COGNITIVE STRATEGY INSTRUCTION AND INDIVIDUAL DIFFERENCES: AN EXAMINATION OF TEXTBOOK INFORMATION SEARCH IN THE ELEMENTARY GRADES

by

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Dedication

This thesis is dedicated to my beautiful children, Alexa Marie and Joseph Cyrus. They gave balance to my years in graduate school and helped me keep perspective on what was truly important.

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Abstract

The Guthrie and Mosenthal (1987) cognitive model of text search has provided a framework to understand and examine the cognitive processes underlying the ability to search for and locate information in text. Locating information involves a number of stages, including (a) goal formation, (b) selecting appropriate categories of text to search, (c) extracting relevant information, (d) integrating extracted information with prior knowledge and the search question, and (e) recycling through stages until the goal has been met. Using this model as a guideline, Study 1 examined the effects of strategies-based instruction on a sample of 92 students in grades 3 and 4. Students were randomly assigned to one of five groups, each of which received different combinations of category selection (C), extraction (E), and integration (I) instruction. The five groups included CEI, CE, CI, C, and non-instructed controls (CON). Results indicated that only groups that received integration instruction (CEI, CI) were more accurate than controls; and only full instruction (CEI) was more effective than category selection instruction alone (C). Thus, integration, a largely metacognitive skill, emerged as a particularly important component of instruction. Due to the large amount of variance in performance in the non-instructed group, Study 2 was designed to examine the individual differences that may predict text search performance. Sixty-eight children in grades 5 and 6 were administered a series of measures assessing working memory, general reading metacognitive awareness, task-specific metacognitive awareness, text feature knowledge, and word knowledge. Results from a multiple regression analysis suggested that, after controlling for the effects of age and strategy use, working memory, text feature knowledge, task-specific metacognitive awareness, and word knowledge accounted for 39% of variance in search accuracy scores. These findings have significant implications for our understanding of the Guthrie and Mosenthal (1987) model of search and for the instruction of text search strategies in the elementary grades.

List of Abbreviations

ADS	Auditory Digit Sequence
ANOVA	Analysis of Variance
C	Category Selection
CE	Category Selection, Extraction
CEI	Category Selection, Extraction, Integration
CI	Category Selection, Integration
CON	Control
HSD	Honestly Significant Difference
I	Indexed
IALS	International Adult Literacy Survey
IEA	International Studies in Educational Achievement
IRA	Index of Reading Awareness
MD	Mapping and Directions
MQ	Metacognitive Questionnaire
MR	Multiple Regression
NAEP	National Assessment of Educational Progress
NI	Non-indexed
OECD	Organization for Economic Co-operation and Development
PPVT-R	Peabody Picture Vocabulary Test – Revised
QAR	Question-Answer Response
RW	Rhyming Words
S-CPT	Swanson Cognitive Processing Test
SD	Standard Deviation
SR	Story Retelling
TFS	Text Features Survey
VM	Visual Matrix
WISC-R	Wechsler Intelligence Scales – Revised
WRAT	Wide Range Achievement Test

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Chapter 1

General Introduction

Literacy in Context

The ability to read and write has become increasingly important over the past century. In fact, the written word has become so common in modern industrialized societies that literacy now has a significant impact upon our general awareness, our ability to communicate, and our ability to meet the functional requirements of daily living (Montigny, Kelly & Jones, 1991). This "general awareness" refers to the information that we gather from a number of different sources, including newspapers, books, and other types of written documents. It has been proposed that the main purpose of literacy is to promote participation in society and to gain access to the most valuable resources of the culture: knowledge and information (Olson, 1987). Hence, the importance of literacy is defined by what it permits us to do with the information that we extract from written documents at home, at work, and in the community. There has been an increased emphasis on educating students to be competent and independent users of information that they obtain through the written word (Bucher, 2000).

Reading researchers have been able to reach some agreement about what it means to be literate, with most definitions taking social contexts and individual differences into consideration. For example, the authors of a recent international literacy survey defined literacy as "the ability to understand and employ printed information in daily activities, at home, at work and in the community - to achieve one's goals, and to develop one's knowledge and potential" (Tuijnman, 2001). Despite a general consensus, the vagueness of such definitions tells us little about the literacy demands that people encounter in specific contexts (Cervero, 1985). Even in cultures where access to formal education is fairly prominent, subgroups of people within the culture will have different literacy needs. By interacting with different types of materials in different ways, readers develop their own unique reading competencies that become a set of ordered reading skills (Kirsch & Guthrie, 1984b; Kirsch, Jungeblut, Jenkins, & Kolstad, 1993). Thus, literacy is conceptualized as a multidimensional skill, and individuals are no longer classified as simply "literate" or "illiterate". Individuals may be very proficient at certain types of literacy tasks (e.g., comprehending prose), but have difficulty performing other tasks (e.g., interpreting documents such as charts and maps). Furthermore, these levels of proficiency are only relevant to the extent that they facilitate or interfere with an individual's ability to meet his or her personal needs and goals (Ehringhaus, 1990).

One type of literacy that has received increasing attention is "workplace" or "occupational" literacy. Concern has been raised by employers who find that many university graduates are unable to prepare resumes and fill out application forms without making the kinds of errors that were once made by high school students (Chase, 1991). Furthermore, an individual's daily performance at work and his or her potential for upward mobility are dependent upon meeting the necessary literacy requirements of the workplace (Chang, 1987; Krahn & Lowe, 1998). Thus, if an individual's reading and writing competencies are not matched to the demands of his or her job, he or she is at serious risk for becoming unemployed. In addition, there appears to be a very strong relationship between education and literacy, and between literacy skills and level of professional attainment (Shalla & Schellenberg, 1998). At one time, industrialized societies supported their economies by delivering goods, but current economies are largely built on the delivery of information (Kallaus, 1987; OECD, 2000). As a result, western societies are seeing a rise in the number of knowledge-based and technical jobs and a decline in the number of low-skilled production jobs. In fact, most occupations now require at least some post secondary education or technical training (Chase, 1991) and more people will require university degrees in the future (Thomas, 1989).

In times of liberal international trade policies, the countries that have the most literate and skilled workers are the most competitive because they have the capabilities needed to generate the newest technologies (Shalla & Schellenberg, 1998; OECD, 1995a). One survey of human resource and general management personnel in Canadian businesses suggested that poor workplace literacy is threatening our ability to compete in the international marketplace (DesLauriers, 1990). In total, 70% of the businesses reported that they were experiencing significant problems in the workplace because of the poor literacy skills of their workers. For example, many companies felt that literacy problems had compromised product quality (27%), reduced productivity (32%), increased the number of workplace errors (40%), interfered with the introduction of new technologies (26%), and impeded training efforts (34%).

Given the importance of workplace literacy skills, and the fact that many workers are having difficulty meeting the literacy demands of their jobs, increased efforts have been made to describe the types of reading tasks usually performed in the workplace. A number of studies have suggested that one of the most critical workplace reading skills is the ability to search for and locate information in various document formats (e.g., charts, graphs, tables, memos, books). This reading skill has become particularly important in knowledge-based societies. Technological advances such as the printing press, the photocopy machine and the computer have increased the rate at which information is transmitted so dramatically that the amount of information available to us has been estimated to double every five years (Wurman, 1989). This has placed increasing demands on our ability to understand the structure of documents so that we can easily locate information without reading unnecessary sections of text.

One of the first studies of reading behaviours in the workplace focused on the literacy acts of Navy personnel (Sticht, 1977). This study made the distinction between "reading to do" tasks, which involved searching for information in a written document to perform a work-related duty, and "reading to learn" tasks, which involved comprehending and retaining the information in a lengthy section of text. Except for those who were actively involved in educational settings (e.g., teaching or upgrading), personnel at all job levels frequently engaged in reading to do tasks but rarely engaged in reading to learn tasks during the course of the work day. Many people could not even identify one reading to learn task that was required of them at their place of employment. More recent research has validated the distinction between reading tasks, suggesting that the purpose for reading influences the way that the text is read (Mills, Diehl, Birkmire, & Mou, 1995). University students were asked to use a manual to a) put together a toy or learn how to put on a gas mask or b) remember the contents. Reading to do tasks resulted in a faster reading rate and better task-performance, and reading to recall resulted in a slower reading rate and better recall for the contents of the instructional text.

Mikulecky (1982) studied the reading behaviours of professionals, middle level employees and blue-collar workers, and compared these with the reading activities of students in high school and technical training programs. It was found that the reading behaviours of employees and students were significantly different from one another, with those in the workforce spending more time reading to do, and those in school spending more time reading to learn. For example, blue-collar employees spent 58% of their workplace reading time reading to do and only 25% reading to learn. In contrast, high school students spent 66% of their reading time at school reading to learn, but reading to do activities accounted for only 2% of school reading time.

Two studies by Kirsch and Guthrie support these findings. In the first study, 98% of service and clerical employees at a telephone company reported that they spent an average of two hours a day at work engaged in text search tasks (Kirsch & Guthrie, 1984b). For the 45% who said that they engaged in text search activities at home, an average of only 5 minutes a day of such reading was reported. The reverse trend was seen for reading comprehension behaviours, which were common at home but were virtually never reported at work. The second study by Kirsch and Guthrie (1984a) examined the workplace and leisure reading activities of employees at a high technology company. These authors were interested in not only the uses of reading in these settings, but also in the subject matter and formats of the documents that were being used by the employees. In the occupational context, employees spent most of their total reading time (121 min/day) reading informational texts such as brief documents and reference books, but at home they were more likely to read about news/business, science/society, recreation and fictional stories (77 min/day). Prose documents dominated reading activities at home, but formats such as forms and directions were more common at work. Interestingly, locating information (in training manuals, books, memos, diagrams, labels, etc.) was the most common goal of reading at work (48 min/day), but was rarely a reading goal at home (8 min/day). During leisure time at home the most common reading goals were relaxation, keeping informed about issues and current events, and gaining knowledge (56 min/day).

Guthrie and Kirsch (1987) have also reported that engineers spent 25% of their reading time at work searching for information (24 min/day), and technicians spent 35% of their reading time engaged in this activity (34 min/day). Similarly, Guthrie, Schafer and Hutchinson (1991) found that young adults (aged 21 to 25 years) in various occupations spent 29% of their reading time locating information in reference books and manuals. Furthermore, the amount of time spent engaged in such reading activities was associated with higher occupational status (with education, parental education and parental occupation held constant). These findings have been supported by Canadian data obtained from the International Adult Literacy Survey (IALS), which indicated that more workplace reading time was associated with more lucrative and desirable careers (Krahn & Lowe, 1998). It is clear from these studies that the ability to search for and locate information is not only an important workplace literacy skill, but it is also a necessary component of being a successful employee.

The importance of information location in the workplace has led to new definitions of literacy that incorporate a) the ability to recognize the need to locate information, b) the ability to locate, evaluate and use information, and c) the ability to locate and learn from information across the lifespan (Hasan, 2000). With new workplace literacy demands has come the expectation that employees will be information problem-solvers. In our modern world, potential sources of information include both printed text and new computer technologies such as CD ROMs and the Internet (OECD, 2000). The advent of the computer has changed the face of literacy at work and at school, but it has not rendered traditional written text obsolete. Approximately 50% of Canadian employees on the international literacy survey mentioned above (the IALS) reported that they read or used information from letters and memos every day, and 35% used articles, reports, magazines or journals on a daily basis (Krahn & Lowe, 1998).

Text Search Proficiency

Adults. The results from national and international literacy surveys consistently report deficiencies in the ability of adults to search for and locate information. Although most people are capable of performing one-word matching tasks, performance deteriorates significantly when multiple features must be located or interpretations of the extracted information are required. Findings from the widely cited U.S. National Assessment of Educational Progress (NAEP) literacy scale (Kirsch & Jungeblut, 1986) clearly illustrated this pattern. This survey showed that 95% of adults aged 21 through 25 years could locate specific pieces of information in a newspaper article, but only 37% of this same sample was able to locate and integrate three pieces of information. This is an alarmingly low success rate, given the fact that 63% of the participants had completed post-secondary education.

A survey of literacy skills in a sample of 26,091 adults over the age of 16 years in the United States analyzed reading in prose and document formats separately (Kirsch et al., 1993). Prose literacy involved a series of tasks, which required the reader to understand and use information in prose documents such as editorials, news stories, poems and fiction. Document literacy tasks focused on the use of information in various formats such as job applications, payroll forms, transportation schedules, maps, tables and graphs. Almost all of those tested were capable of performing both prose and document tasks that involved little more than matching single words from the question with words in the text. Approximately 80% could continue making these word-matches when distracters were added to the text and some low-level inferencing was required. Performance dropped to approximately 50% when tasks required the integration of information in more complicated texts and to about 20% with greater degrees of inferencing and conditional information. Finally, only 3% of participants could complete the most complex prose and document literacy tasks, which required the reader to search through text with many distracters, make high level inferences, use specialized background knowledge, or draw complex comparisons.

The reading skills of Canadians aged 16 through 69 years have been similarly surveyed and findings were similar to those reported in American samples (Montigny et al., 1991). In this survey, approximately 84% of Canadians were able to perform familiar word location tasks in a simple document (such as a medicine label), but only 62% were able to find and interpret information in a more complex text. Even among those classified in the most proficient reading category by this survey, only 40% could make judgments about the information that they located or complete multiple-feature locating tasks.

One adult literacy scale examined literacy on an international level (OECD, 1995a), with a focus on the following industrialized nations: Canada, Germany, Netherlands, Poland, Sweden, Switzerland, and the United States. All participants were between the ages of 16 and 65 years, and approximately 3000 people from each country took part. Literacy was viewed as a continuum of skills and performance on both prose and document tasks was assessed on a five-level scale. In most countries, approximately 50% of the participants were functioning in the two lowest levels of performance for both prose and document tasks. That is, they could perform very simple word matching or low-inference tasks, but could not locate and integrate information that was dependent on conditional information in more complex documents. Two exceptions to this pattern were observed: In Sweden, only 25% of participants were at the bottom of the continuum, but in Poland approximately 75% of the participants were at the bottom of the range. A detailed analysis of each country's literacy profile supported the relationship between literacy skills and employment: participants with higher levels of literacy were more likely to be employed and have higher paying jobs than the less literate. Further reports from this survey, with data from an additional 15 countries, have now been published and would rank Canada's overall performance as "average" (Tuijnman, 2001). What is of particular concern is the fact that there was a bimodal performance distribution, with large numbers of Canadians having excellent literacy skills, and large numbers having extremely poor literacy skills. This pattern was mimicked in the American data.

Empirical studies have also shown deficiencies in the ability of many adult readers to perform difficult text search tasks. Guthrie, Britten, and Barker (1991) found that less than half of university students could locate answers to computerized search questions based on conditional information in tables (46%) and directories (38%). Furthermore, O'Donnell (1993) found that university students searching flow charts and prose text were more than twice as successful on declarative search questions that required verbatim information retrieval than they were on inference questions that required the reader to go beyond what was explicitly stated in the text.

These findings have been replicated in studies that examined textbook search skills. Dreher and Guthrie (1990) found that 97% of students in Grade 11 could answer a single feature search question in a life sciences textbook ("What are cocci?"). Conversely, only 55% could answer a search question that required them to integrate three pieces of information in the same book ("What are the 3 characteristics of living things?"). Furthermore, Dreher (1992) reported that 57% of university students could locate the answer to a question that included a searchable (indexed) term in a psychology textbook. The success rate dropped to 29% when the task was more difficult, including no searchable term. Students who gave the wrong answers to the more difficult search questions were able to use the table of contents, index and glossary to find the correct area of text to search, but could not locate the information once they found the correct chapter or pages.

Children. It has been well established that one of the best ways to predict what will be taught in a content area class is the textbook that is used for the course (Jitendra at al., 2001). Moreover, there is more control over the reliability of material children are reading when it is textbook-based. This suggests that even though computers are now prominent in many educational settings, textbook use is still a central feature of the education system. Armbruster and Armstrong (1993) outlined three features that define the types of text search tasks performed by students throughout the school years. First, the *source* of the task refers to the origin of the search question. That is, questions may be externally posed by a teacher or textbook, or internally posed when the student generates questions independently. Second, the *time* at which a search question is formed may be before reading a text, or after it has been read and forgotten. Finally, the *specificity* of the question can range from a specific task that requires the extraction of information directly from the text, to a more general research question. The purpose of these questions is to both promote and assess student learning (Armbruster and Ostertag, 1993).

Most empirical research has focused on specific, externally cued questions, in part because these are the easiest tasks to assess experimentally (Armbruster & Armstrong, 1993). Research by Armbruster and her colleagues has suggested that children throughout the elementary grades also frequently encounter these types of questions. In an analysis of teacher-posed questions in Grade 4 science and social studies classes, twice as many text-based questions required simple extraction of explicitly stated information from the students' textbooks than required complex inferencing skills (Armbruster, Anderson, Armstrong, Wise, Janisch, & Meyer, 1991). In related research, Armbruster and Ostertag (1993) examined the types of questions asked in elementary school textbooks. These researchers found that approximately half of all questions asked in Grades 4 and 5 science and social studies textbooks required little or no inferencing or integration skills. More recently, Jitendra et al. (2001) completed a detailed analysis of middle school geography textbooks and found that they are densely laden with factual information, averaging one fact every 18.9 words. Approximately 60% of the questions found in these textbooks involved reiterating or summarizing explicitly stated facts and about 40% were more complex in nature (e.g., predicting or evaluating information).

Although there is limited research concerning children's ability to perform text search tasks, evidence does suggest that many readers have difficulty knowing when to modify their reading strategies to meet the demands of different types of reading tasks. Even when the goal of a task appears to be explicitly stated, children are sometimes unaware that they are expected to use specific reading strategies to complete the task successfully. A study by Garner, Wagoner and Smith (1983) illustrates this point. Good and poor comprehenders in Grade 6 were asked to help average readers in Grade 4 answer questions after reading a short paragraph. Three of these questions were text-based (i.e., the answers were located explicitly in the text but could not be easily recalled), and two were reader-based (i.e., the reader was expected to use their own knowledge base and overall comprehension of the paragraph to answer the questions). Relative to tutors with good comprehension skills, tutors with poor comprehension skills could not differentiate between questions that demanded review of the text for specific pieces of information and "Do you think...?" questions. They were also less likely to suggest to the children who they were tutoring that the text be sampled, rather than read in its entirety, for text-based questions.

As with adult populations, children seem to have more difficulty locating the correct answer to search tasks that require inferencing skills. Hare, Rabinowitz, and Shieble (1989) studied this phenomenon in students who were searching to locate main ideas in prose text. Main idea location can be classified as a search task because the goal of the reading task is to identify discrete pieces of information. The main idea may be stated explicitly in the text, or it may be embedded in the text and require that the reader use inferencing and high-level integration skills. Most students in Grade 4 were capable of performing explicit search tasks on Grade 3 textbook paragraphs (70%), but this performance decreased significantly for implicit search tasks (5%). On these same paragraphs, Grade 6 and 11 students showed a similar pattern of performance (89% and 91% respectively on explicit tasks, and 14% and 31% on implicit tasks). As the need for higher-level inferencing and integration increased, the students' ability to locate main ideas decreased, even in texts below grade level.

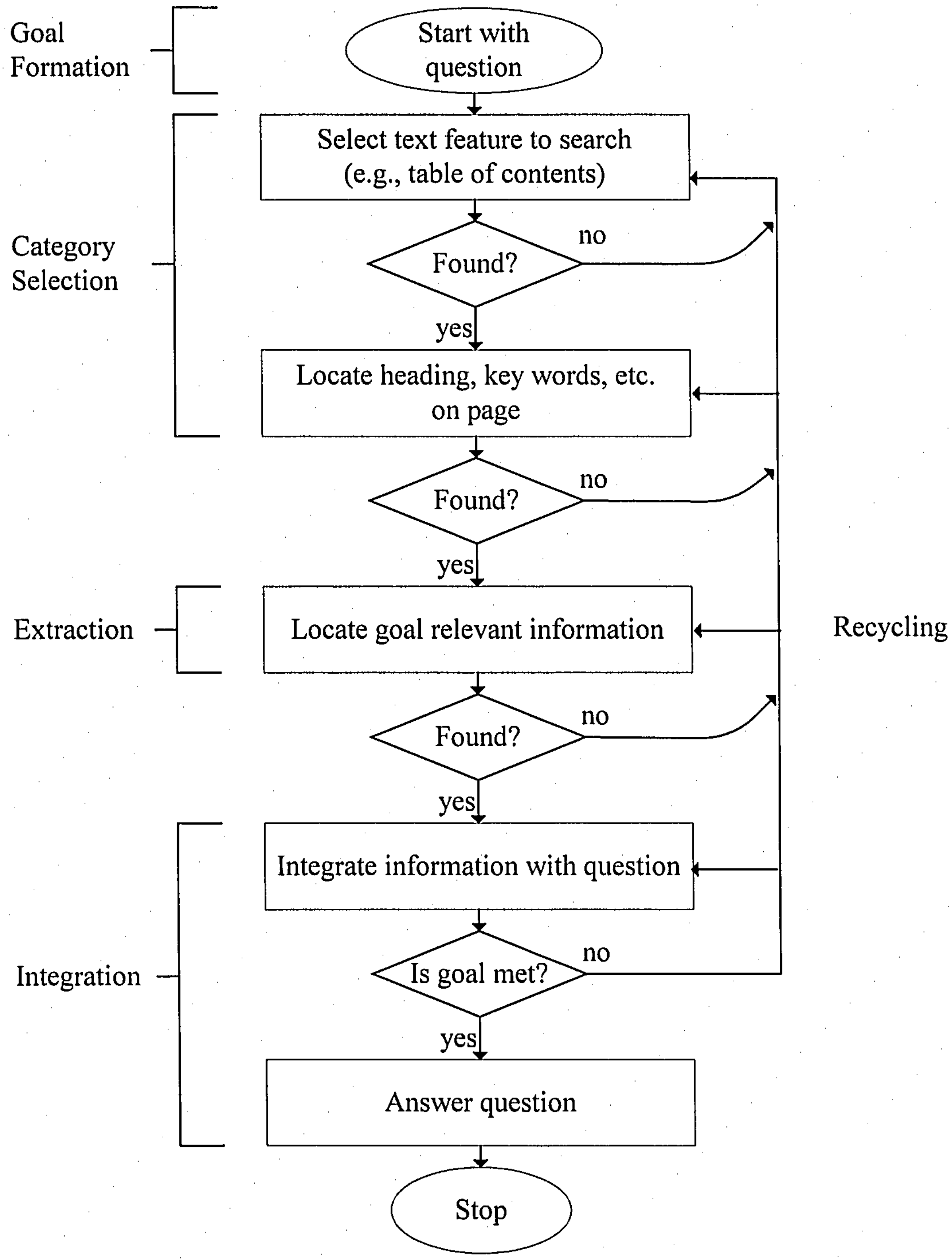
The International Studies in Educational Achievement (IEA) literacy survey was conducted to evaluate the narrative, expository, and document literacy skills of students in Grades 3 and 8 in various countries (Elley, 1994). Different tests were designed for each grade level to match the reading materials to the reading levels of the students. Consistent with previous studies, the results indicated that 68% of students in Grade 3 and 97% of students in Grade 8 were capable of locating discrete pieces of information in simple prose and document formats. As one would expect, performance again dropped significantly on tasks that required advanced reading and search skills such as inferencing, comparisons, and integration with prior knowledge (4% performance for students in Grade 3 and 37% for students in Grade 8).

Better general reading skills have been associated with better performance on text search reading tasks. In one such study, Grabe (1989) divided students in Grade 4 into groups of more and less able readers (as measured by the Iowa Test of Basic Skills), and assessed their performance on a series of computerized text search tasks. The search questions were relatively complex, as they required the readers to combine information across sentences or recognize an answer in paraphrased form. Before answering the questions, however, students were required to view a number of paragraphs in succession and indicate whether or not each contained the relevant information necessary to meet the goal of the search task. Accurate identification and rejection of paragraphs was considered to be indicative of good category selection skills. As expected, the better readers were more capable of identifying question-paragraph matches than the less able readers. More surprising was the finding that the poorer readers had difficulty answering the search questions accurately even when they correctly identified the paragraphs that contained relevant information. Similarly, better readers who did not identify question-paragraph matches performed more like the less able reading group.

Understanding the Cognitive Processes of Text Search

Much of reading research focuses on the development and testing of cognitive models that guide us in understanding the processes involved in various types of reading. This has been particularly evident in the literature focusing on reading comprehension, which has produced a variety of different comprehension models. To date, the most influential model of text search has been proposed by Guthrie and Mosenthal (Guthrie, 1988; Guthrie & Mosenthal, 1987), who likened text search to a problem solving or analytical reasoning task. In fact, one of the primary reasons for the introduction of the model was to distinguish the processes of text search from the processes of comprehension. According to these authors, successful searchers cycle through a series of five cognitive stages until the goal of the search task has been accomplished. These stages include (a) goal formation, (b) category selection, (c) information extraction, (d) integration, and (e) recycling. Efficient search is characterized by the *sequential* processing of each stage, but requires the repetition of stages if the search goal is not met (see Figure 1). Following is a description of this model.

Figure 1. Representation of Guthrie and Mosenthal's (1987) sequential text search model, modified from Guthrie (1988).



A person throughout the course of a day may encounter a wide range of search tasks. The purpose of the first stage of search, *goal formation*, is to formulate and verbalize the goal of a search task, and this is dependent upon an understanding of what type of information is being sought. Once the goal has been established, *categories of text are selected*, with the purpose of identifying the areas of text that are most likely to hold the sought-after information. Attention to and awareness of relevant structural cues facilitates this stage. For example, when searching for information in a table, particular consideration must be given to the headings of rows and columns. Similarly, a textbook or manual has many features that can guide the reader to important sections of text: the index, the table of contents, section headings, bold-faced words, etc.

If a category is selected, and information relevant to the goal of the task is found, this *information will be isolated and extracted* from the text. If, however, no relevant information is found, the category must be rejected and a new category selected. Extraction of information is followed by *integration* of these new facts or concepts with the goal of the task and other relevant information such as prior topic knowledge. The purpose of this component of search is to create an ongoing stream of goal-relevant information that will help answer the search question. By this stage, if the reader is not satisfied with the information obtained, he or she must *recycle* through the stages of search until the search goal has been met. Efficient search is dependent upon recognizing the stage at which he or she must begin recycling. Was the goal misinterpreted? Was the wrong category selected? Was incorrect information extracted or was it simply incomplete? When the searcher feels that the goal of the task has been satisfied, searching is discontinued.

The Guthrie and Mosenthal (1987) model has enabled researchers to devise studies that use concrete measures to quantify individual processes in the complex task of text search. In Guthrie's (1988) initial analysis of this model, the amount of variance in text search performance that could be attributed to each cognitive stage was assessed. University students were presented with a question on a computer screen, which asked them "which flight or connection of two flights could be taken to get from New York to Los Angeles by 7:00 p.m. (Pacific time), without exceeding the cost of $400?" They were then required to search for the answer by using a menu-based computer system. Any information that the student deemed relevant could be entered into a computer notepad. Search procedures were recorded by the computer, which provided estimates of all search stages (except goal formation, which was inherent in the question itself). Dependent measures were chosen to reflect each stage of search: category selection (the number of menu choices selected), information extraction (the percentage of relevant information entered into the notepad), integration (the number of times returned to the question), and recycling (ratings of the quality of the search sequence). Multiple regression analyses revealed that these four cognitive components accounted for 68% of the variance in time to complete the search task. These findings lend credibility to the model and suggest that these reading behaviours are indeed critical components of text search. By breaking text search into its cognitive components, these authors were also able to gain some understanding of the relative importance of each stage in the process. Unique variance in the amount of time taken to locate answers to the tasks could be attributed to only two components of the model: category selection (30%) and information extraction (9%).

Dreher and Guthrie (1990) performed a similar examination of the relative importance of various stages of search. These authors examined the processes of search in eleventh graders who were presented with two computerized textbook chapter search tasks (one simple and one complex). Students were provided with a menu system, which permitted direct examination of the chapter features (table of contents, glossary and index) and allowed the readers to page through the text, review their assignment, or answer the question. The time spent engaged in category selection, information extraction and integration were recorded, and recycling was evaluated by ratings of the efficiency of their search sequences. The search sequence ratings were correlated with the total time to complete each task, suggesting that more efficient search strategies facilitated task completion. In addition, more efficient (faster) searchers were found to spend proportionally more time selecting categories and proportionally less time extracting information than less efficient (slower) searchers on the complex question. Those searchers who concentrated on selecting categories of text to search reached a more timely satisfaction of the search goal.

Work by Symons and Specht (1994) also suggested that category selection and extraction efficiency were the key components of efficient search. This study examined the search behaviours of university students who were looking for the answers to low-inference questions in an eleventh-grade science textbook chapter. Faster searchers were more focused in their selection of categories than slower searchers: they searched fewer pages that did not contain goal-relevant information, and they examined fewer categories of text. Furthermore, faster searchers were more thorough in their extraction of information than slower searchers; they were less likely to overlook key information when it was encountered, and they did not have to re-inspect pages of text as often. Finally, the more accurate searchers examined more goal-relevant pages than the less accurate searchers.

Thus, the Guthrie and Mosenthal (1987) model has provided a structure for the design and interpretation of text search studies, and it has contributed to our understanding of strategy use. Clearly, optimal text search is achieved when the searcher makes the best use of his or her time by selecting the most appropriate reading activities. In other words, the searcher optimizes his or her performance by knowing when to start reading at a more or less detailed level. This efficiency is characterized by spending more time planning the search, particularly when selecting appropriate categories to examine. The most detailed searching is postponed until the reader is fairly certain that he or she will not be wasting time on the wrong sections of text. The "art" of knowing when to switch gears is difficult to quantify, but the Guthrie model provides a basis for developing meaningful measurements of these reading activities. Such findings have helped expand our understanding of good and poor strategy use in text search and, as one would expect, category selection skills are particularly important in this process (e.g., Guthrie et al., 1991).

Chapter 2

Study 1: Introduction

The role of educational psychologists is twofold: first, as outlined in Chapter 1, they must understand the cognitive processes underlying the skills that they study; second, they must be able to translate this theory into practice (i.e., an instructional protocol). In fact, it is widely accepted that one of the key components of effective instruction is a cognitive model that can guide the instructional program (Rosenshine, 1995). Problem solving tasks such as locating information are particularly amenable to cognitive strategies instruction because they involve a clear sequence of steps (or stages) that can be directly outlined and modeled for the students. Unfortunately, educators are not always aware of or informed about research developments that should have an impact upon what they do in the classroom. For example, there is an implicit assumption among educators that children will learn how to locate information in documents such as textbooks through practice, and that formal instruction is unnecessary. According to Benito et al. (1993), teachers do not provide instruction about how to answer text-based questions, and they do not provide corrective feedback when children have difficulty. Rather, there is a sense that students will learn by hearing the correct answers provided by others. In one study, it was found that junior high school students were not being taught how to outline their textbooks or search for information in encyclopedias, but they were required to complete in-class assignments requiring these skills (Durkin, 1978-1979). This was also reported in an observational study of reading activities in Grade 4 science and social studies classrooms (Armbruster et al., 1991). In approximately six and a half hours of classroom time involving text-based learning, there was no explicit instruction related to reading textbooks, but teachers asked an average of more than 1 question per minute.

Similar findings were reported in a study of junior high basal reading programs, which focused on the practice and application of text search skills, but neglected to make recommendations about how search strategies may be taught in the classroom (Durkin, 1981). Likewise, Armbruster and Gudbrandsen (1986) reviewed both student and teacher textbooks commonly used in elementary school social studies programs. Promotional literature accompanying the textbooks highlighted the importance of incorporating the development of reading skills (including the location of information) into social studies programs. Although textbook chapter questions found in the texts did ask students to search for information, the textbooks did not provide any specific strategies for the students to use, and teachers were not provided with instructional suggestions. In other words, the students were expected to employ reading skills that they were never formally taught by their textbook or their teacher.

Children in the elementary grades are also expected to perform complex information-seeking activities in the library setting with virtually no guidance (Moore, 1995). Students are typically given a research topic and then asked to write a report without any direction about how to do so. Such high expectations for children seem unwarranted, given their difficulty with even the most basic search tasks. Searching for information in a library not only requires complex search skills, but also the ability to negotiate the library setting. As outlined above, educational psychologists have been able to clarify our understanding of the cognitive processes involved in search, but there appears to be little overlap between this research and the work of educators in the library sciences. The study of "information problem solving" or "information literacy" has grown substantially in recent years, with an emphasis on the promotion of library instruction and integration with classroom curriculum. For example, Bucher (2000) recently outlined a number of information problem-solving models which outline the stages or steps that an individual must take to narrow a search goal in the context of a library setting. It is noteworthy that text search is subsumed within this type of model, but only represents a small component of the larger set of information seeking skills. Unfortunately, because of the split between research and practice, such models and their components have not been well validated.

One difficulty is that text search researchers within educational psychology do not typically translate their research into practical tools that can be used to help students learn how to more efficiently locate information. This is true, despite the fact that several studies have suggested that even minimal instruction can improve text search skills. For example, a series of studies by Kobasigawa and colleagues have shown students in elementary and junior high school can benefit from text search instruction. More specifically, search speed and accuracy was facilitated by cueing children to skim text by use of headings, particularly in the elementary grades (Kobasigawa et al., 1980; Kobasigawa et al., 1988). Although Grade 8 students were also able to generate search terms for the index or table of contents when provided with a hypothetical search question, Grade 4 students could not do so without first reviewing the table of contents and receiving instruction to do so (Kobasigawa, 1983). These studies are interesting because they suggest that the operation of cognitive components of the model are developmental and can be influenced by instruction, resulting in improved search skills. It should be noted that these studies focused on both category selection (headings, features) and extraction (reading speed) skills, which have been shown to play an important role in efficient search.

An important component of an educational program is the incorporation of metacognitive (self-monitoring) instruction, which is an overriding feature of all cognitive tasks. Academically successful students tend to be more plannful and monitor their success as they complete school-related tasks (e.g., August, Flavell, & Clift, 1984; Borkowski, 1992) and use more effective strategies (Cataldo & Oakhill, 2000). As such, one could postulate that better searchers would spend more time selecting categories before reading sections of text in detail and would monitor their success as they completed search tasks with the purpose of integrating goal relevant information with the question. Analyses of textbook search have shown that metacognitive prompts can indeed improve search. Dreher (1992) and Armbruster and Armstrong (1993) have suggested that students who are instructed to use a self-monitoring routine to complete text search tasks may also be able to improve their text search efficiency. Although little research has been conducted in this area, empirical studies have suggested that such an approach could be beneficial in the classroom. For example, Dreher and Brown (1993) found that university students' search efficiency could be improved by giving them very simple planning prompts before they searched for information in a university textbook. These included: 1) How will you proceed?; 2) What parts of the textbook will you use? Why?; and 3) What specific topics or key words will you look for? Why?. Those students who were prompted to monitor their success and think about selecting appropriate categories of text to search were significantly faster and more accurate at locating information than the non-prompted students.

Although students in the Dreher and Brown study did benefit from the text search prompts, it is noteworthy that they were actually given no direct instruction. That is, text search strategies were never modeled, described or outlined for the students, and they were given no feedback when they were completing the search tasks. University students were encouraged to think about what they were going to do, where they would look, and what they would be looking for, but they were given no direction to help them make such decisions. This is a somewhat artificial way to assess search performance, and appears to lack external validity. One goal of the present research will be to examine text search in the context of more empirically sound instructional interventions.

A similar criticism can be made of a second study by Dreher and Sammons (1994), which encouraged children in the elementary grades to plan and monitor during search, but did not help them evaluate what they were doing or show them how they might change their approach. Because text search is a strategic form of reading, explicit strategies-based instruction may prove to be a more practical approach, particularly with young children who have little previous experience performing search tasks and less familiarity with document structures. In addition, because university students probably know more about the structure of textbooks and have better general reading skills than students in elementary school, it is less likely that prompting children to think about search would help them improve their search skills. However, Dreher and Sammons (1994) found that children in Grade 5 who were aided in the planning and monitoring of textbook search tasks were more accurate than non-cued students. While completing the search tasks, students were cued to plan (Are there words in this question that you might be able to use to help you find the answer? How could you use this book to help you find the answer?), remain goal-focused (What information are you looking for? Does that part seem to have the information you need?), and monitor their success (Before we go on, read the question again. Do you think you have all the information you need to answer the question, or do you need to search a bit longer?). It appeared that these prompts were most effective in helping students select categories of text to search because they indirectly cued students to use the index, an important structural feature of textbooks. Moreover, the effectiveness of the prompts suggests that the children did have some knowledge about textbook features prior to testing, but they were not using this information spontaneously.

Thus, the present study will add significantly to the text search literature by more closely examining the effects of direct instruction of text search strategies, an area of the literature that has largely been ignored. Support for this approach comes from research on question-answer-responses (QARs) conducted by Raphael and colleagues during the 1980s (e.g., Raphael, 1982; Raphael, 1984; Raphael, 1986; Raphael & McKinney, 1983; Raphael & Pearson, 1985; Raphael & Wonnacott, 1985). These authors designed an intensive instructional protocol aimed at helping children identify sources of information to answer questions in prose and content area textbooks. The ultimate goal of this program was to help students be more aware of question-types (i.e., text-based or reader-based), with an emphasis on how these question types influence the way that you answer a question. Briefly, it could be characterized as a two week, metacognitive and strategy-based instructional program to be used by teachers in elementary and junior high school classrooms. Children were first taught how to identify different types of questions and how to answer them, with direct modeling, feedback and guided practice. Although such complete and effective instructional programs are the ultimate goal of educational reading research, it was not clear why improvements were seen in question-answer responding after instruction had taken place. It is possible that it was not necessary to initiate such a rigorous intervention to effect change. In fact one study suggested that Grade 8 students benefited as much from a 10-minute session as they did from the entire two-week intervention, but the same was not true for Grade 5 students who apparently needed a more intensive approach (Raphael, 1983). Therefore, comparisons of complete instructional protocols with protocols that target selected components of the intervention would permit us to identify which components must necessarily be taught to maximize efficiency and success.

This approach is particularly meaningful because it makes it possible to separate out strategies that relate directly to the Guthrie and Mosenthal (1987) model. As such, the results can inform us not only about instructional strategies, but also about the relative importance of behaviors related to each stage of search. Students who are instructed to use particular strategies can be assumed to use the strategies more often than children who are not given this type of instruction. It may then be postulated that improvements in search performance or strategy use resulted from increased cognitive processing at specific, identifiable, stages of search. Therefore, the present study was designed to separate and compare different components of text search instruction, and represented the first attempt to study the Guthrie and Mosenthal model in this way. Moreover, no systematic analysis of the cognitive stages of search had ever been attempted with a sample of children.

The Present Research

The purpose of the present study was to test the effect of teaching students to use strategies that have been influenced by the cognitive stages of text search (Guthrie, 1988; Guthrie & Mosenthal, 1987). This is consistent with recommendations made by Armbruster and Armstrong (1993) regarding text search instruction for children in the elementary grades. As outlined in Chapter 1, the five components of the text search model include goal formation, category selection, extraction, integration, and recycling (refer to Figure 1). Two components, goal formation and recycling, were not included in the instructional protocol, as direct instruction was considered to be inappropriate for these components of search. Text search goals were inherent in the questions themselves, as these were designed to be relatively simple in nature. Moreover, it would be difficult to explicitly teach students how to recycle through the cognitive stages of search in a brief instructional session, as this is dependent on an awareness of which steps need to be repeated.

The central feature of the instructional protocol was category selection, as this stage of search has been shown to have the strongest relationship with search performance (Dreher & Guthrie, 1990; Guthrie, 1988; Symons & Specht, 1994). This stage is perhaps the most straightforward to teach, as it involves the use of textbook features such as the index and headings. Guthrie and Mosenthal's text search model would suggest that category selection is a particularly important feature of the search process because the ability to select categories helps the reader narrow down the amount of text that needs to be searched. Poor category selection, or no category selection, would lead to inefficiency and likely result in the searcher being unsuccessful. However, it was unclear whether or not an instructional protocol that introduced only category selection strategies would be sufficient to improve search performance.

Based on Guthrie and Mosenthal's model, one could postulate that successful text search would also involve the use of strategies related to information extraction and integration. Once categories have been selected, it is then necessary to identify relevant information (extraction), and ultimately decide whether or not it matches the search goal (integration). Therefore, these components were also taught to selected groups. The inclusion of information extraction strategy instruction was supported by studies indicating that information extraction skills are related to search performance (Dreher & Guthrie, 1990; Guthrie, 1988; Symons & Specht, 1994). Empirical evidence for the important role of integration comes from the fact that teaching students to self-monitor has a positive effect on text search performance (Dreher & Brown, 1993; Dreher & Sammons, 1994). In addition, others have highlighted self-monitoring as an important feature of text search instruction (Armbruster & Armstrong, 1993; Dreher, 1992).

Two primary research questions were therefore addressed by the present research:

1. Does category selection instruction improve text search efficiency?

2. Does the effectiveness of intervention improve when strategies that address other components of the model are also taught during instruction?

Four different instructional groups and one no-instruction control group (CON) took part in the study. Instructional groups included the following: (a) Category Selection only (C), (b) Category Selection and Extraction (CE), (c) Category Selection and Integration (CI), or (d), Category Selection, Extraction and Integration (CEI). To address question 1, the effects of category selection instruction on students' text search performance could be compared to the performance of non-instructed students. Question 2 was addressed by an examination of text search performance across all five groups. Significant group differences would be indicative of the combined effects of teaching students more than one type of strategy, and the operation of related cognitive processes.

The study focused on children in Grades 3 and 4 because it is at this age that students are being exposed to more text search tasks in the classroom. Most of these tasks are associated with content-area textbooks, a type of reading format with which they have had little previous experience. Consequently, all search tasks were textbook-based, of a fairly simple nature, and in topic domains that were familiar to the students (i.e., science and social studies).

It has been well established that strategy instruction should involve a graduated approach that begins with description, modeling, guided practice and independent learning (e.g., Benito, Foley, Lewis, & Prescott, 1993). Students in each of the instructed groups were taught using a direct instruction model similar to Baumann (1984). In a one-to-one instructional session, students were taught about various cognitive strategies that could be used to improve efficiency in locating information in textbooks. To guide this instruction, a four-step teaching paradigm was used which emphasized the importance of modeling, student practice, and feedback. In the first phase, the students were taught about the importance of locating information and encouraged to think about their own text search experiences. In the second phase, the students were taught about the stages of search more explicitly, as the researcher modeled a text search task from beginning to end. Differences among the four instruction groups were established during this phase. To lessen task demands, the researcher used a worksheet that outlined the stages of text search as a guide. Students watched as the researcher self-monitored and performed a search task following Guthrie and Mosenthal's (1987) cognitive stages of text search. In the third phase, the students took on more responsibility for his or her learning by practicing some tasks with the worksheet as a guide, while the researcher provided ongoing feedback. Finally, in the test phase, the student took on full responsibility for the tasks and completed them independently.

Inter-group comparisons were made on a series of dependent measures. Performance measures included efficiency (total accuracy / total time to complete search questions) and the accuracy of the responses. Search behaviours were also observed and recorded during each task, which provided a record of search strategy. These observations included a) viewing the table of contents and index b) viewing key pages (i.e., pages containing the answer), c) viewing non-key pages, and d) flipping through the text. An estimate of overall strategy use was calculated based on these observations (search sequence scores).

Based on the findings of previous research the following hypotheses were advanced:

1. It was proposed that category selection instruction would help students narrow their searches, which would result in improved accuracy (as compared to controls). Moreover, it was expected that the CEI students would be the most accurate and efficient group because accurate extraction and integration would be facilitated by the additional instructional interventions. Hypotheses about

the performance of students who received extraction *or* integration instruction, in addition to category selection instruction, were considered exploratory in nature.

2. Search sequence scores were calculated by giving numerical values for the order of steps taken to locate answers to search questions, regardless of time or accuracy. It was hypothesized that these scores would be higher for students who had received strategy instruction than for those who did not because they directly reflected the skills that were being targeted by the instructional protocol. In other words, the search sequence scores would provide an estimate of how well students followed instruction. Therefore, students who received full instruction were expected to be the most strategic, as measured by search sequences.
3. Finally, students who received instruction would be more likely to engage in strategic search behaviours such as using important textbook features (index, table of contents) to narrow search and being able to find more key search pages. These measures differed from search sequence scores because they were not dependent on ordered steps, and were categorical in nature. That is, using the index at the beginning of search was considered to be the same as using the index later in search. Again, the full instruction group was expected to be most strategic, but specific predictions about the removal of extraction and integration instruction were not made.

Chapter 3

Study 1: Method

Participants

The participants in this study were 92 students in the spring of Grade 3 (n = 41) or fall of Grade 4 (n = 51) who were attending public schools in the Annapolis Valley Regional School Board. Forty-eight of the students were male and 44 were female. None of the participants were experiencing any academic difficulties, as reported by their homeroom teachers. Students in these grades were considered to be an appropriate sample because instructional interventions were not likely to be impeded by deficits in their basic reading skills (i.e., average students at this grade level should be able to reliably decode text). Furthermore, these students commonly use informational texts in the classroom and could benefit from direct instruction concerning their usage.

Each participant was randomly assigned to a non-instructed control group (n = 16), or one of four instructional groups. These groups involved the instruction of strategies related to category selection (n = 19), category selection and extraction (n = 19), category selection and integration (n = 20), or category selection, extraction, and integration (n = 18). Participants had an average age of 8 years, 10 months (range of 8 years, 0 months to 10 years, 9 months), and there was no significant difference in age across the five groups, $F(4, 87) = 0.40$, $p > .05$. All students received a pencil for their participation.

Text Search Tasks

Textbook

One textbook was used for all of the text search tasks. The textbook was a general science and social studies reference guide, entitled *Barron's Illustrated Fact Finder* (Dupre, 1987). It was written for students in the upper elementary school grades and was considered to be appropriate, if not challenging, for the students to read. It is well organized, with a detailed table of contents and index. The table of contents included 9 general topic areas (chapters) that were further subdivided into subsections of 6-38 topics. Page numbers were clearly identified for each subsection. The index was presented in a standard format, with each section separated by a capital letter in red type, and all index entries were in bold-faced type.

The content of each page was delimited by a thin square border, which separated it from the main subject heading at the top of each page and the page number at the bottom of the page. Within each section, subheadings, colored pictures and diagrams stand out from the text sections and could be used to locate the most relevant sections of text. The subheadings were typically written in bold faced or italic font, which highlighted their importance for the reader.

Questions

All of the questions reflected the types of content areas studied by students in the early elementary grades because previous studies have found that prior knowledge of a topic domain can facilitate search success (Symons & Pressley, 1993). The goal of the study was not to create questions that were impossible to complete without instruction; rather, students with adequate prior knowledge and appropriate search strategies should have been able to demonstrate their abilities regardless of their instruction group. If the questions were drawn from completely unfamiliar content areas, ecological validity would also have been questionable. Therefore, questions in the present study reflected areas such as famous inventions, pollution, nutrition, and simple biology.

In total, students were exposed to seven search questions, one modeled by the researcher (who was the principal investigator), three practice tasks, and three test tasks. There was a 5-minute time limit imposed on all of these tasks. The researcher-modeled question read, "In what year did the Wright Brothers fly the first airplane?"

The practice questions were:

In what year was the Red Cross founded?

How many calories does 1 g of fat produce?

How many hours does a baby sleep in one day?

The test questions were:

How many newspapers are printed by the press daily?

What color is a very hot flame?

Garbage is a form of pollution. What is used to burn it?

All of the search tasks included at least one word or phrase that could be extracted directly from the question and found in the index (underlined above). In every case, it was the key concept(s) that needed to be identified and selected from the question. All terms were expected to be fairly obvious searchable terms if the index was being used as a search aid. A more detailed description of these questions and how the answers could be located is presented in Appendix A.

Text Search Worksheet

The text search worksheet was designed to give the instructed students a guide for completing the text search tasks. It was necessary to include the worksheet to reduce the demands on memory, as the participants were being presented with a great deal of information in a very short period of time. For each group, a modified version of the worksheet was used, which corresponded to the type of instruction that participants had received. All worksheets were presented in the same format, with a question printed at the top of the page in boldfaced type, followed by a series of prompts. Category selection cues included prompts to write down key words to look for in the index and to write down the page numbers indicated in the index. The extraction prompt reminded the students to "check the pages carefully", and the integration prompt asked the students if they had found the answer. Following the prompts, the students were provided with a space to write down their response. Participants in the control group received none of the prompts, but were provided with a sheet containing the question and a space to provide the answer. Examples of each version of the worksheet can be found in Appendix B.

Procedure

After a presentation to each class about the study, consent forms were sent home to parents / guardians. Those students who had obtained consent from a guardian, and consented to take part on the day of testing, were randomly assigned to a no-instruction control group (CON) or one of four instruction groups (see Table 1). All testing was completed on an individual basis, by the primary investigator.

Table 1

Description of Instructional Interventions for Each Group

	Group				
Phase	CEI	CE	CI	C	CON
Category Selection	X	X	X	X	
Extraction	X	X			
Integration	X		X		

Note. CEI = Category Selection, Extraction and Integration; CE = Category Selection and Extraction; CI = Category Selection and Integration; C = Category Selection only; CON = No Instruction Control.

Each instruction group received a unique combination of text search strategy instructions reflective of three primary cognitive stages of search: (a) Category Selection, Extraction and Integration (CEI), (b) Category Selection and Extraction (CE), (c) Category Selection and Integration (CI), or (d) Category Selection only (C). Similar to Baumann's (1984) model of direct instruction, the instructional session took place in four phases. All students except for those in the control group received a complete instructional session that included an overview of what text search is, followed by researcher modeling, three practice tasks using the Text Search Worksheet, and three test questions. It was only during the researcher modeling that the instructional groups were treated differently from one another. It was at this point that strategies associated with the different components of the cognitive model of text search (Guthrie & Mosenthal, 1987; Guthrie, 1988) were outlined. Because three of the instruction groups did not receive direct instruction for one of the cognitive stages, a short transition statement replaced those instructions reflecting the stage of text search that was not addressed. This enabled a continuous presentation of the material for each group. Students in the CON group received only the essential information that was outlined in the Introduction Phase, followed by the practice and test questions. However, it should be noted that all students received equivalent exposure to the textbook prior to the practice phase. In the CON group, students were given a chance to familiarize themselves with the contents and structure of the book before beginning their practice exercises. Following is a summary of the instructions that were given to the CEI (total instruction) group and the transition statements that were used for each additional group.

Phase 1: Introduction and Example. All students, including those in the CON group, were given a general introduction to text search. They were told about the importance of text search in school and were given a context in which to understand the relevance of the tasks to their own lives:

> One thing that you are asked to do in school is find information in books. Sometimes this is part of a classroom or homework exercise, and other times you might have to find information in books when you are doing a school project. Can you remember a time when you needed to use a book to find out information about a topic?

If the student responded "yes", he or she was asked to explain what the topic was and where they were at the time (in class, at home, in the library, etc.). A student who responded "no" was asked more specific questions about past school projects and classroom exercises, until a type of reading task that qualifies as text search could be generated.

> It is sometimes very difficult to find things in a textbook because the book has so much information in it. When this happens, there are many things that we can do to make the task easier. What I want to do now is tell you a little bit more about searching for information, and then we will do some tasks for practice.

Students in the CON group were given no further instruction. Hence, the final sentence of the above statement was eliminated and a transition stage was introduced.

> Before we begin, why don't you take a few minutes to look the book over and see what is in it. [Permit the student to look at the book for 3 minutes.] Now let's try a few search tasks for practice.

Control students then moved directly to Phase 3, the Application Stage. It should be noted that those students in the CON group were not shown the worksheet and were required to search for the answers to text search questions without any assistance. They were permitted to use the piece of paper to write down notes if they wished, but they were not instructed to do so.

Phase 2: Direct Instruction. In the Direct Instruction phase, the strategies to be used by the students to complete the text search tasks were modeled by the researcher. In addition, students were shown the worksheet that would be used for the practice search tasks.

Category selection. The purpose of this stage was to model how key words in a question could be selected. Category selection instruction was given to all instruction groups as follows:

> Let's pretend that I have just been given a question by my teacher as an exercise in learning about airplanes. The teacher asks me "In what year did the Wright brothers fly the first airplane?" Now I have to decide where to look to find the

> answer to the question. The best place to look for information like this is in the index, because it lists all of the topics in the book in alphabetical order like a dictionary, and gives page numbers for each one. To use the index, I must first pick out the main words in the question and find them in the index. Can you think of any words that I could look up?

If the student responded with "airplane" or "Wright Brothers", the student was told that he or she was correct and the researcher underlined the word or phrase on the worksheet. If the student had difficulty with this step, additional prompting and explanation was necessary. Following this, the researcher proceeded to model the location of relevant sections of text that could be searched on the selected text pages.

> I will now pick one of these words to look up. I will choose "airplane" because it seems to be the most important word in the sentence and I will write it here on the worksheet [write on worksheet]. Now I will open the book to the index at the back [open book] and find that beside the word "airplane" is the page number "253" [write on worksheet]. I will turn to page 253 and see if I can find any of the words that I underlined in the question in titles on the page, underlined, or highlighted. If I look for words related to the question by skimming down the page [move finger down page], I see a section here [point to "humans take to air"].

Because the C group received no further instruction, students in this group were told to look at the selected page with the researcher and read silently to find the answer. After pausing for 30 seconds, the researcher wrote down a response. Therefore, the remaining descriptions apply only to the CEI, CE, and CI groups.

Extraction. Students in the CI group did not receive information extraction instructions and were simply told to read silently with the researcher for 15 seconds. The CI students then moved on to the Integration phase. Those in the CEI and CE groups were taught how to closely inspect information on text pages by monitoring their reading speed:

> Once you have found the part of the page that probably has the information you are looking for, you should read the text carefully from this point onwards to find the answer to the question. Starting with "humans take to the air", I will slow down and read this section very closely until I find a part that answers the question. It is important that I pay attention and really try to understand what I am reading so that I won't miss it the first time. If I read the paragraph under "humans take to the air", the first sentence contains a year... That's what we are looking for! "After the first successful flight of an airplane in 1903 by Wilbur and Orville Wright, progress in air transportation came quickly."

Integration. For those who did not receive integration instruction, the researcher paused for 15 seconds before writing down an answer. Those receiving integration instruction (CEI, CI) received these final instructions related to monitoring their response:

> The next step is to decide whether or not what I found is the answer to the question. Just because it is a year, it doesn't mean that I have found the *correct* year. I must now inspect what the sentence says more closely and compare it directly to the question. The question reads, "In what year did the Wright brothers fly the first airplane?" The answer that I found states that the "first successful flight of an airplane" happened in "1903" and it was by the Wright brothers. This seems to answer the question, so I will now write the answer down, "1903". Remember, it is very important not to forget this step and just write down the first thing that you find.

Review. Finally, the student went through the outline on the worksheet with the researcher to familiarize him or herself with the stages of locating information in a textbook. Only those components addressed in the Direct Instruction Phase were discussed.

> As you can see, by going to the index first, instead of flipping through a whole bunch of pages, I could find the answer very quickly. We can think of this as a series of steps: What was the first thing that I did?

<u>Phase 3: Application.</u> In the Application stage, the student practiced what he or she had been taught. The student was asked to apply the skills that he or she had

observed and was given corrective feedback and guidance while completing three practice tasks. The student was assisted in using the worksheet while completing the first practice task, but assistance for the second and third practice tasks was less directive. Practice questions were presented in counter-balanced random order. The following instructions were used to introduce this new phase of the session:

> What I would like to do now is try one of these questions together. This is the worksheet for the question, and it should help you remember what to do. If you think you know the answer to one of the questions, look it up anyway and write down the answer that you find in the book. When answering questions, you do not need to use complete sentences. Just write down the word or words that are necessary. Feel free to ask me any questions that you like as you go through it, and I will try to help you as much as I can. Remember to follow the steps on the worksheet as you complete each part. I will be timing and observing you. First I will read the question aloud, then I will get you to read it back to me. Do you have any questions?

Phase 4: Test. After the student completed the practice exercises, he or she began to work independently and take full responsibility for the tasks. This phase was considered the test phase. The students completed three searches using the same book as they practiced with. These were timed with a stopwatch and the researcher recorded the search procedures as tasks were completed. The test phase was introduced in the following way:

> Now what I want you to do is finish three of these tasks on your own without the worksheet. I will be timing and observing you again. Think carefully about what you are doing, and try to remember the stages that we have been talking about as you complete the questions. You can use the paper to make any notes you want to as long as you complete the questions. First I will read the question aloud and then I will get you to read it back to me. Do you have any questions?

Measures

Accuracy and Efficiency

Search performance was assessed in two ways: the accuracy of the response and the efficiency with which answers were located. Accuracy is a straightforward measure, reflecting the ability to locate relevant information and recognize when the goal of the search task had been met. For each question answered correctly, a student could receive 1 point. Thus, students were able to receive an accuracy score of 0, 1, 2, or 3 (based on a total of 3 questions).

In the classroom, it is critical that students also be able to locate information quickly to avoid the frustration associated with falling behind their classmates. However, the time spent searching to locate an answer is a somewhat complex dependent measure because speed should not come at the price of accuracy. That is, searching for three minutes to find an incorrect answer is not the same as searching for three minutes to find a correct answer. Thus, time data is more appropriately considered in the context of correct responses only. However, because children would not be accurate on the same questions, time data collapsed across only the accurate responses would reflect the children's speed on different searches. It would therefore be difficult to draw valid conclusions from time data, since they were not designed to be qualitatively the same.

An alternative way to evaluate time data is to calculate how efficient the participants were in locating correct answers. Efficiency can be calculated by dividing the accuracy score for each participant by the total amount of time that he or she spent searching. A student who searched for any length of time, but got no correct answers, would have a search efficiency score of 0. A student who got one answer correct in 2 minutes of searching would have an efficiency score of .5. A student who took twice as long, but still found one correct answer, would have a search efficiency score of .25. Students who quit searching on any question could not be included because no attempt was made to provide an answer.

Search Processes

Search sequence scores. A number of behavioural observations were recorded during each search task. The purpose of this behavioural record was to identify (a) whether or not different strategies were being used among the five groups, and (b) whether or not the more accurate / efficient searchers were using strategies that differed from the less accurate / efficient searchers. One measure of search strategy was a coding system that was based on the sequence of search behaviours in which the student engaged (modified from Dreher and Guthrie, 1990). Search sequences included the following behaviours: searching the index, searching the table of contents, examining key or indexed pages, examining non-key text pages, flipping through the text, recording an answer, and quitting or running out of time. As the student was completing each search task, the researcher observed and recorded the sequence of behaviours. Each of these behaviours was given a value, based on the quality and the order in which they were executed (see Table 2). Although these values were somewhat arbitrary, they were intended to reflect the relative worth of each action. The most efficient sequence of search behaviours would be the one that would lead most directly to the correct answer to a search question. Because a search question could be answered in three steps (index, key page, record the answer) only the first four sequences were given a rating.

For the *first behaviour* in the sequence, index use was the most highly rated because it was considered to be the most direct route to the key page. Using the table of contents was also a legitimate and useful strategy as a first choice, but this approach leads to a substantially greater number of pages. This may ultimately lead to the location of the key page, but it can be seen as less direct and less efficient than the index. Consequently, table of contents as a first choice was well rated, but less so than the index. The only other behaviour that could receive credit as a first choice was flipping, since it is suggestive of an attempt at strategy use, albeit an inefficient one. A student who viewed key pages or non-key pages as a first step was given no credit because he or she was employing no strategy to select the searched pages. Moreover, recording an answer was given no credit because the child had not used the textbook to locate the answer, despite being instructed to do so.

The value for behaviours changed at the second step of the sequence, because different behaviours are indicative of good strategy use at this point. For *second behaviour* ratings, a student who viewed key / indexed pages was the closest to locating a correct response. Also given credit were index or table of contents use, which may be seen as strategic at any point, because they indicate that the searcher is attempting to narrow the search. Note, however, that the credit for index use decreases at this stage, since the student had not used it as a first option. Value was given to viewing non-key pages because the student may be following-up a more general table of contents or index search. Flipping, quitting and running out of time were given no value for this stage or for or any other point during the search.

The *third behaviour* that received the most credit was recording an answer, since it was indicative of the most direct route to task completion. If, after providing an answer, additional search behaviours were executed, there was a penalty for not completely evaluating the response before providing it. Index use, table of contents use, viewing key pages, and viewing non-key pages were all given equal value at this stage. This was reflective of the fact that all behaviours were appropriate at this point, but reflective of less than optimal search in previous stages.

Finally, for the *fourth behaviour*, doing nothing was the most valuable activity because it reflected completion of the task in the previous stage. If the fourth behaviour was to record the answer, credit was given. Less credit was given for the remaining behaviours, as students engaged in other behaviours had clearly experienced difficulty making good strategy choices in previous steps. The maximum possible score was 20, 5 points for each of four sequenced behaviours: index, key page, recording answer, nothing. Any child who engaged in six or more behaviours received a 2-point penalty. Following is an example of how the score for a search sequence would be calculated:

Behaviour 1: index (5 points)

Behaviour 2: table of contents (3 points)

Behaviour 3: non-key pages (2 points)

Behaviour 4: key page (1 point)

Behaviour 5: record answer (0 points)

Total Search Sequence = 11 points

Table 2

Coding Scheme for Search Sequences

Order of Behaviour	Behaviour	Rating
First	Search Index	5
	Search Table of Contents	3
	Flip Through Text	1
	Examine Key Page(s)	0
	Examine Text Pages	0
	Record an Answer	0
Second	Examine Key Page(s)	5
	Search Index	3
	Search Table of Contents	3
	Examine Text Pages	3
	Flip Through Text	0
	Record an Answer	0
	Quit/Out of time	0
Third	Record an Answer	5[a]
	Search Index	2
	Search Table of Contents	2
	Examine Key Page(s)	2
	Examine Text Pages	2
	Flip Through Text	0
	Quit/Out of Time	0
Fourth	(Nothing)	5
	Record an Answer	3[a]
	Search Index	1
	Search Table of Contents	1
	Examine Key Page(s)	1
	Examine Text Pages	1
	Flip Through Text	0
	Quit/Out of Time	0

[a] If last action, otherwise 2 points were subtracted.

Search behaviours. In addition to search sequence scores, individual search behaviours were considered important measures of how students were completing the search tasks. They were examined individually and in the context of search accuracy, to provide a more complete picture of group differences. Table 3 provides a summary of these dependent measures.

Table 3

Outline of Dependent Variables

	Measure
Performance	Accuracy of responses
	Total accuracy / total time (if an answer was provided for all questions)
Process	Search sequence scores
	# of pages searched
	# key pages searched / # total pages search
	# of key pages located
	# of questions referred to index
	# of questions referred to table of contents
	# of questions flipped through book

Chapter 4

Study 1: Results

Search Performance

Accuracy. The first set of analyses focused on the overall accuracy of participants on the three test questions (see Table 4 for means and standard deviations). To test for significant effects of instruction on accuracy scores, a one-way analysis of variance (ANOVA) was computed on total scores. Consistent with predictions, there was a main effect of strategy group, $F(4, 91) = 6.13$, $p < .01$, suggesting that instructional interventions influenced the ability to locate correct answers to search questions. Moreover, Tukey's HSD tests of means revealed that students who had received the full instructional protocol (CEI) were significantly more accurate ($M = 2.39$, $SD = 0.92$) than students in the category selection (C) group ($M = 1.37$, $SD = 0.90$) and the control group ($M = 0.75$, $SD = 1.00$). However, participants in the C group did not differ from controls. These findings suggested that strategy instruction improved textbook search, but that category selection instruction alone was not a sufficient intervention. This was not consistent with the hypothesis that category selection alone could improve text search success. Additional comparisons indicated that the CI group ($M = 1.85$, $SD = 1.18$) outperformed the control group, but the CE group ($M = 1.58$, $SD = 1.02$) did not differ from any other group. Therefore, integration instruction (monitoring answers) appeared to be playing a key role in search success. The fact that only a combination of category selection, extraction, and integration (CEI) instruction could help students achieve greater success than simple category selection (C) instruction suggested that both extraction and integration are necessary to significantly improve search success beyond index use.

Efficiency. A second set of analyses examined the efficiency (total accuracy / total time to complete the search questions) with which participants completed the search tasks. Mean scores and standard deviations are outlined in Table 4. The total number of participants available for efficiency score calculations was reduced to 64 because 28 participants quit and did not provide an answer for at least one question. Because ten of these participants were from the control group, only the instructional groups were included in these analyses. The ANOVA based on average efficiency scores for test questions approached significance, $F(3, 59) = 2.63$, $p = .06$.

Table 4

Descriptive Statistics of Search Performance

	Instructional Group				
Measure	CEI	CE	CI	C	Control
Accuracy[a]					
M	2.39_{a}	1.58_{abc}	1.85_{ade}	1.37_{bce}	0.75_{c}
SD	0.92	1.02	1.18	0.90	1.00
n	18	19	20	19	16
Efficiency[b]					
M	$.42_{a}$	$.34_{a}$	$.25_{a}$	$.25_{a}$	-
SD	.26	.23	.16	.18	-
n	15	13	17	12	-

Note. CEI = Category Selection / Extraction / Integration; CE = Category Selection / Extraction; CI = Category Selection / Integration; C = Category Selection.

[a]Accuracy scores ranged from 0-3. [b]Efficiency = total accuracy / time to locate answers. Participants who quit on any question were not included in efficiency calculations. Means in the same row that do not share subscripts differ at $p < .05$ in the Tukey honestly significant difference comparison.

Process Measures

Search sequence scores. To get an overall estimate of the quality of search strategies used by the students, mean search sequence scores for the three test questions were calculated (see Table 5). A one-way ANOVA examined whether or not the five groups differed in their approach to textbook search. There was a difference among the five groups, $F(4, 91) = 38.79$, $p < .001$. Although a Levene's test of homogeneity revealed that there was a significant difference among variances, data transformations were not necessary because the groups were approximately equal in size (Shavelson, 1988). Tukey's follow-up comparisons indicated that all instruction groups were more strategic than the control group, as measured by search sequence scores. Although it was expected that students who received the full instructional protocol would be the most strategic, they were actually no more strategic than the other instructed groups. In fact, all instructed groups had average scores at or above 17 (maximum score of 20), while the control participants obtained a mean of only 7 and showed considerably more variability.

Table 5

Measures of Search Process

	Instructional Group				
	CEI	CE	CI	C	Control
Measure	n = 18	n = 19	n = 20	n = 19	n = 16
Search sequence[a]					
M	18.35	18.63	18.22	17.56	7.06
SD	2.39	2.22	2.33	3.83	4.97
Total number of pages searched					
M	6.17	6.47	6.00	7.05	106.13
SD	3.29	2.25	2.49	3.26	75.03
Proportion of key/total pages					
M	0.69	0.60	0.65	0.54	0.10
SD	0.21	0.16	0.20	0.21	0.22

Note. CEI = Category Selection / Extraction / Integration; CE = Category Selection / Extraction; CI = Category Selection / Integration; C = Category Selection.

[a]Search sequence scores ranged from 0-20.

Search behaviours. Search sequence scores are extremely helpful because they give an overall measure of search strategy use, but it is difficult to tell exactly how the students differed from one another without a more detailed analysis of individual search behaviours. One of the most telling measures is the total number of pages searched because it is a good indication of erratic search if the total number of pages is excessive, while fewer searched pages is indicative of a more streamlined and goal-directed approach. It was found that students in the control group searched a mean of 106 pages ($SD = 75$) across the three search tasks, but students in instructed groups searched a mean of between 6 and 7 pages. The ANOVA for these values was significant, $F(4, 91) = 33.62$, $p < .001$, and differences were found between control participants and all four instructed groups (see Table 5).

These findings were supported by an ANOVA that compared the proportion of key pages searched to the total number of pages searched, $F(4, 91) = 23.21$, $p < .001$. Once again, all instructed groups searched proportionally more key pages than the control group across the three tasks (see Table 5). Because the total number of pages searched was so dramatically different across groups, this finding was not considered to be an accurate reflection of key page use.

Therefore, the number of questions for which the key page was located was also examined (see Table 6). Each student was assigned a score that ranged from 0-3. A Kruskal-Wallis ANOVA was computed on these scores and a significant effect of group was found, x^2 (4, 91) = 26.84, $p < .01$. As expected, all instruction groups found more key pages than the control group. Interestingly, the CEI, CE and CI groups also located more key pages than the C group, suggesting that instruction of additional strategies was successful in enhancing this effect.

Because students in the control group appeared to be having difficulty narrowing down their searches to key pages, it was important to examine whether or not important textbook features were being used to help identify key sections of text (see Table 7). All students who were in an instructional group used the index for all three questions but out of the 16 participants in the control group, only 1 student used the index for all three questions. One additional student used it for two questions, and a total of 13 children did not use the index for any of the test questions. A Kruskal-Wallis ANOVA showed that these differences were significant, x^2 (4, 91) = 32.19, $p < .001$. Non-instructed students did use the table of contents with some frequency (3 used it for all three questions and 3 used it for one question) but the instructed students did not use it at all. A KWANOVA again suggested that these differences were significant, x^2 (4) = 30.12, $p < .001$.

Although flipping through pages of a book is a type of strategy, it is not a particularly effective one. It is used when searchers attempt to narrow their search by looking at page features such as headings and pictures, but it typically reflects poor planning and a lack of a more efficient approach. Table 7 outlines the number of questions for which students used this approach across questions. A Kruskal-Wallis ANOVA suggested that there were group differences on this measure, x^2 (4) = 29.59, $p < .001$. Follow-up analyses indicated that the control group used this strategy significantly more than all four instructional groups. No participants in the CEI or CI groups flipped through the textbook. In both the CE and the C groups, 1 out of 19 students flipped through the book on only one question. In the control group, however, this strategy was much more common: 7 out of 16 students flipped for all three questions, 4 children flipped for two questions, and 3 children flipped for one question.

Table 6

Number of Questions for which a Key Page Was Located

	Instructional Group				
Number of questions	CEI	CE	CI	C	Control
0	0	0	0	1	4
1	0	0	1	1	4
2	1	4	3	5	4
3	17	15	16	12	4

Note. CEI = Category Selection / Extraction / Integration; CE = Category Selection / Extraction; CI = Category Selection / Integration; C = Category Selection.

Table 7

Number of Questions for which Search Behaviour Observed

	Instructional Group				
Behaviour	CEI	CE	CI	C	Control
Used Index					
0	0	0	0	0	13
1	0	0	0	0	1
2	0	0	0	0	1
3	18	19	20	19	1
Used TOC					
0	18	19	20	19	10
1	0	0	0	0	3
2	0	0	0	0	0
3	0	0	0	0	3
Flipped					
0	18	18	20	18	2
1	0	1	0	1	3
2	0	0	0	0	4
3	0	0	0	0	7

Note. CEI = Category Selection / Extraction / Integration; CE = Category Selection / Extraction; CI = Category Selection / Integration; C = Category Selection.

Search Process and Accuracy

To examine the relationship between the types of search processes used and the accuracy of the students' responses, a correlation was computed between search sequence scores and accuracy scores on the three test questions. This correlation was found to be significant, $r(92) = .50$, $p < .01$, however, the correlation varied across groups. The CEI group showed the highest correlation, $r(18) = .80$, $p < .001$, followed by the control group, $r(16) = .58$, $p < .01$, and the CE group, $r(19) = .47$, $p < .05$. The correlations were not significant for either the CI group, $r(20) = .06$, ns, or the C group, $r(19) = .32$, ns. These results suggested that there was a relationship between search sequence scores and accuracy, but it was not clear why this was restricted to only certain groups. A scatterplot for each group indicated that the range of the data points was no less restricted for groups that did not show significance. Thus, restricted range is not a valid explanation for this finding.

The performance of students with the highest search sequence scores (i.e., search index, view key page, and record answer) were compared across groups. All students who received a search sequence score of 20 on any question were identified, and the proportion of correct responses to incorrect responses was compared across the four instructional groups (see Table 8). It is noteworthy that only 4 search sequence scores of 20 were obtained across all three questions for the participants in the control group, so comparisons were restricted to only the instructed groups. A Kruskal-Wallis ANOVA indicated that the difference among groups was significant, x^2 (3, 75) = 17.14, $p < .01$. Follow-up analyses showed that the students in the CEI group were significantly more accurate than all other instructional groups when a search sequence score of 20 had been achieved. Even when only examining students with perfect search sequencing, the CEI group still out-performed all other groups.

Finally, a Kruskal-Wallis ANOVA was computed on the accuracy scores for all students who viewed key pages, regardless of search sequence scores. By restricting analyses to cases where students had found a key page, any differences in accuracy among the groups could be attributed to students' ability to find and recognize an answer once the key page was located. Therefore, it did not matter how students located the page, and all preceding steps were irrelevant. It was found that there was an overall difference among groups, x^2 (4, 75) = 11.76, $p < .02$ (see Table 8). Follow-up analyses suggested that the CEI students outperformed all other groups, with 43/53 key page locations resulting in an accurate response. The CI students found correct answers on 37/55 key page locations, making them significantly more accurate than the CE (30/53), C (26/47) and CON (12/24) groups. This again suggests that a significant role was being played by integration, and that the addition of extraction strategies further improved the students' ability to locate information on a text page. The remaining groups did not differ significantly from one another.

Table 8

Proportion of Correct to Incorrect Responses as a Function of Successful Search Behaviours

	Instructional Group				
Behaviour	CEI	CE	CI	C	Control
Maximum search sequence achieved					
Correct[a]	43_a	30_b	37_b	26_b	4
Incorrect	11	27	23	31	0
Key page located					
Correct	43_a	30_b	37_c	26_b	12_b
Incorrect	10	23	18	21	12

Note. CEI = Category Selection / Extraction / Integration; CE = Category Selection / Extraction; CI = Category Selection / Integration; C = Category Selection.
[a]Control participants not included in Kruskal-Wallis ANOVA due to limited search sequences of 20. Values in the same row that do not share subscripts differ at $p < .05$.

Chapter 5

Study 1: Discussion

Consistent with recommendations made by Armbruster and Armstrong (1993), students in the present study were systematically taught strategies that reflected the cognitive stages of text search (Guthrie & Mosenthal, 1987; Guthrie, 1988). As predicted, direct text search strategy instruction improved the ability of young children to locate answers to questions in an informational textbook. In fact, the intervention was so successful that students who received the full instructional protocol were three times more accurate than students who did not receive any direct modeling of text search strategies. This supports research by Dreher and Sammons (1994) who found that children were better at searching to locate information if they were prompted to select key words from search questions, use textbook features, monitor their reading on text pages, and evaluate their responses. All of these were elements of the CEI instructional protocol. It is important to note that these studies were consistent with one another, despite clear differences in the study designs. Dreher and Sammons prompted students to be strategic *during* search, and gave no direct instruction. Results from this study indicated that giving direct strategy instruction *prior* to search, and promoting autonomy through a graduated instructional approach, was also effective.

One of the most significant findings from this study was that instruction of category selection alone (index use, skimming key pages, and key word search in text) was not sufficient to improve accuracy of responses. There did appear to be a *trend* towards improved performance with category selection instruction, but this finding was not significant. Supporting this, Symons, MacLatchy-Gaudet, Stone, and Reynolds (2001) recently reported similar findings. One study compared children in Grades 3 and 4, who received full instruction (CEI), to those who received an overview of both the table of contents and the index, or received no instruction at all. They then searched for information in a different textbook to test for the transfer of strategy instruction to a new book. The full instruction group was found to be more accurate than children who received either no instruction or a simple overview of textbook features when searching a novel book. Given the fact that instruction of textbook use in the classroom is largely limited to textbook feature instruction (Armbruster and Armstrong, 1993), this is of significant practical concern.

A second study from Symons et al. (2001) examined the relationship between age and the effects of teaching students to locate answers using the full instructional protocol (CEI) or full instruction without the integration component (CE). A third group was given no instruction at all. Across all grades, 3, 4, and 5, full instruction resulted in better accuracy than no instruction at all. Although Grade 3 students benefited from category selection / extraction strategy instruction, students in Grades 4 and 5 did not. These findings are consistent with developmental stage theories, which would suggest that as the brain's frontal lobe matures, children become more adept at specific monitoring and control processes, such as those that would be necessary in text search tasks (Jarman, Vavrik, & Walton, 1995). Unlike the older children, Grade 3 students may have benefited from extraction instruction because they were not using extraction strategies (i.e., carefully inspecting pages) spontaneously. Extraction instruction did not appear to influence accuracy in the present study, perhaps because the children were in late Grade 3 or early Grade 4. Moreover, findings from the present study, which included a group of students who received only category selection and integration instruction (CI), did suggest that the children were not monitoring their responses to questions. That is, children in both the CEI and CI groups outperformed students in the control group. Comparisons with older children would be necessary to establish whether or not this skill develops after the ages tested here, but findings from Symons et al. (2001) indicated that children were still not spontaneously monitoring their responses at the Grade 5 level.

From this, it can be concluded that teaching students in the elementary grades text search strategies in a one-to-one setting can improve search success, but question-answer monitoring is a particularly important component of instruction. This finding supports other instructional studies that have emphasized the relationship between question-answer-responses (QARs). Raphael's two-week QAR program, which involves teaching students how to identify and answer different types of questions, followed by modeling, feedback, and guided practice has been very successful; particularly with younger children (e.g., Benito et al., 1993; Raphael, 1983). These studies have highlighted the importance of monitoring what the question is asking, and then comparing it to the answer that has been provided. Although all of the questions in the present study were quite simple in nature (i.e., the answers could be extracted directly from the text without any inference or need for prior topic knowledge), and the instruction was very straightforward, the integration instruction was still very effective.

Results also indicated that there was an effect of teaching students a combination of both extraction (monitor their reading speed and carefully read selected sections of text) and integration (check question-answer matches) strategies. This was evidenced by the fact that only students given the full instructional protocol (CEI) were more accurate than those students who received category selection instruction (C). It can be concluded that it is necessary to teach all steps of the cognitive model, and that teaching students to self-monitor at both the extraction and integration stages is important. Kobasigawa's (1983, 1988) research has suggested that readers in Grade 4 can benefit from instruction to skim text and increase their reading speed by searching for key words (a type of category selection strategy). However, no text search studies have systematically focused on teaching students how to slow down their reading to comprehend important text during search (an important part of extraction). A recent study conducted by Cataldo and Cornoldi (1998) examined the ability of students in Grade 6 and 7 to answer questions found in passages ranging in length from 66 - 152 words. Students had more difficulty answering questions that were at the end of the passage than answering questions that were embedded directly in the text itself (following the relevant section). Providing embedded questions within the text eliminated category selection requirements, by cueing students to slow down their reading and focus directly on the relevant information within the text (an extraction strategy). Furthermore, students with poor comprehension skills were more accurate when they were asked to evaluate the quality of their responses, but only in the embedded question condition. This requirement was likely a cue to evaluate question-answer matches (an integration strategy), but it had no effect when category selection demands were high (i.e., when questions were presented at the end of passages).

Even though students given only category selection strategies were no more successful at locating correct answers than controls, behavioural observations indicated that category selection instruction led to the use of more appropriate search strategies. For example, instructed students tended to be less erratic when viewing text pages (i.e., they searched substantially fewer pages, found the key page more often, and rarely flipped through the textbook). During the administration of the test items, many participants in the control group were observed to be flipping aimlessly from page to page. These findings were meaningful because they demonstrated that the instructed students learned how to narrow their search to the most relevant pages and extract information, even after only minimal strategy training.

Instructed children also typically had high search sequence scores, which were significantly better than the search sequence scores of students in the control group. Similar to the Dreher and Sammons study (1994), they were more likely to use the index to initiate searches than the control group. These authors suggested that students were able to access prior knowledge about textbook structures as a result of the searching prompts, because they had prior experience with these types of tasks. Based on how readily students were able to follow instruction and use the index in all instruction groups, the present study would also suggest that this was not a novel academic activity. Anecdotally, teachers and librarians of the children who took part in this study stated that their students had been exposed to this type of instruction before. However, students in the control group did not spontaneously use the index to locate answers and in fact were quite non-strategic in their approach. This is consistent with the fact that teaching a strategy does not necessarily mean that it has been incorporated into a student's metacognitive awareness and will be used appropriately in a future task (Melot, 1998). That is, the students may be aware of the index but not know when or how to use it without prompting or instruction about how to do so (Dreher & Sammons, 1994; Kobasigawa, 1983; Symons et al., 2001).

It was surprising to find that the CEI, CE and CI groups located more key pages than the Category Selection (C) only group, again suggesting that there was a positive effect of encouraging students to monitor their progress (extraction / integration). Teaching students to read carefully and / or think about their answers resulted in an improved ability to find the correct page. That is, they evaluated the quality of the page that they had selected either before or after an answer had been extracted. Moreover, when a key page was located, regardless of search sequence, students who had received full instruction were more accurate than CI students, who were in turn more accurate than all other groups. The fact that the ability to locate a key page does not necessarily translate into an accurate response is completely consistent with the results of previous research (e.g., Cataldo and Cornoldi, 1998; Dreher, 1992). Moreover, the present study suggested that even children who used the most strategic approach (i.e., search sequence score of 20) were not guaranteed to get the right answers. In practical terms, this means that students were able to use the index efficiently, locate the right page, and extract an answer, but they had difficulty locating the *correct* answer. Those who appeared to be doing everything right, from a behavioural perspective, were not always able to complete the tasks successfully, because successful extraction and integration were not achieved. This was less evident in the CEI group, in which students were much better at locating the correct answer following a perfect search sequence. Such positive effects of monitoring during search adds to the growing body of research that emphasizes the importance of metacognition in problem solving tasks such as information search (e.g., Lucangeli, Coi, & Bosco, 1997; Swanson, 1992b).

Despite overall poor performance on the search tasks in the control group, one participant answered all three questions correctly and two additional participants found two of the answers. This would suggest that although most students who received no instruction were unable to complete the tasks, a few were actually quite effective searchers, perhaps as a result of previous instruction or experience completing search tasks. In fact there was a significant positive correlation between accuracy and search sequence scores among control participants, suggesting that students who used better strategies were more likely to get the answers to search questions correct. It is unclear from the present study, however, what it is that sets good searchers apart from poor searchers, or makes certain students responsive to instruction and others not. The question of individual difference variables that influence search is an area of text search research that has received virtually no attention. The present study suggested that a key component of strategy instruction was monitoring question-answer consistency (integration). This strategy was interpreted as a metacognitive strategy because it encouraged the evaluation of search success. Instruction to monitor what was being read (extraction) was also an important feature of the instructional protocol, adding to the effectiveness of the integration instruction. Extraction instruction may also be seen as a metacognitive skill, because it requires the searcher to attend to information on the page while monitoring content and reading speed.

These findings were supported by the work of other researchers who have found an improvement in children's search success by encouraging the use of search strategies using a self-monitoring routine (Dreher & Sammons, 1994; Symons et al., 2001). In addition, Kobasigawa (1983) found that Grade 4 students could evaluate whether or not a fictitious person had answered a question correctly by comparing the answer with the question. However, they only did so with prompting. Together, these results suggest that teaching children a metacognitive strategy will improve their search success. What it does not provide is direct evidence that better metacognitive skills lead to better search success. Because metacognitive instructions played such an important role in the instruction of students in the present study, one could postulate that metacognitive awareness also plays a role in the ability to locate information when children are given no instruction.

One study directly assessed the relationship between metacognition and text search skills in children (Symons & Reynolds, 1999). These authors administered a measure of general metacognitive awareness, a measure of knowledge about textbook features, and a series of text search tasks to students in Grades 6, 7, and 8. It was found that students who identified the index as an important textbook feature were more likely to use the index while searching to locate information in a textbook than other students were. Thus, conscious awareness of a strategy was related to using that strategy during actual search tasks. Moreover, metacognitive awareness, as measured by the Metacognitive Awareness Inventory (Schraw and Dennison, 1994) was related to text search performance. Knowledge of cognition was correlated with increased search accuracy (.38), decreased search time (-.36) and better ratings of strategy use (.30). Regulation of cognition was correlated with both search time (-.32) and strategy use (.26). These findings give preliminary support to the proposed relationship between metacognition and text search success. However, a substantial amount of variance in text search performance was not accounted for by the metacognitive measure in the Symons and Reynolds (1999) study. Although metacognition may be playing a significant role in text search performance, other individual differences are likely to be influencing children's success on such tasks.

An additional study examined the role played by metacognition in a more complex information search task (Moore, 1995). In this study, students in Grade 6 were asked to search for information in a library to complete a school project on birds, but were given some questions to get them started. Participants were prompted to think aloud as they searched, and they were also interviewed retrospectively while watching a video recording of what they had done. Although this study was largely descriptive, it did suggest that students do have some metacognitive knowledge about how to locate information, but the accuracy and amount of this knowledge varies widely. Moreover, the metacognitive knowledge was not always translated into appropriate strategies. For example, many participants reported that they needed to identify key search terms to guide their search, but had difficulty doing so, particularly when they needed to generate search terms that were not embedded directly in the search question.

Implications and Future Research

From an educational perspective, the implications of the present study are significant. It is clear that students in Grades 3 and 4 who are given no instruction in how to locate information have a great deal of difficulty performing such tasks. Control participants had a mean of less than 1 out of 3 answers correct on the test questions, suggesting that they were not only doing worse than instructed students, but that their performance was extremely poor. The fact that a very brief instructional intervention, such as the one outlined in the present study, can have such dramatic effects on performance highlights the importance of systematically introducing students to the cognitive stages of search and the strategies that may be used to influence performance at each stage. A metacognitive approach that involves modeling, discussion, feedback and practice was used because strategies taught in isolation will not likely be transferable to new situations (Melot, 1998).

The importance of incorporating strategy instruction into the core curriculum cannot be overstated (Armbruster & Armstrong, 1993; Dreher & Sammons, 1994; Moore, 1995). As outlined earlier, it is paramount that students be prepared for real-world literacy tasks such as those that they will encounter in the workplace (e.g., Krahn & Lowe, 1998). The protocol outlined in the present study is by no means complete, but demonstrates the powerful effects of metacognitive strategy instruction on text search performance. This type of research is a necessary first step in the development of new instructional programs because immediate effects are a precursor to enduring long-term effects. Future research will be required to examine whether or not students who are given such strategy instruction retain what they have learned and are able to use it appropriately when new search tasks are encountered. Because students were tested immediately after instruction, generalizability of these results are limited. To clarify the findings, subsequent studies will need to address the permanence of instruction through delayed post-tests. In addition, there is preliminary evidence that the instructional protocol can be used when a new textbook is encountered immediately after instruction (see Symons at al., 2001), but this also needs to be extended over time.

Two design issues related to this study also warrant comment. The basic assumption with this randomized design was that students in the control group were an adequate representation of children who have received no instruction, and group differences were assumed to be a direct result of instructional influences. Although this is a reasonable assumption, consideration should be given to the inclusion of a pre-test. This would permit a more direct examination of the effects of instruction. Moreover, participants interacted with the researcher for different amounts of time, depending on their group assignment. Although it is unlikely that this had an effect on the results of this research, a cleaner design would include controls for this potential confound.

An additional issue is whether or not students can modify their strategies when this particular approach is not effective by introducing an instructional program that addresses a wider range of search skills (e.g., Moore, 1995). For more difficult tasks, it is likely that more detailed instruction will be required. Attempts that have been made in the information library sciences to develop information location programs are promising but not well validated. One such program, known as The Big6 Approach (Berkowitz, 1998; Eisenberg, 1997a, 1997b, 1998a, 1998b), has received a significant amount of attention in the education literature, because it is one of the only programs directly targeted for use with children. In the first stage, *task definition*, students are asked to think about what it is that they are looking for. This is followed by the use of *information seeking strategies*, or the location of the resources that they will need to satisfy the goal. This is accomplished through the act of brainstorming all possible sources (which may or may not include books) and then selecting the most appropriate choice. Next, in the process of *location and access*, students are taught about all different forms of indexes (e.g., in books, on-line, at the mall), how to perform key word searches, and how to generate new search terms. Next, students are taught how to *use the information*, which focuses on the concepts of reading to comprehend, skimming, and identifying relevant information. Finally, students are taught how to *synthesize* the information in such a way that it meets the requirements of the task, and finally, to *evaluate* the quality of their work before they hand it in. Certainly, this approach seems to contain many elements of a strategic information-seeking approach, but there is no empirical research to support it.

To summarize, the results from this study suggested that text search strategy instruction influenced strategy use and success in locating information. Overall, there was a positive correlation between search strategy use and search accuracy, and this finding was also evident when elementary school students did not receive any text search instruction. In other words, behavioural observations made during search (e.g., index use, flipping through pages) were related to task performance. What was particularly interesting was that children who followed the most efficient sequence of search steps did not always find the correct answers to search questions, regardless of the level of instruction that they had received. Moreover, finding the page on which the information was located did not consistently result in finding the answers to search questions. Together, these results indicated that although search strategies facilitate search success, they do not guarantee search success, pointing to the importance of individual differences in text search performance. Therefore, the primary goal of Study 2 was to more closely examine some of the individual difference variables that may account for this variability in text search performance, in addition to observable strategy use, in the absence of instruction. As suggested by the results of Study 1, metacognition and strategy were both likely to be significant predictors of search success. Therefore, the second study of this dissertation examined the unique contribution of these factors in the prediction of text search success. Also of interest were the roles of working memory and vocabulary, which will be discussed in the next chapter.

The second goal of Study 2 was to gain a better understanding of the search processes involved in text search when children were given no instruction, as surprisingly little is known about how children perform such reading tasks. Given that only a small number of students were given no instruction in Study 1 (controls), it was not possible to perform such analyses. Study 2 provided an opportunity to systematically examine what children were doing in their efforts to locate answers to questions in an informational book, and how this related to their search performance. This was also examined in the context of prior knowledge about the textbook features that may facilitate text search performance.

Chapter 6

Study 2: Introduction

Metacognition and Text Search

The term metacognition is typically defined as knowledge about and control over one's own cognitive activities (Garner, 1994; Juliebo, Malicky, & Norman, 1998). There is a general consensus in the literature that becoming metacognitive is a developmental process, with origins of metacognitive thinking corresponding with brain development in the frontal lobes (Frith, 1996; Jarman et al., 1995). Precursors to metacognition take place in the pre-school years when children are developing what is known as a "theory of mind". Young children develop an understanding of their own mental states (e.g., desires, beliefs, and ideas) and learn how to make predictions about others' behaviours. Although exact ages may vary, there has been considerable consensus regarding the stages that children undergo in developing a theory of mind (Bartsch and Estes, 1996). At about age 2, children engage in pretend play. By 2 1/2 they use terms such as 'want' or 'know', and can engage in simple visual perspective taking. At about age 3, children have an understanding of desires and intentions. Between ages 3 and 4, they begin to reason about others' beliefs and can make predictions about others behaviours based on false beliefs. Although there is a clear link between the acquisition of such skills and social development, awareness of one's own mental states also has implications for the later development of metacognitive skills (Kuhn, 2000). In their extensive review of theory and research on metacognition, Jarman et al. (1995) provided evidence that metacognition is a function of both *monitoring* and *control* processes, both of which become more advanced with age. From the time children enter school, until adolescence, children become increasingly aware of their cognitions and develop better strategic control.

Flavell, who coined the term "metacognition" in the late 1970's, has provided researchers with a framework from which to conceptualize and study this process, one that emphasizes the distinction between metacognitive knowledge and metacognitive experiences (Flavell, 1992). According to Flavell, metacognitive knowledge consists of knowledge or beliefs about the factors that will affect the outcome of a cognitive activity. Metacognitive knowledge can be broken down into three categories: person, task, and strategy. Knowledge about the *person* refers to the knowledge that one has about his or her own cognitive skills (e.g., "I can memorize well"), the cognitive skills of others (e.g., "My father is better at reading than my uncle"), and general principles of cognition (e.g., "Attention will facilitate comprehension"). Knowledge about the *task* refers to knowledge that the individual has about the characteristics of the task at hand (e.g., "I already know about this topic"; "The document is well organized"; "This task is difficult"). An understanding of the task characteristics also includes an awareness of how these factors will impact on strategy use, and a prediction about how likely it is that the goal of the task will be achieved. Finally, knowledge about *strategies* refers to the information that the individual has about the strategies that can lead to the successful completion of the cognitive task (e.g., "Summarizing and writing down key points will help me remember them later"). Most cognitive monitoring involves a combination or interaction among different types of metacognitive knowledge.

Flavell (1992) asserted that metacognitive knowledge is typically activated by task-specific retrieval cues without the individual's conscious intent. It can also be selectively accessed, as in the case of an individual who deliberately tries to think of the best possible strategy to solve a problem. The act of accessing metacognitive knowledge does not necessarily guarantee that the individual can then monitor their cognition and achieve success on a particular task. First, metacognitive knowledge has the potential to be inaccurate. A person may misunderstand the purpose of a task, for example, or choose an ineffective strategy, leading to inappropriate cognitive activities. Second, even if the metacognitive knowledge is accurate, the individual may not be able to utilize the information efficiently. For example, a person may know that summarizing main points is a good way to comprehend a passage, but not be able to execute this strategy. Finally, the individual may have the metacognitive knowledge necessary to complete a cognitive task, but the knowledge may not be activated through either conscious intent or automatic activation.

When knowledge becomes activated, it may or may not become what Flavell calls a *metacognitive experience*. Metacognitive experiences arise when metacognitive knowledge is activated and becomes a conscious experience. Such experiences generally involve the evaluation and monitoring of cognitive processes (Juliebo et al., 1998). Flavell (1992) suggested that metacognitive experiences are more likely to occur when situations require highly conscious thinking, as would occur when a person is faced with a novel or difficult task, or one that requires a significant amount of planning. In the context of the present research, this seems particularly relevant, as children in the elementary grades are just becoming familiar with textbook structures and are new to the act of searching to locate information. Although teachers expect children to locate information in their textbooks in response to teacher-directed and end-of-chapter questions (Armbruster & Armstrong, 1993, Armbruster et al., 1991, Armbruster & Gudbrandsen, 1986; Symons et al., 2001), they often have a great deal of difficulty performing such tasks (Elley, 1994; Grabe, 1989; Hare et al., 1989). In addition, searching to locate information is facilitated by instruction to plan search activities in both adults (Dreher & Brown, 1993) and children (Dreher & Sammons, 1994). This combination of (a) task novelty, (b) task difficulty, and (c) the role of planning in search, suggests that metacognitive experiences would play an important role in searching to locate information. The purpose of a metacognitive experience is to influence strategy use that will satisfy cognitive and / or metacognitive goals. A metacognitive experience will alert the individual to the fact that they are having difficulty with a task, but successful performance will be partially dependent upon the individual's metacognitive knowledge (Garner, 1994; Flavell, 1992). For example, a child may have the metacognitive experience of having difficulty with a search question while flipping through a textbook, but not have the metacognitive knowledge about alternative strategies that would lead to success.

Metacognition has received a substantial amount of attention in reading research, with a particular focus on reading to comprehend text (metacomprehension). In an early review of this literature, Baker and Brown (1984) identified a number of metacognitive skills that have an impact on the process of reading. These included clarifying the purpose of the task, identifying and attending to important information, monitoring and correcting comprehension difficulties, and identifying when the reading goal has been achieved. Theoretically, these same metacognitive processes can be extended to text search.

1. Purpose of the task. Research has suggested that younger and less proficient readers have difficulty identifying when it would be appropriate to initiate text search during a reading task (e.g., Garner et al., 1983; Raphael, 1985). This suggests that the goal of reading to locate information may not be obvious for many younger or poorer readers, and metacognitive knowledge about the distinction between different types of reading tasks has the potential to influence appropriate strategy use.

2. Identification of important information. The ability to identify key words and phrases would be critical when selecting categories of text to search. For example, Kobasigawa (1983) found that Grade 4 students had more difficulty than Grade 8 students in generating search terms beyond those contained in a specific search question, but they did not differ in their ability to identify relevant chapters to search. The author suggested that the younger children were not independently accessing relevant prior knowledge (a metacognitive skill) without explicit prompting. Moreover, students in Grades 6 and 7 have been shown to have difficulty locating correct sections of text from which to extract answers in short passages (Cataldo & Cornoldi, 1998) and younger children have been found to have difficulty generating key search terms (Moore, 1995).

3. Comprehension monitoring. Research from the adult literature has suggested that text search is not highly correlated with comprehension skills (Dreher & Guthrie, 1990; Guthrie, 1988; Guthrie & Kirsch, 1987; Guthrie & Mosenthal, 1987; Kirsch & Guthrie, 1984b). Although it is agreed that text search generally does not require the searcher to read and understand all information presented, it may be a necessary component for more difficult search tasks that require higher-level integration and

comprehension of key sections of text (Cataldo & Oakhill, 2000; MacLatchy-Gaudet & Symons, 1995).

4. Goal satisfaction. Finally, regardless of the type of reading task, the reader must be able to identify when a goal has been achieved. This will ultimately take place at the stage of integration in a text search task, when the extracted information is evaluated against the goal of the task. Armbruster and Armstrong (1993) characterized this component of search as metacognitive, since it focuses on both monitoring progress and evaluating outcomes. Again, Kobasigawa (1983) found that younger children tend not to evaluate responses without prompting to do so.

Thus, there appears to be an overlap between the metacognitive skills found in reading to comprehend and reading to locate goal relevant information. What makes text search unique is that it is not only a reading task, but that it is also a problem solving task, which ultimately requires the searcher to coordinate a number of additional task-specific strategies (Guthrie, 1988). It has been suggested that metacognitive knowledge about the purpose of a reading task (i.e., reading to comprehend vs. searching for information) and knowing when to search may be beyond the metacognitive control of young children (Armbruster & Armstrong, 1993; Cataldo & Oakhill, 2000; Dreher and Sammons, 1994). That is, they may *know* what strategy would be useful, but they cannot actually *employ* the strategy.

Despite the interest in metacognition by psychologists and educators, an overriding difficulty has been the measurement of metacognitive skill. Part of the difficulty has been definitional and part of the problem has been accessing metacognitive knowledge and skill (Garner, 1994). Two typical approaches to the measurement of metacognition are the interview format and questionnaires, both of which can be problematic. The value of open-ended interview formats has been questioned, since these reports are frequently inaccurate and do not reflect what children actually do when performing cognitive tasks (Baker & Brown, 1984). That is, what students say they would do during reading tasks is not necessarily what they actually do when observed, suggesting that there is a gap between metacognitive knowledge and regulation of reading behaviours. A further complication is that many children do not have the language development to provide detailed information about their metacognitive knowledge or experiences, and the scoring of responses can be very subjective (Garner, 1987; Swanson and Trahan, 1996). Interviews that are not well structured can also be problematic because asking different questions of each student may influence the results. This may be said to have been playing a role in the Moore (1995) study outlined above. Finally, even well structured and reliable interviews can be prohibitive because of the time demands involved in their administration (Schraw & Dennison, 1994).

As a result of these difficulties, attempts have been made to develop a more objective measure of metacognition in the form of a multiple-choice questionnaire. The most widely used scale that measures the metacognitive knowledge of reading comprehension in elementary aged children is the Index of Reading Awareness (IRA; Paris and Jacobs, 1987). The IRA includes four subscales that target a child's conditional knowledge, evaluation, planning, and regulation skills related to reading comprehension. Despite its widespread use, the reliability and validity of this measure has not yet been established and has in fact been put into question. For example, one study reported Cronbach's alphas for the four subscales that did not justify their use (Mayer-McLain, Gridley, & McIntosh, 1991). However, the IRA's format has been extremely appealing, and attempts have been made to improve upon it (Metacognitive Questionnaire; Swanson & Trahan, 1996) and use it as a model for examining metacognitive awareness in specific content areas (Index of Science Reading Awareness; Yore, Craig, & Maguire, 1998). Attempts have also been made to produce similar scales for older samples (Schraw & Dennison, 1994).

A third approach to assessing metacognition has been the on-line verbal report, known as a think-aloud protocol. This has received a great deal of attention since the publication of Ericsson and Simon (1984), which outlined the importance of verbal reports as data. As with interviews, there has been some concern that metacognitive processes are not reliably reported, and that some critical pieces of metacognitive knowledge and activity get lost in the verbal translation (Garner, 1994). However, Ericsson and Simon (1998) have argued that verbal reports are in fact very consistent with what is observed behaviourally during the performance of a cognitive task. Moreover, individuals with similar skill sets also seem to produce similar verbal reports. A second criticism has been that the production of a verbal report can, in and of itself, change the course of thinking and behaviour (Smagorinsky, 1998). Ericsson and Simon (1998) have again argued that this is not so, pointing to the fact that an appropriately administered think-aloud protocol asks only for a verbalization of thoughts, not for an explanation of these thoughts. Indeed, studies have shown that there is a remedial component to think-aloud when there is an additional expectation for explanation (e.g., Ward & Traweek, 1993).

Guthrie et al. (1991) used the verbal report approach to examine the metacognitive awareness of university students who were searching for information on a computer-based text search task. They broke metacognitive statements down into categories that reflected each stage of search, according to the Guthrie and Mosenthal (1987) model. Students were able to provide information about what they were thinking and doing, and those with a more strategic approach to search were more likely to report thoughts and behaviours reflecting goal formation and category selection. In other words, better strategy choices were related to better awareness of goal formation and category selection activities. It is noteworthy that the cognitive process of search was not found to change with the addition of a think aloud procedure. Given the developmental nature of metacognition (Garner, 1994), it is not clear whether or not these findings would also be present in a sample of children, and no research to date has attempted to examine this question.

Working Memory and Text Search

The concept of short-term memory has been evolving over the last several decades, as researchers move toward a more dynamic understanding of this memory system, which includes working memory (Gaulin & Campbell, 1994). The basic distinction between short-term memory and working memory is that in addition to short-term memory stores, working memory involves the activation of some type of processing system (Cowan, 1995). It has long been accepted that when information is activated above a certain threshold, it becomes represented in short-term memory. Examples of straightforward memory exercises would include the well-known sentence or digit span recall tasks, which require fairly simple cognitive processes such as lexical access and rehearsal. If, however, the individual needs to store information in short-term memory, while simultaneously processing the same or other information, the processing demands are assumed to be much higher and it is said to be a working memory task. Daneman and Carpenter's (1980) Listening and Reading Span Tasks are examples of tests that require these combined cognitive activities. First, the individual listens to (or reads) a series of sentences and states if they are true or false. After all sentences have been completed, he or she is asked to recall the final word of each sentence in order of presentation. This requires processing of information (i.e., comprehension of each sentence) in addition to selective attention (i.e., attention to specific words) and short-term memory (i.e., recall of words). The difficulty of the task is dependent upon the number of words that must be recalled.

Case recently reviewed some of the most significant work on the development of working memory systems in the past three decades (Case, 1995). According to this author, Pascual-Leone first introduced the concept of working memory in 1970 (then called mental-power) to explain Piaget's stages of development. He asserted that the number of units that could be held in memory grew in a set number of predictable units between the ages of 4 and 16. Later research suggested that this developmental growth pattern was accurate, but only when the strategies used by participants were well controlled. Executive strategies were found to improve performance, with significant gains in executive strategy use being seen between the ages of 6 and 10. Interestingly, it was also found that faster processing speed was associated with increased working memory span, but that there was still a developmental limit to what children could store in their working memory. Case suggested that this could be a result of the mylenization of long distance axons in the cortex and increased differentiation in the frontal and posterior lobes.

A particularly interesting theory, introduced by Olson (1993) is that development in working memory capacity is associated with the development of a theory of mind and later metacognitive skills. That is, as children are able to hold more constructs in working memory, they develop the ability to coordinate and compare increasingly complex representations simultaneously, and are then able to assign representations to other people. It is important to note that Olson emphasizes the distinction between a growth in simple short term memory, and a growth in the capacity of a more complex memory system (namely, working memory). It is the act of *holding in mind* and *comparison* that would theoretically result in the ability to successfully complete a false belief task. For example, consider work by Jenkins and Astington (1996), who studied the relationship between memory and false belief among children aged three to five years. Although this study indicated that verbal (sentence recall) and non-verbal working memory (as measured by the Stanford-Binet bead memory task) were related to performance on false belief tasks, this relationship was not significant when the effects of age and language ability were controlled. One criticism of this research is that the memory measures were not sufficient to tap executive processing skills (Keenan, 2000).

Supporting this, Davis and Pratt (1995) found a significant relationship between working memory (backwards digit span) and performance on false belief tasks in a sample of three to five year old children, even when controlling for age and language abilities (PPVT-R). The same was not true of a memory measure that did not involve executive processing (i.e., forward digit span). Work by Keenan, Olson, & Marini

(1998) examined this relationship, using an even more complex measure of working memory. Children (aged 3-5) were asked to count the number of red dots on a series of three faces (with distracter dots), and then recall how many were on each face. Similar to Davis and Pratt, working memory accounted for significant variance in performance on false belief tasks, even after controlling for age-related effects. Likewise, Gordon and Olson (1998) found that there was a significant relationship between working memory dual tasks (requiring simultaneous finger tapping and object labeling, or counting and object labeling) and performance on false belief tasks, again controlling for age effects. Although these findings are not conclusive, Olson's notion of a relationship between working memory and theory of mind would appear to warrant further investigation.

Several models of working memory have been developed. One model that has been given much attention in the literature is the Baddeley and Hitch model, first introduced in 1974. Based on earlier work in short-term memory, these authors intended to create a straightforward model that could account for a wide range of data in the memory literature (Baddeley & Hitch, 2000). Their model is composed of three main features: the central executive, and two "slave systems", called the phonological loop and the visuo-spatial sketchpad. The purpose of the central executive is to act as an attention-control system, with the ability to transfer information from short- to long-term memory, select the most appropriate strategies for a given task, and coordinate the activities of the slave systems (Kemps, de Rammelaere, & Desmet, 2000). The phonological loop is said to include both a passive phonological store and rehearsal properties, while the visuo-spatial sketchpad is responsible for representing and retaining visual information (Logie, 1996). Recent research suggests that information that is presented in a visual format is often transferred to the phonological loop and that the tendency for this transfer to occur increases with age (Kemps et al., 2000).

There are several competing models, despite much empirical support for the Baddeley and Hitch model. The central debate has been whether working memory contains two separate storage regions and one central executive system (consistent with the Baddeley and Hitch model), or two domain-specific systems, reflecting auditory-verbal and visual-spatial regions (e.g., Daneman & Tardiff, 1987). This distinction is not only important in our understanding of the working memory system, but it also has a significant impact on the way that we measure working memory and conceptualize its relationship with other cognitive tasks. To this end, Swanson and colleagues have produced an impressive body of work that has examined the structure of working memory and how it relates to a number of different reading and problem solving tasks in children. Swanson has reasoned that if two separate systems exist, measures of working memory that depend on the phonological loop would be better predictors of verbal tasks than non-verbal tasks, but the reverse would be true for tasks that depend on the visuo-spatial sketchpad (Swanson, 1996a, 1996b).

Swanson (1996a) examined this issue in two studies of individual differences in the working memory of children and adolescents. Participants were administered a number of working memory, achievement, and intelligence tests. If two separate systems exist, verbal working memory tasks and reading tasks would have been more highly correlated than visual-spatial working memory tasks and reading tasks. The same trend would have been seen with visual-spatial tasks and less verbal activities, such as mathematics. Swanson (1996a) found that diverse verbal and visual-spatial working memory measures correlated with one another and with a variety of standardized achievement measures (math, reading recognition, reading comprehension, spelling). Because no distinct pattern emerged, Swanson argued that this was evidence for a central executive system. Moreover, Swanson has suggested that the most reliable and valid estimate of working memory comes from a cross-section of tasks that tap into a range of verbal and visual-spatial skills (Swanson, 1996b).

Research has provided much evidence to suggest that there is a relationship between working memory and measures of reading achievement, and this relationship cannot be accounted for by basic short-term memory. In fact, traditional short-term memory measures such as digit span have been shown to have little or no relationship with reading comprehension. Early work with university students by Daneman and Carpenter (1980, Study 1) examined the relationship between their new working memory measure (reading span) and various measures of reading comprehension. The reading span measure required students to read a series of sentences, and then recall the final words in the sentences in order. The number of sentences increased as the test progressed (three sets each, from two - six sentences) with the test being terminated when the participant failed on two out of three trials for a particular sentence length. Reading measures included Verbal SAT, factual passage-based comprehension, and the ability to identify a pronoun's referent in a passage. This measure involved reading paragraphs of about 140 words, all of which contained a pronoun (she, her, he, him, or it) in the final sentence. The referent was located two - seven sentences before the pronoun, and participants had to answer a question about who or what the referent was for 12 paragraphs. As expected, performance on a simple word span test was not significantly related to any measure of reading comprehension (r = .33 to .37), but reading span was a significant correlate of all three measures (r = .59 to .90). It was later demonstrated that reading span performance also correlated with both inferential and explicit text-based comprehension, but letter span showed no such relationship (Masson & Miller, 1983).

In a similar but more comprehensive study, Dixon, LeFevre, and Twilley (1988) found that working memory (reading span) scores could account for a significant amount of variance in reading comprehension scores, even after word knowledge was accounted for. These authors compared university students' performances on a number of reading tasks (reading comprehension, reading inferences, reading rate), word knowledge scales (vocabulary, number of word meanings identified, lexical accuracy), verbal working memory measure (reading span), and short-term memory tasks (digit span and word list recall). A series of bivariate correlations indicated that working memory was significantly related to all reading measures (r = .21 to .39) and measures of word knowledge (r = .26 to .34). With only one exception, short-term memory measures did not correlate with reading or word knowledge measures. Most importantly, a stepwise regression analysis suggested that reading comprehension scores were predicted by vocabulary (regression coefficient of .44), knowledge of dual word meanings (regression coefficient of .18) and reading span (regression coefficient of .20). Thus, after accounting for variance contributed by two measures of word knowledge, working memory was able to account for a significant amount of additional variance ($R^2 = .37$) but the same was not true of short-term memory scores.

Young children differ from older children and adults in the way that they process information during a working memory task (Baddeley & Hitch, 2000; de Ribaupierre &

Bailleux, 2000; Kemps et al., 2000; Pascual-Leone, 2000). In one study, Gaulin and Campbell (1994) compared the relationship between a verbal working memory task (listening span) and the Peabody Picture Vocabulary Test (PPVT-R) in a group of children aged 6-12 years. They also included a measure of short-term memory (digit span and memory for unrelated word lists) to provide a comparison of the relationship between short-term memory and vocabulary. As expected, all memory measures were intercorrelated (ranging from $r = .47$ to .73), and PPVT-R scores were better correlated with measures of working memory ($r = .63$) than measures of short-term memory (both $r = .35$). From this, the authors concluded that language processing skills play a more significant role in verbal working memory tasks than they do in short-term memory tasks.

More recent research has supported the work of Gaulin and Campbell (1994), suggesting that low-level reading skills, such as phonological processing and decoding, show a stronger relationship with measures of working memory than they do with measures of short term memory. Oakhill and Kyle (2000) examined the predictive power of short-term memory (simple word span) and working memory (sentence span) on two phonological awareness tasks in a group of 7 and 8 year old children. For the sentence span task, children were asked to read and listen to a series of sentences (ranging in length from two to four words), each of which was missing the final word. Once the child supplied the final word, the sentence was removed from sight, and a new sentence was read. After the sentences had been presented, they were asked to recall the final words in order. One phonological task involved the sound categorization task, which required the participants to listen to a series of four words and then select the one that did not go with the others (e.g., plum, plane, **drum**, plod). The second task required participants to listen to a word and remove the initial or end sound (e.g., what is **blame** without the /b/ sound at the beginning?). After controlling for age and reading vocabulary skills, word span accounted for no additional variance in phonological awareness on either task. However, sentence span was able to account for an additional 23% of variance on the sound categorization task. This suggested that working memory does play a role in certain types of phonological tasks.

Kail and Hall (2001) studied the relationships among short-term memory, working memory, and reading decoding (word recognition) in children aged 7-13 years. These authors used confirmatory factor analyses to support their claim that short-term memory and working memory tasks loaded onto two separate factors. Moreover, structural equation modeling indicated that the best-fitting model supported a relationship between working memory and decoding skills, but the relationship between short-term memory and decoding skills was insignificant. This effect was maintained even after the shared variance between short-term memory and working memory was removed. This was taken as evidence that decoding is not an automatic process for many young readers, and that they must actively process information to decode words successfully. The authors pointed to research by Gottardo, Stanovich and Siegel (1996) to support this argument. In this related study, working memory accounted for significant variance in word recognition (4.5%), even after phonological awareness and syntactic processing were accounted for. Interestingly, this finding was even more dramatic in the prediction of scores on a test of reading comprehension, i.e., 12.5% additional variance was explained by working memory once phonological awareness and syntactic processing had been accounted for. As would be expected, the role of working memory in reading appears to be more significant as task complexity increases.

There is also an emerging literature supporting a relationship between mathematics skills and working memory (e.g., Adams & Hitch, 1997; McLean & Hitch, 1999; Passolunghi & Siegel, 2001; Swanson, Cooney, & Brock, 1993; Swanson & Sachse-Lee, 2001). Working memory has been said to be particularly important in mathematical word problems, which require comprehension of the question, preservation of critical information, and the ability to complete required stages of computation (e.g., Dark & Benbow, 1990).

Because text search is a complex reading activity that has problem solving elements, it is proposed that working memory would play a significant role in searching to locate information. Reading and answering questions can be challenging tasks that require the ability to remember and process a great deal of complex information. In completing such tasks, readers are required to encode, analyze and store semantic and process-related information. If working memory resources are not effective in managing such information, comprehension may be compromised or the information may not be stored and accessed successfully (Gaulin & Campbell, 1994). When searching to locate information, it is necessary to maintain the search goal and relevant search terms active in short-term memory. It is also necessary to complete a number of sub-tasks (category selection, extraction, and integration) and continually process new information in an effort to locate the correct answer to the search question. Together, these activities are suggestive of a working memory component within text search.

Guthrie and Mosenthal's (1987) model of text search can be used as a framework for examining the proposed relationship between working memory and searching to locate information in a textbook. Because this model breaks text search down into five stages, each component can be considered individually. It could be argued that because working memory has been linked to both decoding (Kail & Hall, 2001; Oakhill & Kyle, 2000), and reading comprehension (Gottardo et al., 1996) in children, working memory is playing an indirect role throughout all stages of search. Empirical research has suggested that there is a very weak relationship between reading comprehension and text search tasks (Dreher & Guthrie, 1990; Guthrie & Kirsch, 1987; Kirsch & Guthrie, 1984b), so this effect is likely to be minimal. Moreover, decoding would be less likely to take up working memory resources for older children and better readers. Thus, the following section will outline the direct role that working memory is suggested to play in the process of searching to locate information.

From a theoretical perspective, *goal formation* would not require advanced working memory skills, particularly if the goal has been provided by an external source (e.g., the researcher, teacher, or textbook). In the case of an externally posed search question, the goal is established through extraction of goal-relevant information or key words in the question. As the format of the question becomes more complex, working memory demands would increase, but if the question is straightforward and does not require the integration of more than one concept, working memory demands would be quite low.

It is likely that working memory would play a more significant role in the *category selection* phase of search. In Study 1, this stage was broken down into three components: (a) isolating the key words or concepts in the question, (b) looking in the index or table of contents, and (c) turning to the key search pages. Let us assume that the question is fairly simple, presented in a written format, and there is no restriction on how long the question is available for viewing. This would typically be the case in an elementary school classroom. In this case, it is not necessary to store any information in short-term memory during the initial phase of identifying key words. Therefore, working memory would not be playing a significant role at this level of category selection. When looking in the index or table of contents for key words or concepts, it is necessary to hold the search goal and the key ideas in short term memory, while simultaneously decoding and comprehending text, skimming text, and evaluating whether or not categories are relevant. Theoretically, working memory would be exercised at this point. Once a key section of pages has been selected, it must be located in the book. Again, working memory would be required to hold different pieces of information in short-term memory (e.g., the goal, key words, and the page numbers), while simultaneously processing page numbers of the textbook.

The *extraction* stage of search may also require working memory, because it requires holding the goal and search terms in short term memory while processing and reading the information on text pages. At this point, the searcher would be skimming, attending to titles and highlighted words, monitoring their reading speed and attempting to comprehend what they are reading. At the *integration* stage, all stored information regarding the goal and the extracted information will be integrated, merged and evaluated. Finally, during *recycling*, working memory will be important when the searcher repeats stages that require working memory, as outlined above.

To date, only one study has been published that included measures of both working memory and text search performance. Cataldo and Oakhill (2000) examined the searching efficiency of children in Grade 5 who had either good or poor comprehension skills. Children read short stories in a sequential and scrambled version (counterbalanced) on two separate testing occasions. Sequential and spatial memory for the text was assessed immediately after reading it, by having children recall what they had read and by estimating the location of key words on a blank document. They were also administered a test of visual-spatial working memory. It was found that the children with better comprehension skills used more appropriate search strategies, searched faster, and benefited less from text look-backs than the other children, but only in the unscrambled text condition. Unfortunately, the direct relationship between working memory and text search performance was not examined.

Given the fact that empirical research has found a strong relationship between performance on working memory and a variety of achievement measures, it was not clear why this relationship was not explored by Cataldo and Oakhill (2000). Even though working memory has been measured inconsistently across studies (including auditory-verbal tasks and / or visual-spatial tasks), there is some consensus that working memory is related to diverse word decoding, reading comprehension, mathematics, and problem solving tasks. Why then, did Cataldo and Oakhill (2000) fail to examine the relationship between working memory and text search? One possible explanation is that the authors had concerns about the measure that was used as an estimate of working memory. The children played a game of *Pelmanism*, which required them to find matching word pairs in an array of overturned cards. The child was permitted to turn over two cards: if they did not match, they were returned to their original position. This continued until all possible matches had been made. The authors noted that some of the children were familiar with the game and had been more strategic in their approach, which resulted in highly variable data.

This is consistent with studies that have examined the roles of metacognition, working memory and strategy choice in problem solving tasks. For example, Whitebread (1999, study 1) has found that working memory and metacognition interacted with strategy choice and performance on problem-solving tasks in five and six year olds. Students were required to group pictures based on a self-identified characteristic, and then reclassify the same pictures on two additional trials. As expected, increased age and better metacognitive awareness were both associated with better strategy selection. Moreover, metacognition and working memory correlated significantly with performance only for the older children, suggesting that these relationships are associated with developmental change. What was most interesting about this study, however, was that the relationship between working memory and performance was only significant for the students who were less metacognitively aware, and consequently selected less appropriate strategies. It was suggested that the more metacognitive children selected a strategy that reduced demands on their working memory, which consequently reduced the impact of working memory on performance. Therefore, metacognitive awareness seemed to be related to strategy choice, but working memory appeared to be related to the ability to carry out the chosen strategy. This is consistent with a growing body of research suggesting that the development of a more efficient working memory system will facilitate children's ability to complete more complex problem solving tasks, but metacognitive processes are necessary to support the selection of strategies (see Roberts & Erdos, 1993).

In a second study, Whitebread (1999, study 2) examined the relationships among these same variables with a group of children from a wider age range, and using a more complex problem-solving task. Children aged 6, 8, and 10 were told that a pair of identical twins liked to exchange their clothing, but each day they would choose one item of clothing that they would not trade. In as few trials as possible, children were asked to look at pictures of the twins in various outfits and identify which one was "Anna". To summarize briefly, it was found that strategies to solve this problem became more sophisticated with age and more demanding on working memory resources, and they were also associated with a unique set of metacognitive and working memory skills. Again, working memory only showed a significant relationship with performance for children with weaker metacognitive skills, as metacognitively aware students may have been better able to pick strategies that matched their own working memory capacity. These studies are important because they underscore how complex the relationships among cognitive and metacognitive processes are, and that findings are highly dependent upon measurement issues, age, and specific task demands.

Vocabulary and Text Feature Use

Many studies to date have included measures such as the Peabody Picture Vocabulary Test-Revised (PPVT-R) when studying the relationship between working memory and reading comprehension, to control for the influences of word knowledge (Dixon et al., 1988; Gaulin & Campbell, 1994; Oakhill & Kyle, 2000; Swanson, 1992a; Swanson & Trahan, 1996). When vocabulary measures have been included, the predictive power of working memory measures has been weakened, but still remains significant. This suggests that at least some of the variability in reading comprehension scores can be attributed to both of these skills. Interestingly, research that has been conducted on the text search performance of both children and adults has routinely neglected to examine the role of vocabulary skills (research by O'Donnell, 1993, is one exception). This seems to be an obvious oversight, given the relative importance of word knowledge that one could postulate a searcher would need, particularly in generating searchable terms. Research has certainly indicated that this is a component of search with which many younger children are challenged (e.g., Kobasigawa, 1983; Moore, 1995).

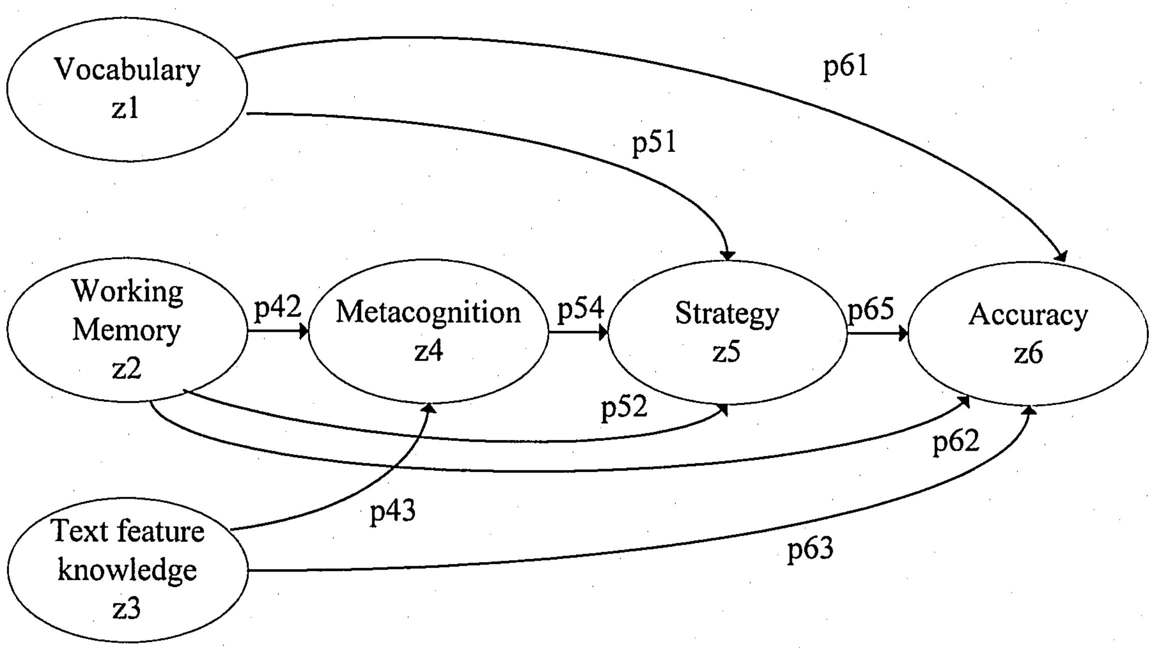
An additional explanation for the inability to use search terms appropriately is the difficulty students have in using textbook features that may aid in the process of search. Armbruster and Armstrong (1993) have argued that children who do not have a good understanding of textbook structure will have significant difficulty searching for information in a textbook, and that this knowledge is acquired developmentally. The results from instructional studies would suggest that students are able to use textbook features such as the table of contents and the index, but that prompting or instruction to do so facilitates their use (Dreher and Sammons, 1994; Kobasigawa, 1983, 1988; Symons et al., 2001). Certainly, the first study of this dissertation indicated that children in the non-instructed group rarely used the index as a way to narrow search. Based on questionnaire data, junior high school students (Symons & Reynolds, 1999) and university students (Yussen, Stright, & Payne, 1993) have been shown to have a good basic understanding of textbook features that may be used to help them locate information. Although Symons and Reynolds (1999) found that there was a relationship between what students knew about textbook features, and using these features during search, this has not been a consistent finding in the literature. According to Dreher and Sammons (1994), there is a gap between what children in Grade 5 say they know about textbook features and what they actually do. These authors interviewed students about the use of textbook features following the completion of three search tasks. They found that the students were able to explain the purpose of the table of contents (88%), find it in the book (93%), and identify how many chapters it contained (71%). Somewhat fewer were able to explain the purpose of the index (69%), but they were fairly good at both locating it (85%) and finding a specific entry (85%). What was most interesting about these findings was that students who were not prompted during search knew the same amount about textbook features as students who had been prompted to think strategically about what they were doing during search tasks. This suggested that knowledge does not necessarily translate into practice.

One difficulty with the interpretation of Dreher and Sammons' (1994) results was that the interview took place after the search tasks had been completed, which may have influenced interview responses in both groups. However, Wray and Lewis (1992) have found similar results in a group of fourth and sixth grade students in Great Britain who were interviewed prior to search. These authors interviewed students about how to locate books, find information in them, and how to use the information once it is found. They then asked some of the students to search for information and observed what they did during search. Like Dreher and Sammons, there was a gap between what they knew about searching and what they actually did. Thus, there is some evidence to suggest that students have knowledge about textbook features but they do not use this knowledge effectively (in the form of strategies).

Proposed Relationships Among Individual Differences and Text Search

The main purpose of this study was to examine the role of individual difference variables in relation to search performance in the absence of instruction. The variables of interest included: (a) strategy use (b) vocabulary, (c) task-specific metacognitive awareness, (d) general metacognitive awareness of reading, (e) working memory, and (f) textbook feature knowledge. No study to date has evaluated this combination of variables, all of which have sound empirical or theoretical support. Although this research was largely exploratory in nature, it was also important to evaluate whether or not some predictions could be made about search task performance, based on this combination of variables, using a path analysis. A proposed causal model is outlined in Figure 2, and depicts the possible relations among variables predicting search accuracy. To summarize, vocabulary, working memory, and text feature knowledge were considered exogenous variables, because the model did not specify their cause. On the other hand, metacognition, text search strategies, and accuracy were considered endogenous, since it was assumed that they were at least partially caused by variables in the model.

Figure 2. Proposed model predicting causal paths to search accuracy from vocabulary, working memory, text feature knowledge, metacognition, and strategy use. Each variable is referred to as a z score (z). Arrows between variables (paths) indicate proposed causal relations. Notation for each path refers to causal direction ($p_{y\_caused\_by\_x}$).



Working memory. The role of working memory, according to this model, is important because it predicts accuracy through three different paths (two indirect and one direct). That is, it assumes that (a) working memory affects accuracy directly, (b) working memory influences performance by causing changes in metacognition, which in turn affects strategy use, which in turn affects accuracy, and (c) working memory directly affects strategies, which again influences performance. Metacognition, theoretically, is directly related to working memory capacity, since it is more likely to be activated when all cognitive resources are not being used up by working memory activities (Whitebread, 1999) and because working memory may have an influence on the development of metacognitive skills (Keenan, 2000). Metacognition, which is essentially a function of monitoring and control processes, in turn has a direct impact on the ability to select and use strategies, which will ultimately influence performance (Jarman et al., 1995). Thus, the relationships among these variables are complex and suggestive of several distinct paths.

Text feature knowledge. Text feature knowledge was also assumed to influence accuracy through more than one path: (a) directly, and (b) through an influence on metacognition, which would affect strategy use and accuracy (for reasons outlined above). The effects of text feature knowledge on metacognition were expected because this measure was one of *knowledge*, while the measure of metacognition was one of *awareness* during search. An individual with more task knowledge (i.e., about text features) may be more aware of their own metacognitive experiences related to strategies (Flavell, 1992). However, the text search literature would not support a path through actual strategies, since there has been a dissociation between what elementary aged children know about search and what they actually do during search tasks (Dreher & Sammons, 1994; Wray & Lewis, 1992; Moore, 1995).

Vocabulary. The third exogenous variable, vocabulary was also said to influence performance through two paths, (a) directly, and (b) through strategies, which would affect accuracy. The indirect path through strategies may be present because students with better vocabulary may have an easier time generating search terms that would help narrow the search (Kobasigawa, 1983; Moore, 1995). It should be noted that observed relationships between vocabulary and metacognition could be better accounted for by another (unmeasured) variable such as IQ or verbal skill.

The Present Research

Participants were children in Grades 5 and 6 at rural schools in Nova Scotia. It is noteworthy that these children were slightly older than those participants in study 1 because they were not given any search strategy instruction. To avoid floor effects, it was important to test children who were slightly older, and would therefore have more developed search skills (e.g., Kobasigawa, 1980; Kobasigawa et al., 1980, 1988; Symons et al., 2001).

Over the course of three sessions, children were tested on a number of measures reflecting the variables of interest. In the first session, children completed questionnaires that evaluated their knowledge of textbook features and metacognitive reading awareness. Textbook knowledge was assessed using the Text Features Survey (TFS), a rating scale designed by Yussen et al. (1993), and later adapted for use with children by Symons and Reynolds (1999). This questionnaire provided the students with an opportunity to demonstrate their knowledge in both an open-ended and a prompted format. The Metacognitive Questionnaire (MQ) was created by Swanson and Trahan (1996) and is specifically focused on reading tasks (subscales include dimensions of person, task, and strategy). In the second session, students completed the Peabody Picture Vocabulary Test-Revised (PPVT-R) to provide an estimate of vocabulary knowledge. This measure has been correlated with verbal working memory (Gaulin and Campbell, 1994; Swanson, 1996b) and it has previously been used as a control variable in examining the relationship between working memory and achievement (e.g., Swanson, 1992a). The working memory measure was also administered in the second session. The Swanson Cognitive Processing Test (S-CPT; Swanson, 1996b), which is the most well validated measure of children's working memory, provided a composite score of both verbal and visual-spatial working memory. In the third session, students completed a total of five search tasks (3 indexed, 2 non-indexed). Only 2 non-indexed questions were used because children often have significant difficulty performing such tasks. That is, there was a higher likelihood that non-indexed questions would result in floor effects.

Measurement of search task performance included search accuracy, strategy use, and task-specific metacognitive awareness. Strategy use was assessed using a search sequence rating scale similar to the one outlined in Study #1. The primary difference was that the researcher recorded the actions of the students on a laptop computer as they searched, and a second rater was available for a percentage of these sessions. Similar to Guthrie et al. (1991), an on-line verbal report was recorded and coded for one of the non-indexed questions.

Based on the findings from previous research, the following hypotheses were advanced:

1. It was expected that all standardized measures of individual differences (S-CPT, PPVT-R, and MQ) would be inter-correlated. More central to this study, it was also hypothesized that performance on these measures would be positively correlated with (a) search strategies (b) search accuracy, and (c) search efficiency.
2. Study 1 suggested that search sequence scores within the control group were significantly correlated with accuracy on textbook search tasks ($\underline{r} = .58$). In the present study, it was hypothesized that children who were more strategic would also be more accurate and efficient in locating information.
3. An additional measure of task-specific metacognitive awareness, coded from the verbal report data, was also expected to correlate positively with search performance. It was hypothesized that this measure would have a stronger relationship with search success than the more general metacognitive questionnaire because text search is said to be a unique reading skill that is distinct from other types of reading, such as comprehension.
4. It was expected that when strategy use and age were entered into a regression equation, vocabulary, metacognition, and working memory would all add unique predictive power to search accuracy and efficiency. The role of text feature knowledge in the prediction of search performance was less likely to be significant, since there has been evidence of dissociation between what children in the elementary grades know about text search and what they actually do when searching (e.g., Wray & Lewis, 1992).

5. Finally, it was expected that the causal model outlined in Figure 2 would be a good representation of the data, but the degree to which it could predict relations among variables was not predicted.

Chapter 7

Study 2: Method

Participants

Participants were 74 children in Grades 5 and 6 who were attending two rural schools in the Annapolis Valley Regional School Board. Six of these students chose not to complete all phases of the study, reducing the total number of participants to 68 (34 in Grade 5 and 34 in Grade 6). Most participants were Caucasian ($n = 65$), one participant was East Indian, one was African Canadian, and one was Native American. In all cases, homeroom teachers confirmed that these children were not experiencing any significant academic difficulties. Students ranged in age from 9 years, 1 month to 13 years, 2 months, with a mean age of 11 years, 2 months ($SD = 9$ months). Out of the 68 participants who completed the study, 37 were female and 31 were male. Students received a pencil and some decorated tape for their participation. A book was also donated to the school library on behalf of each class that participated.

Measures

Working Memory

Swanson Cognitive Processing Test (S-CPT; Swanson, 1996b). The S-CPT is one of the most comprehensive tests of working memory available for use with children. It assesses both verbal and visual-spatial features of working memory, and it also allows the tester to calculate a composite working memory score. A 'static' administration was used in this study, which means that the researcher was not permitted to give any additional help when the participant failed a test item. Because it can take over 1 hour to administer all 11 subtests, practical constraints did not permit administration of the entire battery in this study. Therefore, an abbreviated version of 3 verbal and 2 visual-spatial subtests was administered (Swanson, 1996b). The subtests were chosen on the basis of test manual recommendations for students aged 10-18 years. They included the following subtests: Rhyming Words (RW), Visual Matrix (VM), Auditory Digit Sequence (ADS), Mapping and Directions (MD), Story Retelling (SR).

1. On the Rhyming Words subtest, the researcher presented a list of acoustically similar words, (e.g., *run*, *fun*, *gun*), followed by a process question (e.g., Did I say *sun* or *fun?*). If the participant answered the process question correctly, he or she was then asked to repeat the word list in the order of presentation. Word lists ranged from two to ten words, with each presentation increasing by one item. Testing was discontinued when the participant answered the process question incorrectly or could not reproduce the entire word list without error. The raw score was the highest number of correctly recalled words following a correct process question. Accuracy on this subtest required the participant to ignore the phonological similarities across words and find another way to store them (e.g., through meaning).

2. For the Visual Matrix subtest, the researcher presented the participant with a matrix of boxes for five seconds; some were blank, and others contained a dot. For all questions, the researcher then pointed to the first column of a blank matrix on the response form, and the participant was asked the process question (Are there any dots in the first column?). Matrices grew in number of rows and / or columns with each presentation. Testing was discontinued if the process question was answered incorrectly or if the participant could not reproduce the matrix as presented. The raw score was the

number of the last matrix for which the participant answered the process question correctly and was able to recall the location of all dots in the matrix. Nonverbal memory skills were necessary for success on this test.

3. On the Auditory Digit Sequence subtest, the participant was required to remember the numbers contained in a street address. Although similar to the other subtests described, the participant also had to select a strategy that would best help recall the information. Prior to task exposure, the participant was shown four pictures that described numerical memory strategies. Alternatives included (a) rehearsal, (b) number groupings, (c) concept association, or (d) rhyming. The participant was to imagine that he or she was a taxi driver and needed to give someone directions. All questions followed the same format, beginning with an address (e.g., Suppose somebody wanted to have you drive them to the hospital located at 2-9 Maple Street), and followed by the process question (Now what was the name of the street?). Numbers were presented at a rate of 1 every 2 seconds, and each presentation increased in difficulty by one item. If the process question was answered correctly, the participant was asked to point out the strategy that would help him or her recall the address. After selecting a picture (or after 10 seconds had passed), the participant was asked to state the numbers of the address in order. The subtest was discontinued when a process question was answered incorrectly or the participant could not recall the numbers of the address. The raw score was the highest number of digits recalled following a correct response to the process question. To be successful on this subtest, a participant had to be able to sequence numbers within a verbal context.

4. On the Mapping and Directions subtest, the participant was asked to pretend

that he or she was lost in a city and someone has drawn them a map. Each map contained buildings (squares), streets (spaces between buildings), directions (arrows), and stoplights (dots). After studying the map for 5 seconds, the participant was asked a process question (Were there any stoplights in the first column?). If answered correctly, he or she was given 10 seconds to select the strategy that would best help him or her to remember the map. Choices included starting with the dots first, starting with the design (lines) first, doing the parts you remember first, or working backwards on the map. Difficulty increased with each presentation, through the addition of one or more streets, and the raw score corresponded to the number of the final map correctly recalled. If the participant could not answer the process question or reproduce a map, the subtest was discontinued. Nonverbal sequencing skills were necessary to be successful on this test.

5. Finally, on the Sentence Repetition subtest, the participant listened to a brief story about the miraculous survival of a man who jumped from a burning bomber without a parachute. The participant was then asked the process question (Was the person who jumped out of the plane a man or a woman?). After correctly identifying the character as a man, the participant was asked to recall the story, in order of events. One point was given for recalling each key phrase of the story, but one point was subtracted if the order of recall was incorrect. For example, if a participant recalled sentences 3, 5, 7, and 6, he or she would receive 4 - 1 = 3 points.

The S-CPT was standardized on a sample of 1611 individuals, ranging from 4.5 to 78.6 years of age. Although standardization of this measure was on the entire S-CPT, results from the abbreviated form were said to correlate with Total S-CPT scores at $\underline{r}$ = .95 (controlling for age). All testing took place in a series of studies conducted between

1987-1994 in Canada and the United States. More males were represented (55%), the sample was largely Anglo (72%), the majority of participants were from urban settings (75%), and the socioeconomic status was primarily middle to high income (65%). For each subtest, raw scores can be converted into scaled scores, with a mean of 10 and a standard deviation of 3. A total score can also be obtained by summing scaled scores across subtests and converting to a standard Total Composite Score, with a mean of 100 and standard deviation of 15 points. The S-CPT manual suggests that more consideration should be given to the composite score, since it reflects a wider cognitive domain, and is generally a more reliable measure of working memory. Swanson (1996b) reported that the coefficient alpha for the Total Composite Score on the S-CPT was .92, suggesting that the reliability of this measure is very good. Coefficient alphas on four of the subtests used in this study were in the .7's (RW, VM, ADS, MD), and one reached a coefficient alpha in the .8's (SR).

In a study of 41 normally achieving children (mean age 11.62 years, SD = 2.8) Swanson (1994b) found that the S-CPT had good construct validity. All subtests were correlated with scores on the Sentence Span Task (.39 - .66), a well-established measure of working memory (Daneman & Carpenter, 1980). These subtests did not correlate as well with two measures of short-term memory (.03 - .36). Construct validity is also supported by the fitting of data to a two-factor model for both the complete and abbreviated forms of the S-CPT (called semantic memory and episodic memory factors).

Criterion related validity also appears to be good, as S-CPT composite scores are well correlated with measures of both intelligence and achievement (see Swanson, 1996b, for a complete review). For example, the Wechsler Intelligence Scale for Children-

Revised (WISC-R) correlated with the S-CPT at r = .62 on the Verbal scale and .88 on the Performance scale (N = 30). Likewise, the Wide Range Achievement Test (WRAT or WRAT-R) correlated with the S-CPT on measures of Reading, Mathematics and Spelling, r = .53, .62 and .57, respectively (N = 768). Total Composite Scores also showed higher relationships with academic achievement than short-term memory scores in learning disabled children and adults (Swanson, 1994a). Moreover, working memory and short-term memory contribute unique variance to measures of reading and mathematics achievement.

Convergent validity of this measure is also good (Swanson, 1992a, Experiment 1), as evidenced by a high correlation between the Total Composite score and the Sentence Span Task, $r(96) = .70$, $p < .0001$ (N = 98, mean age = 12.24, SD = 4.34). Moreover, divergent validity was supported by the finding that academic performance is related with S-CPT scores (rs around .50 - .60) more highly than with measures of short-term memory (rs < .20). The Total Composite Score is also good at discriminating between groups of children. A total of 603 children from the standardization sample (aged 7-12) could be discriminated on the basis of academic achievement (measured by the WRAT), with high achievers in reading / math outperforming learning disabled, ethnically diverse low/average achievers, poor readers, slow learners in reading / math, and high math achievers. Slow learners and high math achievers also outperformed the remaining groups. Swanson and Gansle (1994) also reported that children with reading disabilities tend to have lower Total Composite Scores than children with math or math / reading disabilities.

Metacognitive Strategies

Metacognitive Questionnaire (MQ: Swanson & Trahan, 1996). The Metacognitive Questionnaire (MQ) is a modified version of the Index of Reading Awareness, a widely used multiple-choice scale that was created by Paris, Cross, and Lipson (1984). The original scale was designed in an attempt to objectify the measurement of metacognition in reading comprehension with elementary school children. Research has shown that open-ended interviews are difficult for young children because they cannot easily access their metacognitive knowledge. Although the IRA has been widely used, later reports questioned the internal and criterion-related validity of this measure and cautioned against its use (e.g., Mayer-McLain at al., 1991). The MQ was created in an attempt to address such concerns.

The MQ includes 20 multiple choice questions, each with four choice levels, scored from 1 (poorest possible response) to 4 (best possible response). Questions were designed to assess awareness of reading purposes, activating background knowledge, isolating main ideas, critical evaluation, self monitoring and drawing inferences (see Appendix C). The scores were established through prior work by Paris and colleagues concerning appropriate strategy use, teacher ratings of each item, a pilot study using an interview format, and testing with a sample of 30 gifted readers in Grade 5. A composite score may be tabulated averaging scores across all questions. Based on a principal components analysis of scores for normally achieving children, the total score on the MQ can be further divided into three subscale scores. These scales are associated with the Person (4 questions), the Task (9 questions) and the Strategy (7 questions). Averages are tabulated for each subscale, with scores ranging from 1 - 4. Although new, the MQ has shown promising reliability, with a coefficient alpha of .87, and test-retest stability of .92 (Swanson & Trahan, 1996).

Verbal reports (task specific). For one search task, students were audio taped as they told the experimenter exactly what they were thinking and doing. This was transcribed to provide a task-specific estimate of metacognitive awareness. This method has been used widely in problem solving studies (e.g., Hayes, Flower, Schriver, Stratman & Carey, 1987), but reading researchers have also begun asking students to describe their cognitive activities (e.g., Jimenez, Garcia & Pearson, 1996). A substantial body of research has found that this procedure does not alter the performance or strategies used by individuals, but it may have a negative effect on the amount of time necessary to complete various tasks (see Ericsson & Simon, 1993, for a review). With young children, it is sometimes difficult to access strategies through this procedure, so it was necessary to provide prompts to encourage ongoing cognitive descriptions. These prompts included the two following statements: "Tell me what you are doing" and "Keep talking". Students were not asked to describe their motives and reasons for using certain strategies because this may actually alter the processing of the task (Ward & Traweek, 1993). It should be noted that although giving verbal reports can increase the amount of time that it takes to complete a search task, it does not affect the proportion of time spent doing various search activities or the types of strategies used (Guthrie at al., 1991).

All verbal reports were transcribed and each individual statement was coded using an approach similar to Guthrie et al. (1991). Any verbalizations that reflected awareness of a metacognitive search strategy (e.g., goal formation, category selection, extraction, or integration) were given a score of 1.

Knowledge of Text Features

Text Features Survey (TFS; Yussen , Stright, & Payne, 1993). This scale was originally developed as a research tool for use with university students. It was designed to assess university students' knowledge about text features that could be used to facilitate a textbook search task. This measure was later modified for use with a younger sample (Symons & Reynolds, 1999) and is presented in Appendix D. In Part I, students are given an example of a text search question that they may be required to do in school and they are required to list and explain the parts of a book which could conceivably help them locate the answer to the question. In the second section, students are asked to rate how frequently they would use specific textbook features to help them locate information on a scale of 1 (Never) to 10 (Always). Textbook features include the following items: book cover, title page, preface, acknowledgments, table of contents, headings in chapters, boldface terms in chapters, chapter summaries, chapter tables, chapter figures, chapter recommended readings, references, author index, subject index, glossary. In the third section, students are asked to select the most frequently used textbook features (up to 5) and rank order them from the one used most often to the one used the least.

With the original measure, Yussen et al. (1993) found that the most useful data came from the textbook feature ratings and did not include findings from the other parts of the survey. Results suggested that the students' ratings of textbook features were generally consistent among participants, and reflected an appropriate rank-order. However, lack of variability in the data did not permit the authors to explore the relationship between text feature knowledge and text search performance. Results from the modified version of the TFS (Symons & Reynolds, 1999) with students in Grades 6, 7, and 8 indicated that younger students also had a good understanding of textbook features that could be helpful in performing search tasks, with ratings reflecting an appropriate rank order. It was also found that students who spontaneously listed the index as a useful text feature also rated the index more highly on the TFS rating scale than other students (Symons & Reynolds, 1999). In addition, these students used the index more often to locate answers to actual search questions than the other students. This suggested that they were able to identify the text features that they use while searching prior to performing a text search task.

Vocabulary

Peabody Picture Vocabulary Test-Revised, Form L (PPVT-R; Dunn & Dunn, 1981). The PPVT-R is an individually administered standardized test of receptive picture vocabulary. A child's receptive vocabulary is an important part of general intelligence and is a very good predictor of performance on a number of achievement measures. For the purposes of this study, the starting point for each participant was based on his or age. For each word, the participant was shown 4 pictures and asked to select the picture that best represented the word stated by the researcher. Raw scores on the PPVT-R can be converted to standard scores, with a mean of 100 and standard deviation of 15 points.

The PPVT-R was standardized in the United States with 4200 children (aged 2.5 years – 18 years) and 828 adults (aged 19-40 years) from diverse geographical, socioeconomic, and ethnic groups. For children aged 9-13 years, the split half reliability for Form L ranged from .77 - .86, and the alternate-forms reliability ranged from .84 - .90. To ensure content validity, all words that could be illustrated in the Webster's New Collegiate Dictionary were considered potential test items, and a representative sample of these words was selected. Internal consistency was established through an evaluation of PPVT-R raw scores, which showed that test scores improved gradually as participants increased in age. The PPVT-R was well correlated with the PPVT (original version), demonstrating that this measure has good criterion related validity. Subsequent analyses of the PPVT-R indicated positive correlations with WISC-III Vocabulary scores (.75), Verbal IQ scores (.76), and Full Scale IQ (.60), in a sample of normally achieving students in Grades 3, 4 and 5 (Carvajal et al., 1993). Good 11-month test-retest reliability has also been reported in a sample of elementary school children (.84), with no significant difference in test scores between the two test administrations (Bracken & Murray, 1984). In this same sample, PPVT-R scores correlated with subscale scores across a number of academic domains on the Peabody Individual Achievement Test: Spelling (.30), Reading Recognition (.54), Reading Comprehension (.58), Total Test (.59), General Information (.60) and Mathematics (.80) (Bracken & Murray, 1984). Alternate form reliability coefficients for regular education students in elementary school have also been acceptable (.70) (Breen, 1983).

Text Search Tasks

Textbook. As in the first study, one textbook was used for all text search questions. This book was entitled *The Kingfisher's Young World Encyclopedia* (Miles, 1995). It is a 496-page reference book that was written for children in the elementary grades. It contained a table of contents and an index, but no glossary, and the page numbers were written in large print on the lower right hand side of each page. The table of contents outlined 10 general topic areas, or chapters, each divided into 5-10 subsections. Although a page number was given for each chapter, subsections were not identified by page. To locate a particular subsection, students had to turn to the beginning of the chapter, where they would find the subsections listed with their corresponding pages. This book contained a standard index, with all words listed in alphabetical order, and terms referring to important topic areas identified in bold-faced type. The answers to all search questions in this study could be located by finding one of these bold-faced terms. When a term in the index referred to more than one section of the book, the area that contained the most information on the topic was also bold-faced.

The page layout was similar to that of the book used in Study #1, with a thin square border separating the page contents from the main subject heading (top of page) and page numbers (bottom of page). Subheadings, pictures, and diagrams were embedded in the text and could be used to facilitate search.

Search Questions. There were five search questions in total. Three contained search terms that could be extracted and found directly in the index (indexed questions). Two additional questions did not contain indexed search terms and required the searcher to generate search terms independently (non-indexed questions). All participants received the following questions in randomized order:

What shape is liquid? (indexed)

What kind of truck pulls three or more trailers? (indexed)

How are crocodiles good parents? (indexed)

What is a web made out of? (non-indexed)

A final question, which required a verbal report, was always administered last. It read as follows:

What are freckles and moles? (non-indexed)

A more detailed description of these questions and how students could locate the answers is outlined in Appendix E.

Search Strategies

Search strategies were assessed in much the same way as in Study #1. The primary difference is that all search activities were recorded by the experimenter on a laptop, using a Windows-based computer program (Reynolds and Symons, 2001). The experimenter simply used a mouse to click on buttons that corresponded to each type of search behaviour (see Appendix F to view the Windows screen). All time data, search variables and search sequence scores (described in Study 1) were calculated automatically by the computer program. This procedural change also permitted us to examine not only the order of search behaviours, but also the amount of time students were actually engaged in each type of search behaviour.

A second researcher was present for 35% of students as a reliability check on this procedure. For a total of 115 questions (based on 23 participants, five questions each), one-tailed Pearson Product-Moment correlations were computed (see Table 9). Measures included search sequence scores (as calculated in Study 1, Table 2), total search time, time spent searching index, table of contents, key page, non-key pages, and flipping. These correlations generally supported the use of the computer program as a reliable tool in the measurement of text search activities, with all correlations significant at $p < .0001$. Nunnally (1978) suggested that cutoffs of .70 indicate acceptable reliability, .80 reflect good reliability, and .90 reflect excellent reliability. By these standards, most correlations were at or above an acceptable level (ranging from .75 to .99). However, there was one exception to this trend, namely, the amount of time engaged in flipping through the textbook (.34).

The effective percentage agreement statistic, outlined by Hartman (1977), was also used as an estimate of inter-rater reliability. It avoids many of the limitations and concerns about correlational reliability analyses, such as correlated observer errors and the effects of non-normal data variability on correlation statistics. Percent agreement values are outlined in Table 9. These results suggested that most measures were again at an acceptable level of reliability (ranging from 72% agreement to 96% agreement), but the consistency between raters pertaining to flipping behaviours was unacceptably low. A more detailed evaluation of the data suggested that the second rater was much more likely to indicate that flipping had occurred than was the primary investigator. In fact, there were 23 cases of flipping agreement between raters, 48 cases of the second rater coding a text flip when the first rater did not, and 0 cases of the reverse. In all but one of these 48 cases of disagreement, the difference was between flipping and non-key page search. From this, it would appear that the two raters were not using consistent coding criteria for flipping behaviours and that the primary investigator was working from a more conservative operational definition. Although flipping and searching non-key pages are different activities, both behaviours do reflect search of non-key pages, albeit at a different rate. Reliability of this combined category was increased to an inter-rater correlation of .96 for time spent in non-key text pages, and an inter-rater agreement of 91%. Therefore, these categories were combined for the purposes of calculating search sequence scores, reflecting non-text page search. All other categories were coded exactly as outlined in Study 1. It is noteworthy that search sequence scores between raters were correlated at the same level, whether or not categories of flipping and viewing non-key pages were collapsed (.80) or not (.81).

Table 9

Agreement of Text Search Observations Between Coders

Measure	r	% Agreement
Search Sequence	.81	78%
Time		
Total time	.90	-
Index	.99	-
Table of contents	.84	-
Key page	.97	-
Non-key pages	.75	-
Flipping	.34	-
Non-key + Flipping	.96	-
Shared Observations		
Index	-	94%
Table of contents	-	81%
Viewing key page	-	96%
Viewing non-key pages	-	72%
Flipping	-	32%
Non-key + Flipping	-	91%

Note. All correlations, $p < .0001$, one tailed. Total number of questions correlated was 115.

Procedures

Before students could be approached to take part in this study, approval was first granted from the school board, the school principal, and the classroom teachers. Students were then introduced to the study in a classroom presentation by the experimenter. The purpose of the study and the procedures that would be used were described, and they were told that each individual's performance was to remain confidential. Interested students were then given a consent form to be signed by the child and his or her parent / guardian. Participation required each student to take part in three sessions, lasting approximately 40 minutes each. Students were informed that they were able to discontinue their participation at any time and that they did not have to complete all three sessions once they had consented to take part.

Session 1

The first session took place in a group format, ranging in size from 5-15 students. Before the session began, all participants completed a brief participant information form, including name, gender, date of birth, age, and current grade in school. Children were then given a participant identification number, which was also recorded on this sheet. They were instructed to use this identification number on all questionnaires and documents, to preserve their anonymity.

Two questionnaires were filled out during this session: The TFS and the MQ. Students were asked to answer the questions to the best of their ability and to refrain from sharing responses with one another. For both questionnaires, the experimenter read each question aloud and waited until all participants had indicated that they were ready to begin the next question. They were asked to work at the same pace as the rest of the class, to allow all students an equal opportunity to ask questions and to prevent the children from responding too quickly. It was also emphasized that these questionnaires did not contain any right or wrong answers, we simply wanted to find out what children in the elementary grades were thinking and doing as they performed different kinds of reading tasks. Students were instructed to leave answers blank on the rating section of the TFS when the book feature was unknown.

Session 2

The mean length of time between sessions 1 and 2 was 10 days (SD = 6 days), with a range of 1-19 days. Session 2 was conducted in a one-to-one session and again consisted of two tests. The PPVT-R and the S-CPT were administered in counterbalanced order and administration followed the standardized test manuals.

Session 3

Session 3 was conducted approximately 18 days (SD = 7 days) after Session 2, ranging from 0-33 days. In Session 3, participants completed the 5 search tasks in The Kingfisher Young World Encyclopedia (Miles, 1995). Questions 1 through 4 were administered in random order, but question 5 was always the final question administered.

The instructions for the first four tasks were the same as those given to control participants in Study 1. For the fifth question, however, participants were asked to give a verbal report of what they were thinking as they searched for the answer to the question:

Now we are going to do something a little different. You are going to do one last question, but this time I want you to talk out loud as you are searching for the answer. Tell me everything that you are thinking as you search. Don't worry about whether or not what you are saying is right. If you stop talking for more than 30 seconds, I will remind you to continue talking.

The first time that a participant discontinued his or her verbal report for 30 seconds, he or she was prompted with the following statement: "Tell me what you are thinking." On all subsequent prompts, he or she was simply asked to "keep talking".

Chapter 8

Study 2: Results

Descriptive Statistics

Individual Differences. Means and standard deviations were calculated for measures of vocabulary, working memory, and metacognitive awareness (see Table 10). On the PPVT-R, participants had a mean score in the average range (X = 107.12) and a standard deviation of 15.60. Although the range of scores was typical of the PPVT-R, which has a standard deviation of 15, the mean was slightly higher than would be expected in a randomly sampled group of children. According to the PPVT-R manual, scores that are 15 points higher or lower than the standard score of 100 are considered significantly different from the mean. In this sample of 68 students, 20 had scores higher than 115, while only 3 had scores lower than 85. Thus, this sample had particularly good picture vocabulary skills.

Subscale scores for the S-CPT are outlined in Table 10, and indicate that most students in this study were within the average range. All of the scaled score means are within the expected range (scaled scores have a mean of 10 and standard deviation of 3). It is interesting to note, however, that these scores cluster quite heavily around the mean, suggesting that there was little variability in this sample. The total composite score, which is a standard score conversion from the sum of the scaled scores, supports this observation. Students had a mean score in the average range, X = 104.43, but the scores tended to cluster around the mean, SD = 8.74 (expected standard deviation of 15). Thus, the range of scores seen on the S-CPT was somewhat more restricted than that seen on

Table 10

Means and Standard Deviations for Measures of Vocabulary, Working Memory, and Metacognition

Measure	n	Mean (SD)	Range
Vocabulary			
PPVT-R	68	107.12 (15.60)	80-148
Working Memory			
S-CPT			
Rhyming Words	68	11.00 (2.46)	7-14
Visual Matrix	68	10.84 (1.83)	6-15
Auditory Digit Sequence	68	10.81 (2.33)	6-13
Mapping and Directions	68	9.43 (2.09)	7-14
Story Retelling	68	11.35 (1.83)	8-16
Total Score	68	104.43 (8.74)	81-119
Metacognition			
MQ			
Strategies	68	3.20 (0.41)	2.00-3.86
Person	68	2.95 (0.47)	1.75-3.75
Task Parameters	68	2.92 (0.31)	2.22-3.44
Total	68	3.02 (0.26)	2.15-3.60
Number of Metacognitive Statements	64	6.00 (3.63)	0-16
TFS			
Index / Table of Contents Knowledge	68	0.85 (0.70)	0-3
Text Feature Ratings Composite	65	9.47 (10.65)	-12 - 37

the PPVT-R. Only 2 students had standard scores below 85 (significantly lower than the standardized mean), and 7 had scores above 115 (significantly higher than the standardized mean).

Mean scores on the MQ, which has a maximum score of 4, ranged from 2.92 on the Task subscale to 3.20 on the Strategy subscale (see Table 10). The mean total score of 3.02 ($SD = .26$) was slightly higher than that reported by Swanson and Trahan (1996) for a group of 60 average readers ($M = 2.88$, $SD = .44$). A Repeated Measures ANOVA computed across subscale scores suggested that metacognition varied as a function of the type of awareness being assessed, $F(2, 134) = 11.57$, $p = .0001$. Follow-up dependent t-tests suggested that the mean Strategy subscale score was higher than both Person and Task scores, $t(67) = 3.45$, $p = .001$, and $t(67) = 5.23$, $p = .0001$, respectively.

A second estimate of metacognitive awareness was the verbal report that was recorded on-line during the fifth text search question. These reports were considered a task-specific measure of metacognition, since statements could be examined for metacognitive content. Verbal report data were available for only 64 participants, as the recording quality was unacceptable for 4 of the students in this study. The cause of the recording difficulties included excessive background noise ($n = 1$), tape damage ($n = 2$), and a quiet speaking voice ($n = 1$). Any statement that reflected awareness of strategy use (e.g., goal formation, category selection, extraction, and integration) was classified as "metacognitive", and any other statements were classified as "other". All verbal reports were coded without knowledge of the searchers' performance on the text search tasks, and there was 88% agreement of statement categorization between two independent raters. The number of metacognitive statements given by students ranged from 0-16, with a mean of 6 and a standard deviation of 3.6 statements. Appendix G outlines the categories by which each statement was coded.

The following is an example of a think-aloud given by a student who demonstrated very good metacognitive skill:

> First I'm going to read over the question and think about what it means (goal formation). I'll go to the index and I'll search up the letter 'f' for 'freckles' (category selection). I can't find it here, so I'm gonna go to the human body, the body, which is 297-344 (category selection). Now, I'll look under skin (category selection). Where it shows all the moles and freckles and it says freckles and moles are patches of extra melanin on the skin. Freckles can come and go but moles stay. (extraction). I'll check the question again - that's it! (integration). Now I'll copy down the answer (other).

An obviously less metacognitive searcher gave the following verbal report:

> I'm opening the book and going through (other). Still looking (other). I am (other). Can't find anything (other). I'm trying to find (other). Still looking (other). Looking (other). Still looking (other). Still looking (other). I'm on page 297 (other).

Two additional measures of metacognitive awareness could be extracted from the Text Features Survey (TFS). One such measure assessed knowledge without prompting and one required ratings of the relative utility of a number of textbook features. Without prompting, students could receive a score of 2 (mentioned table of contents and index), 1 (mentioned table of contents or index), or 0 (mentioned neither table of contents nor index). The mean score on this measure was .85 (SD = .70), with acceptable kurtosis (.18) and skew (.48). A second measure of textbook feature knowledge on the TFS was the ratings composite score. A number of textbook features could be rated on a scale from 1 (never used) to 10 (always used). The ratings composite score was calculated by subtracting the sum of less important feature ratings from the sum of more important feature ratings. The 7 most important textbook features included the table of contents, headings, boldface, tables, figures, subject index, and glossary. Ratings on less important textbook features included the title page, preface, acknowledgements, summary, recommended readings, references, and author index. Composite scores ranged from -12 to 37, with a mean of 9.47 (SD = 10.65). Kurtosis (.03) and skew (.30) were both acceptable for this measure. The results from the TFS will be described in more detail at a later point.

Search accuracy. Overall accuracy on the search questions could range from 0 to 4 (one point for each of four questions). Question 5 (Freckles / Moles) was not included in the overall accuracy calculation because this was the only question that required a think aloud report, and was therefore qualitatively different from the others. The mean number of correct answers for the entire sample was 2.29, with a standard deviation of 1.20. The total score frequency distribution indicated that performance was normally distributed, with acceptable kurtosis (-.62) and skew (-.38). Thus, there was no overall ceiling or floor effect and the text search questions were considered to be at an appropriate skill level.

Search efficiency. Efficiency scores were calculated as outlined in Study 1 (number correct / total time spent searching). A total of 54 students who did not quit on any of the first four questions were included in these analyses, with a mean search efficiency score of .36 (SD = .30). A frequency distribution again indicated that the search efficiency scores were normally distributed, with acceptable kurtosis and skew (1.82 and 1.35, respectively). Efficiency scores for individual questions are outlined in Table 12. It is noteworthy that the standard deviations tended to be quite large, in some cases larger than the mean, reflecting a substantial amount of variability.

Search sequence scores. As in Study 1, search sequence scores could range from 0 to 20, with 0 reflecting no strategy and 20 reflecting the most strategic approach (i.e., search index, locate key page, record answer). The mean search sequence score for questions 1 through 4 was 12.75 (SD = 3.20), with acceptable kurtosis and skew (-.11 and -.19, respectively). Participants achieved a perfect search sequence score on 21% of these questions. Table 13 outlines the search sequence scores for students across all five questions.

Table 11

Key Page Location and Accuracy on Textbook Search Questions (N = 68)

Question	Key Page Located	Answer Correct	Answer Incorrect	Out of Time	Quit
Liquid	32	23	23	13	9
Truck	55	36	25	4	3
Crocodile	66	47	19	1	1
Web	65	50	12	3	3
Freckles / Moles[a]	48	33	16	6	12

Note. Time limit of 5 minutes for each question. [a]Data missing for one participant on the Freckles/Moles question.

Table 12

Means and Standard Deviations of Efficiency Scores on Textbook Search Questions

Measure	n	Mean Efficiency Score	SD
Liquid	54	.24	.30
Truck	54	.54	.60
Crocodile	54	.60	.48
Web	54	.90	.18
Freckles/Moles	54	.24	.42

Table 13

Means and Standard Deviations of Search Sequence Scores on Textbook Search Questions

Question	n	Mean Search Sequence Score	SD
Liquid	68	12.90	5.56
Truck	67	11.94	5.01
Crocodile	68	11.66	3.99
Web	68	14.76	4.66
Freckles/Moles	67	14.82	4.69

Correlations Among Individual Difference Measures and Search

A series of one-tailed Pearson product-moment correlations was computed among all individual difference measures, partialled for age (see Table 14). As expected, the S-CPT, MQ and PPVT-R were all inter-related, with correlations ranging from $r = .26$ to $.37$, all $p < .02$. These correlations all remained significant after Bonferroni's adjustments were made to control for error rate ($p < .016$). It should be noted that although performance on the working memory measure was significantly correlated with both PPVT-R and MQ scores, the magnitude of the correlations were somewhat lower than those reported in the S-CPT manual for children in junior and senior high school (Swanson, 1996). For these older children, both picture vocabulary and MQ scores correlated with the S-CPT at $r = .57$.

A second series of correlations examined the relationships among measures of individual differences and text search (i.e., search sequence scores, accuracy, and metacognitive statements). These correlations are also outlined in Table 14. As expected, there was a significant correlation between accuracy and search sequence scores $r = .25$, $p = .02$, indicating that good strategy use is related to whether or not students locate correct responses to search questions. After Bonferroni adjustments ($p < .004$), however, this correlation was no longer significant.

It was also expected that all individual difference measures would be correlated with measures of search. Although both accuracy and search sequence scores were significantly correlated with S-CPT scores and PPVT-R scores, only correlations with S-CPT scores remained significant after adjusting for error rate, smallest $r = .34$, $p = .003$. Interestingly, metacognitive reading awareness, as measured by the MQ, was not related to either search sequence scores or accuracy after Bonferroni adjustments. Moreover, a task-specific measure of metacognitive awareness (the number of metacognitive statements made while searching on an unrelated question) did show a significant relationship with accuracy, $r = .37$, $p = .001$. This finding supported the hypothesis that text search tasks do require a distinct set of metacognitive skills that are not as well accounted for by the more general questions found on the MQ.

An additional set of correlations evaluated the relationships among efficiency, measures of individual difference, and search strategies (see Table 14). The total number of participants for these analyses was limited to 54 students because of the time data restrictions discussed above. After Bonferroni adjustments ($p < .01$), these correlations indicated that the more efficient searchers were also more strategic, had better working memory skills, and had better vocabulary skills, smallest $r = .36$, $p = .004$. However, there was no apparent relationship between efficiency and metacognitive skills, as measured by the MQ or the task-specific metacognitive statements.

Finally, a set of correlations was conducted to evaluate whether or not knowledge about textbook features (as measured by the Text Features Survey) was related to measures of individual difference and search (see Table 15). These analyses suggested that knowledge of textbook features had little relationship with measures of working memory, metacognition, or picture vocabulary. However, two correlations between text search performance and text feature knowledge were significant; knowing that the table of contents and the index are useful tools (TFS Index / TOC) in search correlated with both accuracy, $r = .26$, $p < .02$, and efficiency, $r = .32$, both $p <. 05$. These correlations were no longer significant after Bonferroni adjustments were made ($p < .004$).

Table 14

Correlations Among Individual Difference Measures and Search Performance Measures (Partialled for Age)

Measure	S-CPT Total	MQ	PPVT-R	Search Sequence	Metacognitive Statements (Question 5)
Set 1					
MQ	**.32** (**n = 68**) ***p* = .004**	-	-	-	-
PPVT-R	**.26** (**n = 68**) ***p* = .016**	**.37** **n = 68)** ***p* = .001**	-	-	-
Set 2					
Search Sequence (Questions 1 - 4)	**.34** (**n = 66**) ***p* = .003**	.21 (n = 66) *p* = .047	.29 (n = 66) *p* = .010	-	-
Metacognitive Statements (Question 5)	.32 (n = 64) *p* = .006	.13 (n = 64) *p* = .157	.15 (n = 64) *p* = .128	.17 (n = 62) *p* = .099	-
Accuracy (Questions 1 - 4)	**.44** (**n = 68**) ***p* = .0001**	.16 (n = 68) *p* = .104	.32 (n = 68) .005	.25 (n = 66) *p* = .021	**.37** (**n = 64**) ***p* = .001**
Set 3					
Efficiency (Questions 1 - 4)	**.37** (**n = 54**) ***p* = .004**	.03 (n = 54) *p* = .409	**.41** (**n = 54**) ***p* = .001**	**.36** (**n = 53**) ***p* = .004**	.17 (n = 51) *p* = .116

Note. Correlations in bold-faced type are significant after Bonferroni adjustments. Efficiency correlations include only those participants who did not quit before providing an answer.

Table 15

Correlations of Text Feature Survey Results with Individual Difference and Search Measures (Partialled for Age)

	Measure						
	S-CPT Total	MQ	PPVT-R	Metacognitive Statements	Search Sequence	Accuracy	Efficiency
TFS Index / TOC	-.04	-.04	-.001	.02	.16	.26	.32
	(n = 68)	(n = 68)	(n = 68)	(n = 64)	(n= 67)	(n = 68)	(n= 54)
	$p = .386$	$p = .400$	$p = .488$	$p = .418$	$p = .111$	$p = .023$	$p = .014$
TFS Composite	.12	-.17	.22	-.18	.21	.16	.17
	(n = 68)	(n = 65)	(n = 65)	n = 61	(n = 64)	(n = 65)	(n = 51)
	$p= .193$	$p = .100$	$p = .041$	$p = .077$	$p = .056$	$p = .113$	$p = .130$

Note. None of these correlations were significant after Bonferroni adjustments ($p < .004$). TFS = Text Features Survey. TOC = Table of Contents.

Relationship Between Working Memory and Search

Because relationships were found between working memory, as measured by the S-CPT Total Composite Score, and all three measures of search (search sequence scores, accuracy, and efficiency), it was important to evaluate whether or not specific measures of working memory (i.e., subscales) were uniquely related to search strategies and performance. First, a series of Pearson Product Moment correlations were computed, controlling for age. As can be seen in Table 16, only one of these correlations was significant after Bonferroni adjustments. The search sequence scores and the Auditory Digit Sequence scores, an auditory-verbal working memory task, were correlated at r = .40, p = .0001.

To assess whether or not the S-CPT Total Score was accounting for more variance in search skills than the individual subscale scores, a series of stepwise Multiple Regressions (controlling for age) was computed. Predictor variables included total S-CPT scores and all five subscale scores (Rhyming Words, Visual Matrix, Auditory Digit Sequence, Mapping and Directions, Story Retelling). For the prediction of search sequence scores, age and Auditory Digit Sequence scores accounted for 19% of variance (R^2 = .19), but no other scores entered into the regression equation. Conversely, Multiple Regressions predicting accuracy and efficiency scores suggested that total S-CPT scores were most predictive of both accuracy (R^2 = .20) and efficiency (R^2 = .15), and no other subscales entered into the equations. Thus, auditory-verbal working memory was most strongly related to search strategies. A more general estimate of working memory, accounting for a range of verbal and non-verbal working memory skills, was most strongly related to measures of text search performance (i.e., accuracy and efficiency).

Table 16

Correlations Among Working Memory (S-CPT) Subtests and Performance

(Partialled for Age)

	Search Performance		
S-CPT Subtest	Search Sequence	Accuracy	Efficiency
Rhyming Words	.07	.27	.20
	p = .279	p = .025	p = .074
Visual Matrix	.21	.16	.03
	.044	p = .130	p = .409
Auditory Digit	**.40**	.26	.27
Sequence	**p = .0001**	p = .029	p = .027
Mapping and	.10	.21	.20
Directions	p = .214	p = .062	p = .079
Story Recall	.26	.19	.27
	p = .019	p = .092	p = .025

Note. Correlations in bold-faced type are significant after Bonferroni adjustments ($p < .003$). Efficiency correlations include only those participants who did not quit before providing an answer.

Prediction of Search

Because the MQ showed no relationship with any measures of search performance, results from this measure were not used in any regression analyses. No specific hypotheses were made regarding order of entry, and they were considered exploratory in nature. It should be noted that the number of participants for the following multiple regressions was acceptable, as the minimum requirement for this type of statistic is 5 participants for each predictor variable (Tabachnick & Fidell, 1989).

Search strategies. The correlations outlined above indicated that measures of working memory (S-CPT), metacognition (MQ), and picture vocabulary (PPVT-R) were all significantly correlated with search sequence scores. Therefore, a stepwise multiple regression was conducted to assess the unique contribution made by each factor to the variance in search sequence scores on questions 1 - 4. Figure 3 outlines the zero order correlations among these variables, prior to regression analyses. It should be noted that it did not make theoretical sense to enter accuracy scores into the multiple regression, since these may be more appropriately viewed as an outcome measure. Because these analyses were considered to be model-building, variables meeting significance at $p < .10$ were considered significant (see Table 17).

The effect of age was controlled by forced entry on the first step, and measures of working memory (S-CPT Total Composite), vocabulary (PPVT-R), metacognitive statements, and text feature knowledge (TFS Index / TOC and TFS Composite) competed for subsequent entry. It is important to note that this equation was equivalent whether S-CPT Total Composite or Auditory Digit Sequence scores were used as the working memory measure. Therefore, for consistency, only total scores are reported here. The regression equation indicated that age accounted for only 2% of variance in search strategy scores. An additional 19% of variance was accounted for by S-CPT scores and an additional 4% of variance was accounted for by PPVT-R scores. Neither task specific metacognition (i.e., verbal reports), nor text feature knowledge, entered into the equation. Thus, a total of 25% of variance in search sequence scores were accounted for by the predictor variables.

Figure 3. Relationship among variables predicting search sequence scores.

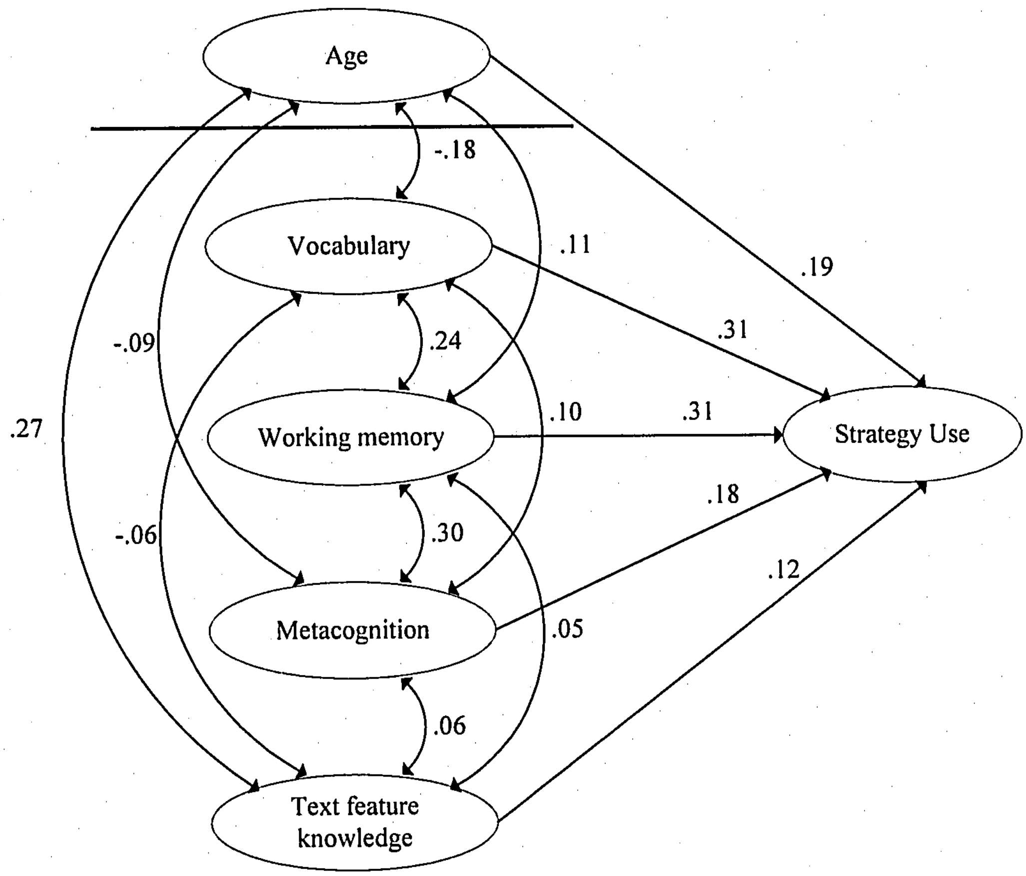


Table 17

Stepwise Multiple Regression for Variables Predicting Search Sequence Scores (N = 66)

Variable	Partial	Part	B	SE B	Beta	R^2
Step 1						
Age	-.142	-.142	-.567	.519	-.142	.02
Step3						
Age	-.173	-.151	-.631	.481	-.158	
S-CPT	.386	.361	.129	.041	.378***	
PPVT-R	.248	.221	.044	.023	.232*	.25
Variables Not in the Equation						
Metacognitive Questionnaire						
TFS Index / TOC						
TFS Composite						

*$p < .10$, **$p < .05$, ***$p < .01$, ****$p < .001$

Accuracy. A stepwise multiple regression was also computed to examine which cognitive skills, in addition to search strategies, best predicted text search accuracy on questions 1 - 4 (see Figure 4). Therefore, search sequence scores and ages were entered on the first step to control for the effects of these variables. Additional independent variables included working memory (S-CPT), vocabulary (PPVT-R), number of metacognitive statements, and the two measures of text feature knowledge (TFS Index / TOC and TFS Composite), which competed for entry on subsequent steps. Again, variables were considered to add significantly to the regression equation if they entered at $p < .10$ (see Table 18).

On the first step, age and search sequence scores accounted for 8% of total variance in accuracy scores. Interestingly, search sequence scores were significantly related to search accuracy scores, but this predictive value became insignificant when other variables were entered into the regression equation. It would appear that there was a relationship between these two search measures, but that this relationship is better explained as a function of other cognitive skills. On subsequent steps, S-CPT scores accounted for an additional 13% of variance, knowledge about the index / table of contents accounted for an additional 7% of variance, metacognitive statements predicted 7% of variance, and vocabulary skills accounted for an additional 4% of variance. This entire combination of variables accounted for 39% of variance in accuracy scores.

Figure 4. Relationship among variables predicting search accuracy.

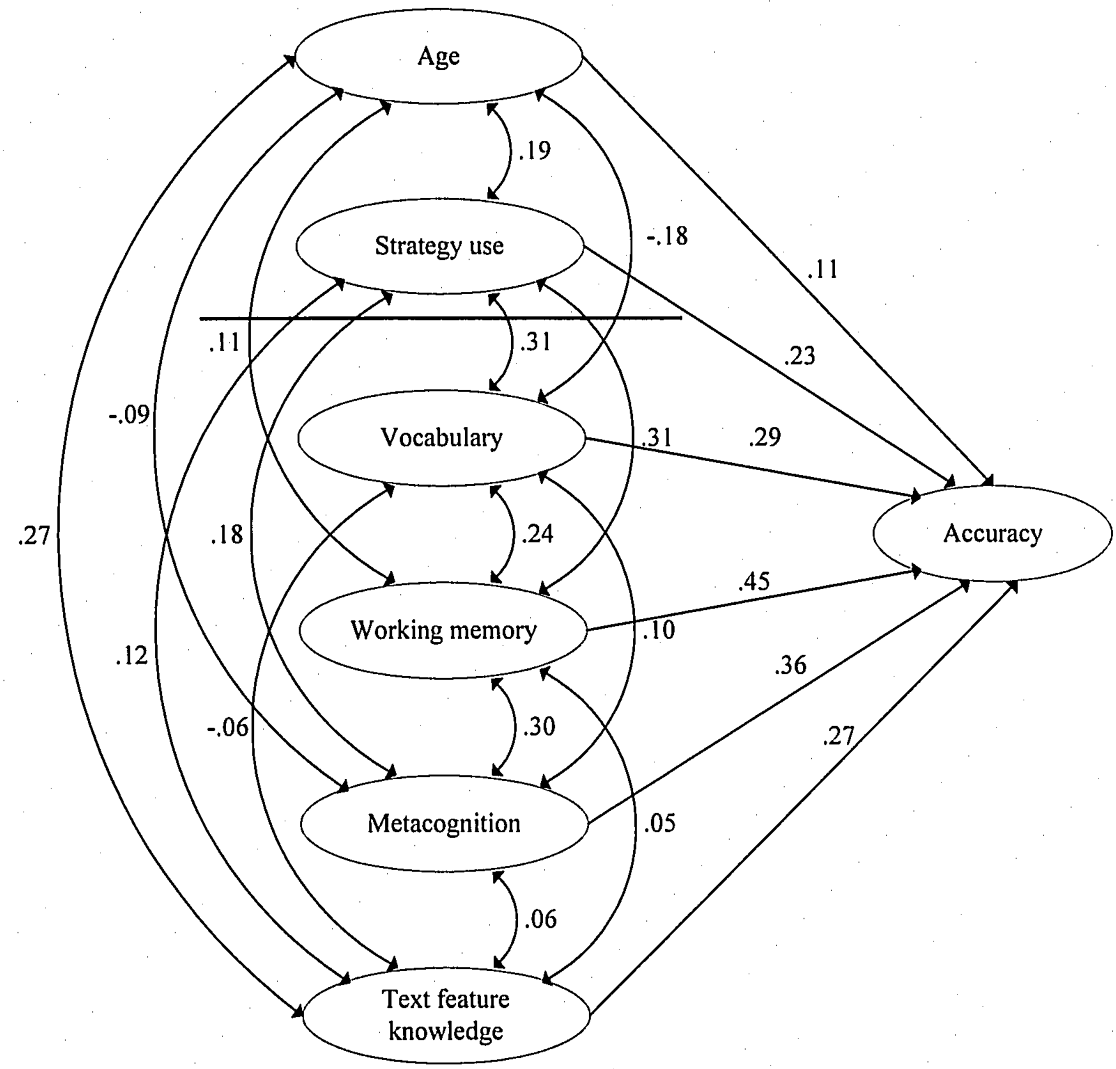


Table 18

Stepwise Multiple Regression for Variables Predicting Text Search Accuracy (N = 66)

Variable	Partial	Part	B	SE B	Beta	R^2
Steps 1 and 2						
Search Sequence Scores	.274	.273	.114	.053	.280 **	
Age	.115	.111	.185	.211	.110	.08
Step 6						
Search Sequence Scores	-.024	-.019	-.009	.053	-.022	
Age	-.007	-.005	-.010	.199	-.006	
S-CPT	.345	.288	.048	.018	.341 ***	
TFS Index / TOC	.321	.265	.484	.197	.284 **	
Metacognitive Statements (Question 5)	.290	.238	.085	.039	.251 **	
PPVT-R	.245	.198	.017	.009	.216 *	.39
Variables Not in the Equation						
TFS Composite						

*$p < .10$, **$p < .05$, ***$p < .01$, ****$p < .001$

Efficiency scores. An additional regression analysis was carried out to examine whether or not cognitive skills were also predictive of efficiency (see Figure 5). Although efficiency scores are not independent of accuracy scores, it was hypothesized that different cognitive skills would be important when the emphasis was placed not only accuracy, but also on time (see Table 19). Again, age and search sequence scores were entered first, accounting for 20% of variance in efficiency scores. On Step 3, S-CPT scores accounted for an additional 8% of variance. Knowledge about the index / table of contents features predicted an additional 5% in efficiency scores, and vocabulary predicted an additional 6%. Interestingly, metacognitive awareness, as measured by metacognitive statements on the fifth text search question, did not enter into the equation.

Figure 5. Relationship among variables predicting search efficiency.

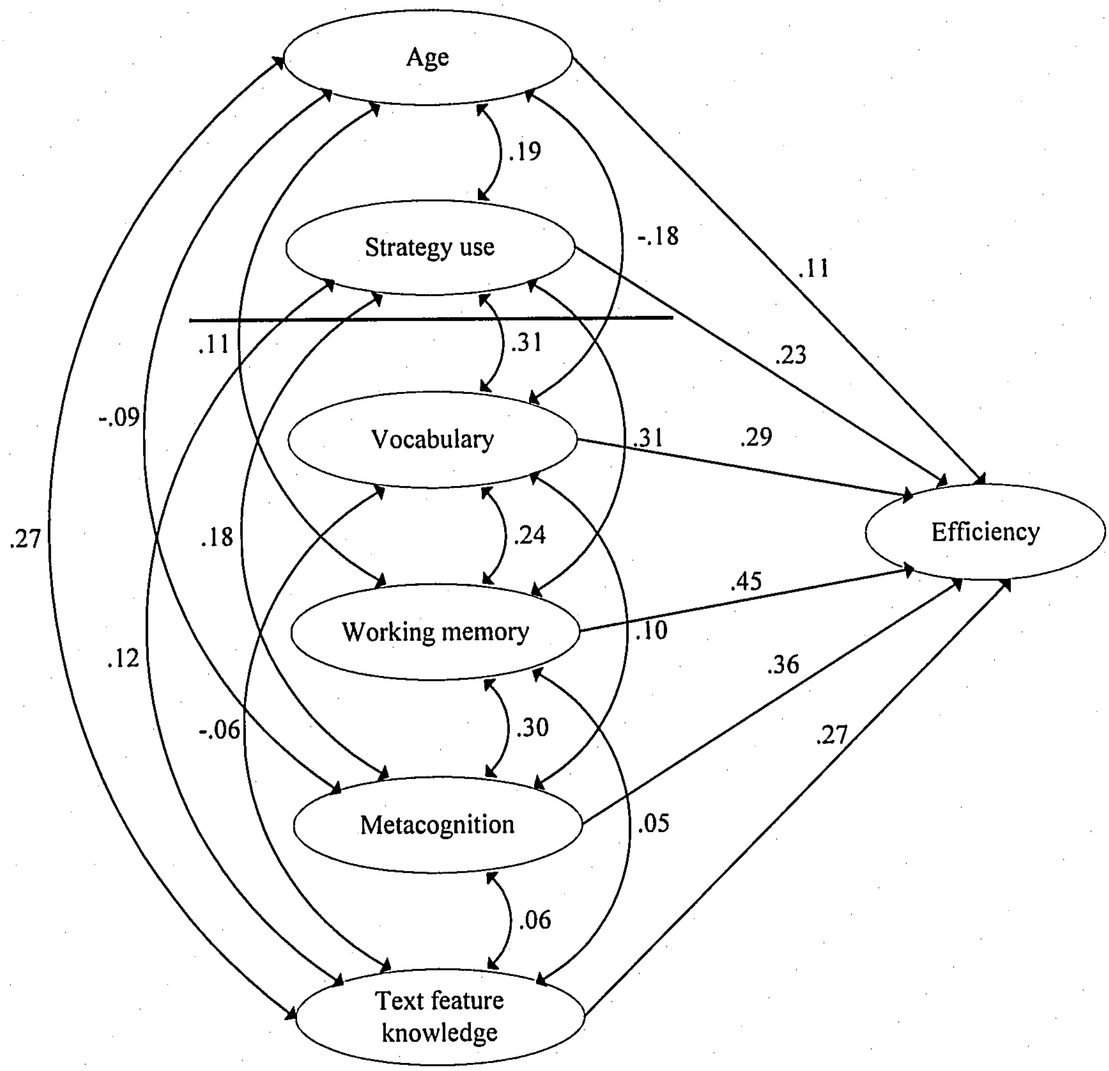


Table 19

Stepwise Multiple Regression for Variables Predicting Efficiency Scores (N = 54)

Variable	Partial	Part	B	SE B	Beta	R^2
Steps 1 and 2						
Search Sequence Scores	.422	.417	6.766	2.168	.419 ***	
Age	.198	.181	.001	8.362	.181	.20
Step 5						
Search Sequence Scores	.242	.195	3.481	2.154	.215	
Age	.027	.021	1.526	8.573	.024	
S-CPT	.309	.254	1.623	7.696	.282 **	
TFS Index / TOC	.306	.252	.002	7.696	.276 **	
PPVT-R	.299	.245	7.911	3.896	.258 **	.39
Variables Not in the Equation						
TFS Composite						
Metacognitive Statements						

*$p < .10$, **$p < .05$, ***$p < .01$, ****$p < .001$

Prediction of performance based on search activities. An additional MR was computed to assess whether or not better searchers were spending more time on certain aspects of the search process (see Table 20). To do this, the proportion of time spent on table of contents / index search, key page search, and non-key page search was calculated. A stepwise multiple regression suggested that once variability due to age was accounted for (4% of variance), search sequence scores were best predicted by the proportion of time spent searching the index and table of contents, accounting for 36% of unique variance. The proportion of time spent searching the key page accounted for an additional 7% of variance in search sequence scores.

A different pattern was seen for the prediction of accuracy scores, based on the proportion of time measurements (see Table 21). Once age was accounted for (1% of variance), accuracy was significantly predicted by the proportion of time spent searching key pages, which alone accounted for 34% of variance in scores. The remaining variables (proportion of time spent searching index / table of contents, proportion of time spent searching the key page) did not enter into the regression equation.

Table 20

Stepwise Multiple Regression for Activities Predicting Search Sequence Scores (N = 66)

Variable	Partial	Part	B	SE B	Beta	R^2
Step 1						
Age	-.196	-.196	-.804	.504	-.196	.04
Step 3						
Age	-.217	-1.63	-.677	.386	-.160	
Proportion of Time Searching Index / Table of Contents	.609	.561	9.884	1.637	.568 ****	
Proportion of Time Searching Key Page	.335	.260	7.131	2.544	.263 ***	.47
Variables Not in Equation						
Proportion of Time Searching Non-Key Pages						

*$p < .10$, **$p < .05$, ***$p < .01$, ****$p < .001$

Table 21

Stepwise Multiple Regression for Activities Predicting Accuracy (N = 66)

Variable	Partial	Part	B	SE B	Beta	R^2
Steps 1 and 2						
Age	.105	.105	.0740	..157	.048 ****	
Proportion of Time Searching Key Page	.589	.585	5.931	1.036	.585	.35
Variables Not in the Equation						
Proportion of Time Searching Table of Contents / Index						
Proportion of Time Searching Non-Key Pages						

*p < .10, **p < .05, ***p <.01, ****p < .001

Prediction of performance based on types of metacognitive statements. Another source of information concerning the strategies being employed by the students was the verbal report data that was obtained during the administration of the final question. To examine how the types of statements made by the students were related to their search performance on unrelated questions, a series of one-tailed correlations were computed. The number of statements made reflecting goal formation, category selection, extraction and integration strategies were correlated with accuracy and search sequence scores (see Table 22). Results indicated that accuracy correlated significantly with the number of statements reflecting category selection, .37, $p < .001$, and integration, .28, $p < .01$. It would appear that students who made specific reference to category selection and integration (question monitoring) behaviours were more accurate in their responses to search questions. A stepwise multiple regression was computed on these scores, with accuracy as the dependent variable. This analysis suggested that category selection was predictive of 14% of variance in accuracy scores, but goal formation, extraction and integration did not add significantly to the prediction. No significant relationship was found between metacognitive statements and search sequence scores.

Table 22

Correlations Among Types of Metacognitive Statements, Search Accuracy and Search Sequence Scores

Search Measure	Goal Formation	Category Selection	Extraction	Integration
Accuracy	.11	.37	-.06	.28
	$p = .19$	$p = .001$	$p = .33$	$p = .01$
Search Sequence	.12	.19	-.04	.13
Scores	$p = .18$	$p = .07$	$p = .37$	$p = .25$

Note: Search measures reflect performance on questions 1 - 4. N = 65 for accuracy correlations and N = 64 for search sequence correlations.

Path Analysis of Causal Model

Although the examination of the relationships among variables was considered to be largely exploratory, a model was proposed to examine whether or not correlations among variables could be accurately predicted through path analysis. The model outlined in Figure 6 is overspecified, meaning that there are more relations in the correlation matrix than appear in the model. That is, there are lines between only selected pairs of variables, because they are not all assumed to have a causal relation, even though they may be correlated. The standard method of computing path coefficients involves using Beta weights, but this method is not appropriate for overspecified models. This method of computing paths (using Beta weights) is problematic in an overspecified model because it partials out the effects of relationships between variables that are not indicated by the model. Therefore, Figure 6 outlines the path coefficients for direct effects, controlling for only those correlations specified by the model.

The values outlined in Table 23 help to clarify these findings. The amount of the original correlation between variables is indicated (r), followed by a summary of direct, indirect, and spurious effects. As can be seen, the total effect of causal variables was fairly well represented by the model, which should approximately reproduce the original correlations. To summarize some of the more important findings, most of the relationship between vocabulary and accuracy can be attributed to the direct relationship between these variables, while only a very small amount can be attributed to the indirect path through strategies. In addition, almost all of the relationship between text feature knowledge and accuracy is attributed to direct effects, with only a very small amount attributed to the indirect effects through metacognition and strategy use. The relationship between working memory and accuracy, which was the largest correlation, was also found to be largely the result of a direct effect. That is, there was very little indirect effect through metacognition and / or strategy use to accuracy. These findings would suggest that all three exogenous variables (vocabulary, text feature knowledge, and working memory) were related to the outcome variable through direct paths, which were relatively independent of the other paths.

Supporting this finding, an examination of the path from metacognion to strategy suggested that only about one half of the correlation between metacognition and strategy is attributed to direct effects, while the remainder can be attributed to spurious effects. That is, working memory causes changes in metacognition, and working memory causes changes in strategy use, resulting in a correlation between metacognition and strategy use. A similar pattern emerges in the path from metacognition, through strategies, to accuracy; virtually no indirect effects are present because most of the relationship is accounted for by other correlations. Much of this is due to the influence of working memory, but it is also partially explained by the relationship between text feature knowledge, and both metacognition and accuracy. Finally, the correlation between strategy use and accuracy is also largely due to spurious effects, with only a very small proportion being accounted for by direct effects. Together, these results would suggest that although the correlations were fairly well reproduced as a function of path analyses, there were many paths that actually did not reflect the assumed causal relationships. The fact that working memory was again found to have the most significant influence on text search performance is consistent with the results of the multiple regression for accuracy outlined above.

Figure 6. Direct path coefficients to accuracy from vocabulary (PPVT-R), working memory (S-CPT), text feature knowledge (TFS Index / TOC), metacognition (total metacognitive statements), and strategy use (search sequence).

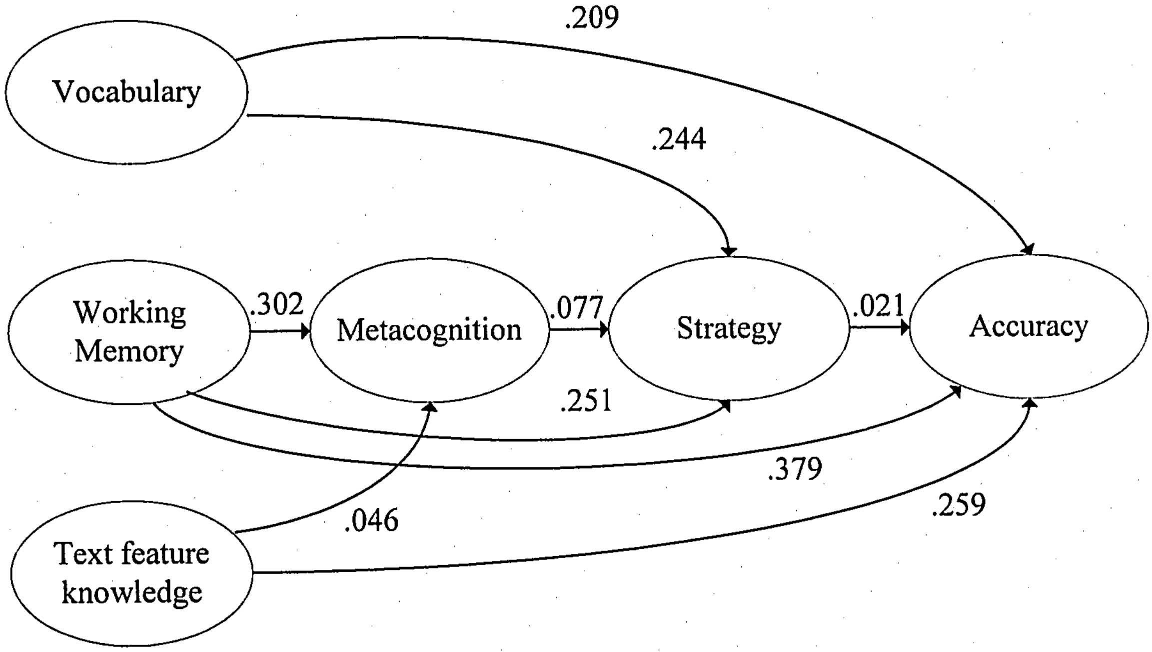


Table 23

Direct, Indirect and Spurious Effects of Correlations

Effect	r	Direct effect	Indirect effect	Spurious effect	Total effect	Unexplained effect
Of vocabulary						
on strategy	. 311	.244	.000	.000	.244	.067
on accuracy	.289	.209	.005	.000	.214	.075
Of working memory						
on metacognition	.304	.302	.000	.000	.302	.002
on strategy	.311	.251	.023	.000	.274	.037
on accuracy	.448	.379	.006	.000	.385	.063
Of text feature knowledge						
on metacognition	.061	.046	.000	.000	.046	.015
on strategy	.120	.000	.004	.000	.004	.116
on accuracy	.267	.259	.001	.000	.260	.007
Of metacognition						
on strategy	.178	.077	.000	.076	.153	.025
on accuracy	.359	.000	.002	.119	.121	.238
Of strategy						
on accuracy	.225	.021	.000	.152	.173	.052

Textbook Knowledge

One goal of this research was to evaluate elementary-aged students' knowledge of the structure of textbooks and whether this is related to actual search activities. This was partially explored by the multiple regression analyses outlined above, which suggested that text feature knowledge was not related to a general estimate of search strategies (search sequence scores). However, it was felt that a more detailed analysis of the Text Features Survey would help clarify some of these findings.

Descriptive results. Results from the TFS (Part 1) suggested that many students were aware of the index as an important textbook feature. When trying to "find something specific like the population of Manitoba", 45 out of the 68 participants spontaneously reported that the index could help them locate the answer. Only 14 of the participants named the table of contents as a useful textbook feature, and only 11 of the students listed both the table of contents and the index as useful resources. A very small number of students identified figures (19), tables (4), book covers (1) and glossaries (1), but other important textbook features were never cited (e.g., headings and boldface terms). These results suggested that, without prompting, children generally have a poor representation of the textbook features that may be helpful during a search task.

With prompting on the TFS (Part 2), students identified a wider range of textbook features that could be used to locate information (see Table 24). Frequency ratings could range from 1 (never) to 10 (always). If a student did not know what a specific text feature was, he or she gave no rating. Thus, ratings that were 2 or higher reflected using a textbook feature at least some part of the time. Frequencies could then be calculated for the number of participants who reported using each feature (score of 2-10), never using each feature (score of 1), or not knowing what a feature was (blank).

Organizational textbook features such as the subject index and the table of contents were cited as the most important elements. Participants were more likely to report using these textbook features as search aids than not, $\underline{x}^2(1) = 19.06$, and $\underline{x}^2(1) = 60.24$, both $\underline{p} < .001$, respectively. This pattern of results was also seen for the title page, chapter headings, chapter summaries, and tables, smallest $\underline{x}^2(1) = 4.77$, $\underline{p} < .05$. Although most of these textbook features are useful when searching for information, it is curious that 65% of students reported using the title page, which will rarely be useful in a text search reading task. Chi square analyses suggested that fewer participants reported using a number of textbook features than using them: the preface, acknowledgments, and figures, smallest $\underline{x}^2(1) = 4.77$, $\underline{p} < .05$.

For each textbook feature listed on the questionnaire, mean frequency ratings were computed (Table 24). Although it would have been interesting to compare ratings across the different features, the number of participants who responded in each category ranged from 33 – 66. Therefore, it was not appropriate to perform a Repeated Measures ANOVA on the frequency ratings. However, observation of mean frequency ratings suggested that the table of contents ($\underline{X} = 8.13$, $\underline{SD} = 2.26$) and the subject index ($\underline{X} = 6.84$, $\underline{SD} = 3.41$) were rated higher than the other textbook features. A dependent t-test could be computed on these ratings because 51 participants reported that they used both of these textbook features to help them locate information in textbooks. The difference between these ratings was not significant, $\underline{t}(50) = 1.25$, $\underline{p} = .22$. Moderate ratings were seen for chapter headings, chapter summaries, chapter tables and chapter recommended readings (all mean scores were in the 'sometimes' category on the TFS). It is interesting to note, however, that the standard deviations for these ratings were all fairly high when compared to the means (> 2.5), indicating substantial score variability.

Table 24

Textbook Feature Survey (TFS) Ratings Prior to Search Task Completion

TFS Subscale	Feature Unknown (No Rating)	Would Not Use (Rating = 1)	Would Use (Rating = 2 - 10)	Mean Rating	SD Rating
Book Cover	4	26	38	3.16	2.81
Title Page	3	21	44	3.13	2.22
Preface	43	5	20	3.88	2.28
Acknowledgments	31	13	24	3.53	2.95
Table of Contents	2	0	66	8.13	2.26
Chapter Headings	7	1	60	5.52	2.57
Boldface Terms	31	3	34	4.68	2.45
Chapter Summaries	19	7	42	5.32	2.94
Chapter Tables	24	1	43	5.03	2.60
Chapter Figures	35	8	25	3.91	2.75
Recommended Readings	26	4	38	5.74	2.93
References	20	9	39	4.89	2.70
Author Index	11	22	35	3.18	2.93
Subject Index	8	8	52	6.84	3.41
Glossary	28	7	33	4.71	3.09

Note: Ratings for listed features could be unknown (blank), never used (1), or used with some frequency (2-10). Mean frequency ratings were calculated for those participants who provided a rating ranging from 1-10. TFS = Text Features Survey.

Relationship between text feature knowledge and search activities. Results from the TFS were used to examine the relationship between what students said that they would do during search and what they actually did during the text search tasks. Correlations were conducted between text feature ratings (children who did not provide ratings were not included in the analysis) and the frequency with which students used those same features during search. Two particularly important textbook features, the index and table of contents, were the focus of these analyses. It was found that ratings of index use were correlated with the number of questions for which the index was used, $r(59) = .24$, $p < .05$. However, a closer examination of the data revealed that 26 out of the 52 students who said that they would use the index during search never used it at all, while 19 used it for all five questions. Higher ratings of table of contents use were not correlated with the actual number of questions for which the table of contents was consulted during search, $r(65) = .05$, ns. Moreover, 15 out of the 66 students who said that they would use the table of contents did not do so, while 26 did so for each question.

Chapter 9

Study 2: Discussion

This study examined the impact of strategy use, metacognition, vocabulary, text feature knowledge, and working memory on the ability of children to locate information in a textbook. Overall, the results suggested that performance on text search tasks related to all of these variables. However, the magnitude of these relationships changed as a function of the way that text search performance was defined (i.e., search strategies, accuracy, or efficiency) and the way that metacognition was measured (i.e., general reading awareness, or task-specific strategy awareness).

As predicted, most individual difference and search performance measures were inter-related. Consistent with Study 1, there was a significant positive correlation between accuracy and search sequence scores, although the strength of the correlation was somewhat lower in the present study. Thus, students who were more strategic in their approach to information location were also more accurate, but the impact of good strategy use appeared to be of more significance in the lower elementary grades (Study 1) than in the upper elementary grades (Study 2). In addition to age-related differences, some additional distinctions between the two studies may help explain why this difference was found. First, the calculation of search sequence scores was slightly different, with flipping and text page search being collapsed as one category in the second study. This resulted in less variability in scores, which can have a direct impact on the strength of a correlation. Second, the textbooks and questions were different from one another, making direct comparison of results difficult.

If the relationship between search sequence scores and accuracy actually does decrease with age, it may be because younger children are less likely to notice when a strategy is ineffective, or have difficulty generating an alternate strategy when they are unsuccessful. Older children, who are more metacognitive, may be able to generate a new plan and begin using a more effective strategy if they recognise that they are having difficulties. In this case, the search sequence score would be lower because of early search difficulties, but result in accurate search because new strategies have been employed. This explanation is consistent with the literature supporting a developmental change in metacognition with age (Garner, 1994). If search difficulties give rise to the metacognitive experience that the task is not proceeding well, older children may be more likely to access needed metacognitive knowledge regarding more appropriate strategies (Flavell, 1992). This is certainly a question that warrants further investigation.

Search accuracy and search sequence scores were both found to correlate with working memory and vocabulary scores, giving preliminary support to the proposed relationship between text search and these cognitive skills. In addition, a particularly interesting pattern emerged with respect to the metacognitive measures. As outlined earlier, there has been a debate regarding the measurement of metacognition and how it relates to other types of cognitive performance. There has been support for both questionnaire (Swanson & Trahan, 1996) and think aloud (Ericsson, 1998) procedures. Results from this study indicated that general reading awareness, as measured by a questionnaire, did correlate with search sequence scores ($r = .21$, $p < .05$), but showed no relationship with accuracy. The opposite pattern was found for the metacognitive statements that were coded from the think-aloud protocol on the final question. The number of metacognitive statements made while searching to locate the answer to question #5 was correlated with accuracy on the other four questions, but did not show any relationship with search sequence scores. In other words, metacognitive reading awareness was related to strategy use on text search tasks, but the ability to locate the correct answers to questions was related to task-specific strategy awareness. Symons and Reynolds (1999) found somewhat different results in their examination of junior high school students. These authors indicated that general metacognitive awareness, as measured on the Metacognitive Awareness Inventory (Schraw & Dennison, 1994), was related to both search sequence and accuracy. Note, however, that the instrument used to measure metacognition by Symons and Reynolds examined general metacognitive awareness, rather than metacognitive awareness specific to reading.

Although awareness of both category selection and integration were significantly related to accuracy, statements reflecting category selection awareness appeared most influential on a multiple regression equation. In terms of the significance of category selection awareness, other research has indicated that this is a particularly important part of being a successful searcher. For example, university students' awareness of category selection strategies during search was significantly related to their use of appropriate strategies on search tasks (Guthrie et al., 1991). Other support for the important role of category selection comes from studies that have examined the prediction of search performance based on behavioural observations. For example, Symons and Specht (1994) found that the best predictor of accuracy on textbook search tasks in university students was the ability to locate and select the most appropriate categories of text to search. Guthrie (1988) has also found that category selection is one of the most important components of search, accounting for 30% of time to complete search tasks. Likewise, Dreher and Guthrie (1990) found that more efficient searchers spend proportionally more time on category selection activities than on extraction activities. More recently, children with good comprehension have been found to have better category selection skills than children with poor comprehension (Cataldo & Oakhill, 2000). The fact that category selection awareness was related to accuracy in the present study is additional evidence that search success is not only related to the *act* of using category selection strategies, but also to the *awareness* of category selection strategies.

The prediction of search sequence scores, based on working memory, metacognition, vocabulary, and text knowledge scores was exploratory in nature. After controlling for the effects of age, search sequence scores were predicted by working memory scores and, to a lesser extent, receptive vocabulary. It would appear that the ability to store information such as search goals and key words in short-term memory, while simultaneously performing text search actions, permits students to search more strategically. This is a particularly important finding, because searching to locate information requires the coordination of a number of complex cognitive activities. These steps require the student to plan the search, be aware of the search goal, examine and turn to different sections of text, skim and / or read text, and repeatedly evaluate performance. According to Whitebread (1999), the ability to use strategies that satisfy such complex cognitive activities during problem solving would be dependent upon adequate working memory skills. Without a strong working memory, students could easily forget what words or phrases they were looking for and be forced to repeat search steps, begin the search task over again, or search without any clear direction. These would all contribute to lower search sequence scores, regardless of how accurately the students answered the questions.

One of the primary goals of this study was to evaluate the role of individual difference variables in text search performance, beyond what could be explained by strategy use. It was found that after entering age and search sequence scores into the equation, working memory, text feature knowledge, the total number of metacognitive statements, and vocabulary predicted 39% of variance in accuracy scores. As expected, a number of different cognitive skills were playing a role in the ability of elementary school students to find the correct responses to search questions. Working memory was found to be the most critical component of accuracy in text search, for reasons outlined above. Two task-specific measures of metacognitive awareness, number of metacognitive statements and knowledge of important text features, were also found to add significantly to the prediction of text search accuracy. This is particularly interesting because text feature knowledge was assessed prior to search task completion, and represents an estimate of metacognitive knowledge. Moreover, the metacognitive statement scores were generated from the fifth question, which was not included in the total accuracy calculations. That is, task-specific metacognitive awareness was not derived from the same tasks that contributed to the accuracy score. Awareness of specific parts of textbooks, and of the search process (goal formation, category selection, extraction and integration), would appear to influence how competent students were at providing answers to text search questions. The inclusion of these measures was important because they gave an estimate of both task-specific knowledge (Yussen et al., 1993) and task-specific cognitive processing (Ericsson, 1998).

Another significant factor in the prediction of search accuracy was vocabulary, possibly because students with better vocabulary skills were better at generating search terms to locate in the index and table of contents. Moreover, language processing skills are important in the processing of cognitive tasks that require working memory (Gaulin & Campbell, 1994). An alternate explanation for the significant contribution of vocabulary to the prediction of accuracy scores is that the children with better PPVT-R scores were more intelligent (Carvajal et al., 1993), and that variability in accuracy would be better accounted for by IQ. It is noteworthy that results from the multiple regression analysis for efficiency scores very closely resembled the accuracy analysis, suggesting that the same factors that contribute to accuracy are important in negotiating the accuracy / time tradeoff.

These findings were further clarified by the results from the path analyses, which suggested that most of the relationship between working memory and accuracy was the result of a *direct* effect. Contrary to hypotheses, there was very little indirect effect through metacognition and strategy use. Moreover, the relationship between metacognition and accuracy was mostly the result of spurious effects (the relationships between other variables in the model) and non-causal co-variation that was not specified by the model. Therefore, the relationship between metacognition and accuracy was most appropriately defined as a function of the relationship between working memory and accuracy, and working memory and metacognition. Because the zero order correlations in this study were quite small, it is difficult to draw strong conclusions from these results, however, it is important to recognize the significant role of working memory that again emerged. Moreover, these findings suggest that instructional interventions to improve accuracy should target strategies that reduce working memory demands (e.g., following an outline, writing down information, referring to question more than once).

Some researchers have posited that children may know about search strategies but not be able to identify when the goal of a reading task requires search, or may not be able to employ known strategies effectively (Armbruster & Anderson, 1993; Cataldo & Oakhill, 2000; Dreher & Sammons, 1994; Moore, 1995). This could be considered a gap between metacognitive knowledge (what the searcher knows) and strategy use (what the searcher does). Ideally, a metacognitive experience should give rise to monitoring and evaluation of performance on a cognitive task (Juliebo et al., 1998), but this is only useful if the searcher can make use of the experience. Take, for instance, a searcher who is having difficulty locating information in a textbook. He has the 'metacognitive knowledge' about textbook features but this knowledge has not yet been activated. As the searcher flips through the text, he has the 'metacognitive experience' that he is not going to find the answer and begins to consciously monitor his progress. Now, by chance, he comes across the index. Because he is attending to the task, his metacognitive knowledge regarding textbook features should be activated and lead to the use of more effective search strategies. However, a child without the required metacognitive knowledge or monitoring skills would not be aided by seeing the index. Anecdotally, both of these scenarios were observed during testing. Some children would flip randomly, locate the index by chance, and then proceed to use appropriate search strategies. Others would see the index and virtually ignore it.

A complicating factor in the examination of text search strategies is how exactly these should be measured. The search sequence scores outlined in Studies 1 and 2 were based on work with university students (Dreher & Guthrie, 1990) and have been modified for use with children (Reynolds & Symons, 2001; Symons et al., 2001). Although the measure has been related to both search accuracy and speed, the scoring system is somewhat arbitrary, and warrants comment. For example, the specific values for behaviours at each step are assigned according to their relative efficiency at that stage of the search process. Because these numbers are based on judgment, they may not be a true reflection of relative worth (e.g., the table of contents at the first step received a 3, but may be more accurately scored as a 4 or 5, depending on the specific search). In addition, ratings at each step are dependent on what the searcher has done in the previous steps, which may unnecessarily penalize students for beginning inefficiently. Further research is necessary to examine the effects of making modifications to this scoring system. In addition, it may be helpful to consider the data as categorical, rather than continuous, and to perform cluster analyses in relation to performance. For example, students who follow a certain sequence of steps may be just as likely to find the correct answer as children who follow the most highly valued sequence in the scoring system used in this research. This question certainly needs to be explored more fully in future studies.

In addition to this, the present study suggested that students in Grades 5 and 6 actually had quite poor awareness of strategies that may help them locate information. Without prompting only 16% of students mentioned both the table of contents and index as important textbook features that could help guide them through a search task. With prompting, these numbers rose, suggesting that students may in fact be influenced by the presence of a cue. Prompted responses on the TFS may therefore be considered a more accurate reflection of how some students use a feature-based strategy during search. That is, viewing textbook features may trigger metacognitive experience if latent metacognitive knowledge is activated. This would not be the case if there were no such awareness, and relevant sections would be ignored.

Despite the fact that the children performed better on the TFS with cueing, there appeared to be dissociation between what students said they would do and what they actually did during search. Consistent with Wray & Lewis' (1992) and Dreher & Sammons' (1994) prediction, there was a gap between textbook feature knowledge and strategy use regarding these features. There appeared to be little relationship between textbook awareness and search sequence scores. This is in contrast with Symons and Reynolds (1999), who found that there was a relationship between pre-task feature knowledge and searching among older children. Consistent with the observations of Kobasigawa (1983, 1988), younger children appear to need more explicit cues.

Students in the present study likely had better than average cognitive abilities, as evidenced by the relatively high PPVT-R scores. It is unlikely that test characteristics of the PPVT-R, which was published in 1981, contributed to this finding. In fact, children actually tend to score lower on the PPVT-R than on the new PPVT-III (Dunn & Dunn, 1997). The high receptive vocabulary skills (and likely higher IQ scores) unfortunately reduced the generalizability of these results. The inclusion of students with a wider range of cognitive skills would add to our understanding of individual difference variables and how they influence performance on text search tasks. It would also be helpful to include measures of additional reading skills, such as decoding and reading comprehension, particularly since both have been related to measures of working memory (Daneman & Carpenter, 1980; Dixon et al., 1988; Gottardo et al., 1996; Kail & Hall, 2001; Oakhill & Kyle, 2000). Although there is some preliminary support that reading comprehension plays a role in text search in children (Cataldo & Oakhill, 2000), it is unlikely that these reading skills were playing a role in the present study, since none of the children were identified as having reading problems by their classroom teachers. In fact, research by MacLatchy-Gaudet and Symons (1995) indicated that reading comprehension is only related to text search on tasks that require integration of information in a complex reading passage. It would seem that the relationship among different reading skills is fairly complex and task-specific. In future studies, it may be appropriate to control for the effects of such skills (e.g., decoding, reading speed, reading fluency, and reading comprehension). This may be particularly important in the examination of textbook search skills, since very little is known about the role of such reading skills in this type of task, particularly among poor readers.

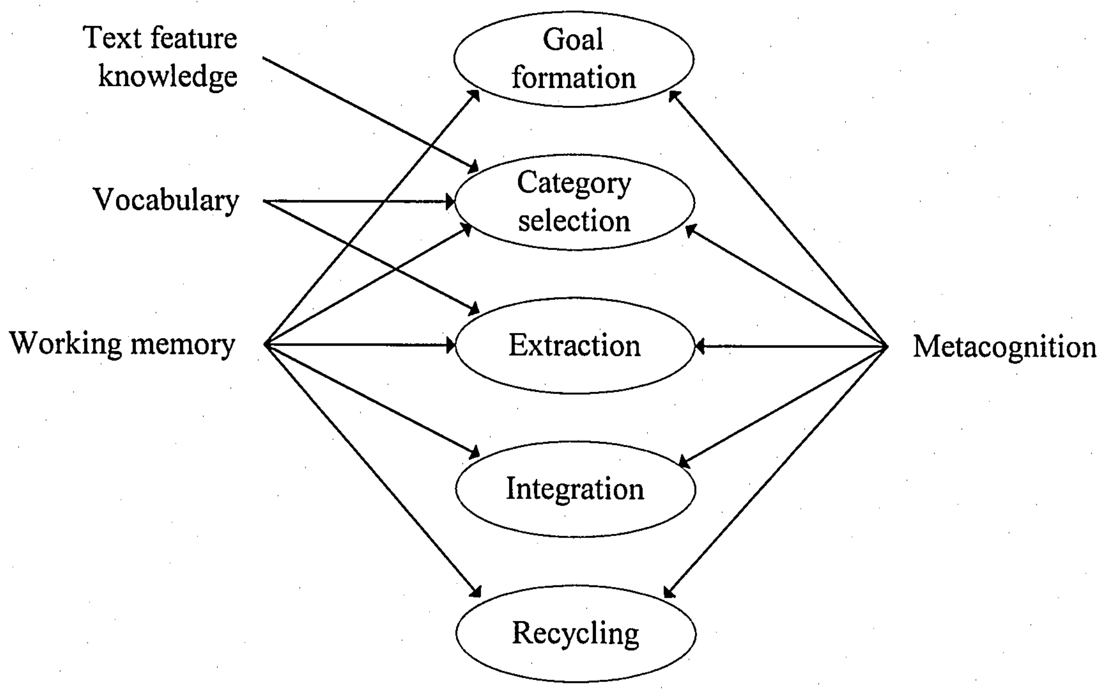
To illustrate this point, consider a study that evaluated the roles of metacognition and working memory in the ability to comprehend text. Swanson and Trahan (1996) evaluated whether or not metacognition and verbal working memory contributed to the prediction of reading comprehension beyond what could be explained by vocabulary, in children with and without reading disabilities. These authors found that when word knowledge was entered first into the regression equation, metacognitive knowledge about the task was the best predictor of reading performance among the children with reading difficulties. Among average readers, working memory was a better predictor of reading comprehension. Thus, both working memory and metacognition were found to add to the prediction of reading comprehension skills, but the pattern of findings was different for children with and without reading difficulties. An additional study by Swanson and Trahan (1992) found that students with reading disabilities who had weaker verbal working memory skills were less successful on computer-based comprehension questions that permitted text look-backs, than reading disabled children with better working memory skills. The same was not true for a group of average readers. These text look-back questions may be likened to text search tasks because they required the students to search through the document for answers. Interestingly, the role of working memory was not significant in reading comprehension that did not allow text look-backs. Moreover, metacognition, as measured by a metacognitive questionnaire like that administered in the present study, played no significant role.

Research has strongly supported the influence of development on metacognition (e.g., Bartsch & Estes, 1996; Kuhn, 2000), working memory (e.g., Case, 1995), and text search (e.g., Symons et al., 2001). Therefore, the study of these variables needs to take age-related influences into account. Unfortunately, the restricted age range in the present study did not permit a comprehensive study of developmental differences. In fact, age did not appear to be playing a role in text search performance in this sample. Future studies that examine working memory and metacognition in conjunction with text search would benefit from a selection of students at more varied grade levels

Also important will be the continued examination of the measurement of metacognitive skills. The fact that such different results were found using the metacognitive questionnaire and verbal report data indicates that special care needs to be taken in the selection of measures. One concern in the present study was that the metacognitive questionnaire assessed metacognition in the context of reading comprehension. Because some studies have found that text search and reading comprehension have only minimal overlap (Dreher & Guthrie, 1990; Guthrie & Kirsch, 1987; Kirsch & Guthrie, 1984a) it may not be the ideal estimate of metacognitive influence in search. The results from this study suggest that task-specific questions could prove to be more useful in the prediction of text search accuracy. The TFS measured general knowledge of textbook features, but did not evaluate what students knew about how or when to use these. Development of a questionnaire that more closely examines what students know about the search process would be a worthwhile pursuit to help identify children who may have more difficulty on such reading tasks.

Age, working memory, vocabulary, text feature knowledge, and task-specific metacognitive awareness accounted for 39% of variance in accuracy scores, but there still remains a significant amount of variance that needs to be explained. For example, text search performance has also been related to motivation (Reynolds & Symons, 2001) and prior knowledge of subject matter (Symons & Pressley, 1993). A more comprehensive understanding of text search would involve the inclusion of such variables and an examination of how they work in concert with the individual differences outlined in the present study. Moreover, relationships among the individual differences and measures of search performance may reflect specific influences at certain stages of search (see Figure 7 for example). A more direct examination of these relationships would be an important step in gaining a better understanding of the Guthrie and Mosenthal (1987) model of text search.

Figure 7. Possible influence of individual differences on stages of search.



Chapter 10

General Discussion

The primary objective of this thesis was to examine the ability of children in the elementary grades to search for and locate answers to questions in an informational textbook. The purpose of Study 1 was to examine the effects of different combinations of strategy instruction, using Guthrie and Mosenthal's (1987) cognitive model of text search as a general guideline for the development of an instructional protocol. Due to the variability in performance in the non-instructed control group, Study 2 was designed to more closely examine individual differences that may influence performance on text search tasks. Both studies added significantly to our understanding of text search as a unique reading skill, have implications for the way that we conceptualize these tasks, and provided empirical data supporting the importance of metacognitive strategy instruction in the elementary grades.

Guthrie and Mosenthal's (1987) Cognitive Model

Although some research has addressed the individual stages of Guthrie and Mosenthal's (1987) model in adults, systematic analyses of each component of text search have not been undertaken in the literature on children's search processes (Armbruster & Armstrong, 1993). Study 1 examined the roles of category selection, extraction, and integration by comparing instructional interventions that corresponded to these cognitive stages of search. Of all stages, category selection has been the most strongly related to performance measures in adult populations (e.g., Dreher & Guthrie, 1990; Guthrie, 1988;

Symons & Specht, 1994). This thesis was informative because it suggested that alerting children to category selection strategies (i.e., selecting key words in the question and using the index to narrow the search) increased the likelihood that they would use the index. This finding was significant because using the index is a key action in searching for information in a textbook, and has been linked to significant increases in accuracy (Dreher & Sammons, 1994). Category selection instruction alone, however, was not sufficient to significantly influence accuracy on text search tasks for this sample. To significantly improve accuracy above that of the category selection group, it was necessary to also teach metacognitive strategies related to the extraction and integration stages of search (i.e., monitoring page content and reading speed, and checking question-answer matches). Thus, as would be predicted by the cognitive model, being an accurate searcher appeared to be a result of a combination of skills.

Study 1 also suggested that integration was playing a particularly important role during search, as children who received category selection and integration instruction were more accurate than control participants, but the same was not true of children who received category selection and extraction instruction. The important role played by integration in this research is completely consistent with a metacognitive perspective of problem-solving tasks, which would suggest that monitoring is a critical aspect of being successful (Schraw et al., 1995). But research with adult populations has not found integration to be predictive of search success. One example is Guthrie's initial examination of the text search model (Guthrie, 1988), which highlighted category selection and information extraction as the two most predictive stages of search in a multiple regression analysis, while integration did not add significantly to the regression equation.

There are a number of explanations to help us understand why these differences may have existed between studies. First, and perhaps most importantly, developmental differences almost certainly exist between Guthrie's (1988) sample of university students and elementary school aged children. Second, Guthrie defined search performance as the time to find the correct answers to search questions, with participants being permitted to make errors and then keep trying until they had found the correct responses. Participants in the present research projects discontinued searching once an answer had been provided, regardless of their accuracy. Third, Guthrie's participants were searching computerized text, while the participants in these studies were searching textbooks in paper format. Finally, this dissertation was designed to assess the cognitive model in an entirely different way. Guthrie inferred that strategies related to specific stages of search were being used on the basis of behavioural data. Of particular importance was the measure of integration, calculated as the number of times that a participant referred to the question. Although integration was most likely taking place while participants were reviewing the question, it is possible that integration was also occurring at other times, and this behavioural measure was unable to capture what was ultimately an internal metacognitive process. In contrast, Study 1 inferred that specific strategies and monitoring activities were more likely to be used by specific groups of children, as a result of direct instruction. This points to the importance of design and measurement issues in this area of research.

Study 2 further supported the important roles played by category selection and integration activities during search. This study suggested that students who made more statements related to category selection activities and integration activities found more correct responses to search questions. Thus, in terms of search accuracy, the two most influential types of instruction in Study 1 were also found to be the most important markers of metacognitive awareness in the absence of instruction in Study 2. It should be noted, however, that there was little relationship between the total number of metacognitive statements made during search and search strategies in Study 2 ($r = .17$). That is, students who reported more metacognitive activities during search did not necessarily follow a better sequence of steps to locate the answers, but they were more likely to find the correct answers. Moreover, students who indicated that they would use specific textbook features during search on a questionnaire typically did not do so. These findings were consistent with the view that metacognitive knowledge itself does not lead to appropriate strategy use; strategies are chosen through a higher-level metacognitive skill, known as strategic control (Roberts & Erdos, 1993).

Thus, Guthrie and Mosenthal's cognitive model of search seems to capture what children are doing while searching, but locating information in a textbook is undoubtedly related to a number of cognitive and metacognitive activities which are not explicitly accounted for by their model. Study 2 indicated that there was a relationship between working memory and metacognitive awareness on a text search task, and that these factors had differential effects on text search performance. Metacognition is typically associated with the ability to select strategies and monitor progress (Juliebo et al., 1998), while working memory is associated with the ability to process information and execute strategies (Cowan, 1995). The fact that working memory played the most significant role in accuracy on text search tasks in Study 2 suggested that performance was constrained by working memory capacity. Moreover, working memory was the best predictor of search sequence scores, supporting research that has emphasized the role of working memory in the execution of strategies. But why did metacognitive awareness enter into the prediction of accuracy scores only after the effects of working memory were accounted for?

A possible explanation may be found in Whitebread's (1999) conceptualization of the relationships among working memory, metacognition, strategy use, and performance. He proposed that metacognitive activities themselves take up space in working memory, and that these two cognitive processes influence one another during the process of strategy selection and execution. The use of more effective strategies is usually associated with lower demands on working memory, so if all working memory resources are not being used during problem solving, there is additional room for metacognitive processes to take place. As such, repeated experience in successful problem solving leads to the automatisation of effective strategies, a concomitant increase in working memory space, and the potential for more active metacognitive processing. This should ultimately lead to more successful future experiences with increasingly complex problem-solving tasks.

Children in Study 2, who were expected to have difficulty with text search tasks, were not likely using automatic strategies, even when they were following appropriate search sequence steps. Thus, the working memory resources necessary to complete the tasks would have been considerable. As a result, it is quite likely that working memory resources were largely being used to manage the execution of the chosen strategies, and little available space was remaining for metacognitive activities. Metacognition (as measured by both textbook feature knowledge and strategy awareness) was only able to play a role if all working memory resources were not being used in strategy execution. This is supported by the view that expert problem-solvers have a larger, better-connected network of knowledge structures, resulting in better access to prior knowledge about subject matter and potential strategies (Rosenshine, 1995). Experts consequently have less difficulty acquiring new information and have more working memory space available for problem solving and reflection. In the present research, most children were not experts in searching to locate information (as evidenced by low search sequence scores) and were likely to be challenged by the tasks, leaving little room for reflection.

Thus, one could argue that any instruction that is given to students to be more effective searchers may be constrained by their working memory capacity. Interestingly, research has suggested that teaching students strategies to reduce working memory demands can in fact improve performance on cognitive tasks (McNamara & Scott, 2001). In retrospect, it is possible that category selection instruction in Study 1 reduced demands on working memory, by having students write down information, such as search terms and page numbers. Thus, students were not required to store as much information in working memory as they completed each stage of search, and they were cued by the worksheet to remember the next step in the search process. These students would have been less likely to waste working memory space by using less efficient strategies. Results of Study 1 did suggest that search strategies were improved by giving this type of instruction. What is particularly interesting is that these reduced demands on working memory may have freed up working memory space for metacognitive activities, but students did not automatically find accurate answers to questions. In order to make use of the available resources for monitoring activities, students needed to be taught to use this space through direct instruction (extraction and integration). An alternate explanation to this finding is that the integration instruction (which has been considered a metacognitive strategy throughout this dissertation) also tapped working memory. That is, cueing children to check their responses may have actually reminded them to refresh their working memory, by accessing stored information related to the search goal.

Instruction and Educational Implications

The literature on strategy instruction has grown considerably over the past two decades, accompanied by significant growth in the number of programs aimed at teaching students how to approach academic tasks more strategically. Ultimately, a better understanding of cognitive and metacognitive processes should be translated into good instructional programs that maximize teaching efforts (Rosenshine, 1995). In terms of text search, this is particularly important because children are expected to be able to complete text search tasks in the classroom, with little guidance, even though they have great difficulty completing such tasks (e.g., Armbruster & Armstrong, 1993; Moore, 1995). As such, the results from this thesis have significant implications for educators. First, Study 1 suggested that direct instruction, using a well-validated modeling, practice, and feedback approach (e.g., Baumann, 1984; Harris & Pressley, 1991) was effective, particularly when category selection instruction was combined with metacognitive strategy instructions (extraction and integration). The important role of metacognition was also found in Study 2, which highlighted the importance of task-specific metacognitive awareness. Thus, any attempts at instruction must take metacognition into consideration, ensuring that students be able to use, select, and evaluate the most effective strategies.

These findings are completely consistent with the strategy instruction literature, which emphasizes the importance of metacognition in instruction. For example, research suggests that teaching children how to use a strategy does not result in metacognitive knowledge about when to use it, and the relationship between strategy and improvements in performance needs to be made explicit (Melot, 1998). This is an important aspect of instruction, since young children do not appear to have an understanding of how their own actions relate to the outcome of a task (Justice, Baker-Ward, Gupta, & Jannings, 1997). Paris, Lipson, and Wixson (1994) defined strategies as "skills that are made deliberate", suggesting that there is a conscious intent to execute strategies during reading. The ability to follow a strategy-based instruction protocol does not mean that the reader has become strategic. In order for a reader to be considered strategic, there must be an internalization of the strategies that result in an ability to access them at a later point in time, use and modify them in new situations, choose to use them from among alternatives, and continually evaluate their progress. According to Paris et al. (1994) this requires an understanding of the goal of the task (declarative knowledge), a number of strategies to select from (procedural knowledge) and the ability to assess when and why to use a specific strategy (conditional knowledge).

Supporting this view, Roberts and Newton (2001) have emphasized that the selection of strategies is dependent upon strategy availability, and that flexibility in strategy choice is characteristic of better problem-solvers. In other words, it is only through using new strategies that more effective ones may be discovered. These authors suggested that simple tasks are typically associated with a limited number of strategies, and that task complexity is associated with an increased number of potential strategies. In order for children to meet the demands of these increasingly complex tasks, new strategies intermingle with older strategies and gradually increase in frequency if they are found to be more effective. Unfortunately, it is the individuals with the least effective strategies who are also the least likely to discover new strategies. As a result, it is the role of educators to make text search strategies explicit during instruction (Symons et al., 2001) and to do so in the context of real-world tasks (Dreher & Sammons, 1994). Empirical research by Moely et al. (1992) demonstrated that it is important to not only teach strategies, but to also encourage continued use of the strategies over time. Because Study 1 focused on the immediate effects of instruction, no conclusions can be drawn about the effectiveness of the strategies long-term. Research would suggest that in order for the strategies to become internalized, automatic processes, they would need to be taught in the classroom as part of the curriculum. Moreover, additional strategies, contingent on the specific goals of the tasks, would also have to be addressed.

Recent efforts to devise such programs are promising. For example, Guthrie and colleagues (Guthrie & Alao, 1997; Guthrie et al., 1996) have designed a reading program aimed at increasing students' engagement in a wide range of activities related to literacy. Teaching students to search for information was considered by these researchers to be an important part of the literacy program and was given considerable attention. Students in Grades 3 and 5 were encouraged to select learning topics, and were then taught how to search for information using strategies related to textbook features (e.g., the table of contents, index, headings, pictures) and self-evaluation skills. Modeling, practice, and opportunities for student learning were all central to the instructional program. Students in both grades showed significant improvements in their ability to search for and locate information after one year in the program, with Grade 3 children developing skills equivalent to those of children in the beginning of Grade 5. This study is encouraging because it suggests that text search instruction can be integrated with other types of literacy skill development, but it was unclear what aspects of this program influenced the changes in performance. Moreover, the lack of a control group limits the interpretation of the results.

Future Research Directions

More research has focused on the instruction of specific strategies than on teaching students how to monitor and evaluate their success, but there is evidence that metacognitive skills are also amenable to instruction. For example, a recent study of a 7-month training program that focused on the development of reading comprehension, metacognition, and problem solving skills showed that children in Grade 3 could benefit from an integrated instruction program, and actually became better at self-regulating (Vauras, Riitta, & Tiina, 1999). What was particularly interesting about this study was the fact that responsiveness to training on the dimension of reading comprehension was related to metacognitive skills approximately 18 months prior to the onset of the instructional program. This is important because it highlights the fact that individual differences can have a significant impact on the effectiveness of an intervention. Individual differences such as those examined in Study 2 may have played a role in the responsiveness of students to instruction in Study 1, and could account for some of the variability in performance.

One individual difference that was not addressed in these studies and deserves special note is the motivation of children when they are searching to locate information, and how this may affect performance on text search tasks. A recent study by Reynolds and Symons (2001) examined the ability of students in Grade 3 to search for information in a textbook following a brief introduction to textbook features (i.e., the table of contents and index) and strategy instruction similar to that used in the present study. It was found that children who were given a choice of book to search were actually faster at searching, and had higher search sequence scores than the students who were given no choice of book. This finding was significant even after the effects of prior knowledge and topic interest were accounted for. Interestingly, the accuracy of responses was not affected by choice of textbook, suggesting that the ability to locate correct answers is less dependent on motivational factors. It would be interesting to more fully explore the concept of motivation in the context of text search instruction, and examine its relationship with other individual differences that have an impact on search performance.

Another important issue that needs to be addressed in future research is that developmental changes may influence responsiveness to text search instruction. Supporting this view, a growing body of research has suggested that a number of skills related to search improve with age. These include knowing when to search for information in text (Garner & Reis, 1981; Garner, Macready, & Wagoner, 1984), knowledge of textbook features and generation of key search terms (Kobasigawa, 1983;), spontaneous use of skimming (Kobasigawa, Ransom, & Holland, 1980), and searching for answers to questions that are implicitly stated (Kintsch, 1990). In addition, there is some preliminary evidence that younger children benefit more than older children from text search instruction (Symons et al., 2001). The ability to identify, select, and execute appropriate text search strategies may be partially a result of the developmental changes seen in metacognition and working memory (Whitebread, 1999). Future research would benefit from combining these related lines of research, and making more explicit the connections between individual differences, cognitive development, and the impact of instruction.

Finally, future research would benefit from examining these issues in the context of computer-based search in children. For example, one recent study in the adult literature explored the relationship between cognitive style (known as field independence / field dependence) and searching to locate information on the web (Palmquist & Kim, 2000). Field independent individuals can isolate a simple figure embedded in a more complex design, while field dependent individuals have more difficulty doing so. On a computer search task, it has been found that people with a field independent style can perform search tasks more quickly. It was suggested that these individuals are more able to identify important visual cues that will lead to the selection of appropriate links, however, experience can compensate for this disadvantage among field dependent searchers. At this time, the relationship between paper and computer-based search tasks is not clear, but many cognitive skills (e.g., working memory, vocabulary, metacognition, motivation, prior knowledge) likely have a strong overlap. One potential difference is that the sheer volume of information available on the Internet may make children who are distractible more prone to "getting lost" while searching for information. Consequently, educators in the library sciences have attempted to modify the Big6 strategies that were originally designed to guide library searches, to include strategies specific to computer-based search (Eisenberg & Berkowitz, 1997; Johnson & Eisenberg, 1996). Aspects of the Big6 program include being able to identify when the computer could be a useful search medium, knowing *how* to use search tools found on the web or in computer software, and strategies for finding, extracting and applying the information found on the computer. Unfortunately, as in paper-based search, there has been no standardization or empirical examination of the Big6 computer search strategy approach.

Concluding Remarks

Children use textbooks and other text documents regularly in school (Jitendra et al., 2001), literacy surveys continue to test text search tasks (Tuijnman, 2001), and workplaces continue to use text as a source of distributing information (Krahn & Lowe, 1998). Thus, the ability to use documents to search for and locate information is a very important literacy skill. As expected, the findings from Study 1 were consistent with research that has demonstrated positive effects of text search instruction in children. Furthermore, this study added a unique contribution to the literature on text search, as it also examined the relative importance of different types of text search instruction, corresponding to Guthrie and Mosenthal's (1987) cognitive model of text search. It was found that category selection instruction alone is not sufficient to improve search success, and that it is also necessary to teach metacognitive strategies. Thus, instructional programs that encourage the use of text search strategies must also incorporate the instruction of monitoring skills.

The second study of this dissertation was informative because it was the first study to date that directly examined the role of individual difference variables in children's text search performance. Working memory, which has been related to a number of cognitive tasks, was most strongly related to text search performance, but vocabulary knowledge and task-specific metacognitive awareness also shared unique variance with text search performance. This finding was important, because it gave rise to new hypotheses about the Guthrie and Mosenthal model of search. Moreover, individual constraints in working memory, vocabulary, and metacognition may influence the ability of students to learn from instructional interventions. Future studies may benefit from an exploration of this relationship. Together, these studies highlighted the importance of continued efforts to introduce and improve text search instruction in the schools.

Appendix A

Description of Questions: Study 1

Practice Questions

Question 1. The first practice question read: In what year was the Red Cross founded? The index listed the term Red Cross, accompanied by one page entry, 75. The table of contents could also be used to identify this page, under the chapter heading entitled History, followed by the subheading, Human Rights Today. Once on page 75, The Red Cross appeared as a heading in bold-faced type, and the answer could be located in the first sentence of this section.

Question 2. The second question read: How many calories does 1 g of fat produce? Two search terms, calorie (p. 267) and fat (p. 266-267), could be used to locate the correct sections of text to search. In addition, the chapter entitled Natural Science, and the subsection Good Nutrition would lead to page 266. Once on pages 266-267, the reader could identify the key section of text under the bold-faced heading, Energy that Can be Measured. The answer was presented in a bullet.

Question 3. The third practice question read: How many hours does a baby sleep in one day? The correct page number, 281, could be located using the indexed search term, sleep. In addition the table of contents could be used to locate the chapter, Natural Science. Although the specific subsection would be difficult to identify (The Stresses of the Nervous System), browsing would lead to a bold-faced heading, entitled, Sleep. The answer appeared in the second sentence of this paragraph.

Appendix A Continued

Description of Questions: Study 1

Test Questions

Question 1. The first test question read: How many newspapers are printed by the press daily? To locate the answer to this question, participants could select the word press directly from the question and find it in the index. This identified the key page (p. 162). Using the table of contents, the correct chapter was entitled Language and its Uses. This included a subsection called Information-Three Powerful Media. This subsection would also lead directly to the key page, on which there was a section called The Press, in bold-faced type. The answer could be found in the first sentence of this section.

Question 2. The second test question read: What color is a very hot flame? The answer to this question could be located by searching for the word flame in the index, which would lead the searcher to the key page (p. 229). The search could also be narrowed using the table of contents, by selecting the chapter entitled Physical Science and the subsection on fire (p. 228-229). The answer was located under a bold-faced section called All Kinds of Flames.

Questions 3. The third test question read: Garbage is a form of pollution. What is used to burn it? The answer to this question could be found by looking up either garbage (p. 309, the key page) or pollution (p. 308-309) in the index. Also possible was to look in the chapter on Natural Science, and then locate the subsection on S.O.S Pollution (p.308-309). Once page 309 had been located, the searcher needed to identify the section called Ground Pollution: Garbage, where the answer could be found in the second sentence.

Appendix B

Example Worksheet for CEI group (Category Selection, Extraction, Integration)

What colour is a very hot flame?

Word to look up in the index: ______________________________

Page Numbers to Check: ___________________________

📖 Check the pages carefully.📖

Did you find the Answer?

✓ Yes?

Answer:

____

- -

NO?

Another word to look up in the index: _____________________________

Page Numbers to Check: ___________________________

📖 Check the pages carefully.📖

Did you find the Answer?

✓ Yes?

Answer:

____

Appendix B Continued

Example Worksheet for CE Group (Category Selection, Extraction)

What colour is a very hot flame?

Word to look up in the index: ______________________________

Page Numbers to Check: ___________________________

🕮 Check the pages carefully. 🕮

Answer:

____

- -

Another word to look up in the index: _____________________________

Page Numbers to Check: ___________________________

🕮 Check the pages carefully. 🕮

Answer:

____

Appendix B Continued

Example Worksheet for CI Group (Category Selection, Integration)

What colour is a very hot flame?

Word to look up in the index: ______________________________

Page Numbers to Check: ___________________________

Did you find the Answer?

✓ Yes?

Answer:

____

- -

NO?

Another word to look up in the index: _____________________________

Page Numbers to Check: ___________________________

Did you find the Answer?

✓ Yes?

Answer:

____

Appendix B Continued

Example Worksheet for C Group (Category Selection)

What colour is a very hot flame?

Word to look up in the index: ______________________________

Page Numbers to Check: ___________________________

Answer:

____

Another word to look up in the index: _____________________________

Page Numbers to Check: ___________________________

Answer:

____

Appendix B Continued

Example Worksheet for Control Group

What colour is a very hot flame?

Appendix C

Metacognitive Questionnaire

1. Reading the same story twice (S)
   (1) a. is boring so you shouldn't do it
   (2) b. takes too much time
   (3) c. helps you so you can tell it to someone else
   (4) d. can help you understand the difficult parts

2. When you finish reading you should (T)
   (4) a. think about the story and make sure you understand it
   (2) b. close the book and do something else
   (1) c. not go back and read it over
   (3) d. write a book report

3. Before you read a story why would you ask if you had to remember the story word for word or just the general meaning? (T)
   (4) a. I would study it differently
   (3) b. It would help me to remember the story
   (1) c. I would know what kind of answer the teacher wants
   (2) d. I would take notes

4. A good reader (P)
   (2) a. is also good in all other subjects
   (4) b. may not be good in other subjects such as math
   (1) c. has lots of books at home
   (3) d. enjoys reading to himself/herself

5. What is the best reason for judging your reading when you finish? (T)
   (1) a. so you can tell your teacher that you're through
   (4) b. so you can be sure that you understand the meaning
   (3) c. so you can tell if the author was telling the truth
   (2) d. so you know if you like the story

6. If you cannot read a word in a story, you should (T)
   (2) a. guess it or make one up
   (1) b. skip it
   (4) c. use the rest of the sentence as a clue
   (3) d. look it up in the dictionary

Appendix C Continued

7. When you read (P)
   (4) a. it helps to know something about the story first
   (3) b. short stories are easier to remember than long ones
   (2) c. read only stories you like
   (1) d. choose books with pictures

8. When you read you should not (P)
   (4) a. skip sentences that are hard to understand
   (1) b. check to see if sentences make sense and fit together
   (2) c. ask for help for new vocabulary words
   (3) d. go back and read the story again

9. The best way to focus on the important points of a story that you read is to (T)
   (2) a. read the story 3 or 4 times
   (1) b. ask someone else to explain it
   (3) c. take notes
   (4) d. underline the main ideas

10. Being a reading detective means that you (P)
   (1) a. use a magnifying glass when you read
   (4) b. read fast or slow depending upon the kind of story and reason for reading it
   (2) c. like to read mystery stories better than animal stories
   (3) d. can answer all the questions

11. Which is quicker? (T)
   (2) a. reading out loud
   (3) b. reading silently to yourself
   (1) c. taking turns reading in a group
   (4) d. having someone read to you

12. What does the last sentence do? (S)
   (3) a. it ends the paragraph or story
   (2) b. it ends with a period
   (4) c. it tells us what the paragraph or story was about
   (1) d. it repeats the first sentence

13. Skimming is (S)
   (3) a. reading all the short ones and not the long ones
   (4) b. a quick way of finding out what the story is about
   (1) c. something that only poor readers do
   (2) d. moving your fingers fast under the words

Appendix C Continued

14. A really good plan for your reading is (S)
    (2) a. to skip the hard parts
    (1) b. to read every word over and over
    (4) c. to look back in the story to check what happened
    (3) d. to read the end of the story first

15. Someone who is a really good reader (T)
    (3) a. practices reading a lot
    (1) b. can say all the words correctly
    (4) c. knows about lots of different things
    (2) d. reads fast

16. Saying a story in your own words is important because (S)
    (1) a. you don't have to worry about what the story means
    (4) b. then you know if you have summarized all the main ideas
    (2) c. you can tell if it is real or make-believe
    (3) d. you can tell the story in the order it happened

17. Inferring the hidden meaning when you read means that (S)
    (1) a. you try to memorize what the author said
    (2) b. you need to use a dictionary to understand it completely
    (3) c. you state the facts
    (4) d. you figure out what happened even though the words didn't say it exactly

18. What does the first sentence usually do for a paragraph or story? (T)
    (3) a. it begins the paragraph or story
    (2) b. it starts with a capital letter
    (4) c. it tells us what the paragraph or story is about
    (1) d. it is indented

19. A good reading detective (S)
    (4) a. gathers clues about the purpose, content, and difficulty of the reading
    (3) b. to read quickly without mistakes
    (1) c. to find an answer
    (2) d. can sound out hard words

20. The main goal of reading is (T)
    (1) a. to say all the words
    (2) b. to read quickly without mistakes
    (3) c. to find an answer
    (4) d. to understand the meaning

<u>Note.</u> P = Person S = Situation T = Task

Appendix D

Text Features Survey (Page 1)

Finding Information

1. Suppose you are taking a social studies class that uses a textbook and that most of what you are learning is covered in this textbook. Suppose further that you are trying to find something specific like the population of Manitoba. List all the parts found in a textbook that could help you to find this information. Briefly explain why each one might be helpful.

Appendix D Continued

Text Features Survey (Page 2)

2. Suppose you had to use a textbook to find answers to specific questions. Below, we have listed a number of different parts of a book. How frequently (on a scale of 1 to 10) do you think you'd probably use each part of the book to help you find the information? To answer, think about what you usually do in using a textbook to find answers to questions. Obviously, there is no correct answer. We are interested in your honest opinion of what you'd probably do. If you do not know what the book part is, put a question mark in the blank.

Use the following scale for your answer.

Never				**Sometimes**					**Always**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Book Part	**Rating (1 – 10)**
Book Cover	____________
Title Page	____________
Preface	____________
Acknowledgments	____________
Table of Contents	____________
Headings in Chapters	____________
Boldface Terms in Chapters	____________
Chapter Summaries	____________
Chapter Tables	____________
Chapter Figures	____________
Chapter Recommended Readings	____________
References	____________
Author Index	____________
Subject Index	____________
Glossary	____________

Appendix E

Description of Questions: Study 2

Question 1. The first question read: What shape is liquid? In order to find the answer to this question, participants could look directly in the index, under the term liquids. This would refer the reader to pages **402-403** (bold-faced) or 410 (not bold-faced). Although both were in the correct chapter, page 402 was the key search page. Alternatively, the reader could select the Science chapter from the table of contents and turn to page 393 of the text. Subsections of the chapter would be unlikely to cue the reader to turn to a specific page (the appropriate subsection was called (What are Things Made of? on pages 400-405) but skimming through the chapter would quickly lead to the correct page, entitled Solids, Liquids, and Gases on page 402. The first paragraph under the heading contained the correct answer: "Liquids take the shape of their container."

Question 2. The second question read: What kind of truck pulls three or more trailers? The index listed the term trucks, with only one entry, page **356**. In addition, the table of contents could be used to locate the chapter on Machines (page 345). The most appropriate subsection listed in this chapter was entitled On the Land (350-359), but skimming would also lead to the page entitled Trucks (page 356). Next to a picture of a truck pulling three trailers was the following caption: "A roadtrain is a truck that pulls three or more trailers."

Question 3. The third question read: How are crocodiles good parents? For this question, participants could search the index for the term crocodiles and find several entries: 178, **183**, 282-283. Only page 183 was bold-faced, however, and this was the page containing the correct answer to the question. The participants could also choose to look in the table of contents, which would lead them to the chapter entitled All Kinds of

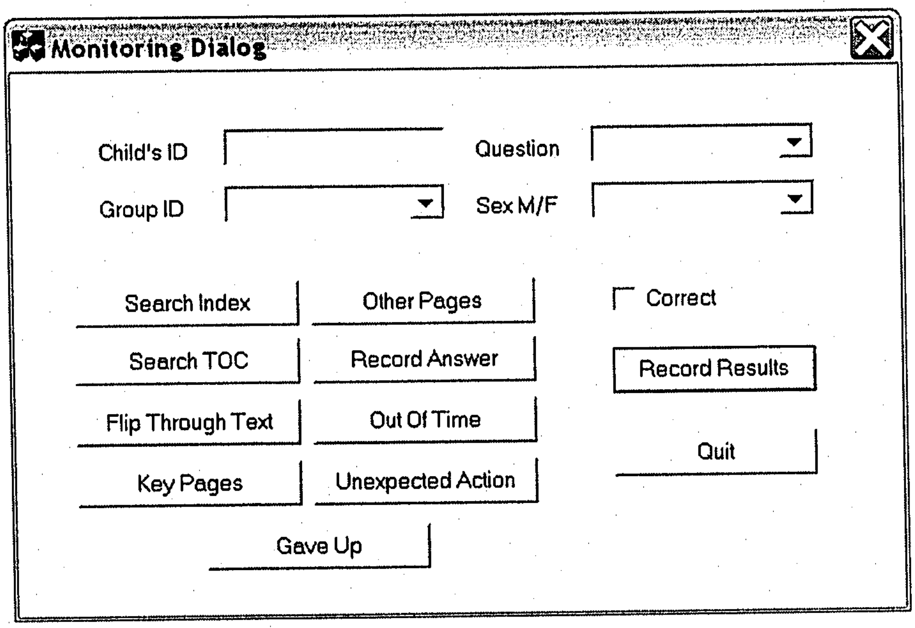
Animals (page 153). The appropriate subsection for this question was entitled Reptiles (page 178-185). Again, skimming would lead to an obvious key page (183), called Crocodiles. Under this heading read the following: "Crocodiles are good parents. They guard their eggs and look after the babies when they hatch."

Question 4. The fourth question read: What is a web made out of? Unlike questions 1-3, a search term could not be extracted directly from this question and found in the index. To use the index, the participants were required to generate a search term on their own. In this case, the term spiders could be located in the index, with several entries: **198-199**, 294, 401. The answer could also be located by finding the chapter All Kinds of Animals in the table of contents and turning to page 153. The subsection Insects (pages 192-195) contained a page entitled Spiders (page 198). Under this heading, the participants could find the sentence "Most spiders find their food by building webs of silk." Also, on the opposite page (199), there is a pictorial representation of how a web is built and a statement that the spider finishes making the web "with a spiral of silk".

Question 5. The final question read: What are freckles and moles? Again, a search term could not be extracted directly from the question. Thus, participants were expected to generate a term to look up in the index on their own. In this case, the term skin was listed with the pages **304-305**. In the table of contents, participants could select the chapter entitled My Body (page 297) and the subsection From Head to Foot (302-311). The subsection title was considered somewhat vague, but simple skimming would lead to an obvious key page (304) entitled The Skin. Next to a picture of a girl with moles and freckles read the following: "Freckles and moles are patches of extra melanin on the skin."

Appendix F

Windows Screen: Study 2



Appendix G

Coding For Verbal Reports: Study 2

Goal Formation

- Any statement reflecting that they are looking at the question
- Any statement reflecting thinking about the question (but not in relation to other information)

Category Selection

- Any statement reflecting table of contents or index use
- Any statement reflecting a letter or word search in table of contents or index
- Identification of key words or sections on the pages

Extraction

- Selection of relevant information from the page (includes reading the answer)

Integration

- Any statement reflecting the integration of information with the search question, prior knowledge, or with something else that has been extracted from the text

Other

- Statements that do not fit into one of the above categories. Includes statements such as: I don't know, It is not here, I will open the book, Found it, I will write it down, hmmm, page numbers.

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