Science IDEAS: Integrating Reading/Language Arts within Science Instruction Across Grades K-5

Nancy R. Romance, *Florida Atlantic University*
Michael R. Vitale, *East Carolina University*

Problem

The proficiency of students in grades 3-12 to read and comprehend subject-matter text is a continuing problem recognized by science and reading educators. In contrast to present efforts addressing this problem, the preparation of students to be successful content-area learners in science at the secondary level must begin in grades K-5. Such preparation in K-5 logically requires expanding instructional time for science and, in doing so, embedding reading and writing in support of greater in-depth science learning. This necessary increase in time for K-5 science can be accomplished by reallocating instructional time from reading/language arts to science. In effect, engaging students in conceptually-oriented reading tasks that further the development of cumulative, meaningful understanding promotes both science achievement and reading comprehension.

Architecture of the Science IDEAS Model

The Science IDEAS architecture combines science, reading comprehension, and writing through multi-day science lessons that integrate six Science IDEAS instructional elements (hands-on activities, reading comprehension, journaling/writing, propositional concept maps, application activities, prior knowledge/ cumulative review). These six elements are implemented within a conceptually-oriented and grade-articulated science curriculum organized around core concepts/big ideas. This curricular framework then serves as the basis for identifying, organizing, and sequencing all instructional activities in a manner that promotes meaningful student understanding of core science concepts.

The six elements specify the instructional components used by teachers in planning integrated science instruction. Teachers in grade level teams begin the planning process by first focusing on the core concepts and concept relationships (e.g., NGSS) that are to be taught and then organizing them in the form of propositional concept maps. These maps provide a conceptually coherent blueprint for identifying multiple sets of materials for hands-on inquiry/investigations, reading multiple non-fiction sources with writing and journaling (re: CCSS), along with student concept mapping, application activities, and the required prior knowledge to be reviewed. Once identified, these sets of materials are sequenced to form multi-day lessons that focus on the concepts to be taught.

Research Evidence of Effectiveness

The pattern of research evidence in support of the Science IDEAS model has been obtained across a series of studies conducted from 1992 through 2008 in authentic classrooms within two large, diverse urban school districts.

Early studies reported from 1992 through 2001. This series of four studies all demonstrated that students receiving the Science IDEAS instructional model outperformed demographically-comparable students on nationally-normed science (MAT, ITBS) and reading comprehension tests (SAT, ITBS). In the first year-long study conducted in grade 4, Science IDEAS students outperformed comparison students by approximately one year's grade equivalent (GE) in science achievement (+.93 GE) and one-third of a GE in reading achievement (+.33 GE). In the second (replication) study, similar levels of achievement effects were found with Science IDEAS students outperforming comparisons by +1.5 GE in science and +.41 GE in reading.

In the third study, the model implemented over a five-month period was tested more broadly by (a) using an increased number of participating teachers, (b) expanding the grade level range to include grades 4 and

5, and (c) increasing participant diversity by including at-risk students. Results of the year 3 study found that low-SES (predominantly African-American) Science IDEAS at-risk students in grade 5 significantly outperformed comparable controls by +2.3 GE in science and by +.51 GE in reading. However, in contrast with the previous first and second year-long studies, no differences were found for the younger grade 4 at-risk students for the 5-month intervention.

In the last study in the series, the number of teachers was increased to 45 across 15 school sites and the model implemented for a full school year. Results of the fourth study found that Science IDEAS students displayed greater overall achievement on both science (+1.11 GE) and reading (+.37 GE). Unlike the third study (implemented for 5 months), in Study four, no Treatment x Grade interactions were found, indicating that the year-long Science IDEAS intervention effects were consistent across both grade levels.

Recent cross-sectional studies from 2002 through 2007. While all of the earlier studies (1992-2001) focused on individual teachers/classrooms located in different school sites, beginning with 2002, Science IDEAS was implemented on a schoolwide basis in grades 3-4-5 in an increasing number of schools (from 2 to 12 over a multi-year project funded by the National Science Foundation). This enhanced research framework allowed the assessment of not only the direct effects of the model on science and reading achievement in grades 3-5; but also transfer effects of the model on science and reading achievement in grades 6-8.

Research to determine the effect of the Science IDEAS model across grades 3-8 on ITBS science and reading achievement involving 12 experimental and 12 comparison schools was completed in 2007. In the study, experimental students in grades 3-5 received Science IDEAS instruction for the entire school year. In providing measures of transfer, the experimental students in grades 6-8 had previously received Science IDEAS instruction while in grades 3-5. For science, linear models analysis found Science IDEAS students obtained higher overall ITBS science achievement than comparison students (adjusted mean difference = +.38 GE in Science with grade level differences ranging from +.1 GE to +.7 GE). Both the Treatment Main Effect and Treatment x Grade Interaction were significant, indicating that the magnitude of the treatment effect increased with grade level. For reading achievement, Science IDEAS students also obtained higher overall ITBS reading achievement than comparison students (adjusted mean difference = +.32 GE in reading with grade level differences ranging from .0 GE to +.6 GE). While the overall Treatment Main Effect was significant, the Treatment x Grade interaction for reading was not. However, in a follow-up study conducted in 2008, HLM analyses showed similar Treatment Main Effects and significant Treatment x Grade interactions for both science and reading, indicating that the treatment effect was magnified consistently with increasing grade level, thus confirming a strong transfer effect of the intervention from grades 3-5 to grades 6-8

Conceptual Framework

The Science IDEAS model is based on a conceptual framework that reflects consensus interdisciplinary research (e.g., cognitive science, applied learning theory, instructional design). A primary emphasis of the model for developing meaningful learning follows from the concept of expertise. One representative example of this perspective has been provided by Bransford et al. (2000 in their book, *How People Learn.* In it, Bransford et al. provided an interdisciplinary foundation as to why and how early conceptual understanding in content domains such as science establishes the prior knowledge and eventual organizational knowledge-structure necessary to support all future learning. Such conceptual understanding also serves as a core element in literacy development (e.g., reading comprehension as a form of understanding, and as the basis for coherent writing).

In their overview, Bransford et al. summarized established research studies of experts and expertise as a unifying concept for meaningful learning. Such studies have repeatedly found that in comparison to novices, experts demonstrate a highly-developed organization of knowledge that emphasizes an in-depth

understanding of the core concepts and concept relationships in their discipline (i.e., domain-specific knowledge) that, in turn, they are able to access efficiently and apply with automaticity. The emphasis by Bransford et al. (2000) on expertise is consistent with an explicit curricular focus on core concepts and concept relationships and on the enhancement of prior knowledge as being of paramount importance for meaningful learning. Further, this emphasis on disciplinary expertise in learning and performance amplifies the importance of a conceptually coherent and well articulated curricular structure that develops both conceptual understanding and knowledge to be used in application tasks (e.g., analyzing and solving problems). With the active development of such in-depth conceptual understanding serving as a foundation, the Science IDEAS model guides students in using previously learned knowledge as a basis for acquiring and communicating new knowledge. As students continue to learn more about what they have been learning across the six Science IDEAS elements, they are able to read with comprehension multiple texts on the same and related topics and link hands-on activities to concepts being learned.

Although the instructional implications of such a perspective are highly supportive of the importance of building student conceptual understanding in science, there are related implications for what is necessary for content-area reading comprehension, in general, that are consistent with the new emphasis from CCSS and NGSS standards that lead toward increased comprehension of informational text and advanced communication skills (e.g., argumentation, explanation, reasoning with evidence) as students progress from elementary through middle and high school.

Policy Implications

A major implication of the Science IDEAs model and supporting research evidence is to approach the development of reading comprehension as a form of meaningful learning. In this regard, all requirements for meaningful learning also apply to and are sufficient for reading comprehension. For example, from an interdisciplinary perspective, effective reading comprehension and meaningful learning both depend on the same combination of factors: (a) well-organized conceptual prior knowledge in combination with (b) the dynamic instructional factors experienced by students that engender in-depth learning and understanding. These key learning requirements are addressed by the Science IDEAS model by insuring that students are always learning more about what they already know as a result of their cumulative experiences in interacting with the elements of the model across multi-day units of study. In this way, the model provides a foundation for linking meaningful learning in science and reading comprehension.

A second major implication is that the implementation of the Science IDEAS model requires changes in curricular policy that would increase the instructional time allocated for science instruction across grades 3-5. As noted previously, the multi-year pattern of research findings demonstrated that the Science IDEAS model resulted in greater reading and science achievement than traditional Reading/Language Arts programs. Such findings justify changes in school-based curriculum policy that would increase the instructional time allocated to the Science IDEAS integrated science and literacy model for all students.

A third and final implication has to do with considering the redesign of achievement tests used for the purpose of accountability. Rather than testing “reading comprehension skills” per se, beginning with grade 3 the focus of tests for accountability should focus upon the assessment of content area learning and conceptual understanding (i.e., comprehension) of science and other content areas rather than reading per se. Such a systemic assessment initiative would result in curricular policy changes far more supportive of the preparation of students for the comprehension of the progressively more sophisticated text that they will encounter in content-focused high school courses.

Regarding each of these three implications, the Science IDEAS model offers K-5 elementary curriculum policymakers an evidence-based alternative for increasing student achievement in both science and reading comprehension.