

**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 Four**

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**Abstract**

An integrative curriculum strategy emphasizing science process skills and hands-on activities expanded the time allocated for in-depth science instruction by replacing a district-adopted basal reading program with science-content reading designed to facilitate applied comprehension skills. This study investigated the combined effect of these curricular components (i.e., in-depth science, science-content-based reading) upon student achievement, attitudes, and self-confidence in both science and reading over the school year. In doing so, teachers in three fourth-grade classrooms each incorporated applied reading (and language arts) objectives into science reading activities as part of a daily, expanded, in-depth science teaching block that encompassed the total instructional time originally allocated to reading and science. Using multivariate covariance analysis, results showed that the students in the experimental group, compared to demographically similar controls, not only displayed significantly greater standardized test achievement as measured by the Iowa Tests of Basic Skills reading subtest and the Metropolitan Achievement Test science subtest, but also displayed a more positive attitude toward science and reading and greater self-confidence in learning science. Implications of the strategy for future curriculum research in science education are discussed.

Lack of adequate instructional time for science teaching in the upper elementary grades is recognized as a major limiting factor in improving the quality of science instruction in schools (Mullis & Jenkins, 1988; Schoeneberger & Russell, 1986). Within the restricted instructional time available, many elementary science programs are reduced to assigned reading activities in science textbooks (Harms & Yager, 1981; Staver & Bay, 1989). In fact, science educators consider the resulting cumulative lack of in-depth science instruction (e.g., hands-on activities, science process skills) in the elementary grades as a major cause of the generally negative attitudes toward science displayed by students at the secondary level (Linn, 1987) and beyond (Mullis & Jenkins, 1988). Although lack of instructional time is by no means the only causal factor (e.g., lack of science knowledge by elementary teachers, poor science teaching curricula and

methods), real improvement in science instruction at the elementary level requires expanding the instructional time available for additional in-depth science teaching (Holdzkom & Lutz, 1985; Stake & Easley, 1978; Weiss, 1978).

Just as science educators have called for the improvement of science instruction, many reading researchers and practitioners (Nessel, 1989; Schmidt, Barry, Maxworthy, & Huebsch, 1989; Stewart & O'Brien, 1989) have emphasized the importance of content-based reading activities (e.g., in science, social studies, literature) as vehicles for developing applied reading comprehension and thinking skills. Paralleling the dominant use of science textbooks, the use of basal textbooks accounts for 80% to 90% of instructional time in reading (Tunnell & Jacobs, 1989). Yet, despite the importance of direct reading instruction in content-area texts to facilitate "reading to learn" (Chall & Snow, 1988), elementary teachers typically use basal reading activities to focus on isolated reading skills while addressing content-area reading applications only indirectly (if at all). Among the more significant flaws of such basal-oriented reading activities (Brandwein, 1981; Thelen, 1986) is an emphasis upon "context-free" vocabulary tasks (e.g., looking up words in the dictionary) that change or ignore the meaning structure to which reading comprehension skills presumably are to be applied (Schwartz, 1988). Other reading researchers have noted that the controlled (Goodman, 1988) or non-information-based (Manolakes, 1989) writing styles of basal textbooks make comprehension more difficult and have advocated the replacement of basal reading selections with content-based reading materials and trade books (Anderson & Armbruster, 1984; Tunnell & Jacobs, 1989). In effect, these views are consistent with recent formulations of the learning process from cognitive psychology (Gagne, 1985) that stress the knowledge-dependence of intellectual (and problem-solving) skills.

With the assumption that the amount of instructional time available for science alone is unlikely to increase, a strong overlap between applied reading skills and science thinking/process skills (Crocker, Dennison, & Butts, 1986) coupled with a need to increase the emphasis upon content-area reading are suggestive of how reading instruction can be structured within a science curriculum. More specifically, a curriculum strategy could be implemented in which additional time for in-depth science activities in the form of science process skills and hands-on activities is gained by the direct teaching of applied reading skills across the range of content of an ongoing science program rather than a basal reading series. In turn, the goal of such a strategy would be to improve the quality of both science and reading instruction within an integrated time frame that reallocates the combined instructional time assigned to both curriculum areas. Clearly, such a strategy is consistent not only with recommendations for improving reading instruction, but also with suggestions from science educators (Ulerick, 1989) regarding different alternatives for using science textbooks in elementary classrooms.

#### Purpose

This year-long study implemented a curriculum strategy that increased the time allocated for in-depth science teaching by replacing the district-adopted basal reading program with science-content-based instruction that concomitantly facilitated reading-comprehension skills. In doing so, the study investigated the combined effect of these curricular components (i.e., in-depth science, science-content-based reading instruction) upon student achievement, attitude, and self-confidence in both science and reading over the school year.

The specific research questions investigated were as follows:

1. How would increasing the instructional time for in-depth science instruction affect student science achievement, attitude toward science learning, and self-confidence in science learning?
2. How would replacing the district-adopted basal reading program with science-content-based reading instruction affect student reading achievement, attitude toward reading, and self-confidence in reading?
3. Could a curriculum strategy to increase the amount of time allocated to elementary science instruction without any increase in the school day by eliminating the basal reading series be justified on the basis of improved student performance in both science and reading?

### Method

#### *Subjects*

Fourth graders in three intact fourth-grade classrooms participated in the study, while students in four intact fourth-grade classrooms in a demographically comparable school (i.e., similar prior standardized test achievement at grade level, ethnicity, housing quality in attendance areas) served as controls. Both schools were located in a large urban school district in southeastern Florida.

#### *Treatment*

Experimental teachers combined the total amount of instructional time for reading and science instruction each day into a single, expanded, two-hour teaching lesson. During each lesson, teachers implemented an in-depth science teaching program by expanding the lesson plans in their science textbook, *Journeys in Science* (Shymansky, Romance, & Yore, 1988), to emphasize an integrated approach to science concept instruction through hands-on science activities, science process skills, and science textbook/tradebook reading assignments. As part of this approach, teachers also applied content-area reading strategies during science reading tasks (e.g., identifying cause-and-effect or the main idea), usually after students had investigated phenomena through manipulative science activities. By scheduling applied reading activities after hands-on activities and focusing on graphics-enhanced portions of the text (e.g., photographs, tables, charts) that promote concept understanding, teachers insured that students had the learning experiences needed to make critical reading more purposeful. Supporting their enhancement of the core science lessons, teachers regularly engaged students in a variety of independent in-class and outside reading activities using trade books and other science print materials. Finally, along with addressing the district's skills-based curriculum objectives in reading within science instruction, teachers also focused on the district's language arts curriculum skills as they were naturally embedded within science activities (e.g., following written directions in order to complete a hands-on activity, writing sentences and paragraphs reporting the results of a hands-on experiment).

In developing a year-long implementation strategy, the teachers in the experimental group followed a four-step curriculum planning model. First, tentative weekly lesson plans were developed for the school year by specifying the instructional activities that were to be taught during the daily 2-hour lessons that comprised the in-depth science

program. Second, the district-wide skills-based curriculum objectives in science and in reading/language arts were referenced to specific science activities to insure they would be taught during the school year. Third, the tentative lesson plans were modified as needed in order to encompass any remaining science or reading/language arts objectives identified in step two as not appearing in science activities. Fourth, daily records regarding activities and objectives taught throughout the school year were maintained by teachers for the purpose of curriculum management, including possible adjustments to the ongoing plan.

By way of contrast, in accordance with the district's curriculum policy, the control-group teachers devoted 1½ hours to reading and language arts and approximately ½ hour to science each day. Within this time frame, the control teachers used the regular district-adopted basal series along with traditional reading/language arts instructional materials and activities to teach the district's curriculum objectives in those areas. In a similar fashion, the control teachers used the district-adopted science textbook and associated paper-pencil activities to teach the required science curriculum objectives. However, because of the ½-hour time limitation for science instruction, control-group teachers only used hands-on science activities in a supplementary fashion and on an occasional basis. Thus, teachers in both the experimental and the control classrooms taught the same district science and reading/language arts objectives and used the same science textbook. However, by not using the basal reading series, the experimental-group teachers had far more time to teach science in-depth, even while using science-content-based strategies and materials to teach the reading (and language arts) objectives.

#### *Design, Instrumentation, Data Analysis*

Table 1 summarizes the overall design of the study. Iowa Tests of Basic Skills (ITBS) reading scores were obtained through the district-wide testing program, while the Metropolitan Achievement Test (MAT) science and the affective measures were administered by the classroom teachers under the direction of the investigators. Both affective measures (attitude and self-confidence) consisted of previously developed, criterion-referenced banks of item formats (Vitale, 1980) constructed to be parallel Likert-type items in science and reading (e.g., *science is interesting, reading is interesting*). Cronbach's alpha coefficient, showing the internal consistency reliability, exceeded 0.85 for each five-item subscale. Statistical analysis was conducted using the Multivariate General Linear Hypothesis module of the SYSTAT (Wilkinson, 1987) system on an

Table 1  
*Design of the Study*

Treatment	Covariate <sup>b</sup>	Performance measures <sup>a</sup>		
		Achievement		Affective
Experimental	ITBS Reading <sup>c</sup>	ITBS Reading	MAT Science <sup>d</sup>	Attitude, Self-Confidence (Reading, Science)
Control	ITBS Reading	ITBS Reading	MAT Science	Attitude, Self-Confidence (Reading, Science)

<sup>a</sup>Spring, 1989. <sup>b</sup>Spring, 1988. <sup>c</sup>Iowa Tests of Basic Skills. <sup>d</sup>Metropolitan Achievement Test.

Table 2  
*Means and Standard Deviations for the Experimental and Control Groups on Achievement and Affective Measures*

Performance measure	Experimental <sup>a</sup>		Control <sup>b</sup>		Total <sup>c</sup>	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
MAT-Science	6.22	1.02	4.60	1.06	5.53	1.19
ITBS-Reading	5.44	0.84	4.91	0.97	5.12	0.95
Science Learning						
Attitude in school	4.09	0.57	3.81	0.81	3.92	0.74
Self-confidence	4.18	0.49	3.69	0.82	3.88	0.74
Attitude out of school	3.68	0.64	3.19	1.10	3.38	0.97
Reading						
Attitude in school	3.77	0.61	3.47	0.87	3.59	0.80
Self-confidence	4.23	0.67	4.06	0.89	4.13	0.81
Attitude out of school	3.56	0.94	3.51	1.02	3.53	0.99

*Note.* Iowa Tests of Basic Skills (ITBS) Reading and Metropolitan Achievement Test (MAT). Science results are grade-equivalent scores. Affective (attitude, self-confidence) responses were scored on a 5-4-3-2-1 scale with higher scores indicating more positive responses. The grade-equivalent difference between the experimental ( $M = 4.29$ ,  $SD = 0.92$ ) and control ( $M = 4.00$ ,  $SD = 0.95$ ) groups on the ITBS-Reading covariate was not significant,  $t(126) = 0.24$ .

<sup>a</sup> $n = 51$ . <sup>b</sup> $n = 77$ . <sup>c</sup> $n = 128$ .

IBM AT-compatible microcomputer. Separate multivariate analyses were conducted for the achievement (ITBS reading, MAT science) and affective criteria (attitude toward learning science in school, self-confidence in learning science, attitude toward science activities out of school, attitude toward reading in school, self-confidence in reading, and attitude toward reading activities out of school).

#### *Procedure*

Investigators met with the three experimental-group teachers and the Directors of Reading and Science in a series of planning sessions prior to the start of the school year. The purpose of these sessions was (a) to establish the four-step curriculum plan as the means to insure all science, reading, and language arts objectives would be taught during the school year, (b) to identify the variety of reading-in-content-area strategies that would be used, and (c) to structure the enhanced in-depth science activities. Using the plan as a benchmark, the teachers and investigators met regularly throughout the school year to refine the detailed daily lesson plans, as necessary. As part of this process, regular classroom visits to the school by the investigators monitored the implementation of the treatment throughout the school year.

#### *Results*

Descriptive statistics for the experimental and control groups on the academic achievement (ITBS Reading, MAT Science) and affective measures (attitude, self-confidence) are shown in Table 2. Results of the separate multivariate covariance analyses (and subsequent univariate analyses) for the two achievement measures and

for the six affective measures appear in Table 3. The multivariate model used in both analyses included the preceding year's ITBS-Reading scores as a covariate and the treatment effect coded as a contrast between groups (e.g., experimentals = +1, controls = -1). As Table 3 shows, experimental-group students performed significantly better than the controls in both reading and science, as measured by the ITBS and MAT, respectively, with the adjusted mean MAT science achievement of the experimental group being almost one grade equivalent higher than that of controls (adj. mean diff. = .95). Adjusted mean differences for both achievement measures are shown in Figure 1.

As Table 3 further shows, experimental-group students also displayed more positive attitudes toward learning (i.e., engaging in) science activities, both in and out of school, and greater self-confidence in learning science. As with science, experimental-group students (see Table 3) displayed more positive attitudes toward reading activities in school. However, no difference was found between experimental- and control-group students on reading self-confidence or on attitude toward reading activities out of school. Adjusted mean differences for the affective measures are shown in Figure 2.

### Discussion and Implications

The combined effects of the experimental curriculum strategy on student achievement, attitude, and self-confidence in science and reading confirmed the validity of systematically addressing applied reading skills within time-expanded, in-depth science instruction. Given the overlap between science process skills and applied reading skills (Crocker et al., 1986), future longitudinal research at the upper-elementary and middle school levels that uses science curriculum as a framework for direct reading instruction by

Table 3  
*Significance of Adjusted Mean Differences Between the Experimental and Control Groups*

Performance measure	Mean difference	Adjusted mean difference	Obtained <i>F</i> value <sup>a</sup>
MAT-Science	1.62	0.95	13.62*
ITBS-Reading	0.53	0.32	8.14**
Science learning			
Attitude in school	0.28	0.27	4.17**
Self-confidence	0.49	0.45	12.54*
Attitude out of school	0.49	0.46	7.07**
Reading			
Attitude in school	0.30	0.28	3.99**
Self-confidence	0.17	0.11	0.56
Attitude out of school	0.05	0.02	0.01

*Note.* Overall multivariate tests for Iowa Tests of Basic Skills (ITBS)/Metropolitan Achievement Test (MAT) achievement measures, Wilks lambda = 0.874,  $F(2, 124) = 8.97$ ,  $p < 0.001$ , and for affective (attitude, self-confidence) measures, Wilks lambda = 0.863,  $F(6, 120) = 3.17$ ,  $p < 0.01$ , were both significant. Table shows subsequent univariate *F* tests for each measure. Covariate consisting of preceding years ITBS-Reading scores was also a significant predictor in the model used. ITBS-Reading and MAT-Science scores are grade-equivalent scores. Affective responses were scored on a 5-4-3-2-1 scale with higher scores indicating more positive responses.

<sup>a</sup>*df* = 1, 125.

\*  $p < 0.001$ . \*\*  $p < .01$ . \*\*\*  $p < 0.05$ .

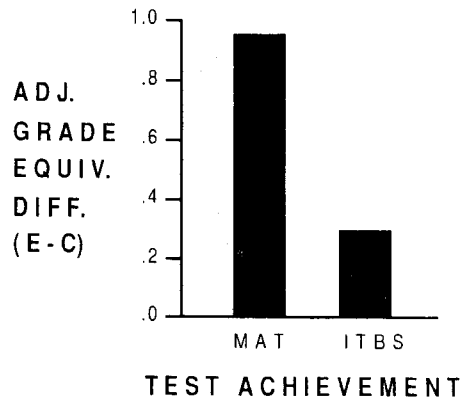


Figure 1. Adjusted mean grade equivalent score differences between experimental and control groups on MAT-Science and ITBS-Reading.

combining the use of science textbooks with hands-on process activities and higher-order questioning might be expected to yield even greater cumulative effects upon academic and affective student performance in both areas. In providing a foundation for such research, this study also is suggestive of how significant educational reform may be approached through integrative curriculum strategies that address multiple learning outcomes through the optimal reallocation of existing instructional time.

The results of the present study also have significant implications for the use of science textbooks in elementary science classrooms. Both Staver and Bay (1989) and Ulerick (1989) have suggested that problems associated with textbook use in elementary science may rest not with the books themselves, but rather, the ways in which they are used as instructional tools by teachers. Since the use of textbooks is likely to continue to dominate elementary science instruction for the immediate future (Staver & Bay, 1989), science educators should pursue the development of instructional strategies

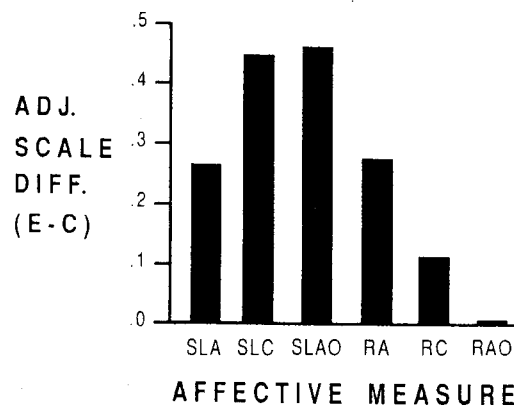


Figure 2. Adjusted mean scale score differences (5 = high, 1 = low) between experimental and control groups on science attitude and self-confidence in school (SLA, SLC), science attitude out of school (SLAO), reading attitude and self-confidence in school (RA, RC), and reading attitude out of school (RAO).

that integrate hands-on science activities and science process skills with direct reading instruction in science content, in order to foster combined science-concept mastery and reading-comprehension skills. More importantly, given the commitment of elementary teachers to textbooks, a potential increase in the amount of instructional time for in-depth science that could result by combining the two curriculum areas of science and reading is a policy goal well worth pursuing by science-education advocates.

In the year-long study reported here, the reading-in-science strategy of discontinuing the use of the district-adopted basal reading program and providing teachers with more time for science instruction allowed the expanded use of classroom science activities that enabled students to experiment, make predictions, gather data, analyze data, draw conclusions, and construct models. Of equal importance, as part of such in-depth activities, teachers were able to provide supportive dialogue that offered greater opportunities for students to pose questions and to interact with one another in ways that never would have been possible in the limited time typically allocated for science instruction. With this in mind, the results of the present study are consistent with other research (Shymansky, Kyle, & Alport, 1983) showing that activity-based approaches produce greater student-achievement gains in knowledge, problem solving, and critical thinking. Complementing this perspective is the view of Staver & Bay (1989) that hands-on activities allowing students to "do" science also contribute toward a more effective learning environment for the construction of meaning from written material by providing concrete referents for the learner.

Also supportive of the strategy reported here are researchers (Wittrock, 1986) who consider reading as an active process of constructing meaning from text that is based on prior knowledge and experience. Within a constructivist framework, Shymansky (1989) has pointed to implications of reading-comprehension models for the learning process in a content area such as science. From these views, students engaging in hands-on science activities are forced to confront currently held cognitive frameworks with new ideas, and, thus, actively reconstruct meaning from experience (Shymansky, 1989). Because hands-on activities encourage students to generate their own questions whose answers are found by subsequent reading of their science textbook or other science materials, such activities can provide students with both a meaningful purpose for reading (Ulerick, 1989) and context-valid cognitive frames of reference from which to construct meaning from text (Nelson-Herber, 1986).

In comparison to work by Chall & Snow (1988) exploring the effects of reading science (and other) content upon the reading achievement of remedial students, the curriculum strategy in the present study is a significant enhancement because it integrated science-based reading instruction with an in-depth science program to demonstrate the combined effects upon science and reading for average and above-average students. In doing so, the results of the curriculum strategy used in this study are highly supportive of current research-based opinions for increasing the quality of reading and science education. In reading, these opinions question the appropriateness of using basal reading series at the upper elementary levels; in science education, these opinions prescribe requirements for improving the quality of science instruction through hands-on activities and the correlated uses of textbooks in elementary grades. In fact, of all of the achievement, attitude, and self-confidence measures included in this study, lack of significant effects were found only on two of the affective measures in reading (self-confidence, out-of-school attitude). Although certainly worthy of attention, these two variables must be considered as less-sensitive transfer criteria—given the differential focus of the study upon science activities for the experimental (versus the control)



group. With this in mind, either augmenting the treatment to enhance these effects or increasing the number of questionnaire items on each measure might improve the statistical power for obtaining significant differences on these measures.

In addition to the statistical results, a number of anecdotal findings bear upon the implications of the study. Initially, the experimental-group teachers were very uncomfortable with discarding the basal reading series, particularly in regard to explaining the curriculum rationale to parents. However, this concern was overcome early in the school year when many parents volunteered to teachers how pleased they were about their children's excitement with classroom science instruction and the fact that their children were, for the first time, enjoying reading their textbook and other (science) materials at home. Thus, informal observations of parents were consistent with the positive affective findings measured objectively that, along with improved understanding of science, form the foundation for more positive student attitudes toward future science instruction, factors identified in the literature as important for improving school science learning.

#### Author Notes

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