A Knowledge-Focused Multi-Part Strategy for Enhancing Student Reading Comprehension Proficiency in Grade 5 [1, 2]

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Abstract

The recent RAND Reading Study Group report re-affirmed the conclusion that the proficiency of students to read and comprehend subject-matter text in grades 4-12 has remained a continuing and significant educational problem. Considering reading comprehension as the process of identifying and assimilating meaning by interacting with text, this study integrated consensus research findings from cognitive science and reading/educational psychology to investigate how student in-depth content-area understanding and reading comprehension proficiency can be developed optimally at the upper elementary level. Specifically, the study embedded a three-part *Reading Comprehension Strategy* (i.e., *text comprehension, propositional concept/story mapping, summarization writing sub-strategies*) in combination with a semantic fluency activity within two instructional settings: (a) a science-oriented model (*Science IDEAS*) that integrated reading and writing and (b) a traditional reading/language arts curriculum that emphasized narrative reading. Results found that the science-oriented model produced significantly greater overall achievement than traditional reading/language arts on both ITBS Reading and Science tests and that the three-part *Reading Comprehension Strategy* significantly enhanced reading and science achievement only for students receiving the science-oriented instruction. On affective outcomes, the study found that the *Reading Comprehension Strategy* did have a positive overall effect on student attitude toward and self-confidence in reading, that traditional classrooms engendered greater self-confidence in reading, and science-oriented classrooms a more positive attitude toward science. Implications of the findings for researchers and practitioners were discussed within a framework of Slavin's (1990) methodological distinction between "model-oriented" and "variable-oriented" research.

In their recent publication, *Reading for Understanding*, the RAND Reading Study Group (Snow, 2002) reported that the proficiency of students to read and comprehend subject-matter text has remained a significant educational problem in grades 4-12 – the grade levels at which cumulative and meaningful learning in content areas (e.g., science) is emphasized and reading to learn becomes a critically important instructional proficiency. A recent National Assessment of Educational Progress (NAEP) report (NAEP, 2000) found that 38 percent of 4th graders were unable to read and understand a paragraph from an age-appropriate children's book, a figure that rose as high as 70 percent in many school districts. Additionally, the RAND report found that international comparisons of performance on reading assessments placed U.S. 11th graders close to the bottom of all industrialized countries in reading achievement, a finding paralleling that of the *Third International Mathematics and Science Study* (Schmidt et al, 2001) for science. Further, even after significant systemic reform initiatives, there is substantial evidence of a continuing achievement gap between low-SES, at-risk students who depend on school to learn and their more advantaged peers on both basic skills and content area achievement (e.g., NAEP, 2000; Florida Department of Education, 2003; North Carolina Department of Public Instruction, 2003).

As noted in the RAND (Snow, 2002) and other national reports (e.g., National Reading Panel, 2000), there are a substantial number of research studies in the fields of reading and educational/instructional psychology relating to aspects of teaching reading comprehension (e.g., Block & Pressley, 2002; Farstrup & Samuels, 2002; Gersten et al, 2001). However, in evaluating the state of

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such research, the RAND report concluded that the resulting knowledge base is not sufficient to systemically reform reading comprehension instruction, a finding that clearly is suggestive of limitations in the scope of present research. With this in mind, this study was based on an interdisciplinary cognitive-science view of meaningful learning and understanding (e.g., Bransford et al, 2000) that serves to broaden the research perspectives relevant to the simultaneous development of student proficiency in reading comprehension and in-depth meaningful understanding of science.

The present study combined two research-based perspectives. The first research perspective has to do with conclusions regarding the effective teaching of reading comprehension offered by Snow (2002) in the RAND report. This view considers reading comprehension to encompass two complementary domains. One domain is the facilitation of student meaningful understanding (i.e., comprehension) of subject-matter content through use of comprehension strategies that enhance reading to learn. The other domain is the development of the capacity of students to access and use their prior knowledge as a framework for acquiring new knowledge independently through reading (i.e., self-reliant reading). Within this context, the RAND report and other sources (e.g., National Reading Panel, 2000; Trabasso & Bouchard, 2002; Gersten et al, 2001) note that very little research on reading comprehension at the upper elementary levels has been conducted in the authentic instructional settings in which students are engaged in in-depth meaningful learning in content areas (e.g., science). Rather, such research typically has been conducted within non-content-oriented settings emphasizing the reading of narrative text (i.e., traditional reading/language arts instruction) or using artificial experimental learning tasks.

The second research perspective has to do with the use of a knowledge-based model (see Bransford et al, 2000) to teach in-depth science through an instructional framework that integrates reading comprehension and writing within meaningful science learning in grades 3-5. A multi-year summary of this research (Romance & Vitale, 2001) found that integrating reading and writing within daily 2-hour blocks of science instruction that replaced traditional reading/ language arts instruction consistently resulted in greater achievement in both science and reading comprehension as measured by nationally-normed standardized tests. Moreover, these findings have been replicated with a variety of students, including at-risk, low SES students that depend on school to learn.

Combining these two research perspectives in the present study involved the following considerations. First, the knowledge-based instructional model applied by Romance and Vitale (2001) has successfully used science as an instructional environment for enhancing achievement in both science and reading comprehension. However, the model used by Romance and Vitale has not taken advantage of in-depth science learning as a context for incorporating the knowledge-focused reading comprehension strategies that research suggests could further amplify student achievement in content-area learning and other reading comprehension settings. Second, research investigating the use of reading comprehension strategies as reported by Snow (2002) and others at the upper elementary grades typically used traditional reading/language arts instruction as research settings. In reporting that such research has failed to demonstrate the transferability of reading comprehension skills to facilitate meaningful content area learning, Snow (2002) implicitly has raised the question of whether research investigating reading comprehension strategies in non-content-oriented settings has sufficient ecological validity to demonstrate such transfer effects.

The purpose of the present study was to integrate consensus research findings in reading comprehension (e.g., reading comprehension strategies) with those from cognitive-science which emphasize the role of knowledge in comprehension and in the development of in-depth understanding of science. The following section overviews the theoretical frameworks and relevant research findings underlying the interventions used in the study.

Cognitive Science Foundations for Meaningful Learning: Knowledge-Based Instructional Models

In outlining educational implications of their research, Romance and Vitale (2001) and Vitale and Romance (2000) noted that the distinguishing characteristic of knowledge-based instructional models is that all aspects of instruction (e.g., teaching strategies, student activities, assessment) are always related explicitly to an overall design framework representing the logical structure of the concepts (and applications) in the subject-matter discipline to be taught. In considering this characteristic as a designconstraint for learning, knowledge-based instruction is best illustrated by the original architecture of computer-based intelligent tutoring systems (ITS) developed in the early 1980's (e.g., Kearsley, 1987; Luger & Stubblefield, 1998). In these systems, an explicit representation of the knowledge to be learned provides an organizational framework for all elements of instruction, including the determination of learning sequences, the selection of teaching methods, the specific activities required of learners, and the evaluative assessment of student learning success. In considering the implications of knowledge-based instruction for education, it is important that one of the strongest areas of cognitive science methodology focuses on explicitly representing and accessing knowledge (e.g., Luger & Stubblefield, 1998; Kolodner, 1993, 1997; Sowa, 2000). Therefore, the general methodological perspectives that guide knowledge-based educational applications and research should be considered as well established.

Knowledge-Based Perspectives on Meaningful Comprehension: Considering Reading Comprehension as a Special Case

Although the role of knowledge in meaningful learning (i.e., comprehension) has received some previous notice in education (e.g., Carnine, 1991; Glaser, 1984; Hirsch, 2001; Kintsch, 1998), such attention was minimal until the recent National Research Council (NRC) publication, *How People Learn* (Bransford et al, 2000). In this book, Bransford et al offered a sound conceptual overview of the role of knowledge in meaningful learning. In equating comprehension with meaningful learning, Bransford et al emphasized consensus research comparing experts and novices in two areas of investigation. The first summarized research showing that experts display greater in-depth conceptual frameworks for organizing their knowledge that, in turn, facilitates their subsequent access and application of knowledge to better understand (i.e., to comprehend) the dynamics of the settings with which they interact. In contrast, novices commonly attend to irrelevant surface features using weak organization schemes that do not enhance their comprehension of the dynamics they face. The second area emphasized the important role of such conceptual frameworks in the form of prior knowledge in facilitating new meaningful learning (i.e., comprehension in learning tasks).

An important implication from the Bransford et al (2000) book supported by a wide variety of sources (e.g., Carnine, 1991; Glaser, 1984, Kintsch, 1998; Vitale & Romance, 2000) is that curriculum mastery is best considered a form of expertise and that student conceptual mastery of academic content should prepare them to function as experts in that discipline. In this regard, emphasizing an in-depth understanding of core concepts and concept relationships is a critical element of general comprehension and, by inference, of reading comprehension. Figure 1 illustrates a knowledge-based perspective of reading comprehension that is consistent with the broad idea of meaningful comprehension presented by Bransford et al (2000). Figure 1 suggests that the nature of comprehension in general learning and in reading comprehension settings are equivalent, with the exception that the specific learning experiences associated with reading comprehension are highly text-dependent.

With this equivalence in mind, Figure 1 outlines three scenarios for reading comprehension. In *Scenario One*, what the student learns is an elaboration of prior knowledge, so the new knowledge is assimilated. In *Scenario One*, which represents reading expertise based on domain-specific knowledge, no comprehension strategies are required. Comprehension as the assimilation of knowledge does imply a core conceptual framework (see Figure 1). In *Scenario Two*, the existing framework of the reader's prior knowledge is not adequate to assimilate new knowledge, so the reader must identify the new content to be understood, meaningfully organize it in a form that encompasses prior knowledge, and, then, meaningfully integrate prior and new knowledge (an accommodation process). Thus, *Scenario Two* does require metacognitive strategies that, in the present study, are addressed as a coordinated three-part knowledge-focused, *Reading Comprehension Strategy* (i.e., a *text comprehension sub-strategy*, a *propositional concept mapping sub-strategy*, a *summarization writing sub-strategy*). Finally, in *Scenario Three*, the reader determines that the content of the text source material is not sufficient for meaningful understanding. Thus, in *Scenario Three*, the reader must apply heuristic strategies to obtain the additional knowledge needed, and then proceed according to *Scenario Two*. In *Scenario Three*, having prior experience in addressing such informational deficiencies (and having access to supplementary sources) is a logical requirement. Considered together, *Scenario Three* is transformed into *Scenario Two* by obtaining additional information; and *Scenario Two* is transformed into *Scenario One* through the application of reading comprehension strategies that create a new organizational framework for assimilating the new knowledge to be understood with the old.

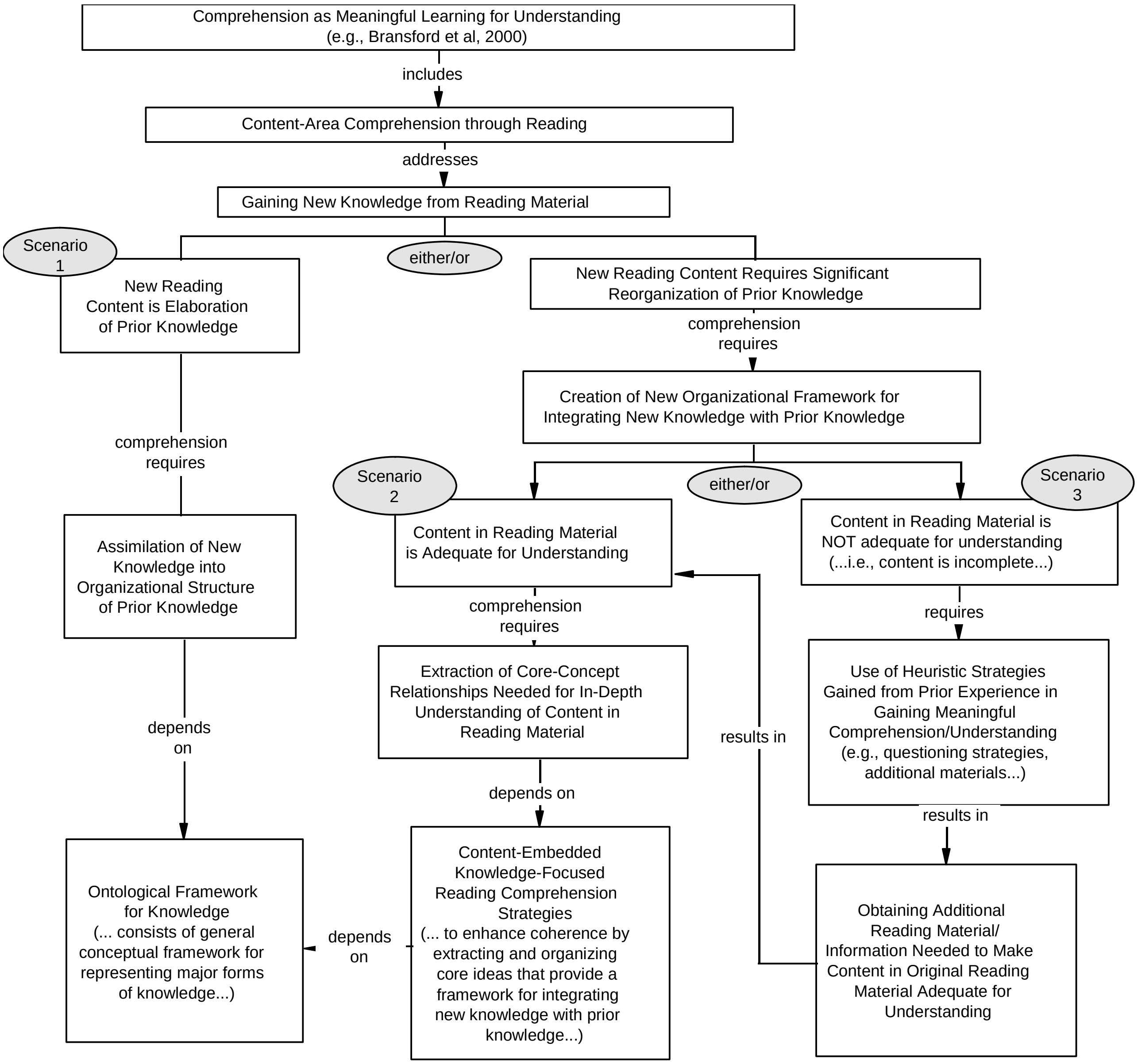

Figure 1.
A knowledge-based perspective considering reading comprehension as subset of meaningful understanding.
Scenarios 1, 2, and 3 identify different contexts for reading comprehension

As a group, these three scenarios reflect a form of reading comprehension proficiency that is characteristic of expert readers. As Figure 1 suggests, training students on reading comprehension strategies in a fashion that does not embed them in content-reading applications that require meaningful learning raises the issue of ecological validity and their subsequent transferability to authentic content-area reading comprehension settings (see Niedelman, 1992). In this regard, summaries of research (e.g., Snow, 2002; Trabasso & Bouchard, 2002) have reported that demonstrations of the transfer of reading comprehension strategies from the specific instructional conditions in which they are learned to other applied settings have met with very limited success.

Dynamics of Developing Skill-Based Proficiency: A Knowledge-Based Perspective

Related to the preceding is general work in cognitive science by Anderson and others (e.g. Anderson, 1992, 1993, 1996; Anderson & Fincham, 1994). This work distinguishes the “strong” problem solving processes of experts that are highly knowledge-based and automatic from the “weak” strategies novices with minimal knowledge exhibit that may range from heuristics to trial-and-error search. Within the context of reading comprehension in the present study, the prior (content) knowledge that students bring to reading tasks can be considered to result in strong knowledge-based problem solving; while reading comprehension strategies can be considered to serve as weak problem-solving strategies (i.e., as heuristic tools) that, when well-developed, can eventually become automatic. Both these processes, presumably, operate in a complementary fashion at a level of automaticity for expert readers in both general comprehension and reading comprehension learning tasks. As Anderson and others have shown, reading comprehension strategies as cognitive skills require extensive amounts of varied practice to reach the degree of automaticity that is characteristic of expert performance in any discipline.

In related work, both Niedelman (1992) and Anderson et al (e.g., Anderson, 1996) have offered interpretations of research issues relating to transfer of learning that are consistent with a knowledge-based approach to learning and understanding and are directly applicable to reading comprehension. In fact such work on transfer of learning is of major importance in understanding the potentially differential effects of having students learn to apply reading comprehension strategies when they are embedded within (i.e., operate on) a cumulative content-domain (science) as opposed to when the strategies are learned in non-content domains that are different from content-oriented contexts in which they are to be used.

These research perspectives in conjunction with Figure 1 also logically suggest that variability in reading comprehension proficiency can be considered to reflect one or more of the following three dynamics operating in a complementary fashion: (a) the development of domain-specific prior knowledge, (b) the development of reading comprehension strategies (as heuristic tools), and/or (c) the development of heuristic strategies for obtaining additional sources information. These dynamics operate automatically for expert readers (i.e., self-reliant readers) in different contexts. Importantly, each of these three key dynamics is amenable to instruction.

Science IDEAS as a Knowledge-Based Instructional Model for Meaningful Science Learning and Reading Comprehension

Science IDEAS is a research-based, cognitive-science-oriented instructional intervention that was initially validated within a grade 3-5 upper elementary setting (Romance & Vitale, 1992). *Science IDEAS* is an integrated instructional model (i.e., combining science, reading, and writing) implemented through a daily 2-hour time block which replaces regular reading/language arts instruction. Multi-day science lessons in *Science IDEAS* engage students in a variety of instructional activities (e.g., hands-on science experiments, reading text/trade/internet science materials, writing about science, journaling, propositional concept mapping as a knowledge representation tool), all of which focus on enhancing science conceptual understanding. As an instructional intervention implemented within a broad inquiry-oriented framework (e.g., all aspects of teaching and learning emphasize learning more about what has been learned from text and non-text modalities), teachers use the core science concepts and relationships (which students master to develop in-depth science understanding) as curricular guidelines for identifying, organizing, and sequencing all instructional activities. From a curriculum integration standpoint, as students engage in science-based reading activities, teachers guide and support reading comprehension in an authentic fashion.

As a simplified illustration of how *Science IDEAS* functions as a strong knowledge-based instructional model, Figure 2 shows how a propositional concept map (see Romance & Vitale, 2001) representing the concept of evaporation serves as a knowledge-based framework for organizing and sequencing complementary instructional activities. Within the knowledge-based curricular framework representing evaporation, teachers identify additional reading, hands-on projects, and/or writing activities to expand student in-depth science knowledge.

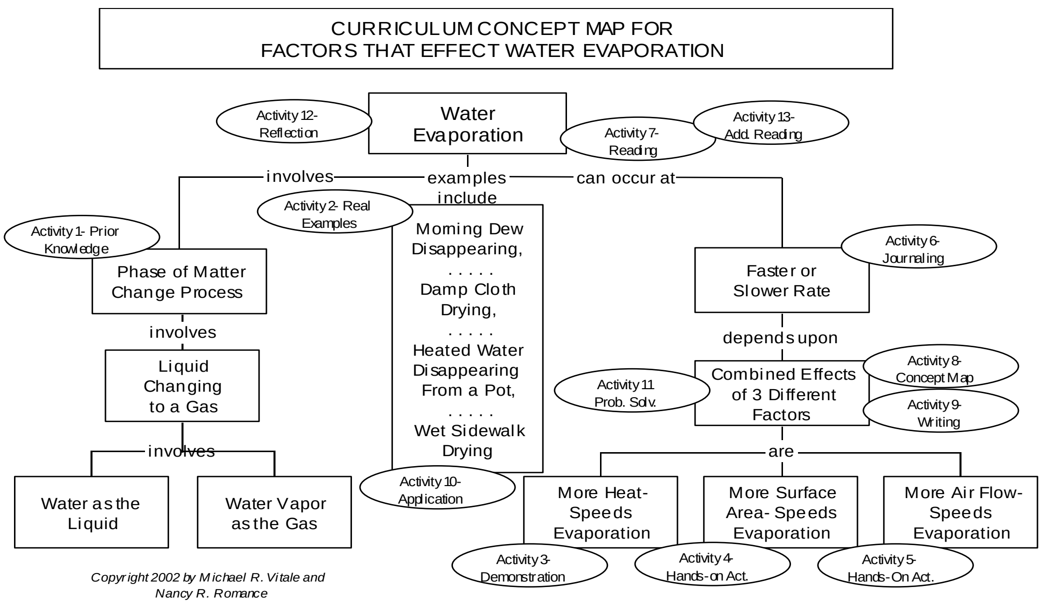

Figure 2. Simplified illustration of a propositional curriculum concept map used as a guide by grade 4 *Science IDEAS* teachers to plan a sequence of knowledge-based instructional activities

Research Results of the Effect of Science IDEAS as a Knowledge-Based Model for In-Depth Comprehension

The foundational elements of the *Science IDEAS* intervention are well established. These elements consider curricular mastery as equivalent to knowledge-based expertise and the development of prior knowledge as the most critical determinant of success in meaningful learning across all varieties of instructional tasks, including reading comprehension. The empirical results of the initial research investigation implemented in grade 4 classrooms reported by Romance and Vitale (1992) were very positive (e.g., the study was recognized with national awards from the *National Association for Research in Science Teaching*). In comparison to demographically similar controls, *Science IDEAS* instruction not only resulted in significantly higher levels of student achievement on nationally-normed tests in science (adj. mean difference in MAT science = .95 GE); but also on reading comprehension (adj. mean difference in ITBS reading comprehension = .32 GE). In addition, *Science IDEAS* students displayed significantly more positive attitudes toward science learning, more positive self-confidence in learning science, and more positive attitudes toward reading.

Using the initial findings as a foundation, the *Science IDEAS* intervention subsequently was extended to a greater number of classrooms across grades 3-5 which included ethnically diverse student populations and a range of academic levels from above average to severely at-risk. As summarized in Figure 3 (see Romance & Vitale, 2001), the expansion of the *Science IDEAS* intervention during that time period to over 50 teachers and over 1200 students revealed a similar and consistent pattern of findings in terms of the magnitude of positive effects in both science learning *and* reading comprehension (along with similar affective outcomes). In addition, the year 4 study addressed an important equity issue by showing that the differences in rate of achievement growth and affective outcomes in favor of the *Science IDEAS* participants were related only to program participation and not to student demographic characteristics (e.g., at-risk, gender, race).

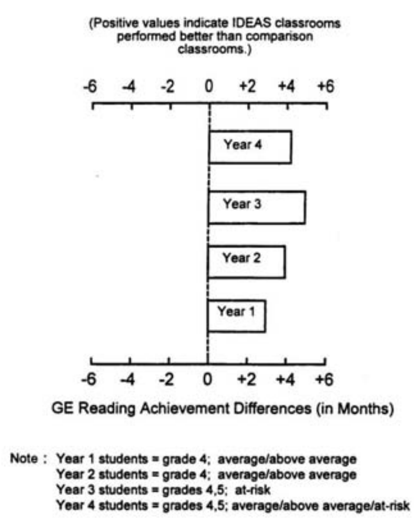

Figure 3. Summary of adjusted mean difference scores in grade-equivalent years showing higher reading achievement of IDEAS vs. comparison classrooms on ITBS-Reading (years 1, 2, 3) and SAT-Reading (year 4).

However, the finding most important to the present study is not that *Science IDEAS* students displayed consistently higher achievement in science. Rather, it is that a knowledge-based, conceptually-oriented intervention that did not explicitly emphasize reading instruction obtained better results in reading comprehension than an alternative (basal) reading curriculum specifically used to teach reading comprehension.

Science IDEAS and Reading Comprehension: Interpreting the Knowledge-Based Transfer of Reading Comprehension Proficiency

The important research finding (Romance & Vitale, 2001) that *Science IDEAS* had a consistently positive effect on student reading comprehension requires further interpretation. First, because the specific (mostly non-science) content of the reading materials used in the nationally-normed reading comprehension tests (ITBS, SAT) was different than the specific science content students learned about and read about in their classrooms, the positive effects of *Science IDEAS* on reading comprehension clearly represented a general transfer of learning outcome in reading comprehension (see Niedelman, 1992). Second, *Science IDEAS* teachers did not explicitly instruct students on reading comprehension strategies that research has recognized as important in content area reading comprehension (e.g., Trabasso & Bouchard, 2002, Gersten et al, 2001).

One possible interpretation of the consistent transfer effects from *Science IDEAS* to reading comprehension is knowledge-based in perspective and follows points made by Bransford et al (2000) that emphasize the importance of the development of prior knowledge in meaningful learning and the work of Kolodner and her colleagues (e.g., Kolodner, 1993, 1997) on case-based knowledge representation and reasoning. More directly relevant, however, are the factors relating to the development of expertise summarized by Bransford et al and Anderson (1996) and the general ontological functions of knowledge representation offered by Sowa (2000).

From a knowledge-based perspective, this working view is that the progressive experiences in gaining cumulative in-depth science understanding within *Science IDEAS* resulted in the developmental refinement of a general framework (see Vitale & Medland, 2002) of fundamental core concepts and concept relationships within which additional knowledge could first be assimilated and then used as an organizational framework that results in a form of expertise-based new learning. As noted earlier, within a knowledge-based framework, Sowa's (2000) analysis of the ontological functions of knowledge representation and the complementary work of both Anderson (1996) and Sidman (1994, 2002) emphasize the importance of extensive and varied practice in the development of concepts and concept relationships. One possible working hypothesis is that students in *Science IDEAS* refine (at some level of automaticity) their basic conceptual proficiency in a fashion that facilitates their representation, assimilation, and access of information as a form of expertise. Such expertise facilitates students acquiring, organizing, and thinking about new information that is embedded in reading comprehension tests, even if their domain-specific prior knowledge is minimal. From this general constructivist perspective (Mintzes et al, 1998), it is reasonable that students with such conceptual experience and expertise would be far better prepared to assimilate new information through reading and then be able to access and think about such information in answering questions about it.

Research in Reading and Educational Psychology Focusing on Reading Comprehension that Complements the Cognitive Science Literature

There is also a substantial body of literature in the area of reading comprehension that supports the present study. In a comprehensive summary of text comprehension strategy instruction, Trabasso and Bouchard (2002) examined 205 empirically-based studies of 12 distinct cognitive strategies for improving reading comprehension (e.g., comprehension monitoring, graphic organizers, prior knowledge, question generation, story structure, summarization, vocabulary instruction) that were conducted from 1980 through the present. In their conclusions, they emphasized the importance of episodic content knowledge as a basis for reader-constructed deeper understanding, the related use of graphically-oriented story mapping (see also Williams, 2002) as a basis for guiding student explication of narrative understanding, and the related role of student summarization involving identification and organization of core concepts and themes in material that is read.

Among the most important finding reported by Trabasso and Bouchard (2002) was that the use of multiple strategy instruction taught through dialogue-rich teacher modeling/guidance was a powerful approach for improving student reading proficiency. In identifying directions for future research, they emphasized the importance of conducting *Reading Comprehension Strategy* research in content area instruction and in focusing on the issue of enhancing the transferability of reading comprehension strategies. In a complementary review, Gersten et al (2001) reported similar conclusions (see also Farstrup & Samuels, 2002).

In another review focusing on children's searching and using informational text, Dreher (2002) stressed the importance of substantially expanding the instructional experiences of upper elementary students with informational (content-oriented) text. Similar concerns relating to the need to emphasize informational text at the elementary levels have been presented by Ogle and Blachowicz (2002). In a review of research designed to improve the comprehension of expository text, Pearson and Fielding (1995) found that organizational enhancements such as summarizing text structure (e.g., hierarchical elaboration summaries, visual organizers) were powerful in facilitating overall comprehension and learning. Finally, within a context of discourse analysis, Weaver and Kintsch (1995) noted the importance of the structure of domain specific prior knowledge in affecting how text is understood and remembered in general, and how the interactive nature of domain specific knowledge impacts the effectiveness of reading comprehension strategies in particular (see also Perkins & Grotzer, 1997)

Although referenced in the reviews cited above, the extensive multidisciplinary work by Guthrie and his colleagues (e.g., Guthrie, Anderson et al, 1997; Guthrie, Cox et al, 1998; Guthrie & Ozgundor, 2002) is important to recognize. This work has shown repeatedly that engaging upper elementary students with content-oriented reading materials (e.g., science, social studies) has a significant effect on both reading proficiency and student motivation to engage in reading. In this regard, Armbruster and Osborn (2001) summarized research findings demonstrating positive student achievement in reading comprehension resulting from integrating science content with reading/language arts. Finally, other sources (Beane, 1995; Ellis, 2001; Hirsch, 1996; Schug & Cross, 1998; Yore, 2000) discussed issues and findings that support interventions in which core curriculum content is used as a framework for embedding reading comprehension.

Research Questions

Within the preceding context, the study investigated the instructional effectiveness of incorporating a research-based, knowledge-focused, three-part *Reading Comprehension Strategy* (a *text-comprehension sub-strategy*, a *propositional concept mapping sub-strategy*, a *summarization writing sub-strategy*) in conjunction with a semantic fluency component within two alternative but parallel instructional environments: (a) a content-oriented science environment (Science IDAS) in which 2-hour daily lessons integrate in-depth science, reading comprehension and writing, and (b) a non-content-oriented environment (traditional reading/language arts) in which 2-hour daily reading/language instruction emphasizes narrative (i.e., non-content) text.

The major research questions addressed by the overall study design were as follows:

- *Did the integrated science and traditional reading/language arts instructional settings result in differential achievement in reading comprehension and science or in affective outcomes?* This question investigated the main effect of type of instructional setting (i.e., integrated science vs. traditional reading/language arts) on achievement, attitude, and self-confidence.
- *Did the use of the research-based, knowledge-focused, three-part Reading Comprehension Strategy (and semantic fluency component) result in greater overall achievement in reading comprehension and science or more positive affective outcomes?*
  This question investigated the main effect of incorporating the use of knowledge-focused, three-part *Reading Comprehension Strategy* into instruction (vs. not using the strategies) on achievement, attitude, and self-confidence.

- *Did the effect of the research-based reading comprehension strategies upon student achievement in reading comprehension and science or affective outcomes depend upon whether they were incorporated with the integrated science or the traditional reading/language arts instructional environments?*
  This question investigated the interaction of type of instruction with use of reading comprehension strategies on achievement, attitude, or self-confidence (i.e., the presence of an interaction would mean that the effect of using reading comprehension strategies depended upon the type of instructional setting within which their use was incorporated).

Method

Participants

The study was implemented on a schoolwide basis in grade five in a total of six elementary schools with a total of 642 students in a large (175,000 students), highly diverse (African American: 29%, Hispanic: 19%, Other: 5%, Free Lunch: 40%) school system in southeastern Florida. Table 1 shows the demographic characteristics of the six participating schools that were used to assign the four different treatment combinations through a stratified random assignment process (described in the following Design section). As Table 1 shows, three schools received the experimental multi-part reading comprehension treatment implemented in grade 5 in either traditional reading/language arts or science-oriented contexts. Two schools received the experimental treatment within a science-oriented context and one within a traditional reading/language arts context (one traditional experimental school withdrew from the study too late to be replaced).

Table 1. *Demographic Characteristics of Participating Schools*

School	N Tch.	N Stud.	Rd. Comp.St	Inst. .Environ.	PCT FRL	PCT Male	PCT ESE	PCT White	PCT Af.Am.	PCT Hisp.
A	4	102	E	TRD	62	55	23	51	24	25
B	5	81	E	SCI	8	54	34	86	3	11
C	2	57	E	SCI	39	42	17	60	30	10
D	4	102	C	TRD	56	44	17	58	22	21
E	6	139	C	SCI	40	53	9	34	42	24
F	6	161	C	SCI	19	53	18	82	6	12

Note- FRL = Free/Reduced Lunch eligible, ESE = Identified as exceptional student (LD, ADD, ADHD).

Instrumentation

Student reading comprehension and science achievement were assessed on a pre- and post-test basis. Pre-tests were part of the State-administered Florida Comprehensive Assessment Test Battery in Reading (*Stanford Achievement Test- Reading Comprehension [SAT-RD]*) and science (*Sunshine State Standards- Science Assessment Test [SSS-SCI]*) administered prior to the start of the study in mid-March, 2004, and served as covariates for statistical controls in data analysis. Post-tests were nationally-normed reading *(Iowa Tests of Basic Skills Reading Comprehension- Level 11 [ITBS-RD]*) and science (*ITBS Science- Level 11 [ITBS-SCI]*) administered at the end of the study, in mid-May, 2004, and served as criterion measures for student achievement. In addition, as a measure of affective learning outcomes, the study also administered as a post-test a criterion-referenced self-report scale for student attitude toward and self-confidence (e.g., self efficacy) in reading and science (*School Science Appraisal Inventory* [SSAI]) developed by Vitale (1980). Both the reliability and validity of this affective assessment system have been established in a variety of experimental (Kaniuka, 1998; Romance & Vitale, 1992, 2001; Woodul et al, 2000) and non-experimental contexts (see Vitale, 1980).

Experimental Interventions

As shown in Figure 4, the experimental interventions in the study consisted of two components. The first was the experimental learning environments (traditional reading/language arts, science-focused) and the second, the multi-part reading comprehension enhancement strategies used within these two settings. This section describes each of these components.

Content-oriented vs. non-content-oriented learning environments. As described previously, *Science IDEAS* (Romance & Vitale, 2001) served as the content-oriented intervention (SCI) and the district-adopted Scott-Foresman Reading/Language Arts Series (Scott-Foresman, 2002) as the non-content-based intervention (TRD). Both were implemented using a daily 2-hour time block that participating schools allocated to reading/language arts or to *Science IDEAS.* In *Science IDEAS* classrooms, integrated in-depth science instruction was used as an instructional context for informational reading and writing. In the Scott-Foresman Series, narrative reading consisting of different literary genres were used as a context for teaching reading skills (e.g., main idea, sequencing, cause-effect, authors purpose) and writing. A content analysis of the Scott-Foresman series in grade 3-4-5 (Romance et al, 2003) found that virtually all (96%) of the reading and writing skills taught in the Scott-Foresman series could be addressed validly in *Science IDEAS*, with the exception of a small number of literature-specific skills.

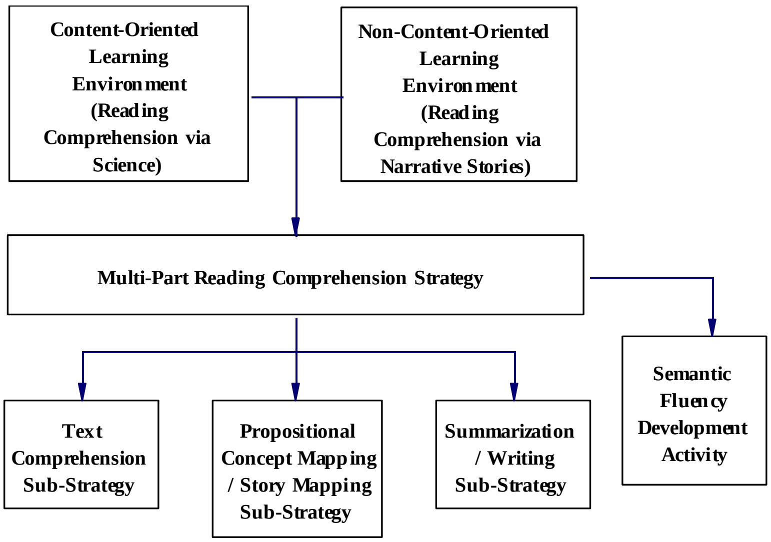

Figure 4. Elements of the two-factor experimental intervention in the present study (Type of Instructional Environment, Use of Multi-Part Reading Comprehension Strategy

Consistent with present school practice, participating *Science IDEAS* schools allocated a limited amount of additional time (approximately ½ hour/day) to address literary content, while Scott-Foresman schools allocated an equal amount of additional time on a weekly basis to teach science. In general, both sets of teachers received initial and continuing support for implementing the two instructional environments (SCI, TRD) in the study, with *Science IDEAS* classrooms being supported by a NSF-funded project and reading/language arts supported by district- and school-based professional development.

Knowledge-focused Reading Comprehension Strategy (with semantic fluency component). The general *knowledge-focused Reading Comprehension Strategy* used in the study was implemented as a three-part procedure consisting of (a) a *text comprehension sub-strategy*, (b) a *propositional concept mapping (or story mapping) sub-strategy*, and (c) a *summarization writing sub-strategy*, all of which have a strong research base (see Dreher, 2002; Snow, 2002; Trabasso & Bouchard, 2002). Each of these procedures were modeled and/or guided for students by teachers until students were able to engage in each sub-strategy procedure. All three sub-strategies were equally applicable to informational and narrative text material and reflect key characteristics of expert readers (e.g., see Figure 1).

In using the *text comprehension sub-strategy*, teachers first introduced a reading selection by accessing student prior curricular or personal knowledge on the topic. Next, teachers selected a student to read the initial paragraph on a sentence by sentence (or set of sentences) basis. As a student read each sentence (or a set of sentences), teachers asked the class to explain the meaning of the sentences read and to relate that meaning to previously read passages, previously taught curricular content, and/or personal prior knowledge, as appropriate. At the completion of a paragraph, teachers queried students on the overall meaning of the paragraph in a similar fashion and guided their recall of previously identified or new prior knowledge linkages to the text read. In implementing the strategy, teachers addressed illustrations, tables, or graphs relevant to the text, in the same manner as sentences (or sets of sentences). The process was again repeated with other students for all subsequent paragraphs (with the emphasis on prior knowledge being broadened to emphasize all previously read material) until the passage was completed. Finally, teachers again selected new student readers and repeated the entire process through re-reading until satisfied that the class understood the passage in a meaningful fashion.

In using the *propositional concept mapping sub-strategy*, teachers used the *text comprehension sub-strategy* as an operational framework for soliciting core ideas in the reading passage from students. In the science-focused (SCI) environments, teachers guided (or modeled) student organization of the concepts in a hierarchical fashion using post-it notes. Once obtained, teachers guided (or modeled) the process of linking the concepts together so that concept(s) - link - concept(s) elements formed sentences (see Figure 2 for an example of a propositional concept map on evaporation). Once constructed, teachers then selected individual students to read and re-read "through" the concept map. Finally, within the context of the reading and re-reading process, the concept map was edited as necessary. For use in the traditional reading/language arts environments, the propositional concept mapping procedure was adapted into a story mapping format which specified the major elements of story construction (e.g., title, plot (time, setting, event-sequences, conflict/resolution), characters, genre) as an initial graphical framework for students.

In the *summarization writing sub-strategy,* teachers used the *propositional concept mapping sub-strategy* (or the story mapping variation) as an organizational framework for writing. For example, within a science environment, referring to Figure 2, writing might begin with "*Water evaporation involves phases of matter.... Examples of water evaporation include... Water evaporation can occur at a faster or slower rate...*"). Within a narrative environment, students used their story maps as a guide for analyzing the story construction and/or summarizing the story content in a parallel fashion.

In the study, teachers were required to use the three-part *knowledge-focused Reading Comprehension Strategy* (i.e., *text comprehension, propositional concept mapping* (or story mapping variation), *summarization writing*) once each week. For teachers using in-depth science as an instructional environment, their use of the multi-part *knowledge-focused Reading Comprehension Strategy* was embedded within conceptually-oriented content instruction. For teachers using traditional reading/language arts, their use of the use of the multi-part *knowledge-focused Reading Comprehension Strategy* was embedded within narrative reading selections that were non-content-oriented.

As a complement to the three-part *knowledge-focused Reading Comprehension Strategy*, student semantic fluency development was addressed through daily 5-minute teacher-led informal (but highly structured) oral activities (see Vitale & Medland, in press) designed to enhance students linguistic/semantic fluency to integrate 11 basic types of knowledge: (1) *What something is named,* (2) *What something does,* (3) *Where something is,* (4) *When something happens,* (5) *What parts something has,* (6) *What feature/characteristics something has,* (7) *How something changes,* (8) *Why something happens,* (9) *What kinds of things something can be (i.e., hierarchical class/subclass relationships),* (10) *What steps something follows,* and (11) *How many of something there are.* This ontological component addressed an important element of reading comprehension that logically provides a foundation for general knowledge representation and assimilation (see Sowa, 2000). Initially students presented examples from their own experiences of knowledge types modeled by teachers (e.g., examples of an object *"boy"*, action *"running"*, or how something changed *"falling down…"*) and then, as students progressed, they combined self-generated knowledge type examples in increasingly complex linguistic fashion (e.g., presenting an example of an object, how it changed, and why it changed: *"the tree fell down because it was hit by lightning…"*).

Teachers use of the both the *knowledge-focused Reading Comprehension Strategy* and the semantic fluency development activity was initiated through initial 3-day professional development sessions (one for science-based and one for traditional reading/language arts) and supported through regular visits to school/classroom settings by the researchers during which fidelity of implementation was monitored on a continuing clinical basis.

Design, Analysis, and Procedure

The study design followed a 2 x 2 ANCOVA with multivariate outcome measures (e.g., *ITBS-Reading*, *ITBS Science*, *SSAI* attitude/self-confidence post-tests). Factor 1 consisted of *Instructional Environment* (content-oriented integrated science (SCI) vs. non-content-oriented traditional reading/language arts (TRD). Factor 2 consisted of use vs. non-use of the knowledge-focused *Reading Comprehension Strategy* (and semantic fluency component). Using a general linear models approach, the achievement and affective outcome post-test measures were used analyzed separately. In both analyses, student characteristics (ethnicity, general, exceptional student status, free/reduced lunch) and prior achievement (via the FCAT reading comprehension and science pre-tests) were used as covariates. The experimental intervention was implemented over an 8-week period, from mid-March through mid-May.

A stratified randomized sampling procedure was used to assign schools to each of the four possible treatment combinations. A completely randomized design was not possible because only four schools in the district had reached full-implementation of the *Science IDEAS* integrated science/reading model. As a result, the study first grouped these four *Science IDEAS* schools into two demographically similar pairs (reflecting medium or low free/reduced lunch, school ethnicity patterns) and then randomly designated one pair member as an experimental or control school. Next, the researchers identified a pool of traditional reading/language arts schools within the district that were demographically comparable to the high- and low-free/reduced lunch *Science IDEAS* schools and followed a randomized sequence to invite them to participate as experimental or control schools.

The FCAT achievement data used as covariates were obtained in electronic form through the district's data processing department, merged with the student post-test data on a database for analysis via SYSTAT's general linear model module.

Results

Descriptive Statistics. Table 2 shows the pre- and post-test results for the participating schools. As Table 2 shows, as a group the grade 5 students receiving the experimental *Reading Comprehension Strategy* performed similarly to the controls on the FCAT SAT Reading and FCAT Science pre-measures (unweighted mean pre-test differences between experimental and control schools = 4.0 in reading and 6.7 in science), though the school selection process only considered schoolwide demographic factors (i.e., FRL and student ethnicity). With respect to science-oriented and traditional schools, the unweighted mean differences were 30.6 and 34.8 for SAT Reading and FCAT Science, respectively. The difference in reading was due to the withdrawal of a higher achieving school just prior to the initiation of the study (too late to be replaced). However, such differences in reading were controlled statistically through the linear analysis methodology used. In the same sense, the pre-test difference in science achievement (which was less than 1 SD) was considered statistically controllable as well.

Table 2. *Means and Standard Deviations of Grade 5 Student in Participating Schools on Pre- and Post-Measures*

School	N	Rd.	Inst.	SAT RD		FCAT SCI		ITBS RD		ITBS SCI	
	Stud.	Comp.St	Environ.	M	SD	M	SD	M	SD	M	SD
A	102	E	TRD	45.1	25.6	278	61	5.6	2.1	6.1	2.6
B	81	E	SCI	75.7	20.5	327	45	8.4	2.4	9.0	2.6
C	57	E	SCI	59.4	24.8	325	66	7.4	2.5	8.4	3.1
D	102	C	TRD	51.7	26.2	289	53	6.2	2.0	6.7	2.7
E	139	C	SCI	55.3	25.6	304	55	6.8	2.2	7.6	2.7
F	161	C	SCI	61.1	23.4	317	47	7.0	2.1	8.1	2.5
Total N	646										

Note- Tests and scale scores are: SAT RD = FCAT Stanford Achievement Reading Comprehension (percentile ranks, FCAT SCI = Florida Sunshine State Standards Science (scale scores), ITBS RD - Iowa Tests of Basic Skills Reading Comprehension (grade equivalents), ITBS SCI = Iowa Tests of Basic Skills Science (grade equivalents).

Analysis of Achievement Outcomes in Reading and Science. Table 3 summarizes the results of the multivariate covariance analysis implemented through a general linear models approach for reading and science achievement. As Table 3 shows, the main effect for traditional (TRD) vs. science-oriented (SCI) instructional environment was significant, with the *Science IDEAS* classrooms performing significantly higher in both reading and science (Adj. Mean Diff. = .38 GE for ITBS Reading and .38 GE for ITBS Science). Although the main effect for use of the multi-part *Reading Comprehension Strategy* was not significant overall, a significant interaction between use of the *Reading Comprehension Strategy* and instructional environment was found. Follow-up simple effects analysis found that *Reading Comprehension Strategy* use did significantly improve achievement for both ITBS Reading (F (1,557) = 7.29, p < .01, Adj. Mean Diff. = .53 GE) and ITBS Science (F (1,557) = 4.84, p < .05, Adj. Mean Diff. = .17 GE) for the science-oriented (*Science IDEAS*) students. However, use of the *Reading Comprehension Strategy* was not significant for either ITBS Reading or Science for students in the traditional reading/language arts environments which emphasized narrative reading.

Table 3. *Results of Multivariate Covariance Analysis of Achievement Outcomes for Reading and Science*

Model Component	Multivariate F Approx.(df)	ITBS Reading F(df)	ITBS Science F(df)
Exp. Effects			
Rd. Strategy (RS)	F(2,556) = .38	F(1,557) = .55	F(1,557) = .02
Trd. vs. Sci. Env. (TSE)	F(2,556) = 4.46 *	F(1,557) = 7.29 **	F(1,557) = 4.84 *
RS X TSE	F(2,556) =53.40**	F(1,557) = 85.70 **	F(1,557) = 59.75 **
Pre-Test Covariates			
SAT-Reading	F(2,556) =70.88**	F(1,557) = 91.18 **	F(1,557) =103.51**
FCAT-Science	F(2,556) = 8.06 **	F(1,557) = 9.69 **	F(1,557) = 1.44
Student Charact. Covariates			
Sex	F(2,556) = .74	F(1,557) = 1.47	F(1,557) = .12
FRL	F(2,556) = 2.30	F(1,557) = 4.38 *	F(1,557) = .12
ESE	F(2,556) = 3.85 *	F(1,557) = .00	F(1,557) = 6.58 *
Race	F(2,1112) =2.81*	F(2,557) = 5.53 *	F(2,557) = 1.07
White vs. Non-White	F(2,556) = .46	F(1,557) = .65	F(1,557) = .61
Af.Am. vs. Hispanic	F(2,556) = 5.20 **	F(1,557) = 10.42 **	F(1,557) = 1.53

Note- F approximations for multivariate tests are based on Wilk's Lamda. * p < .05, ** = p < .01.

Other results shown in Table 3 found the effect of the pre-test covariate SAT Reading significant for both ITBS Reading and Science; however the effect of FCAT Science was a significant predictor only of ITBS Reading but not of ITBS Science. One possible explanation of this finding is that inspection of science test items, in general, suggests a substantial confounding of general reading ability with science content knowledge (e.g., nature of science logical emphases vs. a science knowledge emphasis). In addition to ESE status being negatively related to ITBS science achievement (but not to reading achievement), a significant effect on ITBS Reading achievement was also found due to race. In analyzing the individual degree of freedom comparisons shown in Table 3, these findings suggest a significant adjusted achievement difference in favor of White/Hispanic students vs. African American students for ITBS Reading Achievement. However, the exception of the pre-test covariates, all of the other effects were small.

Analysis of Affective Achievement Outcomes. Table 4 summarizes the results of the multivariate covariance analysis implemented through a general linear models approach for student attitude and self-confidence in reading and science. As Table 4 shows, the multivariate tests found both main effects (*Reading Comprehension Strategy*, traditional vs. science-oriented environment) and their interaction significant. In inspecting the univariate analyses, use of the *Reading Comprehension Strategy* resulted in greater overall positive attitudes toward and self-confidence in reading, the traditional reading/language arts environment resulted in greater self confidence in reading, and the science-oriented environment in greater more positive attitude toward science. Follow-up simple effects analysis for the traditional reading/language arts groups found that *Reading Comprehension Strategy* use resulted in more positive attitudes toward both reading (F (1,572) = 14.46, p < .001) and science (F (1,5752) = 5.11, p < .05). In addition, for the traditional reading/language arts group, *Reading Comprehension Strategy* use also had a significant positive effect on self-confidence in reading (F (1,572) = 11.43, p < .01), but not on self-confidence in science. In comparison, follow-up simple effects analysis for the science-oriented (*Science IDEAS*) group found that *Reading Comprehension Strategy* use had no significant effect on either attitude or self-confidence in reading or science.

Table 4. *Results of Multivariate Covariance Analysis of Affective Outcomes for Attitude and Self-Confidence in Reading and Science*

Model Component	Multivariate F Approx.(df)	Reading F(df)	Reading Att.	Reading SC	Science F(df)	Science Att.	Science SC
Exp. Effects							
Rd. Strategy (RS)	F(6,567) = 4.55 **	F(1,572)=	11.63 **	13.16 **	F(1,572)=	1.11	1.77
Trd. vs. Sci. Env. (TSE)	F(6,567) = 4.48 **	F(1,572)=	.26	5.80 *	F(1,572)=	9.21 **	3.06
RS X TSE	F(6,567) = 3.00 **	F(1,572)=	7.46 **	3.37	F(1,572)=	6.75 *	.14
Pre-Test Covariates							
SAT-Reading	F(6,567) = 7.98 **	F(1,572)=	.47	33.50 **	F(1,572)=	2.19	2.61
FCAT Science	F(6,567) = 3.90 **	F(1,572)=	.30	.06	F(1,572)=	8.89 **	15.25 **
Student Charact. Covariates							
Sex	F(6,567) = 5.76 **	F(1,572)=	12.14 **	5.45 *	F(1,572)=	.33	2.84
FRL	F(6,567) = .47	F(1,572)=	.00	.62	F(1,572)=	.00	1.25
ESE	F(6,567) = 1.76	F(1,572)=	1.45	5.72 *	F(1,572)=	.17	.07
Race	F(12,1134)=1.76	F(2,572)=	1.50	1.51	F(2,572)=	3.45 *	.38
White vs. Non-White	F(6,567) = 1.00	F(1,572)=	1.74	.01	F(1,572)=	.00	.64
Af.Am. vs. Hispanic	F(6,567) = 2.52	F(1,572)=	1.26	3.01	F(1,572)=	6.88 **	.12

Note- F approximations for multivariate tests are based on Wilk's Lamda. * p < .05, ** = p < .01.

Other results shown in Table 4 found the effect of the pre-test covariates, SAT Reading and FCAT Science, significant predictors of reading attitude and science self-confidence, respectively, with sex significantly related to both reading attitude and self-confidence (females were more positive). Finally, ESE status was significantly negatively related to reading self-confidence and Hispanic students were found to have greater self-confidence in science than either White or African American students.

Discussion and Recommendations

The results of this study provide a significant replication and extension of a series of studies involving the *Science IDEAS* model previously reported by Romance & Vitale (2001). One of the two major findings in the present study was that a content-oriented science environment resulted in higher achievement in both reading and science, an outcome paralleling those reported by Romance and Vitale (2001). The results of the study are also consistent with series of studies by other researchers (e.g., Guthrie et al, 2004; Guthrie & Ozgundor, 2002; Klentschy et al, 2004). Together, this pattern of research is suggestive that the development of student reading comprehension is strengthened substantially when the materials students read are embedded within a broader comprehension framework that requires an ongoing acquisition, organization, and access of conceptual knowledge. In turn, this interpretation also is consistent with the emerging recognition of the importance of the use of expository/informational text at the elementary levels (e.g., Duke et al, 2003; Duke & Pearson, 2002; Pearson & Duke, 2002; Vitale et al, 2005). In a complementary vein, Walsh (2003) reported that none of current basal reading series in grades

K-1 can engender meaningful knowledge development because they do not contain such knowledge by design, a finding paralleled by a comprehensive content analysis of two leading basal reading series for grades 3-5 completed by Romance et al (2003). Moreover, rather than committing the substantial instructional time required to build meaningful knowledge at the primary levels, students are passed to upper elementary grades and beyond which, in turn, exacerbate the problem by replacing content area instruction such as science with instruction in non-content-oriented reading (see Jones et al, 1999).

The second of the two major findings in the present study was that the multi-part *Reading Comprehension Strategy* did improve achievement in reading and science, but only in the content-oriented (*Science IDEAS*) instructional environment (i.e., not in the traditional reading/language arts environment). This outcome is a significant extension of previous research with the *Science IDEAS* model reported by Romance and Vitale (2001) because it is suggestive of how a complementary set of knowledge-focused strategies (e.g., *text comprehension sub-strategy, propositional concept mapping sub-strategy, summarization/writing sub-strategy)* implemented in combination with semantic fluency activities can amplify the effectiveness of a knowledge-based instructional model within which students learn more about what they are learning on a continuing basis. If future research can confirm the validity of these findings, then this perspective has the potential for establishing standards to guide the use of the broad range of strategies (e.g., Billmeyer & Barton, 1998) for potentially enhancing reading comprehension (see Trabasso & Bouchard, 2002; Farstrup & Samuels, 2002; Gersten et al, 2001; Williams, 2002). In a related fashion, the results of this study are also suggestive of why the effectiveness of reading strategies demonstrated in controlled experimental settings have not been found transferable to applied settings (see Snow, 2002). Neither controlled short-term experimental contexts nor narrative reading passages that are the focus of the majority of reading/language arts instruction provide the type of instructional environment in which cumulative meaningful learning occurs. More specifically, the present study demonstrated clearly the benefits of a content-oriented environment both in terms of an overall effect on reading comprehension and as a context in which reading comprehension strategies were differentially effective.

One important element in interpreting the findings of the present study has to do with the length of the experimental intervention. On one hand, obtaining significant effects on nationally-normed achievement measures over the relatively short 8-week intervention suggests that the experimental interventions were very powerful since such measures are difficult to impact because they are scaled on a year-to-year growth basis. On the other hand, it may well be an intervention of longer duration would have resulted in a significant effect of the multi-part *Reading Comprehension Strategy* for students in the non-content-oriented environments as well. In fact, the affective findings of the present study that showed the use of the reading comprehensive strategies in the non-content-oriented settings to have a positive affect on reading attitude and self-confidence are supportive of this interpretation.

In considering the implications of the present study, researchers and practitioners should note the methodological interplay between two important approaches. In the first, offered by Slavin (1990, 2002), the methodological approach follows a developmental framework for conducting “high-impact” applied school research. In distinguishing between variable-oriented vs. model-oriented research, Slavin (1990) pointed out that while research on variables leads to understanding of principles, transforming research-based knowledge into practice is best accomplished through the implementation of multi-faceted models. In assessing the validity (i.e., impact) of such models, the models themselves are treated as composite experimental variables. And, while such a validation process does not address the question of what model components produced the obtained outcomes, it is not resource-efficient to conduct such variable-oriented research until the composite model itself is validated. However, once the effectiveness of the model is established, then it is feasible to allocate the resources to conduct variable-oriented research that would result in refinement of the model through subsequent experimental study. In summarizing a second related methodological approach, Guthrie et al (2004) pointed out that the research on reading comprehension strategies has primarily investigated the effects of single cognitive strategies under controlled conditions. Given this status of research in the field, Guthrie et al argued the need for studies that investigate how multiple strategies can be combined in long-term comprehension instruction within regular classroom settings (see also Trabasso & Bouchard, 2002).

The design of the present study, therefore, can be considered to reflect both methodological perspectives with the elements of the multi-part *Reading Comprehension Strategy* being based on a combination of empirical findings and extrapolations from interdisciplinary research literatures (e.g., cognitive science). In fact, the implementation of the *Reading Comprehension Strategy* provides the research context needed to insure that any subsequent variable-oriented research conducted within the scope of the model has the ecological validity necessary for the finding to be applicable to applied school settings. Further, in establishing such an operational context, the implementation of such a model also provides a setting for conducting other more general research studies of other variables that can further the understanding of learning and instruction. In following Slavin's (1990) perspectives, an important secondary purpose illustrated by the present study is the establishment of content-oriented implementations themselves as settings for future longitudinal research investigations of meaningful learning and comprehension.

Within the preceding framework, specific recommendations can be offered. For researchers, it is clearly important from a knowledge-based perspective to approach instructional content as a conditional methodological factor in all studies that purport to further understanding of cumulative meaningful learning in a fashion that is relevant to school practice. In this regard, more comprehensive replications and extensions of the present study are needed, including research that (a) expands the content-oriented instructional settings to areas other than science (e.g., social studies, mathematics), (b) expands the scope of study through longitudinal multi-year designs, and (c) begins to analytically study how the development of student discipline-specific curricular expertise and the associated dynamics of in-depth meaningful learning (see Anderson, 1992, 1993, 1996; Anderson & Fincham, 1994) can result in the development of reading comprehension proficiency that is transferable not only to improved performance on nationally-normed reading comprehension tests; but also to successful content area learning tasks (see Niedelman, 1992).

For practitioners, the results of the present study in combination with the research literature presented in this paper offer two significant implications. The first is that significant revisions of curricular policy in grade K-5 should be initiated to emphasize the cumulative development of student meaningful knowledge (see Schmidt et al, 2001). In this regard, the curricular policy should maximize the allocation of instructional time to areas of instruction that offer students the opportunity to develop cumulative, in-depth, content-area knowledge by reducing the amount of instructional time presently allocated to areas of instruction that do not offer students such opportunity, particularly traditional reading/language arts programs at the upper elementary level. The second is that practitioners should adopt as a standard the requirement that all instructional interventions, approaches, and strategies have a research-validated foundation prior to implementation on a widespread basis (see Carnine, 1995). In this regard, promising approaches should be implemented only on a trial basis and rigorously evaluated in terms of student achievement outcomes. As an example, such an approach involving practitioner collaboration with researchers would be appropriate at the present time for the instructional interventions investigated in the present study.

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