Effects of Embedding Knowledge-Focused Reading Comprehension Strategies in Content-Area vs. Narrative Instruction in Grade 5: Findings and Research Implications [1, 2]

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Abstract

Presented is a knowledge-based perspective for considering the enhancement of reading comprehension proficiency through the use of reading comprehension strategies applied in instructional settings that emphasize the development of meaningful learning in science. In doing so, the paper (a) distinguishes between major research settings addressing reading comprehension, (b) considers how an expertise-oriented view of comprehension can serve as a basis for content-area reading comprehension and reading comprehension strategies, (c) suggests and applies criteria for developing optimal reading comprehension strategies, (d) reports the results of a proof-of-concept study in which the effectiveness of a three-part *Knowledge-Focused Reading Comprehension Strategy* was found effective within content-oriented (science) but not narrative instruction, (e) presents selected interdisciplinary linkages to other areas of research related to the present paper (e.g., discourse analysis, instructional design, behavior analysis), and (f) offers suggestions for future 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 student proficiency. A recent National Assessment of Educational Progress (NAEP) report (National Center for Educational Statistics-NCES, 2000) found that 38 percent of 4^{th} 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. 11^{th} 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). Even after 20 years of 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., NCES, 2000; Florida Department of Education, 2005; North Carolina Department of Public Instruction, 2005).

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). In evaluating the state of such research, the RAND report concluded that present knowledge in the field is not sufficient to systemically reform reading comprehension instruction, a finding suggesting serious limitations in past research. Of particular relevance to this paper, two important and interdependent conclusions reported by RAND were that the field of reading had made only minimal progress in the area of content-area reading comprehension and that, although reading comprehension strategies could be taught experimentally, the benefits of such

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strategies were not transferable to enhancing comprehension in applied settings requiring content area reading.

With these issues as a context, this paper presents a knowledge-based perspective for considering the enhancement of reading comprehension proficiency through the use of reading comprehension strategies applied in instructional settings that emphasize the development of meaningful learning in science. In doing so, the paper develops and integrates six sections. As a conceptual basis for the paper, the first section distinguishes between major research settings for addressing questions of reading comprehension in science. Building on the first, the second section considers how an expertise-oriented view of comprehension can serve as a basis for addressing instructional applications involving both content-area reading comprehension and reading comprehension strategies. The view presented reflects recent developments in applied cognitive science (e.g., Bransford et al, 2000) which emphasize as the characteristics of expertise the organization, accessibility, and applicability of conceptual knowledge which experts are able to accomplish with automaticity. In doing so, an underlying emphasis in the paper is on how such research-based characteristics associated with expertise can provide a focus for developing the forms of content-area student mastery that imply meaningful comprehension.

The third section considers how prior knowledge provides a foundation for how experts (i.e., individuals having disciplinary expertise) are able to assimilate new knowledge through text and other means can provide a foundation in the form of criteria for guiding the development of optimal reading comprehension strategies. As noted, such criteria also provide a means for analytically evaluating the potential usability of the wide variety of reading comprehension strategies that appear in the literature. The fourth section reports the results of a proof-of-concept demonstrational study with 5th grade students that used an instructional engineering approach to design and empirically test the validity of a specific *Knowledge-Focused Reading Comprehension Strategy* consisting of three parts: (a) a *Text Elaboration Sub-Strategy* emphasizing use of prior knowledge, (b) a complementary *Propositional Concept Mapping Sub-Strategy* emphasizing knowledge representation, and (c) a *Summarization/Writing* S*ub-Strategy* derived from propositional concept mapping. The fifth section presents selected interdisciplinary linkages to other areas of research related to the present paper (e.g., discourse analysis, instructional design, behavior analysis). And, finally, the sixth section offers suggestions for future research investigating meaningful content-area comprehension, general reading comprehension, and reading comprehension strategies. In addressing the above, the paper attempts to present perspectives in a fashion that is meaningful both to researchers studying cumulative meaningful learning in applied settings and to practitioners working to optimize meaningful student learning. Because of this dual emphasis, the literature (e.g., papers, articles) in support of the topics in the paper were limited to representative aspects of applied cognitive science, reading comprehension, and other related disciplines.

PERSPECTIVES ON READING COMPREHENSION IN SCIENCE: AN INFORMAL ANALYSIS

The primary assumption of this paper is that in school content-area learning environments, the idea of comprehension is a far more general one than that of reading comprehension. This distinction is important because the primary emphasis in upper-elementary grade levels (grades 3-4-5) in the U.S. by design is upon instructional environments that focus on the development of reading comprehension proficiency using reading curricula that exclude meaningful content learning (see Hirsch, 1996; Walsh, 2003). Here the issue is not whether or not reading comprehension proficiency can be engendered as a transferable skill; but rather the determination of the conditions through which comprehension can be developed by using reading as a means for learning. In particular, a question yet to be answered through research is the degree to which cumulative meaningful content-area student learning opportunities are necessary for the development of reading comprehension proficiency, both within and across disciplines.

From the point of view of this paper, considering the idea of comprehension as more general than that of reading comprehension magnifies the role of prior knowledge as a primary factor in student meaningful learning. In this sense, the development and subsequent access/use of prior knowledge can be considered in a parallel fashion as an important basis both for both the development of expertise (Bransford et al, 2000) and for cumulative school learning (Hirsch, 1996) approached as a form of expertise development.

Three approaches to the study of reading comprehension and science can be distinguished. The first approach emphasizes the development of in-depth science understanding as a vehicle for enhancing subsequent learning success in science through a variety of instructional activities, of which reading about science is one. This approach, which may or may not incorporate reading comprehension strategies as part of science instruction, always considers the enhancement of reading comprehension proficiency as a side effect of meaningful learning in science. In such an approach (see Romance and Vitale, 2006), the emphasis is upon having a coherent, concept-oriented, science curriculum (see Schmidt et al, 2002), within which reading is one of several instructional modes that provide prior knowledge for future learning. The second approach emphasizes the use of narrative curriculum content (i.e., stories) common to basal reading series as a vehicle for developing general student reading comprehension proficiency, typically through the use of reading comprehension strategies. In such an approach, enhancement of student content-area reading comprehension proficiency is a matter of transfer to content-area reading in science. As noted previously, accomplishing such transfer through this approach has proven difficult (e.g., Snow, 2002). The third approach is highly analytic and involves providing interactive comprehension-assistance to students engaged in reading content-area passages in computer-based instructional environments. When effective, the third approach offers two complementary forms of outcomes- one that provides greater understanding of the reading comprehension process itself, and one that could provide a means for the delivery of effective content-area reading comprehension instruction in school settings. As noted previously, the issue is not which of these settings is best, but rather how can research be designed to support their integration with one another in a form that furthers understanding of the reading comprehension process.

The final topic to be addressed in this section is methodological issues in the assessment of science understanding. Although beyond the scope of this paper, it is important to recognize that research on science comprehension requires valid assessment of science understanding. One approach to methodological concerns identifies facets of science understanding (e.g., relating science concepts to observed phenomena in the world, using science knowledge to predict (or engender) outcomes, interpreting phenomena that occur in terms of science knowledge) that teachers (or researchers) can use to measure science understanding (see Vitale & Romance, 2000; Vitale et al, 2006). In general, using such facets of science understanding as a guide, even a casual inspection of nationally-normed science tests shows that they place little emphasis on the type of curriculum-based science knowledge students should gain through effective school instruction in grades 3-5.

LINKING KNOWLEDGE, EXPERTISE, AND READING COMPREHENSION

This section considers perspectives from applied cognitive science that integrate the role of prior knowledge in meaningful learning (i.e., content area comprehension), with emphasis on the linkage between knowledge-based instructional models and the development of general reading comprehension proficiency.

Knowledge-Based Instruction Models as a Foundation for Meaningful Learning

The distinguishing characteristic of knowledge-based instruction models is that all aspects of instruction (e.g., teaching strategies, student learning activities, assessment) are related explicitly to an overall design framework that represents the logical structure of the concepts in a subject-matter discipline to be taught. In considering this design characteristic as a key focus for meaningful 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, 2002). As Figure 1 shows, in ITS the explicit representation of the knowledge to be learned serves as an organizational

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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, 2002; Kolodner, 1993, 1997; Sowa, 2000). Therefore, the general methodological perspectives that guide knowledge-based educational applications and research should be considered as well established.

A Knowledge-Based Perspective for Considering Comprehension and Reading Comprehension

Although the role of knowledge in meaningful learning (i.e., comprehension) has received previous notice in education (e.g., Carnine, 1991; Glaser, 1984; Hirsch, 2001; Kintsch, 1998), this 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 an informal 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 area 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 conceptual frameworks in the form of prior knowledge to facilitate 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 mastery of conceptual academic content by students should prepare them to function as experts within the limitations (or scope) of what they learn within a content 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 2 illustrates a knowledge-based perspective of reading comprehension

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that is consistent with the broad idea of meaningful comprehension presented by Bransford et al (2000). Figure 2 suggests that the nature of comprehension in general learning and in reading settings are equivalent, with the exception that the specific learning experiences associated with reading comprehension are text-dependent.

With this equivalence in mind, Figure 2 outlines three scenarios for reading comprehension. In *Scenario One*, what is being learned by the reader is an elaboration of prior knowledge, so the new knowledge is assimilated. In *Scenario One*, which represents content-area reading expertise based on the accessibility of domain-specific knowledge, no explicit comprehension strategies are required; however, comprehension as the assimilation of knowledge does imply prior knowledge in the form of a core conceptual framework (see Figure 2). In *Scenario Two*, the existing framework of prior knowledge is not adequate to assimilate new knowledge, so the reader must identify the new content to be understood and then organize it in a form that meaningfully integrates prior and new knowledge (an accommodation process). Thus, *Scenario Two* does require metacognitive strategies that, in the present paper, are addressed as a coordinated three-part *Knowledge-Focused Reading Comprehension Strategy* (i.e., a *Text Elaboration Sub-Strategy*, a *Propositional Concept Mapping Sub-Strategy*, a *Summarization/Writing* Sub-*Strategy*). Finally, in *Scenario Three*, the content of the text source material is not sufficient for meaningful understanding by the reader. Thus, in *Scenario Three*, the reader must apply heuristic strategies to obtain sources of 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 for effective learning. As a conceptual model, *Scenario Three* is transformed into *Scenario Two* by obtaining additional information after which

Scenario Two is transformed into *Scenario One* through the application of reading comprehension strategies that create a new organizational framework for integrating prior and new knowledge. In turn, *Scenario One* provides a framework for potentially assimilating (and understanding) new knowledge in a form that incorporates it as prior knowledge for new learning..

As a group, these three scenarios reflect a form of reading comprehension proficiency that can be considered characteristic of expert readers. As Figure 2 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 question of ecological validity and, as a result, their subsequent transferability to authentic content-area reading comprehension settings (see Niedelman, 1992). As noted earlier, 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 only limited success.

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

If reading comprehension can be considered as a form of expertise, then it is relatable to general work in cognitive science by Anderson and others (e.g. Anderson, 1982, 1987, 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 of novices with minimal knowledge that may range from heuristics to trial-and-error search. Within the context of reading comprehension, 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 metacognitive or 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. Extrapolating from the above work by Anderson and others, the consideration of reading comprehension strategies to be cognitive skills implies that they require extensive amounts of varied practice to reach the degree of automaticity that is characteristic of expert performance.

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 that are directly applicable to reading comprehension. 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 (e.g., science) as opposed to when such strategies are learned in non-cumulative content domains (e.g., narrative stories in typical basal reading programs) that are different from the content-oriented contexts in which such strategies are to be applied. In this regard, a comprehensive interdisciplinary review of reading comprehension research by McNamara et al (in press) concluded that skilled comprehenders are more able to actively and efficiently use knowledge (and strategies) to help them comprehend text and, further, that individual differences in reading comprehension depend on the dynamics associated with knowledge activation.

These research perspectives in conjunction with Figure 2 also suggest that student variability in reading comprehension proficiency could be considered to reflect one or more of the following three dynamic factors operating in a complementary fashion: (a) the development of domain-specific prior knowledge, (b) the development of reading comprehension strategies (as metacognitive tools), and/or (c) the development of heuristic strategies for obtaining additional sources of information. These dynamics presumably operate automatically for expert readers (i.e., self-reliant readers) across different contexts. Importantly, each of these three key dynamics is amenable to instruction.

Application of a Knowledge-Based Science Instructional Model for Building General Reading Comprehension

Science IDEAS is a research-based, cognitive-science-oriented instructional intervention that was initially validated within a grade 4 upper elementary setting (Romance & Vitale, 1992). As an integrated instructional model, *Science IDEAS* combines science, reading, and writing through daily 2-hour time blocks which replace 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 understanding of science concepts. As an instructional intervention implemented within a broad inquiry-oriented framework (i.e., all aspects of teaching and learning emphasize learning more about what is being learned), teachers use 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 3 shows how a propositional concept map (see Romance & Vitale,

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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. The resulting curricular framework addresses curricular mastery as equivalent to a form of 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 effectiveness of the *Science IDEAS* intervention is well established. 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 (adjusted mean difference in *Metropolitan Achievement Test (MAT) Science* = .95 GE); but also on reading comprehension (adjusted mean difference in *Iowa Tests of Basic Skills (ITBS) Reading Comprehension* = .32 GE). *Science IDEAS* students also 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 across a range of academic levels from above average to severely at-risk. As summarized in Figure 4 (see Romance & Vitale, 2001), the expansion of the *Science IDEAS* intervention during that time

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period to more than 50 teachers and 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). However, the finding most important to the present paper 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 consistently better results in reading comprehension than an alternative (basal) reading curriculum whose purpose was to teach reading comprehension.

Interpreting Reading Comprehension Proficiency as Knowledge-Based Transfer

The important research finding (Romance & Vitale, 2001) that *Science IDEAS* had a consistently positive effect on student reading comprehension requires further elaboration. First, because the specific (mostly non-science) content of the reading passages of nationally-normed reading comprehension tests (*ITBS*, *Stanford Achievement Test*) used in the studies was different than the specific science content students learned and read about in their classrooms, the positive effects of *Science IDEAS* on reading comprehension represented a general transfer of learning outcome in reading comprehension (see Niedelman, 1992). And, 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).

Although a variety of interpretations are consistent with the transfer effects from *Science IDEAS* to general reading comprehension, one 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 interpretation 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, 2004) of fundamental core concepts and concept relationships within which additional knowledge could first be assimilated and then used as an organizational framework that resulted 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. A 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. In turn, such an intellectual capacity would facilitate students acquiring, organizing, and thinking about the forms of new information that are embedded in reading comprehension tests, even if their domain-specific prior knowledge of test content is minimal. From this general perspective (see 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 subsequently to be able to access such information in either answering questions about it or continuing to further expand their knowledge.

Related Research in Reading and Educational Psychology Focusing on Reading Comprehension

Complementing the above cognitive science perspectives is a substantial body of literature in the area of reading comprehension that is also consistent with the preceding interpretation. In an extensive 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 date of the review. 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 means 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 findings 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 work by Guthrie and his colleagues (e.g., Guthrie et al, 1997, 1998, 2002, 2004) is important to recognize. This work also 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 addressing reading comprehension.

DESIGN OF KNOWLEDGE-FOCUSED READING COMPREHENSION STRATEGIES

This section considers the development of reading comprehension strategies from two complementary views. The first view consists of criteria based on the research literature that can serve as guides for the design of effective reading comprehensive strategies in school settings. Also considered is the potential application of these same criteria to the analytic evaluation of the many different reading comprehension strategies used by practitioners. The second view presents a multi-part *Knowledge-Focused Reading Comprehension Strategy* based on the criteria, along with the results of a demonstrational (i.e., proof-of-concept) study conducted to explore its potential effectiveness within content-oriented (science) and narrative-oriented (basal reading) instruction in school learning settings with grade 5 students (Romance & Vitale, 2005).

Toward Research-Based Criteria for Reading Comprehension Strategy Design and Analysis

The following criteria focus on the question of how to optimize the effectiveness and usability of reading comprehension strategies with the forms of cumulative meaningful learning that occur in applied school settings (vs. more short-term controlled research settings). As noted earlier, this concern was identified as a major problem in the recent RAND report (Snow, 2002). In fact, questions of effectiveness and usability are the two major considerations that logically underlie the design of any form of instructional intervention (see Dick et al, 2004).

With the preceding in mind, three interdependent criteria for reading comprehension strategy design and analysis can be identified. The first criterion is *power*. Following experimental approaches for establishing the generalizability of research findings outlined by Sidman (1960), the idea of *power* is that effective reading comprehension strategies must address major sources of variance in learning if they are to have a replicable (and dynamic) impact across applied settings within which many other types of uncontrolled learning dynamics are operative. The second criterion is *functionality.* The idea of *functionally* is that any form of reading comprehension strategy should be proceduralized in a fashion that insures it enhances the ongoing process of reading comprehension in a causal fashion. That is, the strategy should enhance comprehension rather than require comprehension as a prerequisite for use (i.e., a strategy that requires comprehension has a testing rather than a tool function).

The third criterion is *engineering efficiency.* The idea of *engineering efficiency* is that the reading comprehension strategy should be easily useable by teachers and students. Whenever the necessary conditions can be met, *engineering efficiency* occurs most readily when a strategy results from an explication of naturally ongoing processes that result in the identification of key aspects of that process. Such key aspects then can be enhanced through standard forms of training that result in the establishment of the process or processes as a form of a strategy by learners (i.e., through a sequence of modeling, guiding, and independent practice of the strategy). In particular, the idea of using an expertise-oriented approach for designing reading comprehension strategies meets this requirement (i.e., teachers are able to reflect on their own behavior as a guide for using the strategy and then use their reflection as a guide for modeling and guiding student use of the strategy).

Considered together, the three criteria provide a strong set of constraints for either designing or analytically evaluating reading comprehension strategies. With regard to the design of the multi-part reading comprehension strategy described in this paper, the criterion of *power* applies in that the sub-strategies focus on amplifying the access of prior knowledge for comprehension of what is being read and, then, organizing and integrating new knowledge with existing knowledge that, in turn, is accessible as prior knowledge for future comprehension. The criterion of *functionality* applies in that each of the sub-strategies is described as a procedure whose application enhances the process of comprehension, both in real-time and in follow-up review. And, the criterion of *engineering efficiency* applies in that the sub-strategies represent explications of forms of expertise all teachers display when they read with comprehension and on which students can be guided procedurally as they read or reflect on what they have read.

In a related fashion, the three criteria also could be used to analyze the potential effectiveness of reading comprehension strategies typically used by practitioners. In general, the majority of such strategies (see Billmeyer & Barton, 1998, page 69) either require comprehension as a prerequisite for use (i.e., confuse engendering comprehension when reading with testing for comprehension after reading) or address aspects of comprehension that are of minimal importance to content area understanding at best. Although the majority of the 40 different strategies reported by Billmeyer and Barton are easy to use, such ease of use does not matter if the strategies are inadequate for substantially enhancing reading comprehension when used in classroom settings.

A Multi-Part Reading Comprehension Strategy Meeting the Design Criteria

The *Knowledge-Focused Reading Comprehension Strategy* described in this paper consists of three sub-strategies which, together, explicitly address (and support) recognized aspects of the process of reading comprehension. This section describes each of these sub-strategies (*Text Elaboration Sub-Strategy, Propositional Concept Mapping Sub-Strategy, Summarization/Writing Sub-Strategy)*. In considering them, it is important to note that each represents and augments aspects of the process of reading with comprehension as a form of expertise along with the key roles of knowledge in reading comprehension (knowledge access and organization). As forms of expertise, the sub-strategies are engineered for use by teachers in regular classroom settings and have a strong research base (see Dreher, 2002; Snow, 2002; Trabasso & Bouchard, 2002).

Table 1 summarizes the teacher planning and implementation procedures that comprise the *Text Elaboration Sub-Strategy*. This is the pivotal sub-strategy among the three because it operates in "real

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time" and forms a basis for the use of the other two. As Table 1 shows, the *Text Elaboration Sub-Strategy* is a reflective explication of the prior knowledge individual teachers "think about" as they read a passage with comprehension (i.e., related knowledge that helps make the passage meaningful). In a parallel fashion, the implementation of the sub-strategy consists of teachers guiding students to actively relate what they are reading to both their prior knowledge in general and what they previously have read with understanding within the passage. Through re-readings of the passage, knowledge that appears later in the passage can be related as prior knowledge to earlier parts of the passage previously read, a sequence particularly useful with technical content. Overall, this sub-strategy is designed to teach students to actively relate what they are reading to prior knowledge gained through previous learning, including the preceding content in the passage being read, as a means to enhance comprehension.

Table 2 summarizes the teacher planning and implementation procedures that comprise the *Propositional Concept Mapping Sub-Strategy*. As Table 2 shows, the *Propositional Concept Mapping Sub-Strategy* is best understood as a "follow-up" to the application of the *Text Elaboration Sub-Strategy*

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to a specific passage (or series of passages) in which students learn to identify, arrange in hierarchical form, and link together the core ideas, subordinate ideas, and illustrative examples in a visual display (see Figure 5 for an example of a propositional concept map). Again, in a fashion parallel to that of the *Text*

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Elaboration Sub-Strategy, the implementation of the *Concept Mapping Sub-Strategy* as a process consists of teachers guiding students to build the same basic propositional concept map as a meaningfully organized representation of the knowledge in passages they have read. Overall, the *Concept Mapping Sub-Strategy* is designed to teach students to actively organize the knowledge about which they are reading by identifying key concepts and concept relationships in order to enhance comprehension.

Table 3 summarizes the teacher planning and implementation procedures that comprise the *Summarization/Writing* Sub-*Strategy*. As Table 3 shows, the *Summarization/Writing* Sub-*Strategy*

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is primarily a "side effect" of the *Propositional Concept Mapping Sub-Strategy* that involves transforming propositional concept maps into standard text prose, a task for which the structure of propositional concept maps provides a strong prosthetic starting point. Overall, this sub-strategy is designed to teach students to meaningfully access and organize knowledge they want to communicate as a prerequisite for maximizing writing coherence.

In considering the operational elements of the *Knowledge-Focused Reading Comprehension Strategy*, the three sub-strategies are designed to be used in a complementary fashion on a continuing basis across wide a varieties of reading tasks. Together, the combined focus of the three sub-strategies is to provide students with strategies whose application- driven by reading that occurs- enhances in-depth understanding of the knowledge to be gained with regard to (a) accessing prior knowledge, (b) representing/organizing new knowledge learned with prior knowledge, and (c) generating oral and written expressions that summarize understanding of knowledge in a coherent fashion. Applied across cumulative, meaningful learning environments, the potential result is the integration of new and existing knowledge as a form of expertise. Additionally, the engineering design allows the sub-strategies to be learned and applied by students (and teachers) as a form of expertise that consists of an elaboration of naturally occurring processes that engender comprehension.

EXPLORING THE EFFECTIVENESS OF THE READING COMPREHENSION STRATEGY IN CONTENT VS. NARRATIVE INSTRUCTION

Research context. The proof-of-concept study reported in this section (Romance & Vitale, 2005) addressed two elements reported in the research literature. The first element addressed the findings reported by Snow (2002) regarding the lack of success in the field of reading regarding the improvement of content area reading comprehension and the corresponding lack of evidence that the effects of reading comprehension strategies in experimental settings have been replicable in applied settings. The second element addressed the findings reported by Romance and Vitale (2001) which showed that in-depth science instruction within which reading and language arts were integrated over a school year (*Science IDEAS*) was more effective than traditional reading instruction in engendering reading comprehension proficiency as measured by nationally-normed tests.

Overall design of the study. Within the preceding context, the primary goal of the study was to explore a possible differential effect of the multi-part *Reading Comprehension Strategy* on student reading comprehension proficiency and science achievement in the two different instructional settings. Therefore, one factor of the study was a replication of the Romance and Vitale (2001) investigations which compared the effectiveness of the *Science IDEAS* intervention with traditional reading instruction upon reading comprehension proficiency and science achievement. An implicit methodological question for the present study was whether the effects of the *Science IDEAS* model would be replicable over the 12-week duration of the present study rather than over an entire school year. Given the first factor, the second factor investigated in the study was whether the multi-part *Knowledge-Focused Reading Comprehension Strategy* would engender improved reading comprehension proficiency overall, or, of greater relevance to the questions raised in this paper, whether the treatment would be differentially effective when embedded within a content-oriented science learning environment vs. a non-content-oriented basal reading environment.

Following a structure for programmatic research in applied school settings advocated by Slavin (1990, 2002), the study implemented the multi-part *Knowledge-Focused Reading Comprehension Strategy* as a composite practitioner-oriented intervention model composed of the *Text Elaboration Sub-Strategy*, the *Propositional Concept Mapping Sub-Strategy,* and the *Summarization/Writing* Sub-*Strategy).* As suggested by Slavin, once the effect of a composite model (e.g., the multi-part *Reading Comprehension Strategy* in the present study) can be shown effective in a school setting, then subsequent research addressing the analytic question of how to optimize the effectiveness of the model can be pursued in a far more efficient fashion than by trying to analytically investigate the separate effects of the combined elements in an initial study.

Within the study, classrooms using the *Reading Comprehension Strategy* intervention also engaged students an oral semantic fluency activity (Vitale & Medland, 2004) as a methodological enhancement to the *Reading Comprehension* intervention. The purpose of the *Semantic Fluency Activity* was to facilitate student verbal responsiveness required by the *Reading Comprehension Strategies* through daily 5-minute exercises in which students generated experience-based sentences illustrating one or more of 11 forms of knowledge (e.g., *What something is named, What something does, Where something is, How something changes, Why something changes, What parts something has*). Although there is an extensive research literature on using semantic (or ontological) frameworks as an analytic comprehension tool (e.g., O'Donnell et al, 2002), in the present study the oral activities of students were never linked to the academic content to be learned nor to the *Reading Comprehension Strategy* activities themselves. Because its role was methodological, the semantic fluency activity is not considered further in this paper.

In the study, student reading comprehension proficiency 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* (*FCAT*) in reading (*Stanford Achievement Test (SAT)- Reading Comprehension*) and science (*FCAT Science Assessment Test*) that occurred prior to the start of the study in mid-March, 2004, and served as covariates for statistical control in data analysis. Post-tests which served as criterion measures of student achievement were nationally-normed reading (*Iowa Tests of Basic Skills (ITBS) Reading Comprehension- Level 11*) and science (*ITBS Science- Level 11*) tests administered at the end of the study, in mid-May, 2004.

Implementation of the study. The study was implemented on a schoolwide basis in grade five in a total of six demographically-representative elementary schools located in a large, diverse school system in southeastern Florida (Students = 175,000, African Americans = 29%, Hispanic = 19%, Free/Reduced Lunch = 40%). Four of the participating schools used *Science IDEAS*, and two, the District basal series. The experimental reading strategy intervention (see following for details) was assigned on a random basis to two of the four *Science IDEAS* schools and one of the two traditional basal schools. Because schools selected either *Science IDEAS* or the District-adopted basal reading series on a voluntary basis, the selection of the non-*Science IDEAS* schools that were demographically similar was considered an adequate methodological control for the purposes of the study.

Figure 6 shows the two parts of the experimental intervention in the study. As described previously, *Science IDEAS* (Romance & Vitale, 2001) served as the content-oriented intervention,

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and the district-adopted Scott-Foresman Reading/Language Arts Series (Scott-Foresman, 2002) as the non-content-based intervention. Both were implemented using a daily 2-hour time block that participating schools allocated to either *Science IDEAS* or to reading/language arts. Consistent with present school time-allocations, participating *Science IDEAS* schools allocated a limited amount of additional time (approximately ½ hour/day several days per week) 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 approaches in the study.

In *Science IDEAS* schools, the *Knowledge-Focused Reading Comprehension Strategy* was implemented as described above. However, in the schools using the traditional basal reading program which emphasized narrative (rather than content-oriented) reading, the *Propositional Concept Mapping Sub-Strategy* was adapted to serve as a story mapping activity that was more appropriate for the narrative stories emphasized (see Figure 7) . Within the context of the study, it should be noted that because the story mapping activity used an explicit graphic framework, it was closer in operation to structural analytic frameworks (e.g., O'Donnell et al, 2002) used to enhance reading comprehension than to the "free-form" propositional concept mapping used in science instruction. However, both variants represented visual/graphic enhancements of the elements identified by students applying the *Text-Elaboration Sub-Strategy* to their reading materials.

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In each of the experimental settings, the sub-strategy procedures were modeled and/or guided for students by teachers until students were able to engage in each sub-strategy procedure. Thus, all three sub-strategies were equally applicable to informational and narrative text material and reflected key characteristics of expert readers in those settings. In the study, teachers were asked to use the *Text Elaboration Sub-Strategy* once each week and the *Propositional Concept Mapping/Story Mapping Sub-Strategy* and *Summarization/Writing* S*ub-Strategy* once every two weeks.

Teachers use of the both the *Knowledge-Focused Reading Comprehension Strategy* and the supporting *Semantic Fluency Activity* was initiated through 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.

Statistical analysis and findings. Table 4 shows the pre- and post-test results for the participating schools. As Table 4 shows, as a group the grade 5 students receiving the experimental (*Knowledge-*

- - - Insert Table 4 Here - - -

Focused 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 scale units in reading and 6.7 in science), though the school selection process only considered schoolwide demographic factors (i.e., free/reduced lunch, student ethnicity). With respect to *Science IDEAS* vs. traditional basal reading schools, the unweighted mean differences were 30.6 and 34.8 for FCAT/*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 5 summarizes the results of the multivariate covariance analysis implemented through a general linear models approach for reading and science achievement. As Table 5 shows, the main

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effect of content-oriented (*Science IDEAS*) vs. non-content-oriented (traditional basal) instructional environment was significant, with the *Science IDEAS* classrooms performing significantly higher in both reading and science (Adjusted Mean Difference = .38 GE for *ITBS Readin*g and .38 GE for *ITBS Science*). Although the main effect for use of the *Reading Comprehension Strategy* treatment 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, Adjusted. Mean Difference = .53 GE) and *ITBS Science* (F (1,557) = 4.84, p < .05, Adjusted. Mean Diff. = .17 GE) for the science-oriented instructional environment (*Science IDEAS*) students. However, use of the *Reading Comprehension Strateg*y was not significant for either *ITBS Reading* or *Science* in the traditional reading/language arts environments which emphasized narrative reading.

Other results shown in Table 5 found the effect of the pre-test covariate *FCAT/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 a follow-up inspection of science test items, in general, suggested 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 students with exceptionalities (e.g., *LD, ADD, ADHD*) performing more poorly on *ITBS Science* achievement (but not on *ITBS 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 5, these findings showed significant adjusted achievement difference in favor of White/Hispanic students vs. African American students for *ITBS Reading Achievement*. However, with the exception of the pre-test covariates, all of these other significant effects were small.

Interpretation of the findings. The results of the study are supportive of a number of the major principles presented previously in this paper. First, *Science IDEAS* resulted in greater reading comprehension achievement overall than did traditional basal reading instruction. This finding is consistent with those reported by Romance and Vitale (2001) and reaffirms the principle that engaging students in in-depth cumulative meaningful learning is a more effective approach for developing reading comprehension proficiency than engaging them in unrelated stories which are designed to be “content free” (see Hirsch, 1996; Walsh, 2003). Second, the fact that the use of the *Reading Comprehension Strategy*) only enhanced reading comprehension for *Science IDEAS* students is suggestive that being engaged in a content-oriented learning environment that emphasizes cumulative meaningful learning may be an important condition for positive transfer of the effects of metacognitive instructional enhancement procedures such as reading comprehension strategies. This interpretation is also consistent with the report by Snow (2002) that despite a well-established research base (e.g., Block & Pressley, 2002), there is minimal evidence of the positive influence of reading comprehension strategies to content area reading in applied settings. And, third, the findings are consistent with the broader perspective that reading comprehension can be approached as a special case of comprehension in general. In this regard, replication and extension of the present study should be undertaken to establish the interactive treatment effects over longer instructional time intervals in school settings.

A primary question raised earlier in this paper was why in the original studies (Romance & Vitale, 2001) *Science IDEAS* students displayed greater reading comprehension achievement than students in traditional reading/language arts instruction, given that *Science IDEAS* students received no formal instruction in reading or guidance in use of reading comprehension strategies. One general answer to this question could be that engaging in cumulative meaningful learning was, itself, sufficient for the development of reading comprehension proficiency that was transferable. However, a retrospective analysis of the instructional dynamics of the original *Science IDEAS* model itself suggested a more explicit explanation. While it was true that teachers implementing the original *Science IDEAS* model did not use explicit reading comprehension strategies at a macro level (i.e., across different types of activities that involved learning more about what was being learned), it became clear that *Science IDEAS* teachers did incorporate the same processes as those used in the multi-part *Knowledge-Focused Reading Comprehension Strategy* in the present study, but from a perspective focusing on general comprehension rather than on reading comprehension per se. For example, in studying a topic such as evaporation (see Figure 3), students would actively relate different kinds of activities (e.g., hands-on experiments, reading, concept mapping, journaling/writing, projects) to the common set of concepts and concept relationships being studied. So, as students engaged in reading, they were actively involved in relating what they were reading about to prior knowledge they would have gained through earlier reading and other activities. Thus, insofar as the present study is concerned, the processes for in-depth learning in *Science IDEAS* and the present *Knowledge-Focused Reading Comprehension Strategy* can be considered as variants of a common instructional architecture (see Dillon & Tan, 1993) which relates what is being learned to prior knowledge (see also Gagne et al, 2004). In this regard, explicit inclusion of the *Knowledge-Focused Reading Comprehension Strategy* might well be expected to magnify the effects of the *Science IDEAS* instructional model.

AN INTERDISCIPLINARY LINKAGE OF THE PRESENT PAPER TO RELATED AREAS OF RESEARCH

Because the overall goal was to present perspectives in a fashion meaningful both to researchers and practitioners, the literatures used to develop topics in the paper were limited primarily to representative sources in applied cognitive science and reading comprehension research. However, all of the perspectives presented in this paper are interdisciplinary in that they reflect important work in a number of related areas. This section briefly notes selected work in some of these disciplines with the recognition that the scope of the work cited is far broader than can be considered here.

One important area is the *Construction-Integration* model developed by Kintsch and his colleagues (e.g., Kintsch, 1994; 1998a, 1998b, 2002, 2004, 2005) which has been applied extensively to reading comprehension. As an informal overview, Kintsch's model explains the process of reading comprehension by distinguishing between the propositional structure (i.e., explicit semantic meaning) of a text that is being read and the prior knowledge the reader brings to the process of reading. Within this context, meaningful comprehension results when the propositional structure of the text is joined with the prior knowledge of the learner. If the propositional structure of the text is highly cohesive (i.e., knowledge is explicitly well-represented in propositional form), then there is less demand upon reader prior knowledge. But if the text is not cohesive (i.e., contains significant semantic gaps), then reader prior knowledge is critical for coherent understanding. In either case, comprehension results from the integration of the propositional structure of the text (textbase) with the reader's prior knowledge and is represented semantically in propositional form (a situation model). Within this framework, much of the research conducted by Kintsch and his colleagues has focused on the interplay of meaningful text structure and the prior knowledge of the reader considered as a learner. As considered above, the focus of Kintsch's work is directly relatable not only to the general concept of meaningful reading comprehension; but also to comprehension in general for cases in which learning experiences are other than text. As a result, the scope of Kintsch's model is broader than the treatment and analysis presented in earlier section of this paper because it addresses the complementary roles of the prior knowledge of the learner and the structure of the learning environment. In this regard, Kintsch's model fits well with strong instructional models for curriculum development (e.g., Engelmann & Carnine, 1991).

A second area considered here is the work of Landauer (2002) and his colleagues (Landauer & Dumais, 1996, 1997; Landauer et al, 1998) addressing vocabulary acquisition as an inductive process that is based upon the utilization of the prior knowledge derived from the experience of the learner. As an element in their research, Landauer et al (1998) have developed a computational model, *Latent Semantic Analysis*, through which the relatedness of words to words, words to prose, and prose to prose can be expressed mathematically via a statistical index ranging from 1 to -1 across a large number of underlying semantic dimensions. In effect, Landauer and his colleagues have been able to show that the "gist" of the meaning of a passage is measurable as a sum of its composite words and, in turn, that the meaning of individual words can be measured in terms of its relationship to other words (e.g., think informally of the meaning of a word as a "bag" of words, i.e., a group of semantically related words consisting of synonyms and antonyms to which it is related via a set of fundamental underlying dimensions). As considered here, the work of Landauer is directly related to the question of how, once gained, prior knowledge can be measured as a form of comprehension and, then, how such prior knowledge can function as a foundation for future learning. Again, as with Kintsch's work, Landauer's work can be broadened readily to encompass learning experiences beyond text that result in comprehension.

Complementing the preceding is related work from other areas of research. Again, although far broader than the scope of this paper, Graesser and his colleagues (Graesser & Wiemer-Hastings, 1999; Graesser et al, 2002a, 2002b; Graesser et al, 2003) have applied principles from discourse analysis to narrative and expository reading comprehension. Engelmann and Carnine (1991) have presented an instructional design model consisting of principles in algorithmic form for structuring learning experiences so that they are optimally coherent to learners and maximize transfer of learning (see Adams & Engelmann, 1996). Finally, Sidman (1994; 2000) and others (e.g., Artzen & Holth, 1997; Dougher & Markham, 1994) have explored the conditions under which learning outcomes that are not taught can arise indirectly (i.e., inductively) from the structural properties of knowledge learned through instruction. Combining the views in this section with those presented in this paper provide a rich source of research for advancing the role of knowledge in comprehension and the relationship between knowledge and the conditions under which reading comprehension strategies can enhance student content area comprehension.

ISSUES RELATING TO RESEARCH ON READING COMPREHENSION STRATEGIES

The general question raised in this paper is whether research on reading comprehension strategies can be conducted with ecological validity without adopting a contextual approach that frames such research within the forms of cumulative content-area learning environments (e.g., science, social studies) that imply comprehension. In this regard, it is important to note the complementary approaches to research in reading comprehension presented in an earlier section. With regard to the first approach, the authors of this paper are engaged in an ongoing research initiative to replicate and extend some (but by no means all) of the implications of the preceding findings and perspectives. Included within the scope of this work is (a) longitudinal implementation of the *Reading Comprehension Strategy* across grades 3-5, (b) incorporation of an assessment/transfer component on a content-neutral cumulative (multi-day) reading comprehension task in U.S. History, and (c) assessment of the transfer impact of the grade 3-5 *Reading Comprehension Strategy* upon subsequent reading comprehension proficiency at the middle school level as measured by a nationally-normed reading comprehension test and by judgments of student content-area reading proficiency middle school content-area teachers.

At the same time, even if the findings of the above content-oriented research are found consistent with and extend prior research (e.g., Romance & Vitale, 2001; Vitale & Romance, 2006) in having a substantial impact on student reading comprehension, a regular school setting- no matter what its ecological validity - is not optimal for investigating the detailed mechanics of how reading comprehension strategies are supportive of the content-area reading comprehension process. In this regard, the third approach noted in the paper which uses computer-based implementations as interactive instructional media are optimal for such analytic work. In fact, the results of some of these research programs are presented in this symposium (e.g., McNamara, 2006; Dalton et al, 2006). However, at the same time, for purposes of ecological validity, such analytic studies must eventually evolve into or be applied to the forms of cumulative meaningful learning that are characteristic of school content-area environments.

Considered together, in context of present research and theory perspectives presented in this paper, the future of research in content-area reading comprehension in general and in science text comprehension in particular is a highly promising one. However, in comparison to these two research approaches, a major point of this paper is that the second research approach presented earlier which would use traditional basal reading series for the development of student reading comprehension proficiency faces a difficult challenge. Rather than providing students with opportunities for cumulative meaningful learning, much of such traditional reading materials simply involve students reading stories that involve the arbitrary arrangement of common objects (e.g., people, events) that minimize informational knowledge development (see Romance et al, 2003; Walsh, 2003). While there is an increasing national emphasis on increasing the use of informational text in such settings (e.g., Duke, Bennett et al , 2003; Duke, Martineau et al, 2003; Duke & Pearson, 2003), it is unclear at the present time how any instructional environment that does not emphasize the development of cumulative meaningful knowledge can enhance either general or content-specific reading comprehension proficiency.

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Table 1
Overview of Text Elaboration Sub-Strategy

Teacher Planning Process :
- Read passage for understanding
- Re-read and generate "knowledge notes"
  - - Read sentence or set of sentences
  - - Think about what knowledge made the text passage understandable (also flag key ideas)
- Link "knowledge notes" (via post-its) to passage locations
- Transform "knowledge notes" into "knowledge link" questions answered by the "knowledge notes" (for use with students)
- Result of teacher planning process
  - - Teacher has meaningful set of questions for guiding student use of prior knowledge for comprehension
  - - Questions are based on individual "teacher expertise" in reading passage with understanding

Teacher Implementation Process
- Initial reading of passage
  - - Select student to read passage/section aloud
  - - During reading, model (ask/answer), guide (ask) "knowledge-link" questions, or accept student-initiated "knowledge links," as appropriate
  - - Guide:
    - - - student passage/section summary
    - - - student cumulative passage summary
  - - Continue process with new students until passage read
- Multiple re-readings of same passage
  - - Select student to read passage/section
  - - During reading, guide or solicit/accept student-initiated "knowledge-link" questions/answers as evolving process
  - - Solicit:
    - - - Student passage/section summary
    - - - Student cumulative passage summary
  - - Continue process with new students until passage re-read
  - - repeat re-reading until students are able to initiate "knowledge links"

Note 1: Teacher models, guides, accepts student-initiated "knowledge link" questions/answers as evolving process (objective is to obtain student-initiated "knowledge-links" across repeated re-readings of the same passage and then generalize the process across new passages)

Note 2: Teacher "knowledge-link" questions emphasize linking what is being read to what has been read previously and to prior knowledge

Note 3: Goal of sub-strategy goal is for students to learn to use prior knowledge for reading comprehension

Table 2
Overview of Propositional Concept Mapping Sub-Strategy

Teacher Planning Process :

- Read passage for understanding
- Identify key ideas/examples and write on post-it notes
- Organize ideas/examples in hierarchical structure (via post-it notes), arranging big ideas on top, sub-ideas below, and examples on bottom
- Generate links for connecting concepts so each concept-link-concept unit is in form of a simple sentence (i.e., noun-verb-noun)
- Result of Teacher Planning Process:
    - - Teacher has coherent organizational structure representing the core knowledge in text passage
    - -- Structure can be used in a variety of ways (e.g., planning instruction/assessment), but emphasis here is on planning for students learning to concept map

Teacher Implementation Process:

- Students read passage and identify key ideas/examples, write ideas/examples on post-it notes
- Students identify core ideas, subordinate ideas, examples, arranging post-it notes in real-time to form hierarchical structure
- Students identify links that form concept-link-concept units into simple sentences (i.e., noun-verb-noun)
- Students read the map *as if it were prose* (editing/re-reading as necessary)

Note 1: Teacher models, guides, accepts student-initiated participation as appropriate (i.e., as evolutionary process)

Note 2: Goal of sub-strategy is for students to learn to organize/represent knowledge into a coherent structure to enhance comprehension and accessibility

Table 3
Overview of the Summarization/Writing Sub-Strategy

Teacher Planning Process (None: Side-effect of concept mapping):

Teacher Implementation Process:

- Students use organizational structure of propositional concept map as a guide for written summary of passage (parallels process of reading the map in concept mapping)
- Edit (or elaborate) written summary as appropriate

Note: Goal of sub-strategy is for students to learn to develop and then access an organized knowledge structure as a basis for coherent writing

Table 4
Means and Standard Deviations of Grade 5 Student in Participating Schools on Pre- and Post-Measures

School	N Stud.	Rd.St./ Ont. Act.	Inst. Environ.	FCAT RD		FCAT SCI		ITBS RD		ITBS SCI	
				M	SD	M	SD	M	SD	M	SD
A	102	Yes	TRD	45.1	25.6	278	61	5.6	2.1	6.1	2.6
B	81	Yes	SCI	75.7	20.5	327	45	8.4	2.4	9.0	2.6
C	57	Yes	SCI	59.4	24.8	325	66	7.4	2.5	8.4	3.1
D	102	No	TRD	51.7	26.2	289	53	6.2	2.0	6.7	2.7
E	139	No	SCI	55.3	25.6	304	55	6.8	2.2	7.6	2.7
F	161	No	SCI	61.1	23.4	317	47	7.0	2.1	8.1	2.5

Note 1- Rd. St./Ont.Act. = *Knowledge-Focused Reading Comprehension Strategy*; TRD = Basal narrative reading; SCI = *Science IDEAS*.

Note 2: Tests and scale scores are: FCAT RD = 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).

Table 5. *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.St./Ont.Act. (Trt.)	F(2,556) = .38	F(1,557) = .55	F(1,557) = .02
TRD vs. SCI (Inst.)	F(2,556) = 4.46 *	F(1,557) = 7.29 **	F(1,557) = 4.84 *
Trt. X Inst.	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
Free/Reduced Lunch	F(2,556) = 2.30	F(1,557) = 4.38 *	F(1,557) = .12
Exceptional Children	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

* = p < .05, ** = p < .01

Note 1: *F* approximations for multivariate tests are based on Wilk's *Lamda*.

Note 2: Trt. = use of the *Knowledge-Focused Reading Comprehension Strategy;* Inst. = Type of Instructional Environment (TRD = Basal narrative reading, SCI = *Science IDEAS*)

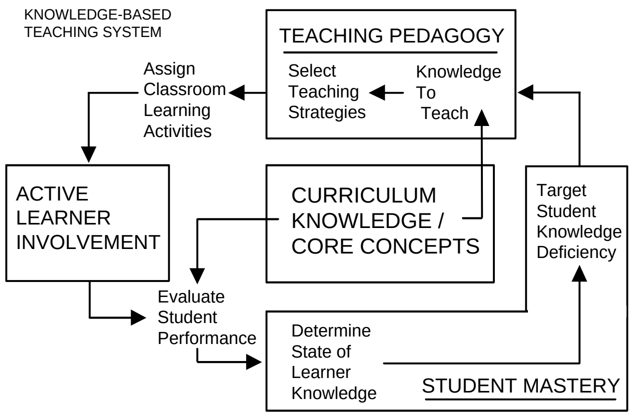


Figure 1. Architecture of knowledge-based intelligent tutoring system in which all aspects of instruction are linked to knowledge to be taught.

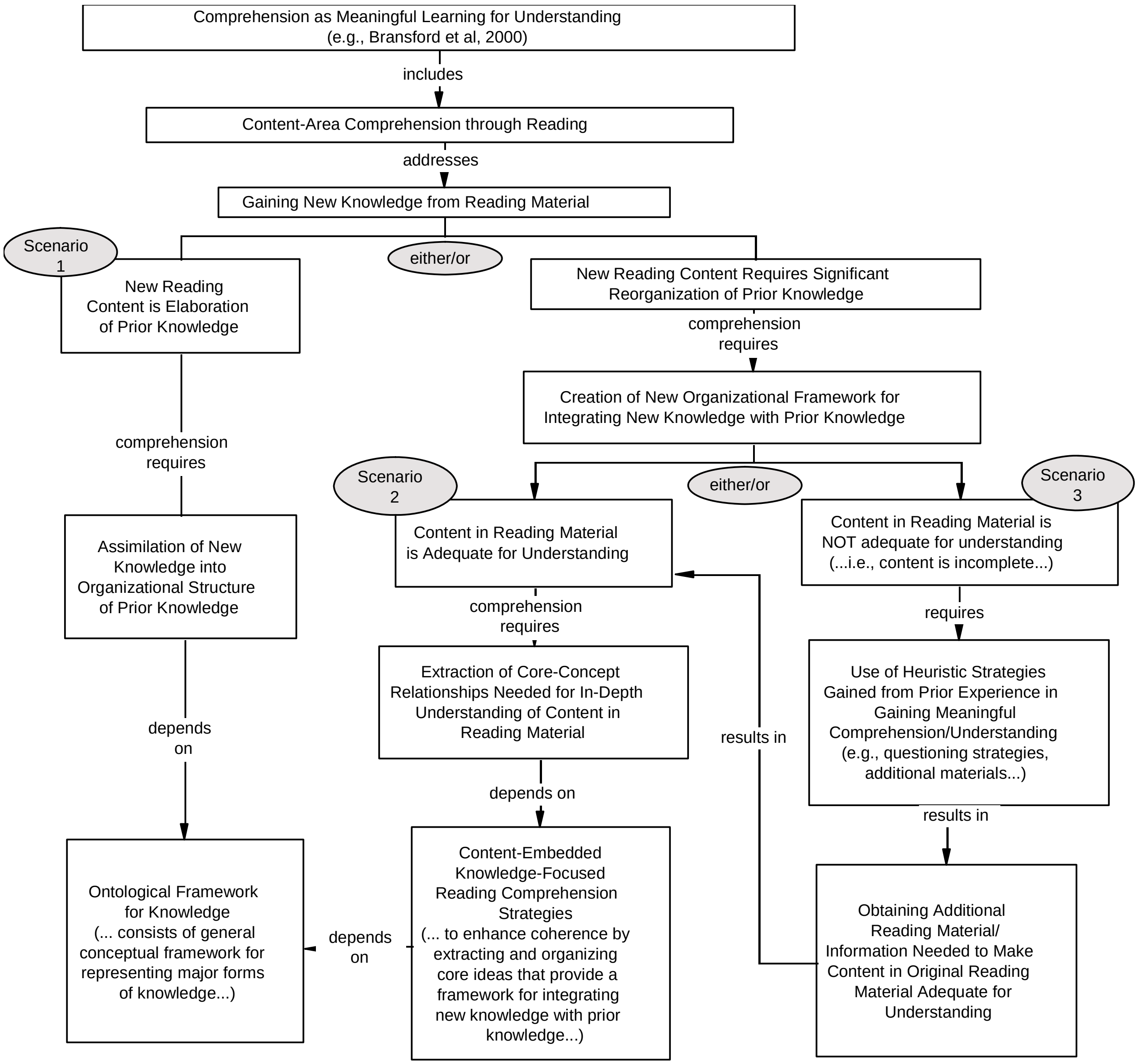


Figure 2. A knowledge-based perspective considering reading comprehension as a subset of meaningful understanding. Scenarios 1, 2, and 3 identify different contexts for reading comprehension.

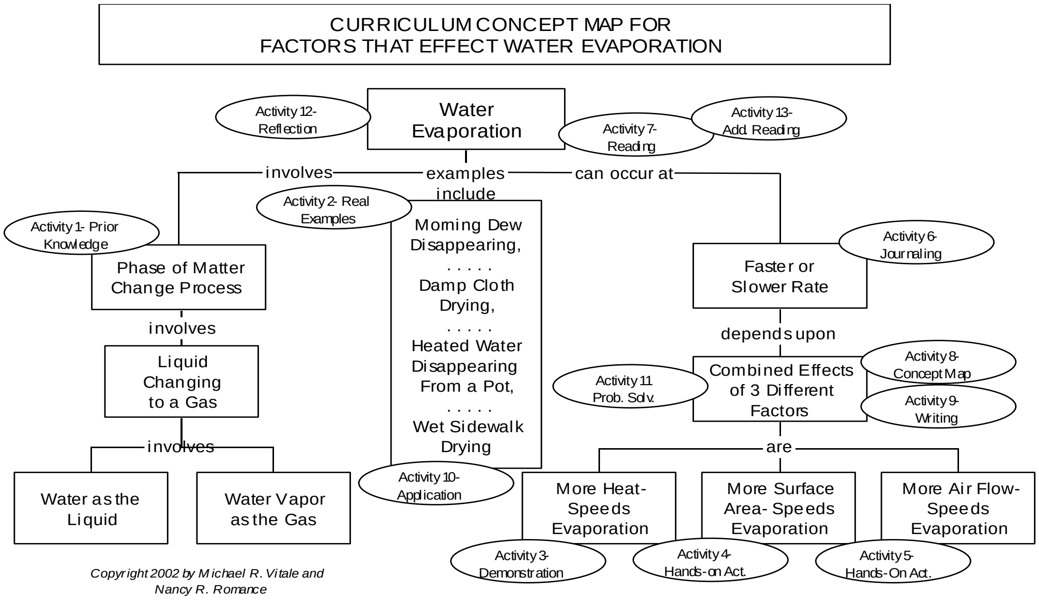
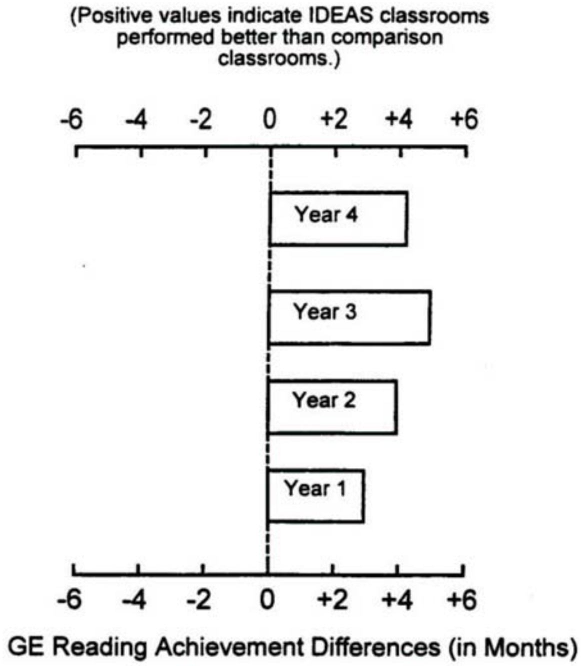


Figure 3. Simplified illustration of a propositional curriculum concept map used as a guide by *Science IDEAS* teachers to plan a sequence of knowledge-based instructional activities



Note : Year 1 students = grade 4; average/above average
Year 2 students = grade 4; average/above average
Year 3 students = grades 4,5; at-risk
Year 4 students = grades 4,5; average/above average/at-risk

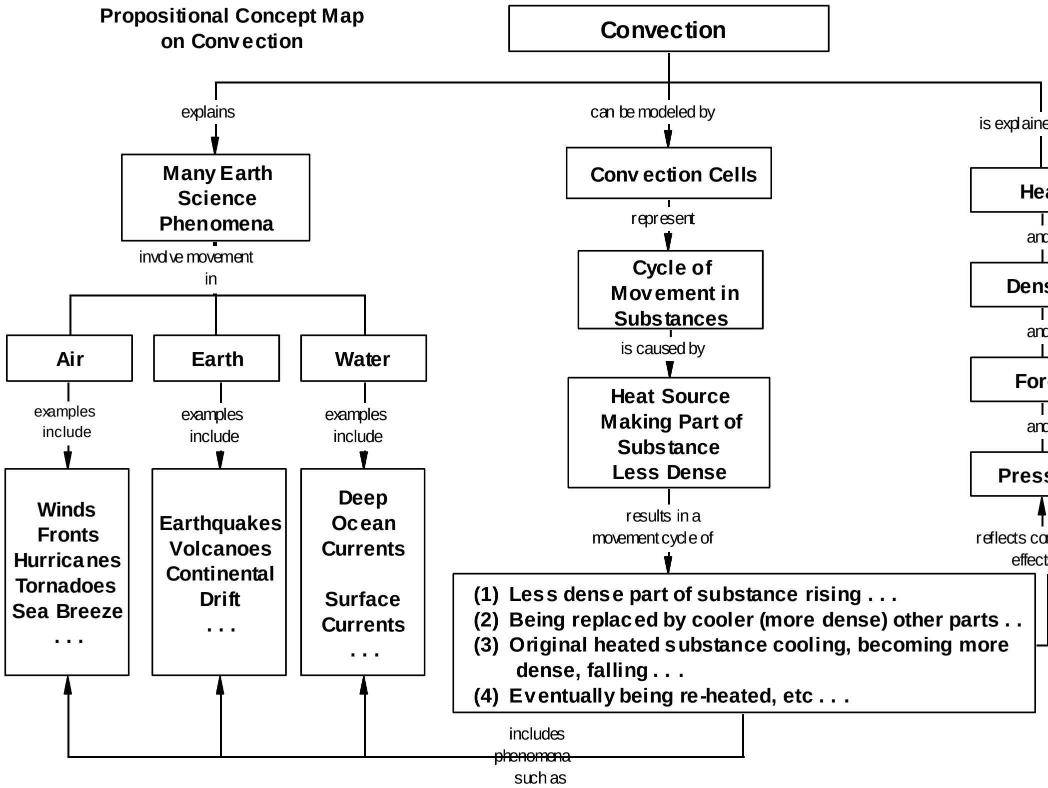


Figure 5. Example of a propositional concept map showing the role of convection in earth science (see also Figure 3).

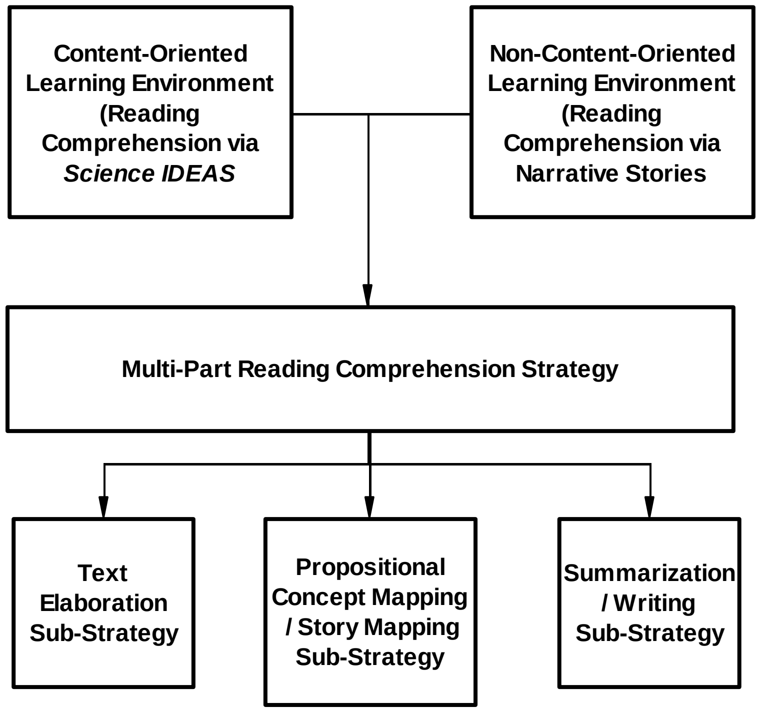


Figure 6. Elements of the two-factor experimental intervention (Type of Instructional Environment, Use of the Knowledge-Focused Reading Comprehension Strategy/Ontological Fluency Activity).

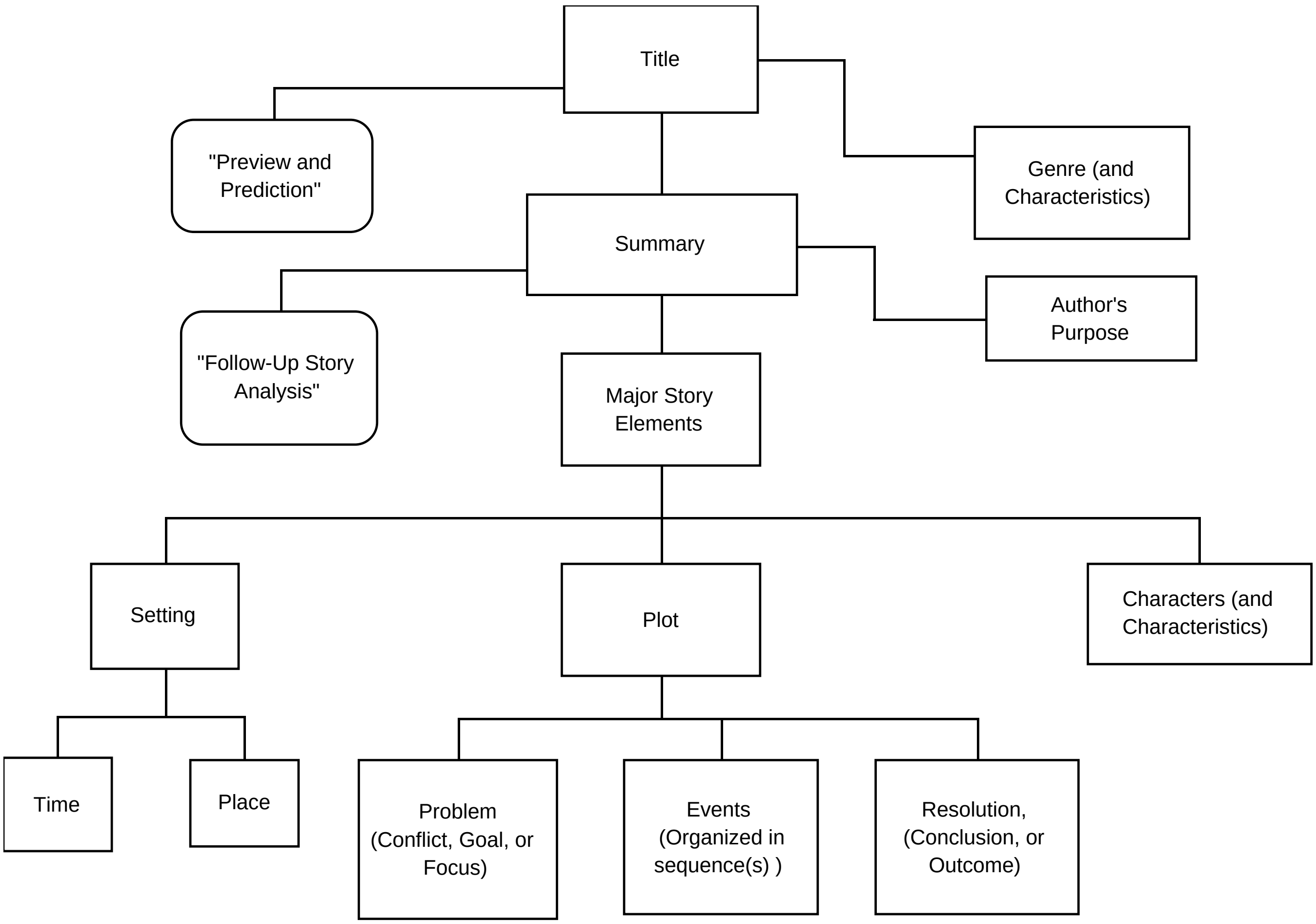


Figure 7. Framework for story mapping variant of propositional concept mapping used for basal narrative stories.