search question and seeks similar words within the hypertext to inform prediction about where information might be found • *My question says, 'What causes hurricanes to slow down?' So I am going to click on this link because it also says causes of hurricanes.* (IP-LM) • *I'm going to go to 'South China tiger' because the question has to do with Chinese medicine. (IP-LM)*
Inferential prediction informed by structural cues (IP-SC)	Makes connections between the way the website is organized and the type of information needed to inform prediction of where information might be found • *I am just going to read the subtitles and a little information about it to see which one to choose. (IP-SC)* • *I'm reading the things underneath the topics [e.g., the descriptions under the bolded hyperlinks] to see if it has anything more specific. (IP-SC)*
Inferential prediction informed by context cues (IP-CC)	Makes use of the descriptions, icons, graphics, and headings to inform prediction about where information might be found • *It [information about the weight of the cubs] would probably be on this page because it has a cub right here, a picture."* [IP-CC] • *I am trying to look at the questions and look for words in there that would have the same kind of context as a link or a section, and see if anything matches up.* [IP-CC]
Inferential prediction informed by anticipations across multiple levels (IP-ML)	Makes use of understanding that information may be "hidden" beneath several layers of links on a website to inform prediction about where information might be found • *This link could take us to a diagram of a tiger, and then if you click on a certain part of it, they might show what it's used for.* [IP-ML] • *They're probably going to have different types of weather put on a label, in a box. And then they'll have a little description and probably a link connecting.* [IP-ML]

Phase 3: RQ2 - What informs the choices skilled readers made while reading on the Internet?	
CATEGORY/CODE	DEFINITION / EXAMPLES
Prior Knowledge of the Topic (PK-T)	Relies on domain specific knowledge and key vocabulary to inform reading choices • *[To find information about the habitat of the Bengal tiger], I'm going to click on 'Where do tigers live?' because "live" and "habitat" are almost the same thing, so they might have something about where their habitat is.* (PK-T) • *I am going to go under the science section since this is talking about hurricanes. I'll see if that works.* (PK-T)
Prior Knowledge of Informational Text Structures (PK-ITS)	Uses knowledge about the ways informational text is organized on a website (e.g. titles, headings, description, captions, etc.) to inform reading choices • *Maybe we should scan the page to see if there are any headings that might show where that would be.* (PK-ITS) • *I'm just skimming… don't need to read the paragraph here…I knew what would be in that usually from what the headings were* (PK-ITS)

Prior Knowledge of Informational Websites (PK-IW)	Uses ability to recognize and negotiate hyperlinks, navigational icons, interactive multimedia, and browser toolbars to inform reading choices • *This looks like it's just a homepage, so I guess we can't find it here, so maybe we should go to one of these four links here on the left side for more specific information*. (PK-IW) • *We could go to [the link]'Multimedia' since they may have slideshows and stuff like that. (*PK-IW)
Prior Knowledge of Search Engines (PK-SE)	Draws from experiences with the processes of browsing, selecting appropriate search engines, formulating keyword searches, negotiating subject hierarchies, and evaluating annotated search results to inform reading choices. • *I don't use a kid's search engine, because it comes up with more kid stuff. And that's not always what you want. So, I usually go to Google. Be specific, and try different things, like if you wanted to find out how much money people spend smoking, don't type in smoking*. (PK-SE)

Phase 4: RQ1 - What characterizes the reading process as skilled readers search for and locate information on the Internet?	
CATEGORY/CODE	DEFINITION / EXAMPLES
Self-Regulation: Plan (SR-PL)	Thinks about multiple choices, sets a purpose, and prepares a plan of action that addresses questions such as: What do I need to find out? Where should I begin? Where do I want to go? What do I need to do first? • *I'm just going to keep rewording this and see if it comes up with anything*. (SR-PL) • *Hmmm…I could do just hurricanes and power – and that would give it more of a general idea of what I'm looking for. Or maybe hurricanes and energy*. (SR-PL)
Self-Regulation: Predict (SR-PR)	Makes, confirms, or adjusts a substantiated guess about what will come next, usually prior to clicking on a particular link • *It's probably going to lead us to something a little more …it's talking about science and how hurricanes work, so it might have something to the effect of how they stop as well*. (SR-PR) • *I'm going to 'Why are tigers in trouble' since it says, 'habitat loss' and their habitat might have something to do with trees and timber*. (SR-PL / SR-PR)
Self-Regulation: Monitor (SR-MN)	Having selected a link with an anticipated result, the reader monitors the choice that has been made • *No, oh wait, yes, here it is I think*. (SR-MN) • *This doesn't sound like what I thought it would be, but maybe I can find it*. (SR-MN) • *I'm kind of stuck now*. (SR-MN) • *I've looked it over again. It doesn't look quite like we've got anything here on a video*. (SR-MN)
Self-Regulation: Evaluate (SR-EV)	*Actively evaluates the relevance of a particular reading choice while considering: Does this choice bring me closer or further away from my goal? Is this a likely and appropriate place for the information I need? Should I move to a deeper level, select a related topic, revert back to an earlier location, or start all over again?* • *I'm reading here to see if it has something about why tigers are white and, yes, this is right, White Tigers*. (SR-MN / SR-EV) • *This is more on how they detect a hurricane with scientific machines and stuff like that. Maybe I was going a little too specific and should try something a little more general (*SR-MN / SR-EV / SR-PL) • *Since that didn't work and we struck out there, I could probably try this link instead*. (SR-MN / SR-EV / SR-PL)
Physical Reading Action (PRA)	*Employs physical reading actions using a mouse or keyboard to navigate Internet text* • Typed in keyword or phrase; typed in website address *(PRA-keystroke)* • Clicked search button; clicked back button; clicked hyperlink *(PRA-click)* • Scrolled up, down, or across the page *(PRA-scroll)*

Table 1. Participant Reading Achievement and Internet Use Information

Pseudonym	Gender	Standardized Reading Score	Reading Report Card Grade	Weekly Internet Use	Preferred Internet Use
Andrew	male	85 [a]	A	< 1 hour	games
Alison	female	99 [a]	A	< 1 hour	games
Chad	male	83 [a]	A	> 3 hours	email/chat
Matthew	male	74 [a]	A-	1-3 hours	searching
Veronica	female	69 [a]	A-	1-3 hours	email/chat
Carrie	female	81 [a]	A	> 3 hours	games/email
Bill	male	95 [b]	A	1-3 hours	searching
Marie	female	99 [b]	A	> 3 hours	email/chat
Jenna	female	95 [b]	A	1-3 hours	email/chat
Kathryn	female	98 [b]	A	1-3 hours	email/chat
Jessica	female	97 [b]	A	> 3 hours	games

[a]Degrees of Reading Power (DRP) Readability Score reported as a national percentile rank

[b]Terra Nova score reported as a national percentile rank

Table 2. Descriptive Data from Tigers Website Reading Task

Tigers Website Reading Task	N	Response	
		Mean	Range
Prior knowledge about tigers[a]	11	1.9	1 – 3.5
Comprehension questions answered correctly[b]	11	6.3	4.5 – 7
Time for task completion[c]	11	33 min.	11 – 44 min.

[a]Participants ranked their prior knowledge on a scale of 1-5 with 5 being the highest

[b]Total correct out of 7 questions; Participants may not have completed individual comprehension questions because of a lack of time or a self-determination that a question was too difficult

[c]Participants were given up to 45 minutes to complete the task

Table 3. Descriptive Data from Two Search Engine Reading Tasks

Search Engine Reading Task	N	Response	
Hurricane Task		Mean	Range
Prior knowledge about hurricanes[a]	10	2.4	1 – 4
Comprehension question answered correctly[b]	10	.9	0 – 1
Time for task completion[c]	10	18 min.	5–40 min.
Landfill/Dump Task		Mean	Range
Prior knowledge about landfills[a]	8	1.75	1 – 3
Comprehension question answered correctly[d]	8	.88	0 – 1
Time for task completion[c]	8	19.8 min.	13-27 min.

[a]Participants ranked their prior knowledge on a scale of 1-5 with 5 being the highest

[b]Scored on ability to locate information and appropriately answer one open-ended question. Response scored as 0 (no credit), .5 (partial credit), or 1 (full credit). Nine students received 1 pt. and one student received 0 pts.

[c]Participants were given up to 45 minutes to complete the task

[d]Scored on ability to locate information and appropriately answer one open-ended question. Response scored as 0 (no credit), .5 (partial credit), or 1 (full credit). Six students received 1 pt. and two students received .5 pts.

Table 4. A comparison of the ways in which reading comprehension on the Internet appears to look the same as reading comprehension of printed informational text, and in other ways, is uniquely more complex.

Reading Comprehension Strategies	**Similarities between the comprehension processes of printed informational text and Internet text**	**Additional complexities associated with the comprehension processes of Internet text**
Prior Knowledge Sources	Skilled readers draw upon their: a. prior knowledge of the topic b. prior knowledge of printed informational text structures	Skilled readers also draw upon their: a. prior knowledge of informational website structures b. prior knowledge of web-based search engines
Inferential Reasoning Strategies	Inferential reasoning strategies are informed by a reader's conventional use of: a. literal matching skills b. structural cues c. context clues	Inferential reasoning strategies are characterized by: a. a high incidence of forward inferential reasoning b. multi-layered reading processes across three-dimensional Internet spaces
Self-Regulated Reading Processes	Self-regulated reading processes occur as: a. independent fix-up strategies for comprehension monitoring and repair b. connected components of a larger strategic reading process	Self-regulated reading processes occur as: a. cognitive reading strategies intertwined with physical reading actions b. rapid information-seeking cycles within extremely short text passages

Table 5. Transcript of the online self-regulated comprehension process captured in the integration of one reader's think-alouds (T), physical reading actions (P), and cognitive reading strategies (C).

T	**[After reading the question "What makes a hurricane lose its power?"] I'm typing in "hurricanes"…**
P	*Typed in keyword - clicked search button*
C	Plan; Infer main keyword from question
T	**… I'm going to go to "Hurricanes FAQ" …**
P	*Scrolled down the page through results list* *Clicked hyperlink*
C	New Plan; Predict/Infer using knowledge of the term FAQ;
T	**…and then [I'm going to] "What is a hurricane, typhoon, tropical cyclone?"…**
P	*Scrolled down the page through text passages*
C	New Plan; Monitor; Evaluate best link; New Plan
T	**and skim it for how it loses power…Didn't find anything there so I'm going to go back..**
P	*Clicked back button*
C	Predict Monitor Evaluate Fix-up strategy
T	**…I'm going to go to "Once the eye has been formed and maintained" because it may be the only one that's good because the question sheet says about losing power and it [the hyperlink] says "maintain"…**
P	*Scrolled down the page* *Clicked hyperlink*
C	New Plan, predict/infer from hyperlink label which link is best
T	**…um… I didn't find anything so I'm going to back again…**
P	*Scrolled down the page* *Clicked hyperlink*
C	Monitor Evaluate Fix-up strategy
T	**…and I'm going to try a search in here and see if there's anything…I'm going to search for "hurricanes losing power'…**
P	*Typed in key phrase and clicked search button*
C	New Plan Predict/Infer what will find
T	**maybe not…hmmm…there's not much about hurricanes here either.**
P	Scrolled down the page
C	Monitor Evaluate

Table 6. Illustration of how a skilled reader simultaneously integrated multiple reading and navigating strategies as she searched for information within a website.

Marina's Think-Aloud	***Coding Guide***
R: So, what were you hoping to find here? **M:** "Well…more generally, [I was] looking for maybe humans and tigers[A1] , what they do basically[A2]. Because the tiger is an endangered species[B1] and you'd probably find[A1] a section[B2] on humans and tigers[A1 & A2] just because figuring out what kind of effects we put on the species[A2 & B1] would probably be a section[A1 & B2]. So that's what I thought we'd find a little more of[A1 & C1] …but maybe not[C1]. Maybe we could go to[C 1 & C2] the Tiger Handbook[B2], because maybe it's a reference manual[A1 & B2], and sometimes they [the websites] have smaller search engines there [A1 & B3 & B4] that you could type in to search the site[B3 & C2].	**Category A: Inferential Reasoning** [A1] = predicting [A2] = making connections **Category B: Prior Knowledge (PK) Sources** [B1] = PK of topic [B2] = PK of printed information text [B3] = PK of web-based search engines [B4] = PK of informational website structures **Category C: Self-Regulation** [C1] = monitor and repair meaning [C2] = physical reading action as part of reading

Figure 1. Screenshot of the homepage for 5 Tigers: The Tiger Information Center (http://www.5tigers.org/index.htm) with the eight sections of the website listed in the left frame of the window and the search tool accessible from the upper right corner.

Figure 2. Screenshot of the homepage for the Yahooligans Web Guide for Kids (http://www.yahooligans.yahoo.com)

Plan: Set a purpose and develop a mental plan.

Predict: Predict where a reading choice may lead.

Open Internet text space

Monitor: Monitor after making a choice.

Evaluate. Evaluate the relevance of the choice.

Figure 3. A recursive pattern of self regulated reading employed each time a reader makes a navigational choice during the process of searching for and locating relevant information within open Internet text spaces.