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ABSTRACT

A study determined the impact of integrating literacy and science programs on literacy achievement, use of literature, and attitude toward reading and science. Six third-grade classes (128 students) of ethnically diverse children were assigned to one control and two experimental groups (literature/science program and literature only program). Standardized and informal written and oral tests were used to determine growth in literacy and science. Use of generic literature and literature related to science was measured by a child survey concerning after-school activities and records of books read in school and at home. Interviews with teachers and children determined attitudes toward the literature and science programs. Children in the literature/science group did significantly better on all literacy measures than children in the literature only group. Children in the literature only group did significantly better on all literacy measures, except for the standardized reading tests, than children in the control group. There were no differences among the groups on number of science facts used in science stories written. In the test of science concepts the literature/science group did significantly better than the literature only group and the control group. Observational data are reported on the nature of literacy and science activity during periods of independent reading and writing. (Contains 42 references, 4 tables, and 4 figures of data. A list of storybooks used for testing is attached.) (Author/RS)

The Effect of a Literature-Based Program Integrated into Literacy and Science Instruction on Achievement, Use, and Attitudes Toward Literacy and Science

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The work reported herein is a National Reading Research Project of the University of Georgia and University of Maryland. It was supported under the Educational Research and Development Centers Program (PR/AWARD NO. 117A20007) as administered by the Office of Educational Research and Improvement, U.S. Department of Education. The findings and opinions expressed here do not necessarily reflect the position or policies of the National Reading Research Center, the Office of Educational Research and Improvement, or the U.S. Department of Education.

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About the National Reading Research Center

The National Reading Research Center (NRRC) is funded by the Office of Educational Research and Improvement of the U.S. Department of Education to conduct research on reading and reading instruction. The NRRC is operated by a consortium of the University of Georgia and the University of Maryland College Park in collaboration with researchers at several institutions nationwide.

The NRRC's mission is to discover and document those conditions in homes, schools, and communities that encourage children to become skilled, enthusiastic, lifelong readers. NRRC researchers are committed to advancing the development of instructional programs sensitive to the cognitive, sociocultural, and motivational factors that affect children's success in reading. NRRC researchers from a variety of disciplines conduct studies with teachers and students from widely diverse cultural and socioeconomic backgrounds in pre-kindergarten through grade 12 classrooms. Research projects deal with the influence of family and family-school interactions on the development of literacy; the interaction of sociocultural factors and motivation to read; the impact of literature-based reading programs on reading achievement; the effects of reading strategies instruction on comprehension and critical thinking in literature, science, and history; the influence of innovative group participation structures on motivation and learning; the potential of computer technology to enhance literacy; and the development of methods and standards for alternative literacy assessments.

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Abstract. *The purpose of the study was to determine the impact of integrating literacy and science programs on literacy achievement, use of literature, and attitude toward reading and science. Six third-grade classes (N = 128) were assigned to one control and two experimental groups (literature/science program and literature only program). Standardized and informal written and oral tests were used to determine growth in literacy and science. Use of generic literature and literature related to science was measured by a child survey concerning after-school activities and records of books read in school and at home. Interviews with teachers and children determined attitudes toward the literature and science programs. Children in the literature/science group did significantly better on all literacy measures than children in the literature only group. Children in the literature only group did significantly better on all literacy measures, except for the standardized reading test, than children in the control group. There were no differences between the groups on number of science facts used in science stories written. In the test of science concepts the literature/science group did significantly better than the literature only group and the control group. Observational data are reported on the nature of literacy and science activity during periods of independent reading and writing.*

From a language arts perspective, literacy learning and content learning can result from stimulating active reading and writing through authentic, meaningful, and functional experiences with children's literature. Such experiences take place throughout the school day within rich literacy environments created to encourage social collaboration within periods set aside for independent reading and writing. When literacy instruction and content learning use an integrated approach, literacy learning benefits from the students' interest in many science and social studies topics. Content learning benefits because literature provides new sources of information, and writing stimulates active engagement with content. By integrating language arts and content learning, student self-regulation is promoted (e.g., self- selection of what is read). The goal of this approach is to develop a competent strategic reader, who is motivated to read for pleasure and for information. Variations on the integrated approach have been described by Dewey (1966), Piaget and Inhelder (1969), and Vygotsky (1978), and by language arts theorists (Bergeron, 1990; Goodman, 1989; Graves, 1975; Stauffer, 1970).

Several researchers have indicated that the use of children's literature provides an ideal opportunity to develop critical reading. Current research indicates that reading is a constructive process. That is, readers come to texts with background knowledge that helps them construct meaning about what they read; furthermore, readers construct meaning as they interact with peers and adults when discussing stories. The content of children's literature lends itself to drawing on background knowledge and to the use of interactive strategies with peers and adults, such as story discussions, role playing, and retelling texts to help construct meaning about text (Jett-Simpson, 1989).

In the project reported in this article, we explored integrating literature-based reading and writing into literacy and science instruction. Scientific literacy is increasingly essential to participate fully in life. As the need to be scientifically literate increases, however, the evidence that many students do not become scientifically literate grows (National Science Foundation, 1989). Even though 95% of teachers use a science text 90% of the time when they are teaching science (Ogens, 1990), too often the result is not scientific literacy, but rather frustration and boredom. Researchers analyzing elementary science textbooks (Baker, 1991; Baker & Saul, 1994; Morrow, Cunningham, & Olsen, 1994) have concluded that such texts often require reasoning beyond the capabilities of students using them. Since one science text is typically offered for all students in a class, a mismatch occurs between reading competence and reading demands for many students, particularly since science texts often are demanding even for excellent readers (Chall, Conrad, & Harris-Sharples, 1991; Meyer, 1991). The science textbook approach fails to stimulate experimentation and scientific inquiry activities as well. Accumulating factual knowledge is the approach to science learning most consistent with science textbook driven instruction.

Recently, there has been a movement toward reform in science education and the role of reading in the science education enterprise (Santa & Alvermann, 1991). An important hypothesis emerging from this reconceptualization of science education is that integration between language arts and science could have a profound effect on the development of scientific literacy (American Association for the Advancement of Science, 1993; Dowd, 1991; Gaskins et al., 1994). Enthusiasm for this hypothesis generates from initial demonstrations that difficult scientific concepts can be understood by students who are taught scientific content using literature (Moore & Moore, 1989). The use of children's literature increases interest in reading, and at the same time students are accumulating knowledge about the content area at hand (Hoffman, Roser, Farest, 1988; Morrow, O'Connor, & Smith, 1990). Learning science through authentic reading and writing experiences is consistent with a variety of language arts models, including integrated language arts, whole language, language experience, and writing process approaches. Such integration can provide students with exposure to and practice with the diverse genres that are science literature, from fiction written to highlight scientific themes, to exposition constructed to expound scientific principles. All of this reading lends itself to the opportunity for learning scientific content. With the careful selection of high quality literature for the science curriculum, it should be possible to provide students with much more interesting scientific reading than is typically experienced through textbooks. This is an important consideration given the critical role of interest as a determinant of learning and a stimulus for future academic work (Renninger, Hidi, & Krapp, 1992). In contrast, conventional science instruction with science texts only has resulted in low motivation to participate in science (National Science Foundation, 1989).

Overview of the Study

The purpose of the study was to determine the effects of a literature-based reading and writing program integrated into literacy and science instruction at the third-grade level. We expected that such integration would have an effect on literacy achievement, attitudes toward literature, and student willingness to engage in literacy activities on their own. We also decided to examine the effects on science achievement, attitudes, and selection of scientific literature to read. We were interested to see if such a program had an effect on literacy and science teaching during the school day, in classes receiving integrated literacy and science, compared to more conventional classes.

The integration in this study only dealt with the use of literature-based reading and writing activities in literacy and science instruction. Since we did not include hands-on science experiences as part of our treatment or assessment, the study favors the enhancement of the language arts more than science. In our original conception of the study, the intent was to determine its effect on literacy. However, we decided it was an opportunity to evaluate the effect on science as well, at least in a preliminary manner. We recognized that simply adding science books would not transform the classroom experiences of children. Consistent with many integrated language arts and science education reform recommendations (Champagne & Bunce, 1991; Glynn, Yeany, and Britton, 1991), the intervention studied here included encouraging social interaction and cooperation by small groups of children and between teacher and students as they used reading, writing, and literature, including scientific literature as part of independent reading and writing. Such peer interaction allows students to attempt a range of roles they would be denied by the asymmetrical power relations of traditional student-teacher participant structures (Cazden, 1986). Thus, social interaction and cooperation in small groups was expected to promote achievement and productivity because children explain material to each other, listen to other's explanation, arrive at joint understandings, and accomplish more together than they could alone (Forman & Cazden, 1985; Slavin, 1983). In addition, there is a greater acceptance of differences among students in cooperative settings. For example, high and low achievers work well together, as do children from varied racial and ethnic backgrounds (Kagan, Zahn, Widaman, Schwarzwald, & Tyrell, 1985; Lew, Johnson, Johnson, & Mesch, 1986; Morrow, 1992). Children bring their prior knowledge to the readings and social cooperative interactions. The text content and prior knowledge provides the beginning of knowledge construction as children and teachers discuss, question, and reflect on what they read (e.g., Jett-Simpson, 1989). From the perspective of theories of shared and distributed cognition, children and teachers in interaction are expected to construct meanings together that none of the children would have constructed alone (Resnick, Levine, & Teasley, 1992). Consistent with Vygotskian theory (1978), such interactions should foster the critical thinking skills of each participant, with individual children eventually internalizing the cognitive activities practiced in the group.

A persistent tension in elementary schools concerns the division of time among the development of basic competencies, such as literacy and numeracy, and content area learning. Integrating literacy and content learning provides one means for lessening the tension. More than time efficient, however, we expected that the advantages of the integrated approach would be apparent on several measures. This investigation sought to determine what effect the literature-based program used in literacy and science instruction had on: (1) children's reading comprehension and ability to write stories with well-formed structures; (2) children's ability to write narratives about science topics with well-formed story structures that include science concepts; (3) children's performance on a commercially prepared measure testing science concepts; (4) teacher and child attitudes toward the literature in the science and reading programs; (5) the nature of science lessons in classrooms in the literature/science program and those not in the program; and (6) literacy and/or literacy/science activities participated in by children during periods of independent reading and writing.

Method

Subjects

The 128 participants (68 girls, 60 boys) were from six third-grade classrooms in one school. The sample was ethnically diverse including 49 children of African-American heritage, 46 Caucasians, 25 Latino (Cuban and Puerto Rican), and 8 Asian Americans (Korean, Indian, and Japanese). The distribution of children was similar in each classroom with approximately 10 African Americans, 8 Caucasians, 4 Latinos, and 2 Asian Americans in a class of 24. The district has been bussing for many years, and diversity within classrooms is the norm. Classes were heterogeneously grouped with respect to achievement, with approximately one-fourth of the students in each class considered "at-risk" and eligible for Basic Skills classes according to state criteria (normal curve equivalency on the California Test of Basic Skills of 34 or less in reading and 36 or less in language). Twenty-eight percent of the children in the study were on "free lunches" and considered disadvantaged. Eligibility for the free lunch program was determined by the state, using a formula that considers the family income and number of children in the family. The socioeconomic status (SES) of the subjects in each ethnic group in the study ranged from disadvantaged to middle-class.

All teachers were female with 5 to 22 years of teaching experience, averaging 12 years. Prior to this study, literature was not an integral part of the regular reading or science programs. The basal text with supporting workbook materials was the main source of reading instruction. A typical three-reading group structure was employed during the daily reading instruction, which lasted 1 hr 15 min. Books from the school and classroom library were available when children were not in reading group or working on seatwork. Occasionally, teachers read to students. None of the classrooms had well-designed literacy centers. About 6½ hr per week were spent on reading instruction.

Prior to this investigation, science instruction was based on a textbook and supporting worksheets. A project accompanied each unit (e.g., construction of a mobile of the nine planets). Four to five units were studied each school year. For half the months of the year, science was offered three times per week in 45 min periods for a total of 2 hr 15 min weekly. (Social studies was offered in the other months.) A textbook publisher unit test was administered at the end of each unit.

The teachers were willing to accept the conditions imposed by the research, since they were interested in changing their teaching. They had not had previous training with integrated language arts and content learning. Teacher participation in the experimental integrated classrooms began with in-service training. The control classrooms were provided with the materials and training at the end of the study.

Design

The six classrooms were randomly assigned to three groups: the control group (19 boys and 26 girls), experimental groups 1 (E1) and 2 (E2). Subjects in E1 (21 boys and 22 girls) received the literature-based intervention in their literacy and science programs; subjects in E2 (20 boys and 20 girls) received the literature-based program intervention only in their literacy program. Control participants continued their basal-reading and science textbook instruction. The literature/science versus control comparison evaluated the effect of the literature plus science integration relative to conventional control instruction. The literature versus control comparison assessed the effect of the literature-based program relative to conventional control instruction. Comparisons between the literature/science and literature only programs permitted a test of the effect of adding the science component as opposed to using a literature-based program only in literacy instruction.

Measurement

Several measures were administered, some individually and some as a group. The measures can be grouped into three categories: literacy and science achievement, use of generic and science literature, and attitudes toward reading and science.

Literacy and science achievement. Informal group tests, individualized tests, and commercially prepared group tests were administered as pre- and posttests to evaluate growth in comprehension, writing, science vocabulary, and factual knowledge.

1. **Story Retelling and Rewriting tests** were used since they are holistic measures of comprehension which demonstrate retention of facts, as well as the ability to construct meaning by retelling text. For the Story Retelling and Story Rewriting tests, two different storybooks were used, one for the pretest and one for the posttest (see Appendix for titles). These were chosen for quality of plot structure, including strongly delineated characters, definite setting, clear theme, obvious plot episodes, and definite resolution. The stories were similar in number of pages and words. Testing books were selected with attention to research on children's preferences in books (Monson & Sebesta, 1991). The books involved characters and concepts familiar and interesting to third-grade children. Research assistants administered the story retelling tests on an individual basis. Story rewriting tests were administered to whole groups by classroom teachers. The story retelling and story rewriting tests (Morrow, 1985) tapped literal knowledge of stories, specific elements of story structure, and story sequencing. Children listened to a story that was read to them and then were asked to retell it or rewrite it as if they were doing it for a friend who had never heard the story before. No prompts were given with the rewriting test. In the oral retelling, which was tape recorded, prompts were limited to "Then what happened?" or "What comes next?" Both written and oral retellings were evaluated for the inclusion of story structure elements: setting, theme, plot episodes, and resolution. A child received credit for partial recall or for understanding the gist of a story event (Pellegrini & Galda, 1982; Thorndyke, 1977). The scorers also observed sequence by comparing the order of events in the child's retelling with that in the original, determining the child's ability to make relationships between story elements and construct a meaningful presentation. The scoring scheme had proven reliable and valid in the range of 90% and above in previous investigations with children from similar diverse backgrounds (Morrow, 1992; Morrow & Smith, 1990; Morrow, O'Connor, & Smith, 1990). For this study, seven coders scored six protocols with 92% agreement for story retelling and 96% for story rewriting.

2. **Probed Recall Comprehension tests** (Morrow, 1985) were administered by research assistants individually to each child after he or she read the story (testing book titles are in the Appendix). The test included eight traditional comprehension questions focusing on detail, cause and effect, classifying, inference, and making critical judgments, plus eight questions focusing on story structure: setting, theme, plot episodes, and resolution. Research assistants read the questions and recorded children's answers. This instrument was reliable in the range of 92% and above in previous research with children from similar diverse backgrounds (Morrow & Smith, 1988; Morrow, O'Connor, & Smith, 1990). In this study six coders scored the five pre- and posttests with 92% agreement.

3. **The California Test of Basic Skills** (1980), a standardized instrument, had been administered by the district in April of the year before the study and was again administered in April of the year in which the study was com-

pleted. The language and reading subtests are included in the results reported here.

4. **Written Original Stories** were collected by teachers. For the creation of original fictional stories, children were shown five figures—a boy, a rabbit, an elf, a house, and an airplane—and told they could use all or some of the figures to help them write their story. The stories were evaluated for story structure, including setting, theme, plot episodes, and resolution; sequence was evaluated, with better performance reflected by stories with elements in story grammatical order as listed above. This instrument was reliable in previous work (Morrow, 1988; 1992). Six scorers in this study evaluated five child protocols, with 87% agreement.

Students were also asked to create written original stories about science themes. The purpose of this test was to determine if students could use learned science concepts and transfer their knowledge to narrative prose. In these narrative science stories, we looked for the inclusion of science concepts along with elements of good narrative plot structure. Classroom teachers administered this test. The four science topics being studied during the school year were written on the board (space, plants, animals, and the changing earth). Students were asked to select the topic they liked best and to write a story about it. They were told to include in the story as many facts, words, and ideas they knew about the topic and to include a setting, theme, plot episodes, and resolution. Stories were evaluated for the number of science concepts included. Science concepts were defined as the use of vocabulary and facts learned from the featured science units. Stories were also to be evaluated for story structure elements. Reliability for grading written original stories for number of science concepts with six coders scoring the same five subjects yielded 82% agreement. Most of the children had difficulty adapting a narrative style for this assignment; they wrote instead in an expository fashion simply including a list of facts. Those who did write narratives were unable to weave science concepts into their storyline, particularly on the pretest. In order to examine this systematically, instead of scoring for elements of story structure as planned, we counted the number of expository pieces written and the number of narrative pieces written before and after the treatment, and counted the number of scientific concepts included in the pre- and posttest writing samples. A piece qualified as a narrative if it had three of the four story structure elements included. A piece was considered expository when it was a statement of facts about the topic.

5. **Science Achievement** was measured by a test from the science textbook for the four third-grade science units used in this study. The tests consisted of 24 questions and measured factual information. The questions asked children to fill in the blanks or identify statements as true or false. A sample fill-in-the-blank question was as follows:

> Mammals are animals that have hair and feed their young with _______.

A sample true or false question was as follows:

> True or False, Birds and toads both come from eggs.

Six questions reflected content from each of the four science units. The test was administered to the groups as a whole by their teachers. Reliability for test scores was 100%, since answers were determined in advance, requiring no judgment by the scorers.

Use of literature. As indicators of literature children in the treatment groups E1 and E2 selected to read, they were asked to name favorite book titles, authors, and illustrators. Children also kept records of books read during independent reading and writing periods, plus titles of books checked out from classroom libraries to take home and read. Children were observed during periods of independent reading and writing in the literature/science and literature only groups to record their choices of books to use during that time and topics they focused on. Thus, we had several indications of the number of self-selected generic titles and science titles read by students in the study.

Attitudes towards literacy and science. For this study, attitudes towards reading and science included teacher and child interview reactions to the literature/science and literature programs. Only children in the experimental groups were interviewed about the literature program, since the control group could not make these comparisons nor answer questions related to the literature program. Interview questions about science were posed to all participants in the study.

Procedures

Schedule. At the end of September the pretests were administered, with interventions beginning in the third week of October and continuing through the following May. Observations were conducted in the experimental rooms once a week during the intervention period. Classes were observed during guided literature activities and science lessons to be certain that all program components were being carried out as intended and to be able to describe the nature of the lessons occurring in the experimental rooms. During periods of independent reading and writing, social collaborative activities in literacy and science were recorded. The posttests were administered in May. Control rooms were also observed to describe the type of activity that occurred during science and reading periods.

Treatment

The intervention was intended to complement the basal reading instruction and the science textbook instruction with a literature-based program. Of course, less time was spent with the basal in the literature/science and literature only classrooms and less time with the science textbook in the literature/science rooms. The same amount of time, however, was spent on literacy instruction and science instruction in the experimental and control groups.

Prior to carrying out the treatment, teachers in the literature/science and literature groups participated in 3 days of in-service training. An additional day was spent with the literature/science group. Teachers were given a curriculum handbook that provided a rationale and background for the programs, materials needed, and lesson plans for the various activities. There was an additional section for the literature/science rooms particular to that program. There was also a section on classroom management, since some of the activities required organizational strategies that teachers might not have used before. In the training sessions, there were demonstrations, simulations, and question and answer periods.

During the treatment, we met with the teachers in the experimental rooms every week for the first month, twice a week for the second two months, and once a month for the rest of the school year. At these meetings, we discussed problems and concerns ranging from classroom management to skill development. We also shared activities that they carried out and materials that children had created, and encouraged teacher input on how to improve the program. The school principal and reading coordinator attended our meetings, which helped demonstrate their support and encouragement for the program. Teachers in the control classrooms were met with separately to discuss the activities in their rooms. Research assistants made weekly visits to experimental and control teachers to answer questions, listen to concerns, and provide additional materials if needed.

The literature/science and literature treatment rooms all included the following.

Classroom literacy centers contained open-faced shelves for displaying featured books, as well as regular bookshelves. There were five to eight books per child at three to four grade levels with varied genres of children's literature, such as biographies, picture storybooks, informational books, novels, and so forth. Books representing the different cultural backgrounds of the children in the study were included. There was a system for checking books out for use at home. Treatment groups E1 and E2 were provided with five titles each for the four science units in the science program: plants, animals, space, and the changing earth. There were multiple copies of these books in the rooms. Pillows, rugs, stuffed animals, and rocking chairs added comfort to the centers. Literature manipulatives such as feltboards with story characters, headsets and taped stories, puppets for storytelling, chalktalks, and roll movies were readily available. Each center had an "authors's spot" with various types of writing paper, booklets, and writing utensils for writing stories and making books. The center made literature accessible and introduced children to several modalities for engaging in social, literacy activities.

Teacher-guided literature activities were carried out three times a week, and children were read to daily. Activities included engaging children in retelling and rewriting stories, creating original oral and written stories, storytelling using roll movies, feltboard stories, and chalktalks, sharing books read, and having children keep track on index cards of books read.

During story activities, emphasis was placed on elements of story structure and on styles of authors and illustrators. Regular discussion concerned literal, interpretive, and critical issues related to stories. Above all, activities emphasized the joy of literature. Teachers used culturally diverse stories and discussed different genres of literature. Activities included writing related to literature selections. The activities demonstrated by teachers provided a model for children to emulate during periods of independent reading and writing.

Independent reading and writing periods (IRWP) in which children were given the opportunity to choose from a variety of literacy activities such as read a book, read to a friend, listen to a taped story, tell a feltboard story, ask someone to read to them, check out books to take home, write a story, and so forth, were held three to five times a week. They could work alone or with others; cooperative activities were encouraged. They were expected to stay with one or two activities during the 30-min period. Each IRWP was intended to emphasize concepts that had been featured by the teacher during her guided literature lessons. During these periods, the teacher worked along with the children as a participator or facilitator.

Rules were established during IRWPs to help children self-direct their activity. It took about a month for students to be able to work independently of the teacher, deciding which activities to engage in and to stay on task. Montessori's (1965) theory emphasizing respect for others and materials helped to keep this time productive and enjoyable.

Literature/science program. In addition to engaging in all of the elements of the literature program in the literature/science rooms, the five titles of children's literature for each of the four units taught in the third-grade science textbook were featured. The featured science books had a special spot in the literacy center during the unit. Science lessons included highlighting children's literature that focused on science. As part of science lessons, students also wrote stories that contained science facts but also included elements of story structure such as setting, theme, plot episodes, and resolution. Books with science themes were in the literacy center for students to select to use. In the report of observational data, later in this paper, transcripts of lessons from the literature/science program are presented.

Managing and monitoring the treatment. The teacher-directed literature activities and IRWPs could be woven into the school day in many ways. A literature activity directed by the teacher could be followed up with an IRWP, or the two activities could be done at separate times. Some teachers conducted basal reading two days a week and the literature program three days, reversing it the following week. Others wove the two programs together or scheduled activities throughout the school day. In science, it was woven into most of the lessons, since science only occurred three times a week. By the second month, all teachers were carrying out all parts of the program and seemed to be comfortable doing so. It was possible to implement the program rather quickly because it was only one piece of the reading and science instruction. Teachers needed only to learn the new procedures and how to allocate their time.

Research assistants visited each classroom weekly and took field notes during each visit. Review of these logs confirmed that treatments were carried out as intended with respect to time spent and number of activities.

Control rooms. Reading instruction and science in the control group continued as it had in the past, with the basal reader as the main source of reading instruction and the science textbook and workbook guiding instruction in that area. The basal reader used was from the late 1980s. Of 90 selections, only 10 were whole pieces of children's literature.

There was some overlap between the type of discussion surrounding literature selections in the experimental groups and the discussions provided by the basals in their comprehension section. For example, both the literature and the basal programs placed emphasis upon literal, interpretive, and critical comprehension skills and structural elements in stories.

Science instruction was solely from the textbook supplemented by workbook pages, with a featured project for each unit. Science classes included lectures, discussions, movies, and some material displays.

The literature and science programs required the allocation of additional time for reading and science in the experimental classes. So as not to confound treatment effects, schedules were adjusted between experimental and control classes, equalizing time devoted to reading and science instruction. Thus, a true experimental contrast existed at the classroom level. During the study, 1½ hr per day was spent on reading in all classrooms for a total of 7½ hr a week. Less time was spent on basal instruction in the experimental rooms, allowing time for the literature component. Teachers spent about 3½ hr a week with the basal and 4 hr with literature in the experimental group. All 7½ hr a week of reading instruction in the control group involved basal instruction. Similarly, of the 2 hr and 15 min spent on science a week, less time was spent using the textbooks in the science/literature rooms to allow time for the treatment.

Control rooms were observed once a week during reading and science instruction. There was no evidence in these rooms of the critical behaviors encouraged in the treatment rooms. The one exception was with respect to storybook reading. It was not possible nor would it be ethical to restrict storybook reading entirely. Control teachers, if they chose, could read stories to their classes. They did so no more than twice a week.

Results

Since individual children could not be randomly assigned to conditions, intact classrooms rather than the child were the unit of random assignment and analysis in this study. Therefore, the classroom mean was used for all measures. This procedure was followed because the behaviors of subjects during independent reading and writing periods were likely to be interdependent. Such interdependence would violate the assumption of independence of experimental units that underlies conventional analysis—that is, using the individual child as the unit of analysis. There were three conditions, two experimental (literature/science [E1] and literature only [E2]) and one control. As indicated earlier, each group included two classrooms of children. The data were analyzed through the use of a one-way, repeated measures analysis of covariance (ANCOVA). In the analysis, the pretests served as a covariate and the posttests were the dependent measures. Post hoc comparisons were carried out for each analysis using Bonferroni's adjustment on the least square estimate of means to determine which between-group differences were significant. On all measures, the tests for homogeneity of the within-group regression, an assumption of the analysis of covariance (Winer, 1971), were nonsignificant.

Literacy and Science Achievement

The literacy and science achievement dependent variables consisted of scores on a Free-Recall Story Retelling and a Free-Recall Story Rewriting Test, a Probed Recall Comprehension Test, The California Test of Basic Skills, Written Original Fictional Stories, Science Stories, and the Science Concept Test. Data were analyzed separately for each test using the ANCOVA.

Table 1 presents the pre- and posttest means and standard deviations for all the literacy and science achievement tests listed above: story retelling, story rewriting, probed comprehension, California Test of Basic Skills, written original stories, science stories, and the Science Concept Test.

The ANCOVA for the total score on the Story Retelling Measure was significant, $F(2,2) = 9.30$, $p < .01$. Post hoc comparisons revealed that all groups were significantly different from each other with E1 scores significantly better than E2 and E2 scores significantly better than those in the control group.

The ANCOVA for the total score on the Rewriting Measure was significant $F(2,2) = 8.98$, $p < .01$. Post hoc comparisons revealed that all groups were different from each other with E1 scores significantly better than E2 and E2 scores significantly better than the control.

The ANCOVA for the total score on Probed Recall Comprehension Test was significant, $F(2,2) = 11.46$, $p < .001$. Post hoc comparisons revealed that E1 scored significantly better than both E2 and the control group, and that E2 scored significantly better than the Control.

The ANCOVAs for the total reading score on the California Test of Basic Skills, $F(2,2) = 8.93$, $p < .02$, and for the total language score, $F(2,2) = 6.36$, $p < .02$, were significant. Post hoc comparisons revealed that El scored significantly better than E2 and the control group in both areas. E2 and the control group were not significantly different from each other.

The ANCOVA comparing the posttest performances of the three groups on the Creation of Original Fictional Stories was significant, $F(2,2) = 7.23$, $p < .03$. Post hoc comparisons revealed that all groups were different from each other with E1 scores significantly better than E2 and the control group, and E2 scores significantly better than the control.

We tested for the ability to transfer knowledge of science concepts learned into the writing of narratives. Children were asked to create a story that included a setting, theme, plot episodes and resolution. To do so, they were to use science words, facts, and ideas that they had learned in science. We did not expect that most of the children would write expository pieces. Therefore, we compared the proportion of expository pieces to narrative stories written before and after the treatment, as well as the number of scientific concepts included in the pre- and posttreatment writing samples. The ANCOVA for the type of written piece received (Expository or Narrative) was significant, $F(2,2) = 17.81$, $p < .0001$. Post hoc comparisons indicated that El children were writing significantly more narratives than E2 and the control group, and E2 students wrote significantly more narratives than the control children. There were no significant differences in the number of science concepts used between the three groups, $F(2,2) = 1.40$, ns.

Table 1. Means and Standard Deviations for Literacy and Science Achievement Measures

	Group											
	Experimental 1				Experimental 2				Control			
	Pretest	(SD)	Posttest	(SD)	Pretest	(SD)	Posttest	(SD)	Pretest	(SD)	Posttest	(SD)
Story Retelling	3.59	(1.24)	10.14	(2.24)[a]	4.37	(0.70)	7.82	(1.80)[b]	4.75	(1.94)	5.34	(1.24)[c]
Story Rewriting	3.46	(1.35)	9.38	(2.14)[a]	3.02	(1.25)	6.09	(2.12)[a]	4.03	(1.23)	5.03	(1.98)[c]
Probed Comprehension	13.62	(2.89)	24.45	(3.01)[a]	12.99	(2.14)	20.41	(3.41)[b]	14.47	(3.06)	16.09	(2.84)[c]
California Test of Basic Skills												
Reading	61.30	(10.87)	69.36	(10.10)[a]	60.67	(11.20)	64.86	(11.11)[b]	61.87	(10.94)	62.71	(10.44)[b]
Language	57.55	(10.91)	65.23	(11.02)[a]	64.77	(11.10)	64.85	(12.10)[b]	64.09	(10.81)	63.30	(11.11)[b]
Written Original Story	4.39	(1.57)	10.97	(1.59)[a]	5.66	(1.13)	8.58	(1.13)[b]	5.92	(1.13)	5.91	(2.38)[c]
Science Stories												
Proportion of Expository vs Narrative	0.70	(0.46)	0.22	(0.41)[a]	0.76	(0.43)	0.61	(0.49)[b]	0.73	(0.44)	0.76	(0.43)[c]
# of Science Concepts	4.01	(1.05)	7.24	(1.12)[a]	3.92	(.13)	6.94	(1.61)[a]	4.51	(.78)	7.12	(.81)[a]
Science Concept Test	8.05	(1.01)	15.14	(1.98)[a]	8.16	(2.10)	12.27	(2.22)[b]	7.89	(1.02)	12.38	(1.14)[b]

Note. Posttest means are adjusted for pretest scores.
[a]$n = 2$ for each group.
[a,b,c]Posttest scores are significantly different ($p < .05$) [illegible] do not share the same superscript.

An Expository Posttest Piece on The Changing Earth

The Many Ways That Our Earth Changes

The Earth has been changing as soon as it came to be. Hurricanes change the earth when the water hits up against the rocks and changes their shape, or the waters hit up against the sand and washes it away into the ocean. Gravity changes the earth by pulling rocks off of mountains. Volcanoes change the earth when the lava that runs out if it burns, everything in its way and only ash is left where there was rich dirt and plants. Earthquakes change the earth. The ground starts moving, then the crust cracks. They can damage buildings. Drought changes the earth. When there is no rain, the ground gets dried out, plants dies, animals die and everything gets barren. The earth has been changing as soon as it came to be and I guess it always will.

A Narrative Posttest Piece About The Changing Earth:

The Treasure Hunt

My friends Amber, Alex, and Kevin found a map of a buried treasure. We decided to look for it. We followed the map to hunt for the treasure. It said go to a stream and find waters that get rough that made the rocks strange shapes from banging up against them. We walked for hours and then Kevin shouted. "Look there are the rocks." We looked for the next clue, Amber found it carved in the rock. It was hard to read from the wear of the wind and water. It said, "Go to the forest and find the clearing with the colored flowers." We walked for hours. It was hot and dry, the ground was hard, it hadn't rained for months, the grass was brown, the flowers were dead with no color in them from the drought. Then the sky got dark, the wind blew 100 miles an hour, the rain came down in buckets, we ran into a cave. This was a hurricane. When the storm ended it looked like a different place. Trees fell, the lake washed away the beach, but colored flowers were growing. We had found the spot. We saw a note that said go to the mountain. We saw it ahead. We r toward it. The earth began to shake, the mountain rumbled. It wasn't a mountain it was a volcano. Red hot lava ran down the side. We ran for cover. When the volcano finished erupting the earth was covered with ash. When it was safe we came out to look for a clue. I saw a paper. It said go to the forest and you will find it. When we got there, the leaves were green, the flowers were pretty, the sky was blue, there was a breeze, there was fruit to eat on the trees and birds were singing and the sun was warm. Alex said, "This is it." "What," we said. Alex said, "We saw changes in the earth that were scarry like jagged rocks from wind and water, and a hurricane that blew down trees, and a volcano burned up the ground. Now we can see the beautiful part of the earth. This is the treasure." We all agreed and enjoyed the pretty earth.

Figure 1. Expository and Narrative Posttest Science Stories

Figure 1 presents samples of original pieces written by children in the study about the topic *The Changing Earth*. In each instance, the child was to select a science topic studied

Table 2. Generic and Science Books Read by Children

	Group					
	Experimental 1			Experimental 2		
# of Books Read	Boys	Girls	Total	Boys	Girls	Total
Generic trade books	225	243	468	295	321	616
Science trade books	139	100	259	61	50	101
Totals	364	343	707	356	371	727

during the year, such as plants, animals, the changing earth, or space. They were told to make a list of all of the science facts they learned about the topic. They were asked to write a story that had a setting, theme, plot episodes, a resolution, and included as many of the science facts they had recorded. The first sample is an expository piece by a child in the control group with many science facts included. The second sample is from a child in the science/literature group. It is a narrative including the elements of story structure and science facts as well.

The ANCOVA for scores on the Science Concept Test were significant, $F(2,2) = 5.05$, $p < .05$. Post hoc comparisons revealed that scores in E1 were significantly higher than in E2 and the control group. No differences occurred between E2 and the control group.

Use of Literature

Books read in school and taken home to read provided information on children's use of literature. Children in the experimental groups were asked to record on index cards the dates and titles of books they read on their own in school. They also recorded the dates and titles of classroom library books taken home to read. These data were not completely reliable because some children were more efficient about keeping their records than others. The two sets of data were combined and evaluated for increased book use over time. (The data were collected for the experimental group only, since the control children did not participate in these activities.) We reviewed records of books read in class and those taken home from the beginning of November to the end of April. The time was divided into three periods: November–December, January–February, March–April. The number of books for each time period was recorded to note if the numbers increased over time. For the 83 children in the four experimental rooms, a total of 1,434 books were recorded as read in school or at home, 714 by the 42 girls and 720 by the 41 boys. Thirteen percent of the books were read in the first period, 32% in the second, and 55% in the third. The numbers of books read by girls and boys was very similar. Table 2 presents the number of books read by boys and girls in the science/literature group and the literature group, indicating how many books were science topics and how many were in other categories. The

Table 3. Number of Generic and Science Book Titles Named by Children

	Group					
	Experimental 1		Experimental 2		Control	
Book Names	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
Total # of books named	81	151	85	145	84	110
Science titles named	10	48	8	24	11	15
Generic literature titles named	71	103	77	121	73	95

children in the literature/science program selected to read more books with science titles, in and out of school than the children in the literature group. Boys selected more science titles than girls in both groups.

Naming book titles in science and generic literature. Literature use was measured through an interview which asked experimental and control children to name book titles they know from school. This was looked upon as a measure of literature use, because it was assumed that a child was more likely to be able to perform this task if he or she were reading books. looking at books, or being exposed to books by the teacher. Table 3 presents the pre- and post-interview results for the total number of science and generic book titles named by children in the three groups. The experimental groups could name more book titles, authors, and illustrators than the control group. The children in the literature/science group were able to name more science titles than children in the other groups. When examining the book titles, those in the literature/science rooms strongly reflected the four science units studied and the books provided about plants, space, animals, and the changing earth.

Attitudes Toward the Literature/Science and Literature Programs

Attitudes toward reading and science in the literature/science and literature programs compared to the traditional reading and science instruction were evaluated through interviews with teachers and children in the experimental and control classrooms.

Teacher interviews. The four teachers in the experimental groups were interviewed individually. Comments were extremely consistent among them. In general, teachers reported that they were at first skeptical about the amount of time that the program would take away from other classroom activities (e.g., basal reading instruction, and science in the literature/science and literature program rooms), but that their feelings changed over time. By the end of the study, they saw literature as an integral part of their reading instruction program. All reported concerns about getting children to work on task during IRWP, but they were able to work through these problems. They reported that they planned to continue the program and to further integrate literature with their basal instruction. The teachers who participated in the literature/science program reported the desire to integrate

What did you like about the program

*Promoted the joy of reading
*The choice of a variety of books for children to read
*The choice of a variety of materials motivated children
*Children enjoyed being read to and I enjoyed reading to them
*The opportunity for cooperative learning which was productive
*The program seemed to build self-esteem since there was something that everyone could be good at
*Stigmas that come from ability grouping were eliminated

What did children learn from the program

*Children were learning skills since they were practicing reading and writing while participating in activities
*Specific skills utilized were oral reading. silent reading. comprehension. learning about authors. illustrators. literature genres and parts of books
*Appreciation for reading and writing

What did you learn from the program

*New techniques for reading and writing instruction
*The value of choice in the learning environment
*The value of a variety of activities for children to select from
*Children can learn in social cooperative settings
*It's okay to give kids freedom of choice
*As a result of the program children became more interested in reading and writing

Comments of teachers concerning the science program from the science/literature group

*The science program became a part of my total curriculum
*Children became more interested in science
*Children combined science with the IRWP. by participating in literacy activities with science themes. such as presenting a feltboard story about a book that had a science topic
*I think both literacy and science achievement were enhanced since children were doing science during literacy periods and literacy during science periods
*The activities added to the science program that were literacy oriented. such as reading trade books and writing stories. increased children's interest in the science topics
*I found this interdisciplinary approach to science and literacy made my teaching more interesting for me
* I'm going to try this with social studies next year

Figure 2. E1 and E2 Teachers' Responses to Interviews

the language arts perspective into other parts of their curriculum such as social studies.

Similar answers emerged from the teachers' responses, which are listed in Figure 2 under

What is the literature program like?

*There are many kinds of books to read (*N* = 55)
*It's nice because there is a lot of time to read (*N* = 48)
*There are lots of good things to do like roll stories, plays chalk talks, feltboard stories, tape stories (*N* = 47)
*It's nice because you can choose to read and write with your friends (*N* = 30)
*I like reading on the rug and sitting in the rocker (*N* = 30)
*You can choose what you want to do and who you do it with, and where you do it in the classroom (*N* = 42)
*It's fun and makes me happy (*N* = 81)
*I like reading the books about science and writing stories about science (*N* = 20)

What is regular reading in your classroom like?

*Regular reading you can only read from one book (*N* = 25)
*You have no freedom or independence in regular reading to choose what you want to do (*N* = 27)
*The teacher tells you what to do (*N* = 20)
*The books aren't about good topics (*N* = 15)
*You have to work at your desks instead of working where ever you would like in the room, like on the rug (*N* = 22)
*The teacher teaches with workbooks, gives tests, asks questions and checks your skills a lot (*N* = 21)
*In regular reading, you just read, in recreational reading you read and can do writing, like writing books and stories too (*N* = 8)
*It's not much fun like recreational reading (*N* = 24)
*It makes you feel bad sometimes when other kids are in higher groups than you, when you do bad on tests (*N* = 15)
*In IRWPs, you can mix science, reading, and writing which makes them all more interesting. In regular reading, the reading doesn't make much sense (*N* = 15)

How would you make the literature program better?

*Add new books and more kinds of books (*N* = 25)
*Make IRWPs longer and have it every day (*N* = 34)
*Let children work together with kids they want to work with (*N* = 10)
*Get more roll movies, puppets, tape stories, etc. (*N* = 28)

Figure 3. Child Responses to Interview Questions

How would you make regular reading better?

*Read more stories to the children (N = 20)
*Let the kids choose the stories they want to read (N = 22)
*Do less comprehension checks, do less skill checks, use less workbooks (N = 28)
*Make it shorter (N = 15)
*Let the kids work in groups they choose, I'd give them more freedom (N = 18)
*Have more activities to choose from and make it like recreational reading (N = 18)
*Let the kids read books about topics that are interesting to them like stories about space, machines and animals (N = 12)

What do you think you are learning in recreational reading

*I am learning to read and write better because I read and write a lot and practice (N = 40)
*I'm learning how to teach my friends to read and it helps me with my reading too (N = 20)
*I'm learning to read better because my friends help me (N = 25)
*I learn a lot of new words from reading and writing (N = 20)
*I'm learning about many different kinds of books (N = 15)
*I'm learning about different authors and illustrators (N = 17)
*I'm learning how to tell and write stories and poetry, that I make up myself (N = 28)
*I'm learning to understand what I read better (N = 17)
*We're learning how to read and write together in groups (N = 22)
*We're learning about ways to tell stories with puppets, crafts, tape stories, imagination, and others (N = 23)
*I'm learning a lot about science because we always read about it from books in the literacy center, and write stories about it too (N = 25)

What are you learning in regular reading

*How to read better (N = 58)
*How to break words into syllables, vowel sounds, vocabulary, phonics, how to spell (N = 30)
*You learn to do worksheets, read flashcards, to answer comprehension questions, and take tests (N = 52)

Is your teacher the same during regular reading and IRWPs.

*In regular reading she tells you what to do, IRWPs you have freedom and can decide that yourself (N = 35)
*She reads to us a lot more during IRWPs (N = 20)
*My teacher seems happier during IRWPs (N = 20)
*In regular reading she yells a lot, in IRWP she doesn't (N = 15)
*The teachers leaves us alone during IRWP's, she's not always checking us like in regular reading (N = 11)

Figure 3. (continued)

Do you like science? If yes why, if no why?

Science/Literature Group

yes 35	no 8

Why?

You learn a lot	It's boring
It's fun	
a. You get to read good books	
b. I like to write the stories	
You get to do it during IRWPs	

Literature Only Group

yes 15	no 25

Why?

You learn a lot	It's not fun
It's fun	It's boring

Control Group

yes 17	no 28

Why?

You learn a lot	It's not fun
It's fun	It's boring

Figure 4. Children's Attitudes Toward Science

each interview question asked. The two teachers in the literature/science program made additional comments that reflected their participation in the science program, with these also included in the figure.

Child interviews. To determine their attitudes toward the literature program, only children in the experimental groups participated in the interviews summarized in Figure 3. This was because control children would not be able to answer questions pertaining to either the science/literature or the literature program. A total of 83 children were interviewed from Groups E1 and E2. The interviews did not pertain to science although children in the science/literature group gave some responses that reflected upon their participation in that portion of the program. During these interviews, the same responses to the questions appeared frequently. These are listed with the number of children who gave a particular response recorded next to the example. Answers in bold print represent those from children in the science/literature group.

Some additional questions related to feelings about science were asked of all children in all groups. Children in the literature/science group had better attitudes toward science than those in the other groups. Figure 4 presents the childrens' responses.

Report on the Observational Data

One purpose of gathering observational data in this study was to monitor the activity in the experimental and control groups to be sure teachers were carrying out their programs as intended. We were also interested in finding out how the intervention led to the outcomes. For the science observations, we observed science lessons in all of the rooms. In the literature classrooms, we observed the IRWPs. These data were collected by research assistants who recorded field notes as they observed.

Observational data were collected for all rooms via videotapes or field notes during 30 science lessons over the course of the school year. There was a total of 180 hr of observation or 60 hr per treatment group and 60 hr in the control rooms. In addition, all rooms involved in the literature treatment were observed in the same manner during IRWPs, which included a teacher-directed literature activity prior to having children work independently. This was done once a week for 30 weeks for a total 120 hr in the four treatment rooms, 60 in the literature/science and 60 in the literature only.

During the first month of observations, the observers and individuals doing the monthly videotaping familiarized themselves with the classroom setting and established their identities within the classrooms. The initial field notes and videotapes provided a basis for clarifying and standardizing the procedures used to collect the data. This information was used to develop guidesheets which were used by the research assistants while observing, writing field notes, and videotaping and transcribing tapes. Field notes were to include detailed information on children's self-selected literacy behaviors during IRWPs as well as the activities provided by teachers for children during science lessons. The observers' notes included information about dialogue between children, dialogue between children and teachers, and materials used. Complete interaction episodes were to be followed from beginning to end. This type of note-taking and videotaping is referred to by Barker (1963) as *the stream of behavior chronicle* because it records minute-by-minute what subjects do and say.

The data were analyzed and categorized using the constant comparative method (Miles & Huberman, 1984) with categories emerging as data analysis proceeded. When categories were identified, their frequency of occurrence was recorded.

Table 4. Types of Experiences in Science Lessons Observed

	Number of Observations		
	Experimental 1	Experimental 2	Control
# of observations	60	60	60
Types of Activities:			
1. Use of literature	45	15	10
2. Developing literacy skills	25	15	10
3. Use of science texts	15	35	40
4. Lecture	25	30	32
5. Discussion	30	25	26
6. Lessons held in literacy center	35	15	0
7. Lessons held at desk	25	45	60
8. Use of worksheets	10	25	34
9. Use of experiments	8	9	8
10. Use of science movies, demonstrations, materials	10	12	11
11. Cooperative group work	18	16	15
12. Independent work	15	14	16

Observations of science lessons. Thirty science lessons in all the rooms were observed in the course of the year. Table 4 presents the list of types of teacher and child activity that took place in the science lessons observed and the frequency of occurrence in the different treatment rooms. The categories of activities that emerged and were used during science lessons included: (1) use of children's literature, (2) developing literacy skills, (3) use of the science text, (4) lecture, (5) discussion, (6) lessons held in literacy centers, (7) lessons held at desks, (8) use of worksheets, (9) use of experiments, (10) use of movies, demonstrations, other science materials, (11) cooperative group work, and (12) independent work.

In the categories of activities that emerged through observing science lessons, all groups were fairly similar in the amount of independent work, cooperative work, demonstrations, movies, experiments, discussion, and lectures held. In the areas of use of literature, developing literacy skills. lessons occurring in the literacy center, and use of worksheets, the literature/science group participated in these activities most, the literature only group next, and the control group the least.

An example follows of an introductory science lesson in a literature/science room in which the teacher uses children's literature to motivate interest in a new unit theme. A second lesson illustrates the use of children's literature to teach science facts and literacy skills.

Introductory Science Lesson in the Literature/Science Program

Ms. S just completed a unit on "Animals" and was about to begin one on "The Changing Earth." When the science period began, she called the children to the literacy center where they sat on the rug and Ms. S in the rocking chair. She had the rack that held the science trade books which were filled with stories about animals. She said, "Since we have completed our animal unit, I will put these animal stories in the science section of our classroom library. I'm going to change the sign on the science book rack to 'The Changing Earth,' since that is our next topic." She asked the children if they could imagine what they might be studying about with the topic, "The Changing Earth." Dominick said, "Maybe how the rocks change from years of wind and rain on them," Ms. S agreed that was a good idea. Stacey said, "Hurricanes can change the earth, when they blow down trees and wash away the sand from th beach." Ms. S agreed with her about that. She then introduced five books and read their titles—*Volcanoes, How to Dig a Hole to the Other Side of the World, Time of Wonder, The Magic School Bus Inside the Earth*, and *Bringing the Rain to Kapiti Plain*. She explained that these stories along with their textbook would help them learn about the Changing Earth. She said she'd be reading them during the unit and that she would leave them in the special featured science book rack for them to read during their free time. She asked if anyone had any more ideas about what "The Changing Earth" unit might be about as a result of hearing these book titles. Tiffany said, "I guess volcanoes change the earth with all that hot stuff that pours out of them." Tim added, "We're probably gonna learn about what's inside earth, from the titles of those books you told us about."

A Science Lesson in the Literature/Science Group Emphasizing Literacy Skills and Science Facts

The class assembled in the Literacy Center for the science lesson. The teacher sat in the rocking chair while the children sat on the rug. Ms. S picked up a book about the **Changing Earth** and wrote the title on a chart *How to Dig a Hole to the Other Side of the World*. She underlined the title and asked the children why she had done that. Bernice replied, "When you write the name of a book, you are supposed to underline it." "Good," said Ms. S. Ms. S continued, "We've been studying the changing earth and what the earth is made up of. This book is factual and it also has fictional information. While I'm reading, try to remember the facts we come across. After I finish we'll record those facts. After that we'll retell the story together, and emphasize the facts." Ms. S read the name of the author and illustrator and began the story. After reading, the class discussed the facts and Ms. S wrote them on the chart. This discussion followed.

"What is the first thing that you hit when you dig a hole in the earth?" Tyrone replied, "Loam, it is like topsoil, then we could find clay." "Good," said, Ms. S. "Then what?" Adelise raised her hand, "Next comes bones, rock and limestone." Joseph asked, "Isn't rock the same as limestone?" "Yes," replied Ms. S, "Now what do we find?" The children responded together, "Crust and then water." "What else?" asked Ms. S. Kevin answered, "I think oil is next, I guess that's what people mean by filthy rich. When you find oil you get rich but you also get dirty from digging." "There are geysers with scalding hot water and Basalt. Who can tell me more about Basalt?" asked Ms. S. Tyshone raised his hand, "Well when it's in the earth it is black, and when it is melted it is called magma. When it comes out of the earth through volcanoes, then its called lava." Jennifer raised her hand, "The next part is fictional, the book talked about going through the layers of the earth in a jet propelled red submarine." "Good. I'm glad you can tell the difference," said Ms. S. "Who can finish up?" Damien and Dan continued back and forth, "Well next they came to mantel, which is hot." Ms. S wrote that on the chart. "Then there is the outer core made of melted rock and iron and the inner core at the center of the earth. After the center he goes back through all the other stuff again till he came out on the other side." Ms. S said, "That was great, now would someone retell the entire story with the facts listed on the chart?" April volunteered and began with "once upon a time there was a boy who wanted to dig a hole to the other side of the world." She followed the facts on the chart to the end. When she finished, everyone clapped.

Observation of Independent Reading and Writing Activities

We observed periods of independent reading and writing in the literature program groups and in the literature/science groups to record the types of literacy activities that occurred and the frequency with which they occurred.

Oral reading. During IRWP, children chose to read orally in pairs, in small groups, and alone. They read books, magazines, and newspapers. Oral reading was sometimes accompanied by manipulatives such as roll movies, feltboard stories, and puppets. Oral reading was observed 98 times in 120 observations. Following is a typical incident.

Mercedes and Patricia selected the book *Bringing the Rain to Kapiti Plains* to read, using felt figures to illustrate the story. Patricia got the book, and Mercedes brought the feltboard and story characters. Patricia said she would read, and Mercedes agreed to place the figures on the board at the right time. Patricia read aloud, and Mercedes followed along in the book. When they finished reading, they discussed that it was good how it finally rained since there was a drought in the jungle.

Silent reading. Children could decide to read alone silently and sitting close to each other in groups. They could select to sit at their desks or curled up on the carpet in the literacy center. A group of children went to the literacy center to look for books to read. Jovanna said, "Hey you guys, I have an idea. Let's all read a book about plants." She went to the featured plant books, since that was the topic being studied in science, and distributed them to group members. "Who wants *Miss Harp in The Poison Ivy Case*?" Phillip took that one. Next she held up, *A Tree is Nice*. Tyshell asked for that. The next book was *Johnny Appleseed*. Adasha raised his hand, and Jovanna gave that one to him. There were two left, *Discovering Trees* and *Cherries and Cherry Pits*. Jovanna said, "Josh, I think you'll like *Discovering Trees*, and Kendra, you take *Cherries and Cherry Pits*." They took their books, found a spot on the rug with a pillow or stuffed animal, and began reading. When they finished reading, each took a turn telling about his/her story. There were 82 silent reading incidents recorded in the 120 observations of the treatment rooms.

Writing. Children's literature and the manipulatives available encouraged writing. Yassin, Patrick, and Darren decided they wanted to write a new episode for the book *Space Rock*. They had read the story along with the unit about Space and thought it would be neat to think of another adventure with the rock. They started writing their story and decided that when it was through, they would make it into a roll movie to show to the class. There were 105 writing incidents recorded in the 120 observations of the treatment rooms.

Comprehension. Children demonstrated understanding of what children were reading or had read through activities they participated in during IRWP. Most of the time, the comprehension was at the literal level. There were 120 incidents of children demonstrating understanding of texts. Ninety were literal and 30 were interpretive. The following demonstrates an incident that illustrates literal comprehension.

After four children read *The Magic School Bus, Inside the Earth* orally to each other, they decided to illustrate the main episodes by making poster scenes of the story. They each selected a part of the story they liked best and illustrated it in a poster. They numbered the posters in sequential order to match the sequence of the story.

An example of interpretive comprehension follows. A group of children had read *Sylvester and the Magic Pebble*. They made stick puppets to represent the characters and were rehearsing to present it to the class. In their preparation, they discussed the voices they should use for Sylvester's mother and father, and what Sylvester should sound like. They gave each other suggestions for the proper expressions in the voices of the characters who were happy or sad.

During the observations of literacy activities, it became apparent that children were using science trade books frequently. In 20 of the 98 oral reading episodes, science books were used; in 25 of the 82 silent reading episodes, science trade books were selected; and in 30 of the 105 writing episodes, topics dealt with science themes being studied in the classroom. In the 115 incidents where children demonstrated understanding of text read, 30 of those involved the use of science books. All of the treatment rooms, science/literature and literature only, had all of the featured science books available to them. However in the literature only rooms, the books had not been featured by the teachers. Ninety-five percent of the science book selection observed took place in the science/literature classrooms. Featuring the books during science and including literacy activities such as writing in science lessons seemed to transfer into the IRWP. We had not anticipated such a dramatic difference between the literature/science and the literature only groups with respect to science book selection.

Discussion

This study produced clear support for integrating literacy and science instruction at the third-grade level with respect to the development of language arts competencies. There were multiple indicators of improved reading comprehension relative to performance in the control classrooms—the retelling, rewriting, and probed comprehension measures as well as on the standardized test. Relative to controls, writing also was affected positively by the integrated literature/science curriculum. These gains did not come at a cost to science content learning, with pretest to posttest improvements on the science concept test greatest in the integrated literature/science condition.

Although the differences between the literature/science and literature only conditions were not as striking as the differences between the science/literature and control conditions, all differences between the literature/science and literature only conditions descriptively favored the literature/science integrated group. Moreover, most of the literature/science versus literature only comparisons were significant. In short, the integrated experience produced better outcomes than even those observed in classrooms experiencing an effective, literature-based approach (i.e., performances in the literature only group were always descriptively better than performances in the control condition). In a previous study with similar treatment, but without the integration of the literature based program into a content area such as science, gains were made in many of the same tests given in this investigation; however, there were no significant differences between the experimental and control groups on the standardized test (Morrow, 1992). In this investigation, significant differences did occur, with the literature/science group achieving higher scores than the literature only and the controls.

Why was the integrated approach so effective? Consistent with the hypothesis that literature-based instruction is motivating, there were indications that students in the literature-based groups did in fact read more than control students. Consistent with the hypothesis that reading of science would be especially motivated by the literature/science integrated approach, there was clear evidence that students in these classrooms, in fact, elected to read science on their own more than did students in the literature only condition. When the literature/science integration students were interviewed, their enthusiasm for the integrated approach was apparent, including the students' belief that the integrated approach made reading and writing more interesting and that the integrated experiences increased understanding of science. One of the most striking outcomes in this study was that whereas the overwhelming majority of students in the literature/science group reported that they liked science, overwhelming majorities of literature only and control students reported that they did not like science. The most common complaint in the latter two conditions was that science instruction was boring, an infrequent claim in the integrated literature/science condition.

The outcomes produced in this study provide reason for expanded study of integrated science and language arts instruction. First, of course, confidence in the integrated approach will increase if it is possible to replicate the benefits observed here. Beyond that, however, much remains to be learned about the entire effect of the integrated approach on classroom experiences and students' perceptions of those experiences. Yes, we documented here that the literature-based approach reduced the amount of seat-based instruction in favor of instruction in the classroom literacy center, but the analyses conducted here did not illuminate the interactions that occurred during instruction. It is important to do so, for, as we reviewed in the introduction, there are important theoretical issues that could be informed by analyses of the interactions during literacy-based instruction (i.e., Vygotskian theoretical positions about the development of thought, distributed models of cognition, cooperative learning models of instruction). More positively, the observational data collected in this study were consistent with the perspective that rich interactions occurred during the integrated literature/science based instruction.

Although the language arts process measures collected in this investigation benefitted from the literature/science treatment, reading of science content occurs at the expense of reading of literature traditionally associated with language arts. There needs to be work on an appropriate balance between literature featured in language arts instruction and content-related literature, and how such a balance can be achieved both during the school day and as part of student self-selected reading.

This study was not aimed at determining qualitative differences in the understanding of science concepts learned through literature-based experiences versus those acquired by traditional textbook presentations. Of course, we hope that concepts would be more meaningfully interconnected with related ideas because of the literature-based experience, but we do not know that based on the data collected here. We hope that literature/science experiences more certainly resulted in students relating new science concepts to prior knowledge, but we do not know that based on the data collected here. We also hoped that scientific understandings produced in the literature/science treatment would prove generally useful. We are somewhat concerned that the students in the literature/science treatment did not do better than students in the other conditions on the one measure in this study tapping generalizations of the science concepts (i.e., use of science concepts in writing stories). Much remains to be learned about the scientific knowledge acquired via an integrated language arts and science program relative to the scientific knowledge acquired as a function of conventional science instruction.

What is reported here is a first study on the effects of integrating literacy and science instruction at the elementary level. Positive effects were observed on a number of variables relative to both of the conditions in this investigation. Perhaps these initial data will stimulate others to join us in the exploration of the robustness and breadth of impact of the integrated approach, providing more complete mapping of the strengths as well as the potential weaknesses of integrating literacy and content area instruction. Future research must go further in its treatment and assessment of science than the intervention used in this investigation. This study used traditional pencil and paper techniques as opposed to performance based, hands-on science tasks for assessment and instruction, a limitation of the experiment. However, this investigation was an important first step in studying the integrated curriculum.

The integration of content and literacy learning deserves careful consideration and analysis if for no other reason than it was so motivating to the students in this study. One possibility is that as its novelty wears off, student enthusiasm for it will diminish. Alternatively, such integration might really make more obvious the relevance and importance of both content learning and language arts. Such integration may be a key ingredient in creating more motivating educational environments at the elementary level, a possibility definitely worthy of additional research.

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APPENDIX

Storybooks used for testing

Probed Comprehension Test

Pretest: Hurd, R. (1980). *Under the lemon tree*. Boston: Little Brown.

Posttest: Steig, W. (1986). *Brave Irene*. Toronto: Collins Publishers.

Oral Retelling Test

Pretest: Lobel, A. (1982) *Ming Lo moves the mountain*. New York: Greenwillow Books.

Posttest: Brown, M. (1997). *Arthur's Eyes*. Canada: Little Brown & Company.

Written Retelling Test

Pretest: Cooney, B. (1985). *Miss Rumphius*. New York: Puffin Books.

Posttest: Anderson, H. C. (1985). *The Nightingale*. New York: Harcourt, Brace, Jovanovich, Publishers.

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