Effects of an Integrated Instructional Model for Accelerating Student Achievement in Science and Reading Comprehension in Grades 1-2 [1, 2]

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Abstract

This study focused on accelerating development of science knowledge at the primary level (grades 1-2) as a means for enhancing comprehension readiness/reading (i.e., early literacy). An adaptation of a grade 3-5 cognitive-science-based, instructional model (*Science IDEAS*) and an earlier 8-week intervention, this year-long study implemented daily 45-minute periods emphasizing in-depth, cumulative learning of science core-concept "clusters" that provided teachers with a thematic focus for all aspects of instruction. Results (a) reconfirmed the feasibility of implementing in-depth science at the primary level and (b) showed that experimental students obtained significantly higher achievement on ITBS Reading and Science tests than comparable controls. Discussed are curricular policy implications for increasing the instructional time for content-area instruction at the primary level.

Despite a twenty year emphasis on educational reform, student achievement in science and reading comprehension remain systemic problems (Schmidt et al., 1999, 2001; USDOE, 2000, 2004, 2007). In particular, the problem of meaningful content area learning from text is a significant barrier (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.

Addressing these issues in a developmental fashion, this study focused on accelerating science learning at the primary level (grades 1-2) as a means for enhancing comprehension readiness (i.e., early literacy). In adapting a cognitive-science-based, instructional model (*Science IDEAS*) shown effective (e.g., Romance & Vitale, 1992, 2001, 2006, 2009; in press; Vitale & Romance, 2006, 2008, 2009) in accelerating science understanding and reading comprehension proficiency of grades 3-5 students, this study addressed a recognized need to develop student science understanding and comprehension proficiency at the primary levels (see French, 2004; Gelman & Brenneman, 2004) in order to raise school achievement expectations for all students. In doing so, the present year-long study expanded a previous 8-week study (Vitale & Romance, 2007b) which found significant achievement growth in ITBS Reading and Science for grade 1-2 students resulting from implementation of the instructional model.

The primary objective of this study was to investigate the effects of implementing the integrated instructional model for a full school year on student science and reading achievement in grades 1 and 2. The overall goal of the study was to advance knowledge regarding the bridging of research and practice by applying a broad set of interdisciplinary research findings to systemic issues regarding the interdependence of the meaningful learning of science and the development of reading comprehension proficiency at the primary levels in a manner that would enhance the preparation of students to be successful in grade 3 and beyond.

Theoretical Perspectives on Science and Literacy

Cognitive science foundations of the original Science IDEAS intervention. The research foundations of the original grade 3-5 *Science IDEAS* intervention consist of consensus findings from cognitive science and related disciplines (e.g., instructional design) that, in turn, are directly applicable to the grade 1-2 *Science IDEAS* adaptation used in the present study (Vitale & Romance, 2006). As a knowledge-based

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[1] *Paper presented at the 2010 Annual Meeting of the American Educational Research Association, Denver, CO.*

[2] *The research reported here was supported by the National Science Foundation through Grant REC 0228353 to Florida Atlantic University.*

instructional model, *Science IDEAS* requires (a) the explicit representation of the knowledge to be taught and learned in the form of core concepts and concept relationships and (b) subsequent linkage of all instructional methods and activities chosen for use by teachers to the same framework of core concept relationships. In implementing the model, teachers select and use a wide variety of reading/language arts and hands-on activities that expand student in-depth science knowledge about what is being learned. This instructional framework enables teachers to adopt a cumulative inquiry style that (a) focuses on what is being learned over a sequence of different activities on the expansion of student conceptual knowledge and understanding and (b) guides students to relate what they have learned as elaborations of the core concepts taught.

Central to the foundations of the *Science IDEAS* model is a report by the National Academy Press, *How People Learn*, edited by Bransford et al. (2000). As an emergent research trend, Bransford et al. stressed the development and access of core concepts and concept relationships as critical elements in the development of any form of expertise. In a parallel fashion, the *Science IDEAS* model emphasizes using the core concepts that reflect the logical structure of the discipline as an instructional architecture for building student cumulative, meaningful learning as a form of expertise (see also French, 2004; Schmidt et al., 2001). A number of other articles (Beane, 1995; Hirsch, 2001, 2006; Schmidt et al., 1999, 2001) have discussed curricular issues and findings that support curriculum interventions represented by knowledge-based instructional approaches such as that used in the present study.

Other research relevant to in-depth science instruction and comprehension. The National Reading Panel (2000, p.464) recognized the original grade 3-5 *Science IDEAS* study (Romance & Vitale, 1992) as one of the few scientifically-based research studies demonstrating combined student achievement in science and reading comprehension. In addition, Romance and Vitale (2001) replicated and extended their initial study over an additional two-year period and obtained similar achievement outcomes in science and reading. Since that time, Klentschy et al. (2004) demonstrated a significant impact of the number of years of science-focused instruction in grades K-5 on California Reading Tests. Guthrie and Ozgungor (2002) and Guthrie et al. (2004) showed that the use of content reading materials at the upper elementary significantly affected reading proficiency and student motivation (see also Armbruster & Osborn, 2001), and Block and Pressley (2002) reported that many of the strategies encompassed in the original *Science IDEAS* and the present grade 1-2 adaptation (e.g., relating prior knowledge, mental imagery, questioning, and summarization) were effective in improving reading comprehension (see also Palincsar & Magnusson, 2001).

Research trends recognizing the importance of informational text in primary grades. The grade 1-2 intervention focused on developing meaningful knowledge in science, in part, by emphasizing informational text (Palmer & Stewart, 2003) for developing comprehension proficiency at the primary levels (see also Holliday, 2004; Klentschy et al., 2004; Ogle & Blachowicz, 2002; Gould, Weeks, & Evans, 2003, for related views). Pearson and Duke (2002) noted that the terms “comprehension instruction” and “primary grades” seldom appear together. Further, they reported that teachers erroneously believe comprehension instruction must wait until students develop decoding proficiency. In doing so, they listed and refuted major unsupported beliefs that serve as barriers to the use of informational text at the primary grades. Duke and others (e.g., Duke et al., 2003a, 2003b; Pressley et al., 1996) found that primary students have minimal opportunities for learning that involves meaningful comprehension, despite extensive research on how such instruction should (and should not) be pursued effectively (see Hirsch, 2001, 2003; Jones et al., 1999; Klentschy et al., 2004; Pretti-Frontczak, 2003).

Research trends recognizing the importance of science instruction in primary grades. Emphasized in this study is how science knowledge provides a meaningful context through which primary students experience cumulative meaningful learning in a fashion that enhances their capacity for comprehension. French (2004) reported the feasibility of a curricular approach in which science experiences resulted in early literacy development as well as science learning. Gelman and Brenneman (2004) showed how a preschool science program including guided hands-on activities can serve as a framework for instruction that supports developing domain specific knowledge in young children. In working with 3 to 6 year olds, Smith (2001) described how active involvement of young children in science learning is naturally motivating (see also Conezio & French, 2002) if topics are approached with sufficient depth and time, a position consistent with "National Science Education Standards" (see Rakow & Bell, 1998). Gould (2003) described an approach for early science instruction with gifted students, Tytler and Peterson (2001) summarized the meaningful changes in 5-year-old's explanations of evaporation as a result of extended in-depth science instruction, Jones and Courtney (2002) addressed the processes of curricular planning and assessment in early science learning, Armga et al. (2002) and Colker (2002) suggested guidelines for teaching science in early childhood settings, and Lee et al. (2000) described the benefits of schoolwide thematically-oriented science instruction.

Method

Participants. The study was implemented in grades 1-2 of two elementary schools which were representative of the student diversity (African American: 29%, Hispanic: 19%, Other: 5%, Free Lunch: 40%) in a large (185,000 students) school system in southeastern Florida. Students in two demographically-similar schools served as controls. Table 1 summarizes the demographic characteristics of the participating students by school.

Table 1. *Participant Numbers (Teachers, Students) and School Demographic Characteristics*

Treatment Group	School	N Tch.	N Stud.	Pct. Minority	Pct. White	Pct. Af.Am.	Pct. Hisp.
Science IDEAS	A	6	101	61	30	41	20
	B	5	79	69	21	17	52
Controls	C	6	104	78	16	41	37
	D	5	79	80	15	13	67

Note. Controls engaged in minimal amounts of instruction in science. Rather, their emphasis was in Reading/Language Arts.

Instrumentation. The nationally-normed *Iowa Tests of Basic Skills (ITBS) Reading Comprehension* and *Science* subtests (*Level 7* for grade 1, *Level 8* for grade 2) were administered by classroom teachers under supervision of the researchers as measures of student learning.

Experimental intervention. The study was implemented over the school year during which daily 45-minute lessons emphasized the core-concept "clusters" (e.g., grade 1- *Solids and liquids, Using your senses, Measuring tools, Gases, Phases of matter, Forms of energy, Energy transfer, Pushes and pulls, Types of forces, Simple machines*; grade 2- *States of matter, Using your senses, Measuring tools, Physical changes, Forms of energy, Energy transfer, Pushes and pulls, Simple machines, Heat energy*).

Unlike the grade 3-5 *Science IDEAS* model which replaces traditional reading/language arts instruction, the daily 45-minute instructional blocks in grades 1-2 complemented existing reading/language arts instruction. In using core science concept "clusters" as a curricular focus, instructional activities in grade 1 emphasized teacher read-alouds and teacher-guided student understanding of age-appropriate science materials complemented by hands-on activities, with follow-up simple concept mapping and journaling. In grade 2, the instructional activities included all of the grade 1 activities, but placed an increased emphasis on teacher-guided student reading and in-depth comprehension of science materials, concept mapping to represent knowledge learned, and writing (or drawing) to communicate what had been learned. In comparison to grade 1-2 experimental classrooms, teachers in demographically comparable control schools followed the regular District science program. Both experimental and control schools also implemented the District-adopted, basal-oriented Reading/Language Arts program.

Teacher professional development and implementation support for the grade 1-2 intervention. The teacher professional development modules and support strategies used were developed and validated in the previous 8-week study (Vitale & Romance, 2007b). Initially, participating teachers completed a two-day professional development "start-up" module. Subsequently, teachers participated in two additional ½ days of follow-up training. Because participating and comparision schools also were implementing the grade 3-5 *Science IDEAS* model, grade 1-2 teachers in all schools were able to gain mentor support from more experienced science teachers. The primary focus of project professional development was on (a) insuring teachers had a sound understanding of the science concepts they were to teach (including proficiency on age-appropriate hands-on activities) and (b) providing assistance in teacher curriculum/lesson planning that focused on the science concepts to be taught.

Design, analysis, data sources, and procedure. As a control for the differential influence of science teaching support for grade 1-2 teachers, both the experimental and control schools selected were implementing the *Science IDEAS* model in grades 3-5. The overall design framework for the study consisted of a 2 x 2 factorial design (Treatment, Grade) with two outcome measures (ITBS Reading, ITBS Science). As shown in Table 1, a total 11 experimental (Grade 1: N = 5, Grade 2: N = 6) and 11 control classrooms (Grade 1: N = 5, Grade 2: N = 6) participated in the study. Selected student demographic variables (Gender, Ethnicity) served as covariates. After preliminary OLS linear models analyses, separate two-level HLM analyses on each of the ITBS measures (Reading, Science) were conducted using HLM 6, with Treatment and Grade assigned to Level 2 (teacher/classroom level) and student demographic characteristics (Gender, Ethnicity - Coded as White vs. Non-White and as Black vs. Hispanic) assigned to Level 1 (student level). Student Title 1 status was not included in the analyses because Title 1 status was highly correlated with ethnicity.

Monitoring of intervention fidelity. Project staff informally monitored all participating classrooms on a regular/continuing basis. Implementation/fidelity forms adapted from the grade 3-5 *Science IDEAS* implementation model were used as monitoring guides (e.g., classroom displays, teacher use of *Science IDEAS* elements/activities, active student engagement in learning). The fidelity monitoring process also provided the project staff with a basis for evaluating teacher implementation needs and providing follow-up support.

Results

Clinical assessment of implementation fidelity. Assessment of implementation fidelity involved a variety of informal observations leading to clinical judgments. Primarily, these consisted of (a) regular informal visits to grade 1-2 classrooms by project staff using the science curricular emphasis and (b) status reports and trouble-shooting requests conducted through professional development and follow-up teacher support provided by project staff. In general, grade 1-2 teachers were judged as effective in implementing the grade 1-2 *Science IDEAS* model throughout the duration of the study.

Descriptive statistics of experimental and control schools. Table 2 summarizes the mean grade-equivalent performance in the treatment and control schools by the academic outcome measures by grade.

Student performance outcomes. Table 3 summarizes the results of the HLM analysis for ITBS Reading and Table 4 for ITBS Science. As the Tables show, the effects of the Treatment/Intervention was statistically significant in favor of the grade 1-2 experimental *Science IDEAS* classrooms for both ITBS Science and Reading. In addition, Grade was significant for both ITBS outcomes, with grade 2 students performing higher than those in grade 1. Because preliminary HLM analyses showed no interactions involving Treatment with Grade, Gender, or Ethnicity, these interactions were omitted from the final HLM analysis models for both Reading and Science.

Table 2. *Descriptive Statistics of Academic Outcome Measures by Grade x School*

Grade/ Treatment Group	School	N	ITBS Rd.[1] M	ITBS Rd.[1] SD	N	ITBS Sci.[2] M	ITBS Sci.[2] SD
Grade 1							
Science IDEAS	A	52	2.5	.62	43	1.3	.10
	B	32	2.5	.35	34	1.4	.15
Control	C	48	2.2	.76	50	1.1	.22
	D	29	2.2	.45	31	1.2	.18
Grade 2							
Science IDEAS	A	48	3.7	1.2	49	2.1	.22
	B	47	3.4	1.0	45	2.3	.29
Control	C	52	2.4	.91	54	1.9	.27
	D	43	2.9	.71	48	2.1	.35

[1] ITBS Rd (Reading) mean grade-equivalents (unadjusted)
[2] ITBS Sci. (Science) mean grade-equivalents (unadjusted)

For ITBS Reading, Gender was also significant, with Females performing higher than Males; but neither Ethnicity contrast was significant. For ITBS Science, Gender was not significant, but both Ethnicity contrasts were significant, with Whites scoring higher than Non-Whites and Hispanics higher than Blacks.

Table 3. *Results of HLM Analysis of Achievement Outcomes on ITBS Reading*

Fixed Effect	Coef.	Stand. Error	Approx. T-ratio	d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	2.78	0.10	30.06	19	0.000
GRADE, G01	0.77	0.19	4.15	19	0.001
TREAT, G02	0.58	0.19	3.12	19	0.006
For GENDER, B1					
INTRCPT2, G10	0.18	0.08	2.15	345	0.032
For WHITE VS NON-WHITE, B2					
INTRCPT2, G20	0.30	0.18	1.66	345	0.097
FOR HISPANIC VS BLACK, B3					
INTRCPT2, G30	0.08	0.11	0.69	345	0.486

In both HLM 6 analyses reported in Tables 3 and 4, all predictor variables were grand-mean-centered to facilitate tests for interactions. However, in addition, each analysis also was re-run using raw-score predictor sets in order to use the Level 2 regression coefficients as estimates of the effects of the Treatment and of Grade on ITBS achievement. The resulting estimates of the effects of Treatment in ITBS GE units were +.16 GE for science and +.58 for reading. The estimates obtained for Grade differences (between grade 1 and grade 2) were +.82 in science and +.77 GE in reading.

Table 4. *Results of HLM Analysis of Achievement Outcomes on ITBS Science*

Fixed Effect	Coef.	Stand. Error	Approx. T-ratio	d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	1.79	0.01	64.35	19	0.000
GRADE, G01	0.83	0.54	15.28	19	0.000
TREAT, G02	0.16	0.05	3.04	19	0.007
For GENDER, B1					
INTRCPT2, G10	- 0.004	0.02	-0.18	348	0.861
For WHITE VS NON-WHITE, B2					
INTRCPT2, G20	- 0.10	0.05	-2.02	348	0.044
FOR HISPANIC VS BLACK, B3					
INTRCPT2, G30	- 0.09	0.03	-2.93	348	0.004

Discussion

In interpreting the findings of the present study, it is important to note that expansion of the duration of treatment in the present study from 8-weeks (Vitale & Romance, 2007b) to a full school year demonstrated the impact of the intervention on student achievement in reading and science across both grade levels in a manner consistent with findings of previous research (Romance & Vitale, 2001, 2009; Vitale & Romance, 2007b). Considered with prior research on the *Science IDEAS* model in grades 3-5, the present findings resulting from the *Science IDEAS* model in grades 1-2 are supportive of the feasibility and effectiveness of in-depth, content-area learning across grades 1-5.

Implications of this year-long study extend well beyond the “proof of concept” findings of the previous 8-week study (Vitale & Romance, 2007b). The findings demonstrated not only the feasibility of implementing a strong 45 minute per day emphasis on science in grades 1-2; but also a significant positive impact on nationally norm-referenced student achievement in both science and reading. Along with findings reported by Romance and Vitale (2001, 2009) at the grade 3-5 level and with the literature presented earlier that emphasizes the importance of informational text at the primary level, the present findings provide support for a general curriculum policy perspective at the grade K-5 levels (see Vitale & Romance, 2010; Vitale, Romance, & Klentschy, 2006;) that advocate greater amounts instructional time being re-allocated from reading per se to content-area instruction that involves meaningful cumulative learning.

The results of the present study also are suggestive of several key issues involving grade 1-2 instructional priorities. Contrary to a review by Appleton (2007) which reported substantial barriers for elementary science instruction, the findings of the present study demonstrated not only the feasibility of implementing a strong 45 minute per day emphasis on science in grades 1-2; but also a significant positive impact on achievement in both reading and science for students of all ethnicities. These findings are consistent with research findings reported by Romance and Vitale (1992, 2001) at the grade 3-5 level and with other literature emphasizing the importance of science instruction at the elementary level (Armbruster & Osborn, 2001; Guthrie & Ozgungor, 2002; Guthrie et al., 2004; Klentschy et al., 2004).

A major emphasis in the present grade 1-2 intervention was that science knowledge provided a meaningful context through which students at the primary levels were able to experience cumulative meaningful learning in a fashion that enhances their capacity for comprehension. In this regard, the present findings in conjunction with research cited previously (Armga et al., 2002; Colker, 2002; French, 2004; Gelman & Brenneman, 2004; Gould, 2003; Jones & Courtney, 2002; Lee et al., 2000; Smith, 2001; Tytler & Peterson, 2001) are consistent with the argument advanced by Vitale and Romance (2007a) considering reading comprehension as a subset of comprehension in general (for a related view see Shanahan, 2010; Shanahan & Shanahan, 2008). In general, the present findings add support to the perspective that focusing on the development of meaningful knowledge in science as a means for enhancing student comprehension is also consistent with emerging literacy trends that emphasizing the use of informational text at the primary levels (e.g., Duke & Pearson, 2002; Gould, Weeks, & Evans, 2003; Holliday, 2004; Klentschy et al., 2004; Ogle & Blachowicz, 2002; Palmer & Stewart, 2003; Pearson & Duke, 2002). In contrast, Duke and others (e.g., Duke, 2000; Duke et al., 2003a, 2003b; Walsh, 2003) found primary students had minimal opportunities for learning that involved meaningful comprehension, despite an extensive research base that provides guidance on how such instruction should (and should not) be implemented effectively (see Asoko, 2002; Carnine, 1995, 1997; Hirsch, 2003, 2006; Jones et al., 1999; Klentschy et al., 2004; Pretti-Frontczak, 2003).

Overall, the findings of the present study provide support for a general curriculum policy at the grade K-5 levels (see Vitale & Romance, 2010; Vitale, Romance, & Klentschy, 2006) that would advocate greater amounts instructional time being re-allocated from basal/narrative reading per se to the forms of content-area learning (such as science) that involve meaningful cumulative learning. Because the implications of the study are directly relevant to enhancing the preparation of grade 1-2 students to be successful in grade 3 and beyond, the study also advanced the forms of knowledge that bridge research and practice by applying a broad set of interdisciplinary research findings to the systemic issue of reading comprehension in education reform. The interdependence of the meaningful learning of science and the development of comprehension proficiency at the primary level are important issues that further research should address. In this regard, the results of the study are supportive of the feasibility of increasing the amount of content-area instruction in science along with content-area reading at the primary (K-2) level that such research would require.

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