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ABSTRACT

How science understandings are communicated and how students construct meaning of these communications are central issues in epistemic research. Students' metacognition of the meaning-making process is embedded in this line of research. This paper reports a study to examine children's declarative, procedural, and conditional knowledge of science text and science reading. A random subsample of 52 subjects in grades 4 (n=10), 5 (n=11), 6 (n=11), 7 (n=10), and 8 (n=10) from a sample of 500 students who completed a survey instrument of a larger study was chosen to be interviewed. The gender distribution was 26 males and 26 females and the subjects ranged between high (n=21), average (n=23), and low (n=8) reading ability. Interviews were conducted after students had completed a 63-item survey instrument designed to determine their metacognitive knowledge of science reading and science text. One of five interview protocols was utilized. Each protocol set is based on 1 of the 21 strategic characteristics of an efficient, successful reader of science text. Each protocol involved declarative, procedural, and conditional questions related to that specific characteristic. Student responses were scored by the researchers and analyzed both quantitatively and qualitatively. Analysis provided the basis for a 10-point profile of the composite metacognitive knowledge of science reading and science text of middle school students. Results indicated: (1) no significant grade differences for any strategy or metacognitive domain; (2) significant reading group differences on one strategy and all cognitive domains; (3) significant gender differences favoring females on two strategies and no differences for metacognitive domains; and (4) good readers' metacognitive knowledge was generally higher than poor readers. An appendix lists the questions for specific strategy and metacognitive domains. (Contains 44 references.) (MDH)

Middle School Students' Metacognitive Knowledge about Science Reading and Science Text: An Interview Study

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INTRODUCTION

The 1991 Special Issue of the Journal of Research in Science Teaching "signal[s] a resurgence of interest in students' models and epistemologies of science" (Linn, Songer & Lewis, 1991, p. 729). How science understandings are communicated and how students construct meaning of these communications are central issues in epistemic research. Embedded in these explorations of ways-of-knowing is the students' metacognition of the meaning-making or knowledge-construction process, regardless of the form or source of information involved. Recent research has investigated children's metacognitive knowledge about the reading process. Brown (1978) referred to metacognition as a process of planning, monitoring, checking, and revising as part of the reading process. Flavell (1979) regarded metacognition as the active ways people orchestrate their cognition. Paris and Jacobs (1984) characterized metacognition as thinking about thinking, and Garner (1987) referred to metacognition as cognition about cognition. Yore and Craig (1990) defined metacognition as the reader's awareness and executive control of the reading process.

Brown (1982) and Paris and Jacobs (1987) have characterized metacognition as a combination of two components. Brown referred to the components as knowledge of cognition and regulation of cognition. Paris and Jacobs labelled the components of their metacognition taxonomy as self-appraisal (awareness) and self-management (executive control) of cognition. Self-appraisal refers to children's declarative knowledge (e.g., knowing that the information you need to make sense of science text is in your head and in the text), procedural knowledge (e.g., knowing how to build bridges between the information in your head and the information in the text), and conditional knowledge (e.g., knowing when and why to use information in your head while reading science text).

Guthrie (1981), Spiro, Bruce, and Brewer (1983), and van Dijk and Kintsch (1983) portrayed reading as interactive. Valencia and Pearson (1987) viewed readers as active learners who use clues from text in concert with prior knowledge, environmental clues, and social context to construct meaning. Spiro (1980) regarded meaning as the product of the interaction between the reader, the text, and the context. He regarded elements of the situation, such as teacher and students, as part of the context. Hunsberger (1985), Shanklin and Rhodes (1989), and Tierney and Pearson (1986) also identified the teacher as part of the context. Bloome (1983) emphasized the importance of the social context as students read. Yore and Shymansky (1991) stressed that science reading, like science learning generally, is an interactive-constructive process involving the strategic integration of prior knowledge, text-based interpretations, and concurrent experiences in a specific context.

BACKGROUND

Myers and Paris (1978) found that grade six students were aware of reading strategies and when and how to use them, were more aware than second grade readers of the importance of constructing meaning and the skills necessary to construct meaning, and focused more on the semantic dimensions of paragraphs rather than the graphophonic aspects of text. Brown (1980) suggested that even when children have knowledge about reading strategies they may not understand why or how to use them. Garner and Krause (1981-1982) indicated that good readers were more aware of the usefulness of reading strategies than poor readers. Garner (1982) found that older readers have greater understanding than younger readers of strategies such as skimming, re-reading, and how and when to use strategies. Garner (1982), Moore (1982), and Wagoner (1983) reported that students may not realize that they should stop occasionally to monitor their own comprehension and adopt corrective strategies to regulate the situation. Winograd (1984) used open-ended questions and found that good eighth grade readers had better declarative and procedural knowledge of writing summaries than poor readers. Duffy, Roehler, Meloth, Polin, Rackliffe, Tracy, and Vavrus (1987) confirmed the findings of Myers and Paris (1978) and Canney and Winograd (1982) that below-average readers' conceptual awareness of the reading process is poor.

Research into children's metacognitive knowledge of reading has focused mainly on children's knowledge of reading narrative text and knowledge of narrative text features (Brown, 1978; Duffy, et al., 1987; Garner, 1982; Myers & Paris, 1978; Paris & Jacobs, 1984; Schmitt, 1990). However, narrative and expository texts have different structural, lexical, semantic, and syntactic features and consequently make different demands on readers as they interact with text in order to construct meaning (Flood, 1986; Yore & Shymansky, 1985). Based on an extensive review and synthesis of reading research and an analysis of science text, Yore and Denning (1989) developed a desired image of an efficient, successful science reader. The characteristics of the desired image reflected the reader's knowledge about science-text-related factors, such as what text represents; its purpose, value, and limitations; its structure; and its features. The characteristics also reflected the reader's knowledge and control of factors related to science reading and science cognition. In order to contribute to the emerging knowledge base and to the developing understanding of children's metacognitive knowledge, Yore and Craig (1990) explored children's knowledge of science reading and science text by combining the Jacobs and Paris (1987) taxonomy of metacognition and the Yore and Denning (1989) desired image of a science reader. Based on the results of this study, the desired image was slightly modified to include 21 strategic factors and 3 metacognitive knowledge domains -- declarative, procedural, and conditional (see Figure 1).

INSERT FIGURE 1 ABOUT HERE

Studies that have explored children's metacognitive knowledge of reading and text have utilized a variety of data collection and data analysis procedures. Paris and Jacobs (1984) constructed a multiple-choice survey instrument to assess children's knowledge of strategies for evaluating, planning, and regulating the reading process. Schmitt (1990) developed a 25-item, 4-option, multiple-choice questionnaire to assess children's metacognitive knowledge of processes they use before, during, and after reading. Yore and Craig (1990) developed two forms of a 15-item multiple-choice with open-response-option test to determine children's declarative, procedural, and conditional knowledge of science reading and science text. Yore and Craig (1992) utilized preliminary data from this pilot study and then revised the desired image of a science reader to develop a 63-item survey instrument equally distributed between the 21 strategies and the 3 metacognitive knowledge domains. Responses to the Paris and Jacobs (1984) and Yore and Craig (1990) tests were scored 2 (comprehensive strategic knowledge), 1 (surface or incomplete knowledge), or 0 (incorrect or no knowledge), depending on the degree of appropriateness of the response. The quantitative results from these tests were analyzed using a variety of statistical approaches to determine the level of metacognitive knowledge of the children involved in the studies.

Interviews have also been used to assess students' metacognitive knowledge. Myers and Paris (1978) began their exploration of children's metacognitive knowledge of reading and text with interviews to determine the children's knowledge of person and task variables. Garner and Krause (1981-1982) and Garner (1982) also used interviews to determine students' metacognitive knowledge. Winograd (1984) used open-ended questions to determine eighth grade students' knowledge of summarizing. Duffy, et al. (1987) conducted four-question interviews with 120 poor readers to assess their global understanding of the reading process. Responses for 60 randomly selected students were qualitatively analyzed to determine categories for examining the interviews. As part of a pilot study Yore and Craig (1990) conducted interviews with 24 grade five students, word association tasks with 44 grade five students, and concept mapping tasks with 39 grade five students. The results of the pilot study indicated that the word association and concept mapping techniques were not efficient or effective metacognitive measures at this time (Craig & Yore, 1992). The interview responses were scored 2, 1, 0 to correspond with scoring on the survey instrument used in the same pilot study. The interview responses were analyzed based on the response scores. Garner (1987) has pointed out potential problems with using interview studies to determine students' cognitive processing. However, Ericsson and Simon (1984) and Duffy, et al. (1987) described interview studies as a reasonable way to initiate the study of students' mental processing.

METHODOLOGY

The study reported in this paper differs from the previously mentioned studies in that the research focused on children's declarative, procedural, and conditional knowledge of science text and science reading; data collection included an interview format with five structured protocols; and the interview responses were analyzed from quantitative and qualitative perspectives. Fielding and Fielding (1986), Marshall and Rossman (1989), and Miles and Huberman (1984) acknowledge that the use of quantitative and qualitative analyses can add to understanding derived from data. It was anticipated that a qualitative analysis of the interview data would reveal dimensions that would contribute to a composite profile of middle school students' metacognitive knowledge about science text and science reading, and extend the breadth and depth of understanding revealed by the quantitative analysis. The remainder of this paper will focus specifically on the data collection, analyses and interpretations of the interviews that formed a part of a larger study (also see Yore & Craig, 1992).

Research Foci

This study addressed the following issues:

1. What do middle school students know about science text and science reading?
2. Is declarative, procedural, and conditional knowledge about science text and science reading hierarchical?
3. Does metacognitive knowledge about science text and science reading differ for middle school students from different grade levels?
4. Does metacognitive knowledge about science text and science reading differ for good, average, and poor readers in middle schools?
5. Does metacognitive knowledge about science text and science reading differ for female and male middle school students?
6. What assertions can be detected from the metacognitive knowledge responses regarding a composite profile of the middle school science reader?

Sample

The study was conducted during the last two weeks of May in four elementary and two secondary schools in a small interior city of British Columbia, Canada. The sample represented a range of rural/urban settings, class sizes, and socioeconomic backgrounds. The 52 interview subjects were from grades four (n = 10), five (n = 11), six (n = 11), seven (n = 10), and eight (n = 10), and represented a sub-sample randomly selected from a sample of 500 students who completed a survey instrument of a larger study. At least ten subjects were sampled from each grade, and the sample was drawn from all six schools participating in the study. The gender distribution was 26 males and 26 females, and the subjects ranged between high (n = 21), average (n = 23), and low (n = 8) reading ability. All students interviewed were English speaking with reasonable oral language skills.

Procedure

Interviews for the study were conducted by the first author, a knowledgeable, experienced teacher who audio-taped, transcribed, and then analyzed the responses from five standard protocols. Interviews took place after students had completed a 63-item survey instrument designed to determine their metacognitive knowledge of science reading and science text. There was a minimum of 60 minutes of activity between the survey and the interview to reduce transfer. The students in each grade were interviewed, with no prior notice, in an order determined by random assignment. Interview protocols were also randomly assigned. Interviews in each school were conducted in a quiet location, free from distraction. Each interview took approximately 10-15 minutes. During all interviews a contemporary, unfamiliar, grade six student science text was open on the table between the researcher and the student and was used as an example or reference when the question warranted it.

Interview Protocols

Interviews were conducted using one of five structured protocols (see Appendix A). Four protocols contained four sets of randomly selected questions, and one protocol contained five sets of questions. Each set of interview questions was based on one of the 21 strategic characteristics of an efficient, successful reader of science text and involved declarative, procedural, and conditional questions related to that specific characteristic. The three questions (declarative, procedural, conditional) in each set were arranged so that each question reasonably lead to the following question and did not prompt future responses. Consequently, questions were ordered in six possible arrangements. The questions were modeled on questions used in metacognitive assessments of Jacobs and Paris (1987), Myers and Paris (1978), Paris, Cross, and Lipson (1984), Paris and Jacobs (1984), and Schmitt (1990).

Transcription

Students' recorded responses were transcribed into a written gist account. Words not considered necessary for understanding the response were not transcribed (e.g., "You could ask the teacher" became "Ask teacher"). Inaudible words, phrases, or sentences were indicated by _______ (e.g., might be some kind of _________ to help in the word). Standard orthography was used to record the students' responses.

Analysis

The transcribed responses were scored by the researchers as 2 (comprehensive strategic knowledge), 1 (surface or incomplete knowledge), or 0 (incorrect or no knowledge). Student responses were compared with responses that represented comprehensive, surface, or incorrect knowledge for each question. These responses were prepared by an effective reader of science text. Following the comparisons, scores were assigned for each response. All scores were cooperatively agreed upon by the two researchers.

Quantitative Analysis

The quantitative scores for the interview responses were statistically analyzed to develop response distributions and descriptive statistics for individual questions, strategies, and domains. These data described a composite metacognitive knowledge profile about science reading and science text for middle school students (Table 1). These data were analyzed to determine if the differences between megacognition domains, good and poor readers, male and female readers, and grades four, five, six, seven and eight readers were significant.

INSERT TABLE 1 ABOUT HERE

Qualitative Analysis

The transcribed responses were analyzed using the constant comparative method (Glaser & Strauss, 1967), domain analysis (Spradley, 1979), and coding procedures outlined by Miles and Huberman (1984). Transcripts were analyzed to identify key words, phrases, and recurring themes. Portions of transcripts containing similar key words were grouped, and cover terms that identified relationships among terms were determined.

The purpose of the qualitative data analysis was to construct a composite profile of the average metacognitive knowledge of science reading and science text of middle school students and to develop assertions about middle school science readers. An examination of student responses led to a grouping of responses for items 1, 2, 3, 6, 7, 8, and 13 (knowledge of the nature of the science reading process), items 5, 9, and 17 (knowledge of science text), and items 4, 10, 11, 12, 14, 15, 16, 18, 19, 20, and 21 (knowledge of science reading strategies). This process allowed a unification of the items on the 21-item desired image of a science reader to three major categories. When these categories were combined with the declarative, procedural, and conditional knowledge of the items in each category, a 3x3 nested matrix was produced. The categories and sub-categories are neither absolute nor exclusive, but they do provide a manageable framework for constructing a composite profile of the middle school science reader.

The composite profile was arrived at by referring to the quantitative average for each cell in Table 1. Student responses for the item in that cell were then analyzed to determine the terms and phrases they shared. This shared description represents a qualitative average response for that cell. The qualitative averages for each cell in the 21x3 matrix, for each strategic factor, and for each metacognitive domain provided a description of the metacognitive knowledge about science reading, science text, and science reading strategies.

RESULTS AND DISCUSSION

Quantitative Results and Discussion

Individual question response distributions (0, 1, 2) indicate that no interview question was too easy or too difficult for middle school students. Only two questions had response patterr ; limited to a single category (1), while 24 questions had response patterns of two categories (0-1 or 1-2), and 37 questions had full range (0-2) response patterns.

Table 1 illustrates that composite performance on all questions was in the surface knowledge range ($0.50 \leq x \leq 1.50$), except two questions judged as incorrect or no knowledge ($x < 0.50$), and four questions judged to be comprehensive knowledge ($x > 1.50$). Examination of composite strategy performances reveals that only strategy #7 (Enjoy science reading and are likely to read science materials outside the prescribed text, and they pursue interests in science topics through science reading materials.) would be judged to indicate comprehensive awareness, while strategy #5 (Realize that the text is not an absolute truth and that all science writing is a form of interpretation and, at least to some extent, may be a distribution or amplification of information and ideas that have been developed or recorded through the processes of science.) indicates incorrect or no awareness. All other strategies would be judged to indicate surface knowledge.

An examination of the average declarative, procedural, and conditional awarenesses indicates very similar levels of performance. A one-way ANOVA of the composite metacognitve domain scores revealed no significant ($p \leq 0.05$) differences between declarative, procedural, and conditional knowledge. This result confirms an earlier finding in the pilot study. The similar knowledge levels across the three self-appraisal categories suggest that metacognitive knowledge about science reading and science text is not hierarchical and that students develop metacognitive awareness evenly across the three domains. This apparently means that a student may acquire knowledge of what, how, and why or when in a unified fashion for a specific strategy rather than acquiring declarative knowledge about all strategies, followed by procedural knowledge about all strategies, and finally by conditional knowledge about all strategies.

Research questions regarding grade level, reading ability, and gender differences were addressed by testing differences between groups for individual strategies and metacognitive domains scores using a Chi-square statistic. No significant grade level differences were detected for any strategy or metacognitive domain. Reading ability groups were defined by global teacher assessment as good, average, or poor. Significant ($p \leq 0.05$) reading ability group differences were found for strategy #1 and for all three metacognitive domains. Good readers' metacognitive knowledge was generally higher than poor readers. Significant ($p \leq 0.05$) gender differences were found between female and male students favoring females for strategies #4 and #13. No significant gender differences were found for metacognitive domains. These results must be considered cautiously because of the small number of students involved in some grade level, reading ability, or gender groups analyzed.

<u>Qualitative Results and Discussion</u>

In order to present a summary of the statements, each cell of the 3x3 nested matrix is labelled, and the summaries of statements for that cell are listed (Figure 2).

The sub-headings are declarative, procedural, or conditional knowledge of the three major categories: knowledge of the nature of the science reading process, knowledge of science text, and knowledge of science reading strategies. Declarative knowledge indicates students' beliefs that something is the case; procedural knowledge indicates students' knowledge of how to proceed; and conditional knowledge indicates students' knowledge of why and when to carry out a procedure. Following each category is a composite of the words and terms that represent the qualitative average metacognitive knowledge of middle school science readers interviewed. It is important to keep in mind that these statements represent a composite and therefore contain a compilation of the shared metacognitive knowledge of the middle school reader of science text and do not represent the responses of any one student. It is also important to remember that these responses indicate students' metacognitive self-appraisal and do not necessarily predict their metacognitive self-management or science reading comprehension.

INSERT FIGURE 2 ABOUT HERE

These responses represent a summary of the metacognitive knowledge of the students and were revealing for what the students did say and what they did not say. By exploring what was said and not said, it is possible to construct a profile of the composite metacognitive knowledge of science reading and science text of middle school students. The profile of a middle school reader of science text material is a student who:

1. believes reading is a problem-solving process.

2. believes reading is an active rather than an interactive process.
3. believes reading is a text-based, social process.
4. believes reading is a process of consuming information rather than constructing knowledge.
5. believes reading involves an emphasis on the readers' graphophonic knowledge.
6. is aware of function and content aspects of science text but is unaware of form aspects of science text.
7. is unaware of the implications of form and content aspects of science text.
8. is strategically aware.
9. outlines inefficient strategy procedures.
10. describes technical strategy application.

Several of these descriptors are the same or similar to categories that emerged from Duffy, et al. (1987) review and categorization of responses to their interviews. They identified ten concepts of the reading process for narrative text:

1. involves problem-solving
2. involves intentionality
3. involves effort
4. is systematic
5. is self-directed
6. is meaning-getting activity
7. uses skills and rules to get meaning

8. involves conscious processing
9. involves selection of strategies
10. is enjoyable

By comparing the results of this study that focused on science text with results from previous studies that focused on narrative text, it may be possible to construct a profile of the metacognitive knowledge of middle school science readers and at the same time determine if differences exist for the two different types of texts. In the following discussion, "students" refers to the composite of students' average metacognitive knowledge reported by the 52 middle school students interviewed.

Students' responses portray science reading as a problem-solving process. Students indicated that if they have a problem, such as inability to read a word, understand a word, sentence or larger portion of text, they do something to solve the problem. The students included referring to text features, sounding out the word, or asking someone for possible solutions to the problem. It is interesting to consider students' views of themselves in this problem-solving process. Although they referred to a variety of actions they could take to solve problems, their role in the problem-solving process appeared to be that of an expediter, one who gathers resources and facilitates actions. They did not see their prior knowledge and experience as resources in solving the problem. Myers and Paris (1978) suggested that younger children refer to external sources for solving reading difficulties whereas older students use more internally oriented strategies. The current results differ from the Myers and Paris' description of an older reader in that these middle school students appear to be in control, but their strategies can not be described as internal because they do not include their prior knowledge as a problem-solving resource.

The students' responses reflect a belief that science reading is an active process. Reading involves physical action to make sense of text. Students indicated that they actively re-read, read slowly, refer to visual adjuncts, take notes, or ask someone. However, these students do not appear to regard science reading as an interactive process in which science readers connect their prior knowledge and experiences with information from the science text and the social context in order to construct understanding. Unless specifically asked about the role of prior knowledge in helping to understand science text, the students did not refer to prior knowledge as a tool to use for that purpose. When students did refer to the use of prior knowledge and experiences as aids in making sense of text, students said that prior knowledge helped them to make sense of text but it was not referred to as a tool that they consciously accessed and combined with information from the text and the social context. These responses could be explained by suggesting that as processing becomes automatic it becomes increasingly more difficult to analyze and report on the metacognitive nature of the process (Paris, Wasik & Turner, 1991). But it is unlikely that students actually maintain an automatic comprehension level in science reading. It is more likely that students' conception of science text assumes truth in the printed message, thus not requiring their prior knowledge to construct meaning.

Although the students regarded reading as an active process, they did not include current explorations such as observing, investigating, or experimenting as a way of making *sense of science text.* This could be because they did not regard reading as an interactive-constructive process, and therefore current explorations were not required as a tool for understanding. Students made no mention of current explorations as a means of making sense of text. This may be related to students conceptualizing their strategic science reading on narrative reading experiences, which requireslittle concurrent exploration. Because of differences between science text and narrative text and the subsequent demands made on the reader, future researchers should ensure that students realize they are talking about science reading specifically, and not reading of narrative text.

Students regard reading as a text-based, social process. The information resides in the text. When they are unable to read, to extract information, to understand or remember that information, the students stated that they do something with the text (e.g., re-read, read slowly, search ahead) or consult another source. In addition, students indicated that if they are having difficulty understanding science text, it is due to the text. In other words, their text-driven model places primary responsibility on truth in text, and the text is responsible when they locate, remember, learn, or understand information; and the text is at fault when they do not. Paris, Wasik, and Turner (1991) indicated that attributions of success or failure to text may be designed to preserve students' self-perceptions of reading ability. It also appears that students believe that the text stores the information and if they just try a variety of approaches that information will be revealed.

Students regard science reading as a process of consuming information rather than constructing knowledge. Science reading was usually referred to as a process of locating and remembering information. The science text is regarded as a storehouse of information, and it is the responsibility of the readers to transfer that information to themselves. This finding differs from Myers and Paris (1978) who found that sixth graders focused on the importance of constructing meaning when reading narrative text. Although students at various times referred to the purpose of science reading as remembering or understanding, these terms were used interchangeably and there did not appear to be a pattern in their use. Because the differences in the terms may be critical to understanding students' conception of the science reading process, future interviews should clarify the students' meanings attached to these terms.

Students believe that science reading involves an emphasis on the graphophonic aspects of science reading to identify words and determine meanings. They indicated that they use their knowledge of sound-symbol relationships to sound out words and determine the meaning of words and sentences. In addition, they emphasized word identification rather than word meaning. It is unclear whether they believe the meaning is in the sound or whether they use this approach to link the verbal vocabulary and the reading vocabulary. Myers and Paris (1978) found that sixth graders focused more on semantic dimensions of narrative paragraphs rather than graphophonic aspects of text. These differences could be accounted for by the lexical differences between narrative and expository text and the cognitive demands placed on the reader by these differences. With larger portions of text, the students in this study changed their focus to the meaning or sense of that portion of science text.

Students' responses revealed metacognitive knowledge of three content aspects of *science text.* Student responses regarding the truth value of the content of science text raised an interesting contradiction. Students were aware that science text represents someone's ideas that may not be true and should be read with some degree of scepticism. However, if there were repeated discrepancies between their information and the text's information, students claimed they would consider the text to be correct. This ultimate acceptance of text as the source of knowledge may be an integral part of their conception of science reading as a meaning-taking process rather than a meaning-making process.

Students' responses regarding the second content aspect of text, visual adjuncts, revealed an awareness of the function of these visuals. However, students indicated an inefficient use of the visuals, referring to them after reading but not to solve problems during reading.

Students' responses revealed lack of knowledge of form aspects of science text. The responses also revealed a lack of metacognitive knowledge that paragraphs in science text are organized differently and consequently require different strategies when trying to learn from them.

Students' responses revealed strategic awareness. The results of this study provide an outline of students' knowledge of strategies and their knowledge of how and when to use them. The students indicated that their use of reading strategies is purposeful and the purposes were to aid in figuring out words and sentences, learning, remembering, or understanding. As stated earlier, students did not appear to differentiate between remembering and understanding and were not selective in deciding which strategy to use for which purpose.

Although students knew that the use of strategies helps readers understand science text, the procedures they describe for implementing the strategies were not carried out in the most efficient way or the identified strategies were not the most efficient way to achieve their goal. For example, students indicated that they summarize by picking out the important parts of text but did not indicate how they determined the important parts of text. In a study of eighth graders, Winograd (1984) found that good readers had better declarative, procedural, and conditional knowledge of writing summaries than poor readers. Students in this study also said that in order to remember information they listed information rather than make an outline or prepare a concept map, both of which establish relationships between ideas and facilitate remembering and understanding (integration of ideas and integration of new and old information).

Students describe themselves as technical rather than spontaneous strategy users. A technical strategy user is one who applies a strategy at one or more set points while reading (e.g. before, during, after the reading). On the other hand, spontaneous strategy users are those who apply strategies as the need arises (e.g., when they do not understand). Garner (1982), Moore (1982), and Wagoner (1983) each concluded that students may not realize that it is important to stop occasionally to check comprehension and take corrective measures if necessary.

One important strategy that did not appear to be a part of the metacognitive knowledge of middle school science readers was identifying a purpose or goal for the reading. Students had a number of opportunities to indicate that they establish a purpose for reading, refer to that purpose as they read, and base their selection of strategies on that purpose; however, they did not include identifying a purpose for reading as a strategy they used.

Myers and Paris (1978) and Garner (1982) found that older students were aware of reading strategies and when and how to use them. On the other hand, Brown (1980) suggested that even though children have knowledge of strategies they may not know when or how to use them. Garner and Krause (1981-1982) concluded that good grade seven readers were more aware of the usefulness of effective strategies than poor readers. Myers and Paris (1978) concluded that younger students were unaware of the need to invoke specific strategies to meet different goals.

CONCLUSIONS

The results of this study contribute to the emerging knowledge base and to the developing understanding of children's metacognitive knowledge about reading generally and their metacognitive knowledge about science reading and science text specifically. The results also suggest a number of research directions and instructional implications.

Results from this study of expository text and previous studies of narrative text differ. Consistent significant differences between good readers and poor readers and old readers and young readers were not found. In many cases the metacognitive knowledge of the students in this study was more like that of younger and poorer readers than the knowledge of older and better readers described by Myers and Paris (1978), Canney and Winograd (1982), Garner (1982), and Winograd (1984). These differences could be accounted for by two explanations. First, these responses are a composite of metacognitive knowledge of readers from fourth to eighth grade and include a small number of readers ranging from poor to good at each grade level. A second, more intriguing possibility is that the differences reflect the differences between narrative and expository texts and students' exposure to these texts. Because of the features and cognitive demands of expository text and the lack of explicit experience with expository text, it may be that students' development of metacognitive knowledge for science text is delayed in relation to metacognitive knowledge for narrative text. Flavell (1978) stressed the influence of person, task, and strategy variables on students' metacognitive knowledge. If the cognitive demands of processing narrative and expository text differ, it could follow that these differences also exist for the metacognitive knowledge of the reader for each type of text and demands on that metacognitive knowledge. A fruitful area of research would be an exploration of whether or not differences do exist between students' metacognitive knowledge of narrative and expository text, and if so, the nature of those differences.

The rather consistent performance on declarative, procedural, and conditional knowledge questions was expected (Yore & Craig, 1990), but still surprising. The cognitive demands of why- and when-type questions appear to be higher than what- and how-type questions. These cognitive demands were not detected in the students' metacognitive knowledge base.

The results of this study also have instructional implications. Because students lack important metacognitive knowledge or use inefficient or technical approaches to strategy use, teachers can move from the familiar to the unfamiliar by using children's metacognitive knowledge about how to use narrative text in order to develop comprehensive knowledge about how to use expository text. Flood (1986) pointed out that "children need to make the transition from narrative text to expository texts through direct instruction from the teacher during reading lessons with basal readers and during subject matter lessons with subject matter textbooks" (p. 786). Pearson and Dole (1987) emphasized that explicit instruction will improve readers metacognition.

The exploration of students' metacognitive knowledge of science text and science reading has been initiated. Future descriptive, correlational, and instructional studies will continue to provide information as researchers focus on metacognitive dimensions of learners and learning. Understandings gained will provide teachers with information that they can use to help students become more knowledgeable about science reading and science text, more efficient and successful readers of science text, and better managers of their own learning.

REFERENCES

Bloome, D. (1983). Reading as a social process. Advances in Reading/Language Research, 2, 165-195.

Brown, A.L. (1978). Knowing when, where and how to remember: A problem of metacognition. In R. Glaser (Ed.), Advances in instructional psychology, Vol. 1 (pp. 77-165). Hillsdale, NJ: Erlbaum.

Brown, A.L. (1980). Metacognitive development and reading. In R.J. Spiro, B. Bruce, & W. Brewer (Eds.), Theoretical issues in reading comprehension. Hillsdale, NJ: Erlbaum.

Brown, A.L. (1982). Learning how to read from reading. In J.A. Langer & M.T. Smith-Burke (Eds.), Reader meets author/Bridging the gap. Newark, DE: International Reading Association.

Canney, J., & Winograd, P. (1982). schemata for reading and reading comprehension performance (Tech. Rep. No. 120). Urbana, IL: University of Illinois, Center for the Study of Reading.

Craig, M.T., & Yore, L.D. (1992). Assessing prior knowledge of science text and science reading. Alberta Science Education Journal, 25(1), 28-34.

Duffy, G.G., Roehler, L.R., Meloth, M.S., Palin, R., Rackliffe, A.T., & Vavrus, L. (1987). Developing and evaluating measures associated with strategic reading. Journal of Reading Behavior, 14, 223-247.

Ericsson, A., & Simon, H. (1984). Protocol analysis. Cambridge, MA: MIT Press.

Fielding, N.G., & Fielding, J.L. (1986). Linking data? Newbury Park, CA: Sage.

Flavell, J.H. (1978). Metacognitive development. In J.M. Scandura & C.J. Brainerd (Eds.), Structural/process theories of complex human behavior. Alphen a.d. Rij, The Netherlands: Setjhoff & Noordhoff.

Flavell, J.H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-development inquiry. American Psychologist, 34, 906-911.

Flood, J. (1986). The text, the student and the teacher: Learning from exposition in middle schools. Reading Teacher, 39, 784-791.

Garner, R. (1982). Verbal report data on reading strategies. Journal of Reading Behavior, 14, 159-167.

Garner, R. (1987). Metacognition and reading comprehension. Norwood, NJ: Ablex.

Garner, R., & Krause, C. (1981-1982). Good and poor comprehender differences in knowing and regulating reading behaviors. Educational Research Quarterly, 6, 5-12.

Glaser, B.G., & Strauss, A.L. (1967). The discovery of grounded theory. Chicago, IL: Aldine.

Guthrie, J. (Ed). (1981). Comprehension and teaching: Research reviews. Newark, DE: International Reading Association.

Hunsberger, M. (1985). When child and curriculum meet in reading class. Reading-Canada-Lecture, 3, 101-108.

Jacobs, J.E., & Paris, S.G. (1987). Children's metacognition about reading: Issues in definition, measurement and instruction. Educational Psychologist, 22, 255-278.

Linn, M.C., Songer, N.B., & Lewis, E.L. (1991). Overview: Students' models and epistemologies of science. Journal of Research in Science Teaching, 28, 729-732.

Marshall, C., & Rossman, G.B. (1989). Designing qualitative research. Newbury Park, CA: Sage.

Miles, M.J., & Huberman, A.M. (1984). Qualitative data analysis: A sourcebook of new methods. Newbury Park, CA: Sage.

Moore, P.J. (1982). Children's metacognitive knowledge about reading: A review. Educational Research, 24, 120-128.

Myers, M., & Paris, S.G. (1978). Children's metacognition about reading. Journal of Educational Psychology, 10, 680-690.

Paris, S.G., Cross, D.R., & Lipson, M.Y. (1984). Informed strategies for learning: A program to improve children's reading awareness and comprehension. Journal of Educational Psychology, 76, 1239-1252.

Paris, S.G., & Jacobs, J.E. (1984). The benefits of informed instruction for children's reading awareness and comprehension skills. Child Development, 55, 2083-2093.

Paris, S.G., Wasik, B.A., & Turner, J.C. (1991). The development of strategic readers. In R. Barr, M.L. Kamil, P.B. Masenthal, & P.D. Pearson (Eds.), Handbook of reading research, Vol. 2 (pp. 609-640). New York, NY: Longman.

Pearson, P.D., & Dole, J.A. (1987). Explicit comprehension instruction: A review of research and a new conceptualization of instruction. Elementary School Journal, 88, 151-165.

Pearson, P.D., & Johnson, D.E. (1978). Teaching reading comprehension. New York, NY: Holt, Rinehart and Winston.

Schmitt, M.C. (1990). A questionnaire to measure children's awareness of strategic reading processes. Reading Teacher, 43, 454-463.

Shanklin, N.L., & Rhodes, L.K. (1989). Comprehension instruction as sharing and extending. Reading Teacher, 42, 496-500.

Spiro, R. (1980). Constructive processes in prose comprehension and recall. In R.J. Spiro, B.C. Bruce, & W.J. Brewer (Eds.), Theoretical issues in reading comprehension (pp. 247-278). Hillsdale, NJ: Erlbaum.

Spiro, R.J., Bruce, B.C., & Brewer, W.F., (Eds.). (1983). Theoretical issues in reading comprehension. Hillsdale, NJ: Erlbaum.

Spradley, J. (1979). The ethnographic interview. New York, NY: Holt, Rinehart and Winston.

Tierney, R.J., & Pearson, P.D. (1986). Schema theory and implications for teaching reading: A conversation (Reading Education Report No. 67). Urbana, IL: University of Illinois. Center for the Study of Reading. (ERIC Document Reproduction Service No. ED 281 140).

Valencia, S., & Pearson, P.D. (1987). Reading assessment: Time for a change. Reading Teacher, 40, 726-732.

van Dijk, T.A., & Kintsch, W. (1983). Strategies of discourse comprehension. New York, NY: Academic Press.

Wagoner, S.A. (1983). Comprehension monitoring: What it is and what we know about it. Reading Research Quarterly, 18, 328-346.

Winograd, P.N. (1984). Strategic difficulties in summarizing texts. Reading Research Quarterly, 19, 404-425.

Yore, L.D., & Craig, M.T. (1990). A preliminary report: an assessment of what grade 5 students know about science text and science reading. Resources in Education. (ERIC). ED 319 589.

Yore, L.D., & Craig, M.T. (1992). Middle school students' metacognitive knowledge about science reading and science text: objective assessment, validation, and results. Paper presented at the National Association for Research in Science Teaching Annual Meeting. Boston, MA: March 24.

Yore, L.D., & Denning, D. (1989). Implementing change in secondary science reading and textbook usage: A desired image, a current profile and a plan for change. Resources in Education. (ERIC). ED 305 270.

Yore, L.D., & Shymansky, J.A. (1985). Reading, understanding, remembering, and using information in written science materials. Resources in Education. (ERIC). ED 258 825.

Yore, L.D. & Shymansky, J.A. (1991). Reading in science: Developing an operational conception to guide instruction. Journal of Science Teacher Education, 2, 29-36.

Table 1

Question, Factor and Domain Means, Standard Deviations and (Subjects Interviewed).

Factor	Declarative Mean, SD (Number)	Procedural Mean, SD (Number)	Conditional Mean, SD (Number)	Strategy Mean, SD (Number)
1	1.00, 0.00 (10)	1.30, 0.48 (10)	1.00, 0.47 (10)	1.10, 0.23 (10)
2	0.80, 0.42 (10)	0.60, 0.52 (10)	0.80, 0.92 (10)	0.73, 0.38 (10)
3	0.91, 0.54 (11)	0.82, 0.75 (11)	1.09, 0.30 (11)	0.94, 0.39 (11)
4	0.82, 0.60 (11)	0.91, 0.30 (11)	0.91, 0.30 (11)	0.88, 0.23 (11)
5	1.55, 0.69 (11)	1.18, 0.87 (11)	1.18, 0.75 (11)	1.30, 0.51 (11)
6	1.00, 0.47 (10)	1.50, 0.53 (10)	0.20, 0.42 (10)	0.90, 0.32 (10)
7	1.40, 0.52 (10)	1.40, 0.70 (10)	1.90, 0.32 (10)	1.57, 0.32 (10)
8	1.60, 0.70 (10)	1.10, 0.32 (10)	1.50, 0.85 (10)	1.40, 0.38 (10)
9	1.60, 0.70 (10)	1.00, 0.67 (10)	0.90, 0.32 (10)	1.17, 0.39 (10)
10	1.55, 0.52 (11)	1.18, 0.41 (11)	0.91, 0.54 (11)	1.21, 0.23 (11)
11	1.00, 0.00 (11)	1.46, 0.69 (11)	1.36, 0.51 (11)	1.27, 0.33 (11)
12	1.00, 0.67 (10)	0.90, 0.57 (10)	0.90, 0.57 (10)	0.93, 0.38 (10)
13	0.91, 0.54 (11)	1.27, 0.79 (11)	1.18, 0.60 (11)	1.12, 0.37 (11)
14	0.80, 0.42 (10)	0.90, 0.32 (10)	1.10, 0.57 (10)	0.93, 0.26 (10)
15	0.30, 0.68 (10)	0.50, 0.71 (10)	1.00, 0.67 (10)	0.60, 0.52 (10)
16	1.36, 0.51 (11)	1.27, 0.65 (11)	0.91, 0.70 (11)	1.18, 0.41 (11)
17	0.70, 0.68 (10)	0.60, 0.84 (10)	1.20, 0.63 (10)	0.83, 0.39 (10)
18	1.00, 0.45 (11)	1.00, 0.78 (11)	1.36, 0.67 (11)	1.12, 0.34 (11)
19	0.80, 0.63 (10)	1.20, 0.63 (10)	0.80, 0.63 (10)	0.93, 0.44 (10)
20	0.90, 0.88 (10)	0.90, 0.32 (10)	0.50, 0.53 (10)	0.77, 0.35 (10)
21	0.60, 0.52 (10)	0.80, 0.63 (10)	1.20, 0.42 (10)	0.87, 0.23 (10)
Domain Means, SD (Number)	1.05, 0.36 (52)	1.04, 0.41 (52)	1.02, 0.32 (52)	

The desired image of an efficient, successful reader of science text materials should be a person who is able to:

1. realize that science reading is an interactive/constructive process by which you construct meaning from personal experience, recorded experiences of other people, and the context of the reading.

2. realize that words are labels for ideas, ideas are based on experiences, and text is stored descriptions of ideas (experience); that readers must evaluate the textual material; and that readers determine their own purposes for carrying out the reading.

3. develop a sense of the motivation and value for the reading and feel confident that the reading will help to understand, reinforce, and enrich personal experiences, interests, and needs, and to solve problems.

4. select reading strategies appropriate to the needs of the reading process, for example, when the purpose of the reading is to obtain an overview of the text, the student uses skimming, key words, titles and headings, and first sentences in paragraphs to retrieve the main ideas.

5. realize that the text is not an absolute truth and that all science writing is a form of interpretation and, at least to some extent, all science writing may be a distortion or simplification of information and ideas that have been developed or recorded through the processes of science.

6. have self-confidence in his/her reading abilities and realize that a comprehension problem may result from poorly written text or abstract ideas, and not just a personal comprehension block.

7. enjoy science reading and is likely to read science materials outside the prescribed text, and to pursue personal interests in science topics through science reading materials.

8. assess his/her own personal skills as a learner and choose strategies for reading the text that fit self-assessment and avoid reading difficult information without access to prior declarative knowledge (critical vocabulary and key background concepts) or prior procedural knowledge (plans to review and re-process difficult ideas or concepts).

9. use visual adjuncts in texts, such as graphs, charts, and photographic reproductions to help clarify, organize, reinforce, enrich, or verify the meanings derived from the text.

10. use efficient vocabulary development skills to determine the meaning of words from context; to dissect words into prefixes, suffixes and root-words; to utilize classification, concept maps, metaphors, and analogues to show relationships of key words; and to use mnemonic aids to help remember key words.

Figure 1. The Desired Image of an Efficient, Successful Reader of Science Text Material

11. identify main ideas in a text, delineate supporting ideas, and rephrase ideas to show logical connections and hierarchical relationships explicit or implicit in the text.

12. summarize text passages using the following macrorules: delete redundancies, delete trivia, provide superordinates, or select topic sentences, or invent topic sentences when missing.

13. evaluate text passages for plausibility, completeness, and interconnectedness by using available knowledge to correct mistakes in science text writing or to fill in missing information necessary to make the text plausible.

14. ask self-questions about the readings that require comprehension and reflect the purpose(s) for reading the textual material.

15. use inferential ar 1 applied comprehension skills to critically synthesize, analyze, evaluate, and apply information regarding fact and opinion, bias, generalizations, causal relationships, and distinctions.

16. utilize efficient search-ahead procedures that allow him/her to construct meaning from related or linked information in other parts of the sentence or paragraph.

17. identify a variety of text structures including description, simple listing, chronological ordering, compare-contrast, cause-effect, and problem-solution and select reading strategies appropriate to the text structures encountered.

18. monitor successes at understanding the reading information as the reading progresses and detect discrepancies in light of the established purpose, and consciously adopt or determine strategies to review the text information, which help create a better fit between schema and the perceived meaning of the text, carry out these strategies, and re-assess the goodness-of-fit for the reviewed textual information and understandings.

19. adjust comprehension monitoring to more conscious levels when demands of the reading increase, when difficulties are perceived, and when comprehension is blocked.

20. choose appropriate study skills when there is a need to remember detailed information from text, such as summarizing, outlining, peer testing, and reciprocal teaching.

21. create organized mental images of information in order to help fit the information into existing schema and to help encode the information into long term memory.

Figure 1 (Contd.)

1. SCIENCE READING

a. Declarative Knowledge of the Nature of the Science Reading Process

Making sense of science text involves re-reading, reading slowly, taking notes, or asking someone.

The purpose of science reading is to find information or to learn something.

When you do not understand, it is probably because of difficult words, difficult topics, or poor explanations in your science text.

Understanding science text is easier if you have studied the topic before or it is a part of your everyday experience.

b. Procedural Knowledge of the Nature of the Science Reading Process

To make sense of science text, you use several sources, such as:

- reading strategies: read back, read ahead, re-read, sound-out words
- text: use visual text adjuncts
- social context: ask someone

c. Conditional Knowledge of the Nature of the Science Reading Process

You read science text to learn more, get more information, remember, or understand.

Before reading, you use several sources to understand and remember: visual adjuncts, headings, highlighted words and social context; ask someone.

2. SCIENCE TEXT

a. Declarative Knowledge of Science Text

Science text is someone else's ideas.

Science text has some sort of structure.

Visual adjuncts help you to understand science text.

b. Procedural Knowledge of Science Text

You decide whether science text is true by checking it against your own ideas.

You use pictures, headings, or the title to figure out the main idea.

Figure 2: Qualitative Profile of Middle School Students' Metacognitive Knowledge about Science Reading, Science Text, and Science Reading Strategies.

You use the pictures or the glossary to help you figure out words.

c. Conditional Knowledge of Science Text

When the science text and the reader do not agree, it is the reader who is wrong.

You look at visual text adjuncts during and after reading science text.

3. SCIENCE READING STRATEGIES

a. Declarative Knowledge of Science Reading Strategies

Some things you do to help you to remember or understand are find the main idea, self-question, visualize, or monitor understanding.

Some things you do to help you to figure out words are search ahead, sound it out, use context, look for root words.

Some things you do to help you figure out sentences are search ahead, sound it out, use context.

Knowing why you are reading will help you to get more information, learn more, or understand.

Summarize means to write the important parts or short form of what you read.

b. Procedural Knowledge of Science Reading Strategies

You should use social context to figure out words and sentences and sound out to figure out words.

You should write the important things to summarize, list information to remember, and re-read or think about what you've read to check your understanding.

c. Conditional Knowledge of Science Reading Strategies

You summarize after reading.

You self-question during and after reading or to see if you understand.

You search ahead when you do not understand.

You sound out, use context, and use pictures when you do not know a word.

You summarize and list information when you want to remember

Figure 2 (Cont'd.)

Appendix A

Interview Protocols (1-5), Strategic Factor (1-21)

and Metacognitive Domain (declarative,

procedural or conditional)

Interview Questions for Specific Strategy and Metacognitive Domain (Protocol indicated in bracket)*.

1d(1). What is involved in making sense of a topic in your science textbook?

1p(1). How could you help other students in your group understand a topic in your science text?

1c(1). If you thought a topic in your science text was going to be difficult to understand, what could you do before you started reading to help you understand?

2d(4). Are words in a science text just words? What is important about them? How are labels in your clothing like science words?

2p(4). When you come to a new science word, what do you do to make sense of the word?

2c(4). Would repeating the word out loud several times help you understand a new science word? Why or why not?

3d(2). What is the main goal of reading?

3p(2). If understanding is the main goal of reading, is there something you should do before you start reading? What is it?

3c(2). Should you stop and think about why you are reading? When should you do this?

4d(3). Is knowing why you are reading important? How does knowing why you are reading help you?

4p(3). Are there things you can do if you are reading and don't understand what a sentence is about? What are they?

4c(3). How would you decide which thing to do? When would you (check other sentences around the difficult sentence)?

* 1d(1) denotes strategy #1 from desired image, d denotes declarative knowledge, and (1) denotes protocol #1.

5d(2). Should you believe everything you read in your science text? Why? (Why not?)

5p(2). How would knowing that text in science books is someone's view of what is true affect how you read science text?

5c(2). If your experiment's results do not agree with your science text, what would you do? Why?

6d(4). Are there times when you don't understand what you read in your science text? What would you say are the reasons you don't understand?

6p(4). What should you do if you don't understand? What if you think it's the text? What if you think it's you?

6c(4). (If you don't understand what you're reading, it could be because the text is poorly written or it could be you.) Is it important to know if the reason you don't understand is you or the text? Why?

7d(1). What might students who are particularly interested in a topic in their science text do?

7p(1). Are there things you could do if you wanted to find out more information about a topic in your science text? What are they?

7c(1). (Students who are interested in a science topic read additional information about that topic.) Why? When do you check out additional library books on a science topic? Any time other than for assignments?

8d(4). What topic in science would you find easiest to understand? Why?

8p(4). If you are reading about a science topic and you realize you don't understand, what should you do?

8c(4). Some students like to have group discussions before they start reading about a new topic. Why?

9d(1). Are there things on the page of your science text that may be useful to you as you are reading? What are they?

9p(1). How and when do you use them?

9c(1). (The author of the text put pictures, diagrams and definitions in your science text.) Why are they there?

10d(3). What is someone doing when you see him/her sounding out words, using context and looking for root words?

10p(3). What do you do when you come to a big word in your science text that you don't know?

10c(3). Sometimes the teacher tells students to use context, break up words and look for root words. Why does the teacher do that?

11d(2). When you are reading, do you try to figure out the main idea of what you're reading? How does figuring out the main idea help you in your reading?

11p(2). How do you find the main idea? What hints do you use?

11c(2). Why do textbooks' pages have titles, headings and illustrations? When do you use them?

12d(5). Sometimes the teacher will ask you to summarize what you have read. What does it mean to summarize?

12p(5). How do you summarize?

12c(5). Should you summarize what you have read? Why? When?

13d(3). From what sources do you get information when you are reading science text?

13p(3). (Do you use information in your head when you read your science text?) How do you use information in your head?

13c(3). Why do you use information in your head when you read your science text? What if your knowledge and the text knowledge do not match?

14d(5). What does it mean to self question? What is someone trying to do when they self question?

14p(5). What should children be thinking about while they are reading? What could someone do to help them think about what they are reading?

14c(5). Should children self question as part of reading science text? When? Why would you want to check your understanding?

15d(5). Sometimes students are asked to read critically. What does it mean to read critically?

15p(5). How do you read critically?

15c(5). Is it important to read critically? Why? If you came to the statement "In my opinion ...", what would you think or do?

16d(3). (Sometimes readers look back or ahead when they read science text.) How is that helpful? Is that cheating?

16p(3). If you are reading your science text and you don't know what a sentence means, what could you do?

16c(3). When should you look back and ahead in your science text? Why?

17d(5). Are sentences in paragraphs in science textbooks arranged in any special order? How?

17p(5). (Sentences in paragraphs are put together in different ways. Some are used to describe, some are put in chronological order, and some compare and contrast ideas.) What should you do as you make notes for different types of paragraphs?

17c(5). (Should you make notes the same way for all paragraphs?) Why? Why not? When you come to a paragraph that describes a problem and solution (cause and effect), what do you do?

18d(2). Good readers often check to see if they understand what they are reading. Would that be a useful thing to do? Why?

18p(2). What could you do to check and see if you understood what you were reading? How could the questions at the end of the chapter/passage be used?

18c(2). Is it important to see if what you're reading makes sense? When should you do this?

19d(5). Should you check to see if you understand what you are reading? Are there times when you should check more often than you usually do? When? Why?

19p(5). What can you do when the reading becomes more difficult?

19c(5). Are there times when it becomes difficult to understand what you're reading? What makes you realize it is becoming more difficult?

20d(1). Is there a difference between reading and reading to remember? What is the difference?

20p(1). If you are reading a science textbook, what can you do to remember detailed information?

20c(1). (Sometimes readers outline what they are reading.) Is that a useful thing to do? Why? When should you do it?

21d(4). (Some readers make mental pictures of what they are reading.) How is this useful?

21p(4). What is something you can do to remember information?

21c(4). Would you suggest to someone to make mental pictures of what they were reading? What reason would you give them for doing that? If they asked when they should do it, what would you tell them?