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, 1998; Vitale & Romance, 2000), 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 (Armbruster & 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 & Byrk, 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 use 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. Figure 2 (see Figure 2 here) 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

American Federation of Teachers (AFT). (1997). *Making standards matter 1997. An annual fifty state report on efforts to raise academic standards.* Washington, DC: AFT.

Armbruster, B. B., & Osborn, J. H. (2001). *Reading instruction and assessment: Understanding IRA standards.* New York: Wiley.

Asoko, H. (2002). Developing conceptual understanding in primary science. *Cambridge Journal of Education, 32*(2), 153-164.

Beane, J. A. (1995). Curriculum integration and the disciplines of knowledge. *Phi Delta Kappan, 76,* 646-622.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (2000). *How people learn.* Washington, DC: National Academy Press.

Carnine, D. (1991). Curricular interventions for teaching higher order thinking to all students: Introduction to a special series. *Journal of Learning Disabilities, 24 (5),* 261-269.

Chall, J. S., & Jacobs, V. A. (2003). The classic study on poor children's fourth grade slump. *American Educator*, *27*(1), 14-16.

Conezio, K. & French, L. (2002). Science in the preschool classroom: Capitalizing on children's fascination with the everyday world to foster language and literacy development. *Young Children, 57*(5), 12-18.

Dillon, S. (March 26, 2006). Schools push back subjects to push reading and math. New York Times. http://nytimes.com/2006/03/26/education/26child.html?pagewanted=1&_r=1

Donahue, P. L., Voekl, K. E., Campbell, J. R., & Mazzeo, J. (1999). *NAEP 1998 Reading Report Card for the States*. National Center for Educational Statistics, Office of Educational Research and Improvement, U.S. Department of Education, Washington, DC.

Donovan, M. S., Bransford, J. D., & Pellegrino (Eds.) (2003). *How people learn: Bridging research and practice*. Washington, DC: National Academy Press

Duke, N. K. (2010). The real world reading and writing U.S. children need. *Kappan*, 91(5), 68-71.

Duschl, R. A., Schweingruber, & Shouse, A. W. (2007). *Taking science to school: Learning and teaching science in grades K-8.* Washington, DC: National Academies Press.

Ellis, A. K. (2001). *Research on educational innovations.* Larchmont, NY: Eye on Education.

Feldman, S. (2000). Standards are working: But states and districts need to make some mid-course corrections. *American Educator, 24*(3), 5-7.

French, L. (2004). Science as the center of a coherent, integrated early childhood curriculum. *Early Childhood Research Quarterly, 19*, 138-149.

Gamse, B. C., Bloom, H. S., Kemple, J. J., & Jacob, R. T. (2008). *Reading First impact study: Interim report* (NCEE 2008-4016). Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U. S. Department of Education.

Gelman, R. & Brenneman, K. (2004). Science learning pathways for young children. *Early Childhood Research Quarterly, 19,* 150-158.

Ginsburg, H. P. & Golbeck, S. L. (2004). Thoughts on the future of research on mathematics and science learning and education. *Early Childhood Research Quarterly, 19,* 190-200.

Glaser, R. (1984) Education and thinking: The role of knowledge. *American Psychologist, 39(2)* 93-104.
Grigg, W.S., Lauko, M.A., and Brockway, D.M. (2006). *The nation's report card: Science 2005*(NCES 2006–466). U.S. Department of Education, National Center for Education Statistics. Washington, DC: U.S. Government Printing Office.
Guthrie, J. T., & Ozgungor, S. (2002). Instructional contexts for reading engagement. In C.C. Block & M. Pressley (Eds.). *Comprehension instruction: Research-based best practices* (pp. 275-288). New York: The Guilford Press.
Guthrie, J. T., Wigfield, & Perencevich, K. C. (Eds.). (2004). *Motivating reading comprehension: Concept-oriented reading instruction.* Mahwah, NJ: Earlbaum.
Hirsch, E. D. (2001). Seeking breadth and depth in the curriculum. *Educational Leadership, 59* (2), 21-25.
Hirsch, E. D. (1996). *Schools we need. And why we don't have them.* NY: Doubleday.
James-Burdumy, S., Mansfield, W., Deke, J., Carey, N., Lugo-Gil, J., Hershey, A., Douglas, A., Gersten, R., Newman-Gonchar, R., Dimino, J. & Faddis, B. (2009). *Effectiveness of selected supplemental reading comprehension interventions: Impacts on a first cohort of fifth grade students*. (NCEE 2008-4015). Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance.
Jones, M. G., Jones, B.D., Hardin, B., Chapman, L., Yarbrough, T., & Davis, M. (1999). The impact of high-stakes testing on teachers and students in North Carolina. *Phi Delta Kappan*, *81,* 199-203.
Kemple, J. J., Corrin, W., Nelson, E., Salinger, T., Herrmann, S. & Drummon, K. (2008). *The enhanced reading opportunities study: Early impacts and implementation findings.* (NCEE 2008-4015). Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance.
Kintsch, W. (1998). *Comprehension: A paradigm for cognition*. Cambridge, U.K.: Cambridge University Press.
Klentschy, M. P., & Molina-De La Torre, E. (2004). Students' science notebooks and the inquiry process. In E.W. Saul (Ed.), *Crossing borders in literacy and science instruction: Perspectives on theory and practice* (pp.340-354). Newark, DE: International Reading Association.
Krajcik, J. S. & Sutherland, L. M. (2010). Supporting students in developing literacy in science. *Science*, 328, 456-459.
Lehrer, R., Catley, K., & Reiser, B. (2004). *Tracing a perspective learning progression for developing understanding of evolution.* Washington, DC: National Academy of Sciences.
Lutkus, A. D., Lauko, M. A. & Brockway, D. M. (2006). *The nation's report card: Science 2005 trial urban district assessment*. National Assessment of Educational Progress: Washington, DC: U. S. Department of Education.
NAEP (2005). *What does the NAEP reading assessment measure?* http://nces.ed.gov/nationsreportcard/reading/whatmeasure.asp
NAEP (2003). *The nation's report card: Science 2000*. Washington, DC: U. S. Government Printing Office. (http://nces.ed.gov/nationsreportcard).
National Center for Education Statistics (2009). *The nation's report card: Trial urban district assessment- reading 2009.* (NCES 2010–459). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education, Washington, D.C.

Newton, L. D. (2001). Teaching for understanding in primary science. *Evaluation and Research in Education, 15*(3), 143-153.

Norris, S. P. & Phillips, L. M. (2003). How literacy in its fundamental sense is central to scientific literacy. *Science Education* 87, 224-240.

Palincsar, A. S., & Magnusson, S. J. (2001). The interplay of first-hand and second-hand investigations to model and support the development of scientific knowledge and reasoning. In S. M. Carver & D. Klahr (Eds.), *Cognition and instruction: Twenty-five years of progress* (pp. 151-195). Mahwah, NJ: Erlbaum.

Pearson, P. D., Moje, E., & Greenleaf, C. (2010). Literacy and science: Each in the service of the other. *Science*, 328, 459-463.

Pellegrino, J. W., Chudowsky, N., & Glaser, R. (Eds.). (2001). *Knowing what students know.* Washington, DC: National Academy Press.

Rakow, S. J. & Bell, M. J. (1998). Science and young children: The message from the National Science Education Standards. *Childhood Education, 74*(3), 164-167.

Raudenbush, S. W., & Byrk, A. S. (2001). *Hierarchical linear models: Applications and data analysis methods*. Sage Publications.

Revelle, G., Druin, A., Platner, M., Bederson, B., Hourcade, J. P., & Sherman, L. (2002). A visual search tool for early elementary science students. *Journal of Science Education and Technology, 11*(1), 49-57.

Romance, N. R., & Vitale, M. R. (1992). A curriculum strategy that expands time for in-depth elementary science instruction by using science-based reading strategies: Effects of a year-long study in grade 4. *Journal of Research in Science Teaching*, *29,* 545-554.

Romance, N. R., & Vitale, M. R. (2001). Implementing an in-depth expanded science model in elementary schools: Multi-year findings, research issues, and policy implications. *International Journal of Science Education, 23,* 373-404.

Romance, N. R. & Vitale, M. R. (2006). Making the case for elementary science as a key element in school reform: Implications for changing curricular policy. In Douglas, R., Klentschy, M. & Worth, K. (Eds.). *Linking Science and Literacy in the K-8 Classroom.* (pp. 391-405). Washington, DC: National Science Teachers Association.

Romance, N. R., & Vitale, M. R. (2008). *Science IDEAS: A knowledge-based model for accelerating reading/literacy through in-depth science learning.* Paper presented at the Annual Meeting of the American Educational Research Association, New York, NY.

Romance, N. R., & Vitale, M. R. (2010). *Toward a curricular policy for advancing school reform by integrating reading comprehension within time-expanded science instruction in grades k-5*. Presented at the Annual Meeting of the National Association for Research in Science Teaching, Philadelphia, PA.

Sandall, B. R. (2003). Elementary science: Where are we now? *Journal of Elementary Science Education, 15*(2), 13-30.

Schmidt, W. H., McKnight, C., Cogan, L. S., Jakwerth, P. M., & Houang, R. T. (1999). *Facing the consequences: Using TIMSS for a closer look at U.S. mathematics and science education.* Boston: Kluwer Academic Publishers.

Schmidt, W. H., McKnight, C. C., Houang, R. T., Wang, H. C., Wiley, D. E., Cogan, L. S., et al. (2001). *Why schools matter: A cross-national comparison of curriculum and learning*. San Francisco: Jossey-Bass.

Schug, M.C., & Cross, B. (1998). The dark side of curriculum integration. *Social Studies, 89,* 54-57.

Smith, A. (2001). Early childhood – a wonderful time for science learning. *Investigating: Australian Primary & Junior Science Journal, 17*(2), 18-21.

Smith, C., Wiser, M., Anderson, C. A., & Krajcik, J. (2006). Implications of research on children's learning for standards and assessment: A proposed learning progression for matter and atomic molecular theory. *Measurement: Interdisciplinary Research and Perspectives,* 4, 45-67.

Smith, C., Wiser, M., Anderson, C. A., Krajcik, J. & Coppola, B. (2004). *Implications of research on children's learning for assessment: Matter and atomic molecular theory.* Committee on Test Design for K-12 Science Achievement, Washington, DC: National Research Council.

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

Stephens, M., & Coleman, M. (2007). *Comparing PIRLS and PISA with NAEP in reading, mathematics and science* (Working Paper). U.S. Department of Education. Washington, DC: National Center for Education Statistics. Available at: http://nces.ed.gov/Surveys/PISA/pdf/comppaper12082004.pdf

U.S. Department of Education. Office of Educational Research and Improvement. National Center for Education Statistics. *The Nation's Report Card: Science Highlights 2000,* NCES 2002-452, by National Center for Education Statistics. Washington, DC: 2001.

U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2005 Trial Urban District Science Assessment.

Van den Broek, P. (2010). Using texts in science education: Cognitive processes and knowledge representation. *Science*, 328, 453-456.

Vitale, M. R., & Romance, N. R. (2000). Portfolios in science assessment: A knowledge-based model for classroom practice. In J. J. Mintzes, J.H. Wandersee, & J.D. Novak (Eds.), *Assessing science understanding: A human constructivist view* (pp. 168-197). San Diego, CA: Academic Press.

Vitale, M. R, & Romance, N. R. (2007). *Adaptation of a knowledge-based instructional intervention to accelerate student learning in science and early literacy in grades 1-2.* Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, IL.

Vitale, M. R, & Romance, N. R. (2010). *Effects of an integrated instructional model for accelerating student achievement in science and reading comprehension in grades 1-2.* Paper presented at the Annual Meeting of the American Educational Research Association, Denver, CO.

Vitale, M. R., Romance, N. R., & Dolan, F. (2006). A knowledge-based framework for the classroom assessment of student science understanding. In M. McMahon, P. Simmons, R. Sommers, D. DeBaets, & F. Crawley (Eds.). *Assessment in science: Practical experiences and education research.* (pp1-14). Arlington, VA: NSTA Press.

Vitale, M. R., Romance, N. R., & Klentschy, M. (2006). *Improving school reform by changing curriculum policy toward content-area instruction in elementary schools.* Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, CA.

Walsh, K. (2003). Basal readers: Lost opportunity to build the background knowledge that propels comprehension. *American Educator, 27*(1), 24-27.

Webb, P. (2010). Science education and literacy: Imperatives for the developed and developing world. *Science*, 328, 448-450.

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

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f	P-value
For INTRCPT1, B0					
INTRCPT2, G00	2.563937	0.235314	10.896	347	0.000
GRADE, G01	0.693687	0.047617	14.568	347	0.000
TRT- C0E1, G02	0.402983	0.135771	2.968	347	0.004
For TITLE1_1 slope, B1					
INTRCPT2, G10	-0.509145	0.089359	-5.698	3857	0.000
For NON-MINORITY slope, B2					
INTRCPT2, G20	0.622932	0.090324	6.897	3857	0.000
For SEXM1_F0 slope, B3					
INTRCPT2, G30	-0.331667	0.065123	-5.093	3857	0.000

Table 2. HLM Analysis of Intervention by Grade level for ITBS GE Science

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f	P-value
For INTRCPT1, B0					
INTRCPT2, G00	1.808822	0.181694	9.955	320	0.000
GRADE, G01	0.586928	0.037741	15.552	320	0.000
TRT-C0E1, G02	0.285723	0.106599	2.680	320	0.008
For TITLE1_1 slope, B1					
INTRCPT2, G10	-0.422993	0.060634	-6.976	3417	0.000
For NON-MINORITY slope, B2					
INTRCPT2, G20	0.479688	0.063998	7.495	3417	0.000
For SEXM1_F0 slope, B3					
INTRCPT2, G30	-0.105690	0.051438	-2.055	3417	0.040

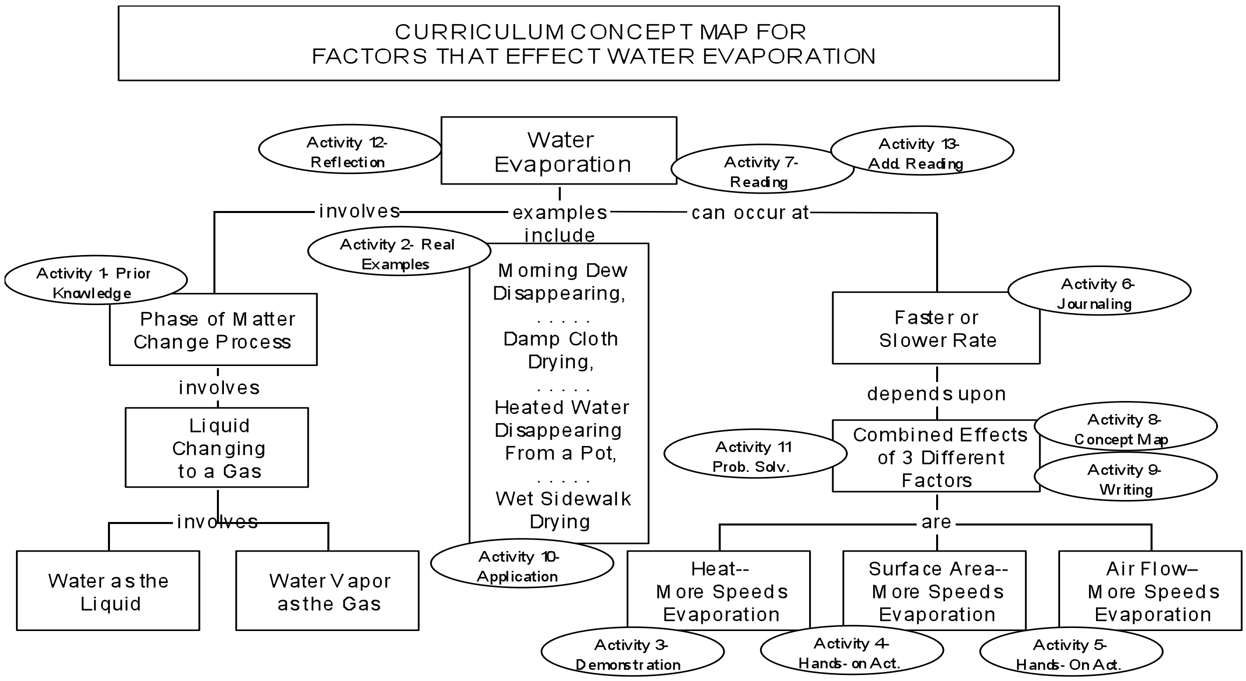

Figure 1. Simplified illustration of a propositional curriculum concept map used as a guide by grade 4 *Science IDEAS* teachers to plan a sequence of instructional activities.

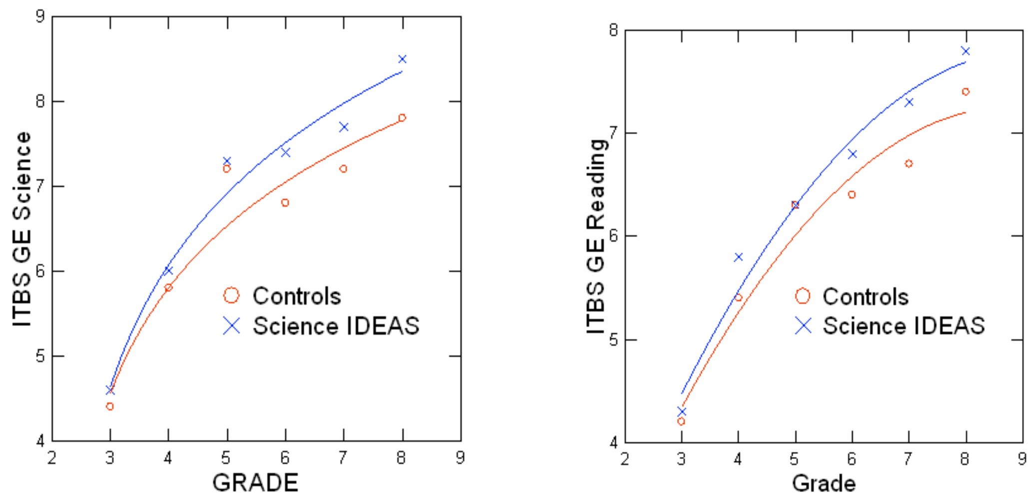

Figure 2. 2006-2007 Achievement Trajectories for Science IDEAS and Control Schools for ITBS Science and Reading. Since project was implemented in grades 3-4-5, performance of students in grades 6-7-8 represents a treatment-transfer effect.