Abstract Title Page

Title:
An Integrated Interdisciplinary Model for Accelerating Student Achievement in Science and Reading Comprehension Across Grades 3-8: Implications for Research and Practice

Author(s):
Nancy R. Romance, Florida Atlantic University
Michael R. Vitale, East Carolina University
Abstract Body

Background / Context:

Despite a twenty-year emphasis on educational reform, student achievement in science and reading comprehension as reported in numerous international (Schmidt et al, 1999, 2001; Stephens & Coleman, 2007) and national reports (NAEP) in science (Grigg et al., 2006; Lutkus et al., 2006; USDOE 2001, 2005) and reading (NCES, 2009) remain systemic problems. In particular, meaningful content area learning from text has continued to be a significant barrier to both science learning and reading comprehension (e.g., AFT, 1997; Donahue et al., 1999; Feldman, 2000; Snow et al., 2002) for low socioeconomic status (SES) students who depend on school to learn (see Gamse et al., 2008; Kemple, et al., 2008; James-Burdumy et al., 2006; NCES, 2009). When reaching high school, many students from all SES strata have neither the sufficient conceptual prior knowledge to perform successfully in secondary science courses nor the more general capacity for building the coherent mental representations necessary for text comprehension (van den Broek, 2010).

Within the present reform framework, the lack of instructional time devoted to in-depth science teaching in elementary schools (see Dillon, 2006; Jones et al., 1999; Klentschy & Molina-De La Torre, 2004) has been identified as a key issue necessary to reform science (Hirsch, 1996; Vitale, Romance, & Klentschy, 2006) and, in a related sense, reading comprehension (Chall, 1985; Guthrie & Ozgungor, 2002; Pearson et al, 2010; van den Broek, 2010). Currently, there are few opportunities for elementary students to engage in the form of content-area reading that enables them to cross borders between everyday language and the discourse of science (Klentschy & Molina-De La Torre, 2004; Norris & Phillips, 2003; Romance & Vitale, 2010; Webb, 2010). Even with strong advocacy from reading researchers (Chall, 2003; Duke, 2010; Guthrie et al., 2002; Pearson et al., 2010; Snow, 2002) to integrate literacy with science, little effort to increase time for ‘reading to learn’ has occurred. In effect, there is sufficient evidence to suggest that the United States is neither providing the general population with the levels of scientific literacy (Krajcik & Sutherland, 2010) necessary to support learning of complex science concepts (van den Broek, 2010) nor the level of reading comprehension proficiency necessary for being successful in the workplace and acting as informed citizens (see Duschl et al., 2007; NAEP 2003, 2005).

Consensus interdisciplinary research perspectives about meaningful learning in science. Current interdisciplinary research related to meaningful learning summarized by Bransford et al. (2000) provides a foundation as to how conceptual understanding in content domains such as science establishes the prior knowledge and knowledge-structures necessary to support future learning as a core element in literacy development (e.g., reading comprehension as a form of understanding, coherent writing). Bransford et al summarized research studies of experts and expertise as a unifying concept for meaningful learning. Because the disciplinary structure of science knowledge is highly coherent, cumulative in-depth instruction in science provides a learning environment well-suited for the development of such understanding. As such, coherent curricular structures (e.g., Duschl et al., 2007; Lehrer et al., 2004; Smith et al., 2004, 2006) can readily incorporate elements associated with the cumulative development of curricular expertise by students. In turn, with the active development of such in-depth conceptual understanding serving as a curricular foundation (e.g., Carnine, 1991; Glaser, 1984; Kintsch,
the use of existing knowledge in the acquisition and communication of new knowledge provides the basis for engendering meaningful learning outcomes in science as well as scientific literacy and content-area reading comprehension.

**Comprehension and Learning.** Comprehension of printed materials (e.g., texts, science trade books, leveled readers) requires students to link relevant background knowledge to their construction of a coherent mental representation that reflects the intended meaning of the text (van den Broek, 2010). In effect, learner background knowledge supports the interpretation of text material. If learner background knowledge is highly organized around core concepts and concept relationships, there is a greater likelihood that the knowledge can be accessed for gaining new knowledge and understanding as well as serve as the basis for interpreting authentic experiences presented within science instruction. And, because the disciplinary structure of science knowledge is highly cohesive, cumulative in-depth instruction in science provides a learning environment well-suited for the development of understanding as expertise.

As a focus for meaningful learning in school settings, science conceptual knowledge is grounded on the everyday events students experience on a continuing basis. In developing science knowledge, elementary students are able to (a) link together different events they observe, (b) make predictions about the occurrence of events (or manipulate conditions to produce outcomes), and (c) make meaningful interpretations of events that occur, all of which are key elements of meaningful comprehension (see Vitale & Romance, 2007). In turn, with the active development of such in-depth conceptual understanding in science serving as a foundation, the use of prior knowledge in the comprehension of new learning tasks and in the communication of what knowledge has been learned provides a basis for key aspects of literacy development.

**Representative research integrating reading and science in grades K-3.** At the K-3 level, researchers (Conezio & French, 2002; French, 2004; Smith, 2001) reported the feasibility of curricular approaches in which science experiences provide rich learning contexts for early childhood curriculum resulting in science learning and early literacy development. Related work has been reported by a variety of science and literacy researchers (e.g., Asoko, 2002; Duke, 2010; Gelman & Brenneman, 2004; Ginsberg & Golbeck, 2004; Newton, 2001; Rakow & Bell, 1998; Revelle et al., 2002; Sandall, 2003; Schmidt et al., 2001; Smith, 2001).

**Representative research integrating reading and science in grades 3-5.** The potential promise of building student background knowledge for cumulative learning within science as a means for enhancing reading comprehension has been established repeatedly by the work of Guthrie and his colleagues (e.g., Guthrie et al., 2004; Guthrie & Ozgundor, 2002) with upper elementary students. In her analysis of basal reading series, Walsh (2003) noted that their use represented a lost opportunity to build the background knowledge necessary for comprehension. Other researchers (Armbuster & Osborn, 2001; Beane, 1995; Ellis, 2001; Hirsch, 1996, 2001; Palincsar & Magnusson, 2001; Pearson et al., 2010; Romance & Vitale, 2010; Schug & Cross, 1998; van den Broek, 2010; Yore, 2000) also have presented findings that support interventions in which core curriculum content in science serves as a powerful framework for building background knowledge and greater proficiency in the use of reading comprehension strategies. Research findings associated with the Science IDEAS model (described below) have repeatedly demonstrated that replacing traditional reading/language arts time with in-depth science instruction within which reading comprehension and writing are embedded consistently results in higher achievement outcomes in both reading comprehension and science on norm-referenced tests (Romance & Vitale, 1992, 2001, 2006, 2008, 2010).
The Science IDEAS instructional model for integrating reading within science.
Science IDEAS is a cognitive-science-oriented model that integrates reading and writing within in-depth science instruction. In grades 3-5, Science IDEAS is implemented schoolwide in 1.5 to 2 hour daily instructional lessons which focuses on science concepts. Implementation of the model emphasizes students learning more about what is being learned in a cumulative fashion that builds upon core science concepts and concept relationships. The architecture of the model (see Figure 1 for an illustration) involves sequencing different types of classroom instructional activities (e.g., hands-on activities, reading, concept-mapping, journaling/writing) according to a conceptually-coherent curricular framework, consistent with recommendations in the literature (e.g., Donovan et al., 2003; Duschl et al., 2007; Romance & Vitale, 2001, 2009; Vitale & Romance, 2010).

In cumulatively linking all their learning experiences together, students are afforded multiple opportunities to engage in fundamental literacy practices such as discussion, reading, writing and developing forms of argumentation based on their inquiry/explorations and learning from text-based and non-text-based instructional activities. Implementation of the Science IDEAS model (see Figure 1) involves teacher construction of propositional concept maps representing the conceptual structure of the science concepts to be taught. In turn, this representation serves as a coherent framework for identifying, organizing, and sequencing all instructional activities and assessments to be used. This framework also provides the means for an embedded approach to assessment (e.g., Pellegrino et al., 2001; Vitale, Romance, & Dolan, 2006).

Purpose / Objective / Research Question / Focus of Study:

The purpose of this cross-sectional study was to investigate the effects of a multi-year implementation of the Science IDEAS model on (a) the ITBS achievement growth in Reading Comprehension and Science of grade 3-5 students receiving the model, and (b) the transfer effects of the model as measured by ITBS Reading Comprehension and Science to grades 6-8.

In doing so, a major objective of the study was to demonstrate the implications for school reform of increasing the instructional time for in-depth science instruction as a means for accelerating student achievement in both reading and science.

Setting:

The study was conducted in a large (185,000 students), diverse (African American: 29%, Hispanic: 19%, Other: 5%, Free Lunch: 40%) urban school system in southeastern Florida.

Population / Participants / Subjects:

The study intervention (Science IDEAS) was implemented schoolwide in grades 3-5 in 12 elementary schools representative of the student diversity of the school system. Students in 12 demographically-similar schools served as controls. In addition, former Science IDEAS grade 6-8 students and comparison students in feeder middle schools were tested to assess transfer effects of the intervention.
**Intervention / Program / Practice:**

The Science IDEAS model (described previously) implemented in grades 3-5 served as the experimental intervention. The Science IDEAS model integrated reading and writing within in-depth science instruction across daily 1.5 to 2 hours instructional lessons which focused on science concepts along with ½ hour daily instruction in literature. The comparison students received the district-adopted basal reading/language arts program as well as ½ hour daily instruction using the district-adopted science curriculum.

**Research Design:**

**Data Collection and Analysis:**

*Instruments/Data Collection.* The nationally-normed Iowa Tests of Basic Skills (ITBS) Reading Comprehension and Science subtests served as measures of student learning. These were administered to participating students in grades 3-8 by classroom teachers under supervision of the researchers. Fidelity of implementation was monitored by researchers on a regular basis throughout the school year.

*Design/analysis.* The project was implemented over a 6-year period. In data preparation, middle school students were linked back to their grade 5 elementary school, in effect creating a grade 3-8 elementary school for data analysis. The overall cross-sectional design was a 2 x 2 factorial (Treatment, Grade), with two outcome measures (ITBS Reading, ITBS Science). Student demographic characteristics (Minority vs. non-Minority status, Gender, and Title 1 eligibility) functioned as student covariates. Analysis was conducted using HLM Version 6.08 (Raudenbush & Bryk, 2002) with students designated as level 1 and teachers as level 2. Treatment and grade were coded at level 2. In addition, a treatment x linear grade design variable was used to test for a treatment by grade interaction.

**Findings / Results:**

*Clinical assessment of implementation fidelity.* Monitoring of implementation fidelity showed that between 86-93 percent of grade 3-5 Science IDEAS teachers implemented the model effectively (with fidelity).

*ITBS student performance outcomes.* Tables 1 and 2 (refer to Tables 1 and 2 here) summarize the HLM analysis results. As Tables 1 and 2 show, the same overall pattern of significant findings was obtained for both ITBS Reading and Science. For both achievement measures, the Science IDEAS model resulted in higher achievement (+.40 GE for reading, +.29 GE for science); with grade level and non-minority status both being positively related to achievement; and with eligibility for Title 1 and Male (vs. Female) being negatively correlated with achievement. Because the treatment x grade interaction tested was not significant, it was not included in the tables. However, the final paper will explore and report the analysis of both higher order treatment x grade interactions and cross-level interactions of the treatment with student demographic characteristics. Because Title 1 status was closely related to prior student achievement levels, these data were not included in the analysis.
graphically illustrates the achievement trends across grade levels for the Science IDEAS and comparison students on ITBS Reading and ITBS Science.

Conclusions:

The findings of this multi-year, cross-sectional study substantially extend previously reported research demonstrating the effectiveness of content-area learning in science as a means for improving student reading comprehension. In doing so, this study is suggestive of reversing current curricular policy that emphasizes the major allocation of student instructional time to non-content-oriented basal reading programs in place of meaningful content-area instruction. Implications of the present study are that a curricular approach integrating literacy within in-depth science instruction potentially has the dual benefit of directly and, on a transfer basis, increasing student academic achievement in these two critical areas.
Appendices

Appendix A. References


Snow, C. E. (2002). Reading for understanding: Toward a research and development program in reading comprehension. Santa Monica, CA: RAND.


Yore, L. (2000). Enhancing science literacy for all students with embedded reading instruction and writing-to-learn activities. *Journal of Deaf Students and Deaf Education*, 5, 105-122.
Appendix B. Tables and Figures

Table 1. HLM Analysis of Intervention by Grade level for ITBS GE Reading Comprehension

<table>
<thead>
<tr>
<th>Fixed Effect</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-ratio</th>
<th>d.f</th>
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Table 2. HLM Analysis of Intervention by Grade level for ITBS GE Science

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Figure 1. Simplified illustration of a propositional curriculum concept map used as a guide by grade 4 Science IDEAS teachers to plan a sequence of instructional activities.
Figure 2. 2006-2007 Achievement Trajectories for Science IDEAS and Control Schools for ITBS Science and Reading. Since project was implemented in grades 3-4-5, performance of students in grades 6-7-8 represents a treatment-transfer effect.