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Implications of a Cognitive Science Model Integrating Literacy in Science on Achievement in Science and Reading: Direct Effects in Grades 3–5 with Transfer to Grades 6–7

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Abstract Reported are the results of a multiyear study in which reading comprehension and writing were integrated within an in-depth science instructional model (Science IDEAS) in daily 1.5 to 2 h daily lessons on a schoolwide basis in grades 3–4–5. Multilevel (HLM7) achievement findings showed the experimental intervention resulted in significant and consistent direct effects in grades 3–4–5 and complementary transfer effects in grades 6–7 on both ITBS Science (+1.08 Grade Equivalent Units [GE]) and ITBS Reading (+.57 GE). Discussed are implications of the findings and related research for changing grade K-5 curriculum policy to allocate increased instructional time for integrated science instruction.

Keywords Integrated science · Science curriculum policy · Science and literacy · Science and reading · Core concept science instruction

Based on findings from the National Assessment for Educational Progress (1996–2009), the pattern of science achievement by US students shows a decreasing degree of proficiency from elementary to secondary grades that has remained relatively unchanged (National Center for Education Statistics [NCES], 2011), much in the same fashion as that of the White-Black achievement gap (Griggs, Lauko & Brockway, 2006; Lutkus, Lauko & Brockway, 2006; U.S. Department of Education, 2001, 2005). Parallel trends in reading comprehension (NCES, 2009) are important to note also because meaningful content-area

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learning from text has continued to be a significant barrier to both science learning and reading comprehension (e.g. American Federation of Teachers [AFT], 1997; Braun, Coley, Jia & Trapani, 2009; Donahue, Voekl, Campbell & Mazzeo, 1999; Feldman, 2000; Snow, 2002), particularly for school-dependent, low socioeconomic status (SES) students (see Gamse, Bloom, Kemple & Jacob, 2008; Kemple, et al., 2008; James-Burdumy et al., 2009; NCES, 2009). International assessments reflect similar trends in science and reading achievement (Schmidt et al., 1999, 2001; Stephens & Coleman, 2007).

Present evidence-based reform efforts in science education (see Vitale & Romance, 2010) and content-area reading comprehension (see Shanahan, 2010) have contributed minimally to improving student achievement outcomes. And, even with the present status of reform, neither the fields of science education nor reading has pursued interdisciplinary research emphasizing cognitive science principles (see Duschl, Schweingruber & Shouse, 2007; Romance & Vitale, 2012b) that have the potential to reverse present achievement trends. More specifically, reform efforts have failed to address the key operational dynamics of most K-5 schools, including (a) curricular policies that have resulted in a serious reduction in time allocated for K-5 science (Dillon, 2006; Jones et al., 1999; McMurrer, 2008), (b) curricular policies focusing on basal (narrative) reading rather than emphasizing content-area reading comprehension, especially at the intermediate grades 3–5 (Chall & Jacobs, 2003; Guthrie & Ozgungor, 2002; Pearson, Moje & Greenleaf, 2010; van den Broek, 2010), (c) the adoption of conceptually weak science standards and curriculum (e.g. [AFT], 1997; Petrilli, Julian & Finn, 2006 [Thomas B. Fordham Institute]; Schmidt et al., 1999, 2001; Wilson & Bertenthal, 2006), and (d) the lack of factoring in the expanding evidentiary base that explicates the mutual benefits associated with the linking of science and literacy achievement outcomes (Duke, 2000a, 2000b, 2010; Guthrie & Ozgungor, 2002; Guthrie, Wigfield & Perencevich, 2004; Heller & Greenleaf, 2007; Klentschy 2003, 2006; Klentschy & Molina-De La Torre, 2004; Norris & Phillips, 2003; Romance & Vitale, 1992, 2001, 2010; Snow, 2002; Yore et al., 2004).

With the preceding in mind, approaching these longstanding educational issues through the application of consensus cognitive science research and instructional systems development principles has the potential to accelerate the rate of student learning in both science and reading comprehension in a manner that also has systemic implications for changing K-5 curricular policy to increase the time allocated to science instruction. In particular, the pursuit of such an initiative also fits closely with the goals of the recently developed Next Generation Science Standards (NGSS, 2013), the Common Core English Language Arts Standards (National Governors Association Center for Best Practices & Council of Chief State School Officers 2010) and the associated National Assessment of Educational Progress (NAEP) framework (Mazany, Pimentel, Orr & Crovo 2014).

Consensus Interdisciplinary Research Perspectives About Meaningful Learning in Science

Current interdisciplinary research summarized by Bransford, Brown, and Cocking (2000) provides a foundation for explaining how conceptual understanding in content domains such as science can serve as a core element in literacy development (e.g. reading comprehension and coherent writing as forms of understanding) by providing both the prior knowledge and knowledge-structures necessary to support future meaningful learning. In doing so, Bransford et al. (2000) summarized research studies of experts and expertise as a unifying concept for meaningful learning. Following this emphasis on expertise, the idea of meaningful learning consists of the cumulative conceptual development of in-depth curricular understanding that results in learners being able to organize, access, and apply knowledge. 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 consisting of the sequential elaboration of core concepts consistent with a learning progression framework (e.g. Duschl et al., 2007; Lehrer, Catley & Reiser, 2004; Smith, Wiser, Anderson, Krajcik & Coppola, 2004; Smith, Wiser, Anderson & Krajcik, 2006) readily incorporate elements associated with the cumulative development of in-depth understanding as a form 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.

Science Learning and Comprehension

Comprehension of printed materials (e.g. texts, science trade books, leveled readers) requires students to link relevant prior knowledge to their construction of a coherent mental representation that reflects the intended meaning of the text (Kintsch, 1998; Van den Broek, 2010). If learner prior knowledge is organized coherently around core concept relationships, there is a greater likelihood for gaining such understanding. If prior knowledge is not strong, then understanding becomes more dependent on the logical coherence of the text (or any other learning experience). Because the domains of science knowledge are well-structured, cumulative in-depth instruction in science provides a learning environment that is well-suited for the development of understanding as expertise.

In developing cumulative science knowledge, students are engaged in (a) linking together different events they observe, (b) making predictions about the occurrence of events (or manipulating conditions to produce outcomes), and (c) making meaningful interpretations of events that occur, all of which are key elements of meaningful comprehension (see Vitale & Romance, 2007b). In turn, with the active development of 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 also provides a basis for key aspects of literacy development.

Representative Research Integrating Reading and Science in Grades K-5

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; Ginsburg & Golbeck 2004; Newton, 2001; Rakow & Bell, 1998; Revelle et al., 2002; Sandall, 2003; Schmidt et al., 2001; Smith, 2001; Vitale & Romance, 2010).

In grades 3–5, the potential promise of building student prior 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 & Ozgungor 2002) with upper elementary students. In complementary work, Walsh (2003) noted in an analysis of basal reading series that their non-content oriented focus represented a lost opportunity for students to build the cumulative 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) have presented findings that support interventions in which core curriculum content in science serves as a framework for building background knowledge and greater proficiency in the use of reading comprehension strategies. Research findings associated with the Klentschy model and the *Science IDEAS* model (described below) have repeatedly demonstrated that replacing time traditionally allocated to reading/language arts with in-depth science instruction in which reading comprehension and writing are embedded have consistently resulted in higher achievement outcomes in both reading comprehension and science on norm-referenced tests (Klentschy, 2003, 2006; Romance & Vitale, 1992, 2001, 2006, 2008, 2010, 2011a, 2011b).

The Science IDEAS Instructional Model as a Cognitive-Science Approach for Integrating Literacy Within Science

Science IDEAS is a cognitive-science-oriented model that integrates reading and writing within in-depth K-5 science instruction (Romance & Vitale, 2012a, 2012c). In grades 3–5, Science IDEAS is implemented schoolwide in 1.5 to 2 h daily instructional lessons which focus on science concepts. The model emphasizes students learning more about what is being learned in a cumulative fashion that builds upon core science concept relationships. The architecture and cognitive science principles that provide the foundation of the Science IDEAS model are shown in Figs. 1 and 2 which outline the role of both the logic of the discipline and knowledge in learning. Figure 3 shows how a curricular concept map representing science knowledge serves as a framework for sequencing different Science IDEAS instructional elements (e.g. hands-on/exploration activities, reading multiple sources, concept-mapping, journaling/writing) across multi-day lessons in accordance with a conceptually-coherent curricular framework consistent with recommendations in the literature (e.g. Donovan, Bransford & Pellegrino, 2003; Duschl et al., 2007; Romance & Vitale, 2001, 2009; Vitale & Romance, 2010). Figure 4 shows advanced teaching components of the model for enhancing instruction that reflect cognitive science findings and instructional design principles (Vitale & Romance, 2006). This advanced framework also provides the means for an embedded

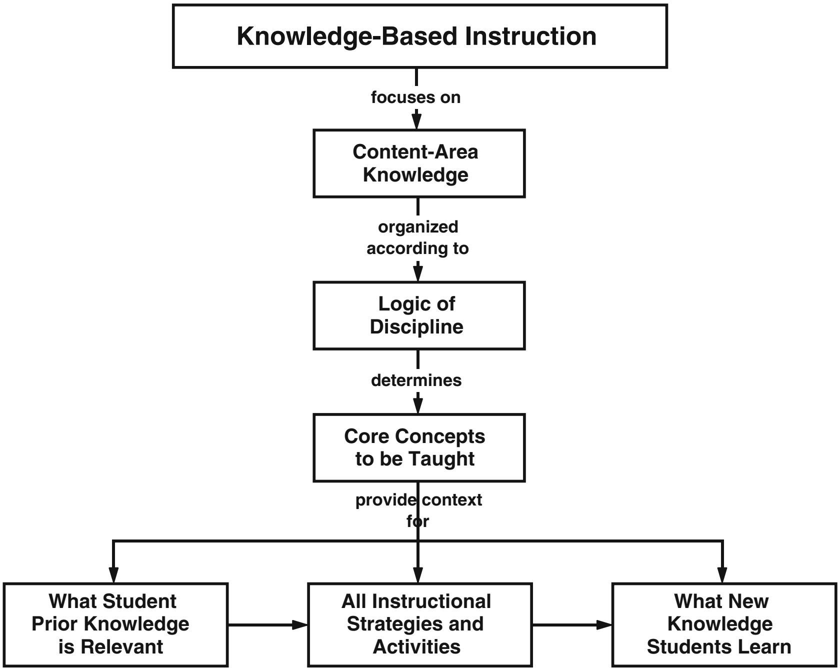

Fig. 1 Knowledge-based instruction (KBI) represented as an instructional architecture in which core concepts to be taught and instructional activities are based on a curricular framework representing the logic of the discipline

approach to assessment (e.g. Pellegrino, Chudowsky & Glaser, 2001; Vitale, Romance & Dolan, 2006).

Focus of Study

A series of multiyear research findings have documented the effectiveness of the Science IDEAS model across grades 1–5 from 1992 through the present (e.g. Romance & Vitale, 1992, 2001; 2012a, 2012c; Vitale & Romance, 2012). The findings reported in the present study are outcomes resulting from the schoolwide implementation of the model across grades 3–4–5 in multiple schools over a 5-year period. Specifically, the objective of this study was to demonstrate the multi-year effects of the Science IDEAS model on science and reading comprehension achievement measured by *Iowa Tests of Basic Skills* (ITBS) subtests on (a) grade 3–5 students receiving the intervention and (b) associated transfer effects of the model on students in grades 6–7 who received the intervention in grades 3–5.

In doing so, an important goal of the study was to suggest implications for advancing school reform following cognitive science principles that would increase the instructional time for in-depth science instruction and emphasize core science concepts as a curricular framework leading to the acceleration of student achievement in both science and reading.

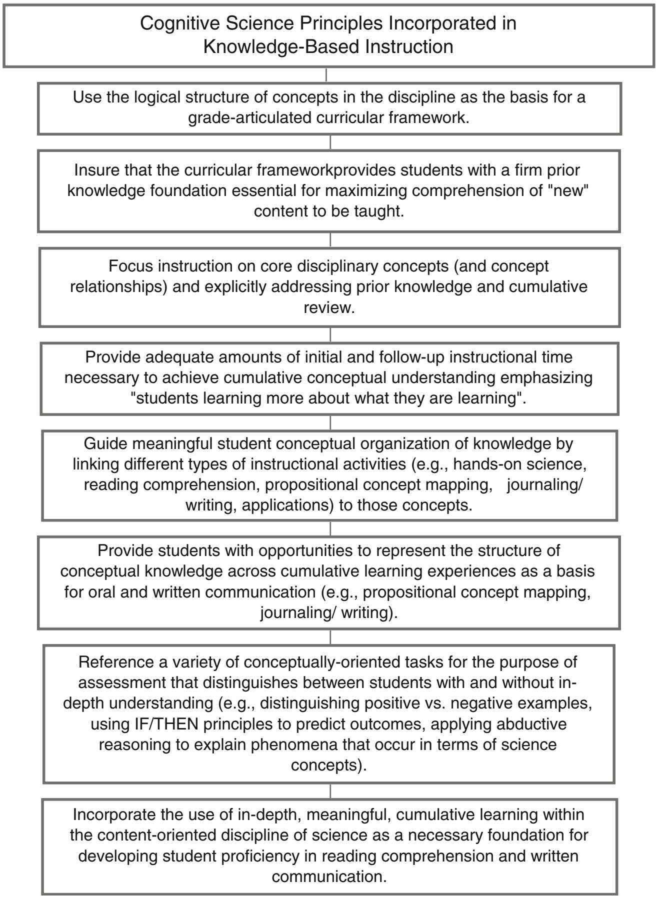

Fig. 2 Major cognitive science principles of instruction incorporated in the Science IDEAS model

Method

Participants

The study was conducted in a large (185,000 students), diverse (African American 29 %, Hispanic 19 %, Other 5 %, Title I/Free Lunch 40 %) urban school system in southeastern Florida. The study intervention (Science IDEAS) was implemented schoolwide in grades 3–5 in six schools representative of the student diversity of the school system. Seven demographically-comparable schools served as controls. In addition, former Science IDEAS grade 6–7 students and comparison students in middle schools in feeder relationships with the experimental and control elementary schools also were tested to assess transfer effects of the intervention. Overall, the number of students consisted of a total of $N=4471$, with $N=2402$ experimental and $N=2069$ control students. Students fell within a total of $N=259$ classrooms/teachers in experimental ($N=139$) and control ($N=120$) schools.

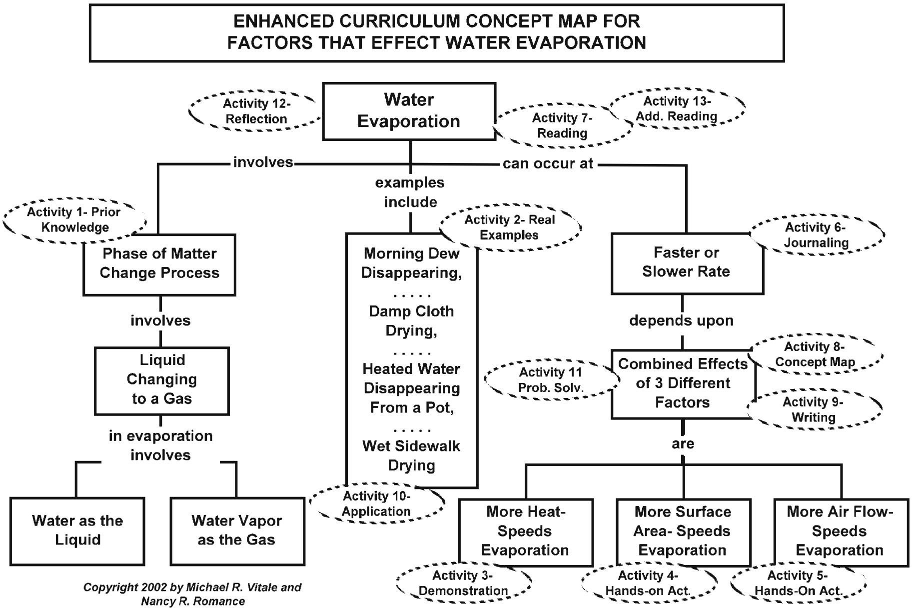

Fig. 3 Simplified illustration of a curricular-oriented propositional concept map used as a guide by grade 4 Science IDEAS teachers in planning a sequence of knowledge-based instructional activities for a multi-day lesson using Science IDEAS elements

Table 1 summarizes the student demographics associated with the experimental and control schools. As Table 1 shows, the pattern of demographic characteristics was similar for the two groups of schools.

Table 2 presents the number of students per grade level for the experimental and control schools. As Table 2 shows, the percentages of students by grade level were similar for the experimental and control schools.

Intervention

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 h instructional lessons which focused on science concepts. In addition, students also received an additional ½ hour daily instruction in literature as part of the Districtwide Reading/Language Arts Program. The comparison students received the Districtwide Reading/Language Arts program (usually 1.5 to 2 h daily) as well as ½ hour of instruction several days each week using the District-adopted science curriculum. As a result, the amount of instructional time allocated to science instruction was increased substantially by reducing the time allocated the Reading/Language Arts.

Instruments

The nationally-normed *Iowa Tests of Basic Skills* (*ITBS*) *Reading Comprehension* and *Science* subtests served as measures of student learning. The *ITBS* is a well-established, nationally-normed achievement test whose development design makes it well-suited for

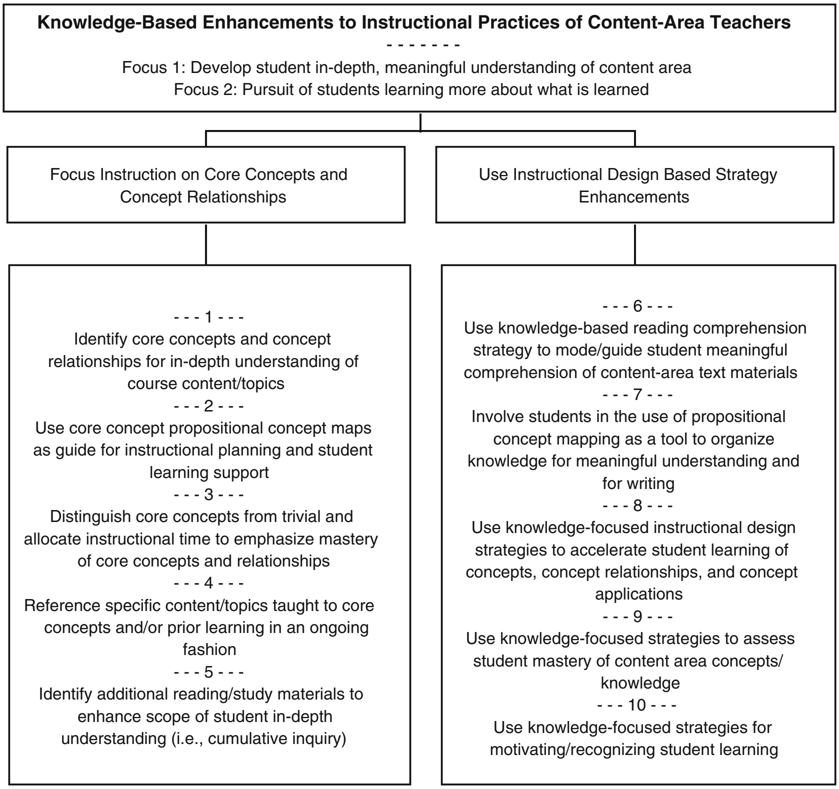

Fig. 4 Advanced instructional strategies for use by grade 3–5 Science IDEAS teachers as enhancements to multi-day lessons using Science IDEAS elements. Strategies are appropriate for adoption and use on a modular basis for any content area teaching/instruction

interpreting student scores using a grade-articulated, cumulative growth scale from which grade-equivalent scores are mapped. These were administered to participating students in grades 3–7 by classroom teachers at the end of the school year under supervision of the researchers. Fidelity of implementation was monitored by researchers on a continuing basis throughout the school year following researcher-developed observational protocols. Fidelity observations consisted of classroom visits in each grade 3–5 experimental classroom by researchers three times per year. Reliability estimates were obtained by duplicating classroom fidelity visits in 20 % of classrooms and correlating the degree of agreement on overall implementation fidelity.

Table 1 Percentages of demographic characteristics of experimental and control schools

Schools	Number	Ethnicity					Free
		White	Hispanic	Black	Asian	Mixed	Lunch
Experimental	6	37	25	28	5	5	48
Controls	7	38	27	28	5	5	47

Table 2 Number and percent of students by grade level in experimental and control schools

Schools	Grade level				
	3	4	5	6	7
Experimental					
N students	454	535	567	469	377
Pct. students	19	22	24	20	16
Controls					
N students	391	443	448	609	178
Pct. students	19	21	22	29	9

Research Design

In order to limit the resource-requirements for the study, the participating Science IDEAS schools were selected randomly from 12 different schools implementing the model, with the constraint that they had implemented the model over the 5-year period ending with the 2007–2008 school year that allowed grade 3 students in 2003–2004 to reach grade 7 in 2008. In the study design, middle school students were linked back to their grade 5 elementary schools, in effect creating grade 3–7 elementary schools for data analysis. The overall cross-sectional design was a 2 × 5 factorial (Treatment, Grade), with two outcome measures (*ITBS Reading*, *ITBS Science*). A 2-Level HLM Model was used for multilevel analysis. In the model, level 1 data consisting of student demographic characteristics (minority (Hispanic/Black) vs. non-minority (White/Asian) status, gender, title I/free lunch eligibility) served as student covariates. In turn, both treatment and grade level were assigned level 2. Analysis was conduced using HLM version 7 (Raudenbush, Byrk & Congdon, 2011).

Results

Clinical Assessment of Implementation Fidelity

Monitoring of implementation fidelity for the six participating schools showed that between 82 and 95 % of grade 3–5 Science IDEAS teachers implemented the model effectively (with fidelity). The pooled estimate for the obtained fidelity ratings across grade levels found them to be highly reliable ($r = .89$).

ITBS Student Performance Outcomes

Tables 3 and 4 summarize the HLM analysis results. As Tables 3 and 4 show, the same pattern of significant findings was obtained for both *ITBS Science* and *ITBS Reading*. For both outcome measures, the Science IDEAS model resulted in higher achievement (+1.08 GE for ITBS Science, +.57 GE for ITBS Reading). For both science and reading, grade level, non-minority status (White/Asian), and female gender were positively

Table 3 HLM analysis of intervention by grade level for ITBS GE science

Fixed effect	Coefficient	Standard Error	T-ratio	Approx. df	*P* value
For INTRCPT1, B0					
INTRCPT2, G00	−2.47	1.22	−2.02	184	.045
GRADE, G01	2.79	0.54	5.13	184	<.001
GRADE SQUARED, G02	−0.20	0.05	−3.67	184	<.001
TRT-C0E1, G03	1.08	0.18	5.77	184	<.001
For NON-MIN, slope, B1					
INTRCPT2, G10	0.51	0.09	5.24	2743	<.001
For gender, slope, B2					
INTRCPT2, G20	−0.19	0.07	−2.48	2743	.01
For TITLE 1, slope, B3					
INTRCPT2, G30	−0.77	0.09	−8.31	2743	<.001
Final estimation of variance components					
Random effect	Standard deviation	Variance component	df	Chi-square	*P* value
INTRCPT1, U0	1.05	1.12	184	906.69	<.001
Level-1, R	2.20	4.84			

Note 1. Robust standard errors used for tests

Note 2. A follow-up hypothesis test for Grade and Grade Squared confirmed a significant quadratic relationship between grade and science achievement X^2 (2 df) = 240.13, $p < .001$

Note 3. A 95 % confidence interval for treatment (+1.08) is [+1.26, +.90]

related to achievement while eligibility for title 1/free lunch was negatively correlated with both ITBS Science and Reading achievement. In addition, a quadratic component was also fit for the grade effect in the HLM model (see Tables 3 and 4, Fig. 5) (Fig. 6).

Complementing the initial analysis for main effects in the HLM model, subsequent analyses explored possible level 2 interaction between grade and treatment and possible cross-level interactions between the level 2 (treatment, grade) and level 1 (non-minority status, gender, title 1/free lunch eligibility). The results of these analyses revealed no significant interactions. With regard to the treatment, these findings show that the Science IDEAS intervention had a consistent effect across the variety of student demographics addressed in this study and across grade levels.

Discussion

The multi-year findings reported here demonstrated the effectiveness of the cognitive-science-oriented Science IDEAS model for improving student science achievement in grades 3–5 directly in a manner in which the effects in grades 3–4–5 also transferred to grades 6–7. In addition, through content-area learning in science in which reading/language arts was integrated, the Science IDEAS model also had a positive effect on student reading comprehension achievement in grades 3–5 and, through transfer, to grades 6–7 as well.

Table 4 HLM analysis of intervention by grade level for ITBS GE reading comprehension

Fixed effect	Coefficient	Standard		Approx.	
		Error	T-ratio	df	*P* value
For INTRCPT1, B0					
INTRCPT2, G00	−2.04	0.89	−2.28	212	.023
GRADE, G01	2.58	0.40	6.44	212	<.001
GRADE SQUARED, G02	−0.18	0.04	−4.35	212	<.001
TRT-C0E1, G03	0.57	0.14	4.00	212	<.001
For NON-MIN, slope, B1					
INTRCPT2, G10	0.46	0.07	6.11	3452	<.001
For gender, slope, B2					
INTRCPT2, G20	−0.37	0.06	−5.51	3452	<.001
For TITLE 1, slope, B3					
INTRCPT2, G30	−0.74	0.06	−10.71	3452	<.001
Final estimation of variance components					
Random effect	Standard deviation	Variance component	df	Chi-square	*P* value
INTRCPT1, U0	0.85	0.72	212	958.16	<.001
Level-1, R	2.00	4.00			

Note 1. Robust standard errors used for tests

Note 2. A follow-up hypothesis test for grade and grade squared confirmed a significant quadratic relationship between grade and reading achievement X^2 (2 df) = 3.16.19, $p < .001$

Note 3. A 95 % confidence interval for treatment (+.57) is [+.71, +.43]

In conjunction with related research (e.g. Duke, 2000a, 2000b, 2010; Guthrie et al., 2004; Guthrie & Ozgungor, 2002; Smith, Wiser, Anderson, Krajcik & Coppola, 2004;

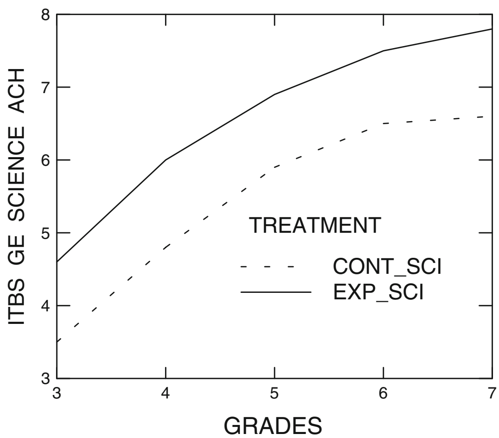

Fig. 5 Graphical illustration of the HLM findings (see Table 3) showing the direct (grades 3–4–5) and transfer (grades 6–7) effects of the Science IDEAS model on ITBS Science achievement. Influence of level 1 variables (minority vs. non-minority status, gender, and title 1 status) was removed from the figure by balancing their effects

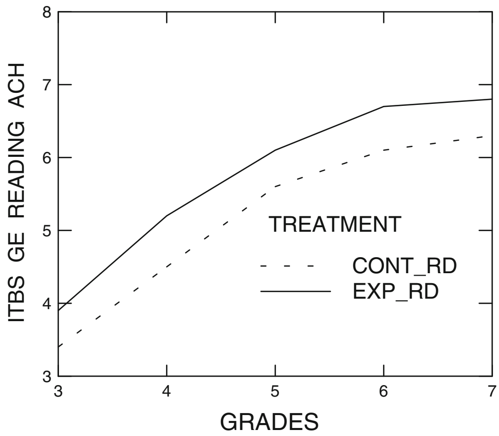

Fig. 6 Graphical illustration of the HLM findings (see Table 4) showing the direct (grades 3–4–5) and transfer (grades 6–7) effects of the Science IDEAS model on ITBS Reading achievement. Influence of level 1 variables (minority vs. non-minority status, gender, and title 1 status) was removed from the figure by balancing their effects

Smith, Wiser, Anderson & Krajcik, 2006; Guthrie et al. 2004; Heller & Greenleaf, 2007; Klentschy, 2003, 2006; Klentschy & Molina-De La Torre, 2004; Norris & Phillips, 2003; Romance & Vitale, 1992, 2001, 2010; Snow, 2002; Yore et al., 2004), results of the present study in extending prior research findings (see Romance & Vitale, 1992, 2001) are suggestive of the potential benefits of applying cognitive science principles as a means for reversing present school K-5 curricular policy that allocates extensive time to reading rather than science instruction (see Jones et al., 1999). Such policy uses the goal of meeting accountability-based student reading achievement requirements as justification for reducing the allocation of K-5 student instructional time to non-content-oriented basal reading programs rather than expanding time for integrated science instruction organized around a core concept curricular framework. Implications of this study and related work (see also Klentschy, 2003; Romance & Vitale, 2009) are that a curricular approach integrating literacy within in-depth science instruction has the benefit of increasing student academic achievement in science and reading comprehension—on both a direct and transfer basis—in a far more effective manner than traditional reading/ language arts programs. With regard to present K-5 curricular policy, an important implication of the present study and related research (see Vitale & Romance, 2007b) is to provide a rationale for increasing the amount of time science is taught in K-5 schools.

From a cognitive science/interdisciplinary research perspective, the adoption of knowledge-focused, content-oriented instructional models by schools in conjunction with a curricular perspective that in-depth, content-area learning is necessary for reading comprehension development has implications for systemically changing present school approaches to curriculum, instruction, and educational reform. Pursuing these implications which amplify the importance of in-depth science instruction would necessarily change the present direction of school reform in elementary grades to an emphasis on the types of content-area instruction designed to prepare students for future success in secondary level content area courses.

In doing so, it is important to distinguish the form of integration of reading within science in the Science IDEAS model from the emphasis on "informational text" emphasized in the Common Core State Standards (CCSS) developed by the National

Governors Association Center for Best Practices (2010). In the Science IDEAS model, students read multiple materials that all focus on the same or similar science concepts within multiday lessons (Romance & Vitale, 2012a, 2012c). In comparison, the idea of "informational text" as advanced by CCSS does not focus on content area concepts. Rather, under CCSS, the idea of "informational text" only means that the emphasis in the materials read by students is not wholly narrative. While the instructional architecture of the Science IDEAS model certainly could be applied to other grade K-5 content areas such as social studies, our belief (Vitale & Romance, 2007a) is that science curriculum has the advantage that most of what students are learning about can be directly referenced to their everyday environments.

Based on the consensus research findings reviewed and reported in this paper, such a re-direction of school reform initiatives would be expected to yield a greater degree of systemic improvement in the academic performance of all students not only science and reading comprehension in grades K-5, but also in all courses at the secondary level. Although working toward the implementation of such research-based implications would be a significant challenge, accepting such a challenge in the face of the present lack of substantial progress in education reform provides schools with a far better alternative than simply continuing to pursue "more of the same" (see Walsh, 2003). In this sense, as a paradigmatically different approach for embedding reading comprehension and writing within in-depth science instruction, Science IDEAS offers school practitioners a research-validated alternative for increasing student achievement expectations that, potentially, could positively impact different aspects of student learning across the K-12 grade range.

With the preceding in mind, the rationale underlying the argument for increasing time for science instruction using cognitive-science-based instructional principles is twofold. First, increased time for science instruction in grades K-5 would provide a content-rich foundation of prior knowledge which middle school teachers could use to enhance their science teaching and, in turn, better prepare students in grades 6–8 for subsequent success in high school science. And, second, increasing instructional time allocated to K-5 science would also provide the means for advancing student achievement in reading comprehension across the K-7 grade range. In contrast, the current reform objective to improve reading comprehension achievement by increasing time for basal reading/language arts while reducing time for science and other content-oriented instruction has been consistently unsuccessful as evidenced by multiple NAEP assessments of reading (e.g. NCES, 2009). More specifically, lack of content-area instruction and content-area reading in grades K-5 may well be a major reason for the failure of educational reform at the secondary levels.

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