

Content Area Literacy: Individualizing Student Instruction in Second-Grade Science

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Integrating comprehension strategies with science content can be an effective way to support students' science learning.

It is day two of Mrs. L's weekly science lesson and the "explain" day of the learning cycle. Students are reading the book *Earthworms Underground* (Beals, 2007) within their groups. Mrs. L is working closely with students in one particular group, because they need more scaffolding to complete their lab sheets; students in other groups are working together independently. Yesterday, the class recorded their observations of live earthworms as part of their "explore" day. This is a high-poverty school with limited resources for classroom supplies, so many of the students had never observed earthworms so closely. Tomorrow, "elaborate" day, the students will build an earthworm habitat. But before they do, they'll read to learn how earthworms live, eat, breathe, and move about, followed by a discussion in their groups on what materials they think would be the best to put in their classroom's earthworm terrarium. The students have just finished think-pair-share in their groups.

Mrs. L: Who can tell me how earthworms breathe?

Student A: They breathe through their skin.

Mrs. L: Yes, they breathe through their skin. What did we learn about the amount of moisture earthworms need in their habitat? Moisture means water; so, what do we

need to remember about the amount of water in an earthworm habitat?

Student B: If you put too much water in earthworms' habitat, they will drown.

Mrs. L: And if you don't give them enough water?

Student C: They will dry out and die.

Mrs. L ensures that her students have comprehended their book on earthworms by probing the students' understanding of the text.

According to a recent report by the National Assessment of Educational Progress (NAEP; 2007), two thirds of children in the United States fail to read at or above proficient levels by fourth grade. This rate is even higher for children living in poverty. Thus, for decades, researchers and educators have tried to improve reading proficiency for all students. Improving students' basic decoding skills has helped us make great strides in improving their literacy overall. Many have assumed that once students decode text fluently, comprehension naturally follows (Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001). Unfortunately, research shows that this "inoculation theory" does not hold up for many students (Shanahan & Shanahan, 2008).

Researchers and practitioners have suggested that teaching students how to comprehend text while teaching content (e.g., science, social studies) may help them increase their reading proficiency and content area knowledge (Duke & Pearson, 2002; Morrow, Pressley, Smith, & Smith, 1997; Palincsar, Collins, Marano, & Magnusson, 2000; Reutzel, Smith,

& Fawson, 2005; Williams, Stafford, Lauer, Hall, & Pollini, 2009). This would be particularly helpful now that many states are including science in their state-mandated assessments (Marx & Harris, 2006; National Academy of Sciences, 2007). The purpose of the study we present here was to develop and assess the efficacy of a second-grade science curriculum that integrated science and literacy learning objectives with the goal that students would improve both their science content knowledge and their overall literacy skills.

Inquiry-based science instruction (American Association for the Advancement of Science, 1993; Duschl, Schweingruber, & Shouse, 2007; National Research Council, 1996) may be effective for developing both content area knowledge and literacy. In this type of instruction, science instruction is expected to provide rich contexts where students can exert their natural curiosity by investigating the world around them and engaging in language- and literacy-related activities (French, 2004). The National Science Education Standards state that students should be able to learn science concepts and processes more effectively when they engage in meaningful activities through manipulating materials (National Research Council, 1996). When hands-on activities are integrated with concept-focused teaching, reading of science print materials, and writing, both science understanding and reading achievement may be improved (French, 2004; Romance & Vitale, 2001).

However, Connor, Rice, Canto, Underwood, and Morrison (2009) found that students who started second grade with weaker vocabulary, reading, and background knowledge (including science knowledge) demonstrated generally small to no gains in science achievement, regardless of how many inquiry-based activities were provided, whereas their peers with average to strong skills did show gains. On the other hand, science activities scaffolded by the teacher were associated with greater gains in word reading and vocabulary. These results suggested that a “one size fits all” approach to the use of inquiry-based science activities may not be helping many of the students who bring weaker language and literacy skills to the classroom. Thus, our challenge was to develop a science curriculum that improved content learning for all students, while simultaneously supporting their literacy development.

With this in mind, we developed the Individualizing Student Instruction Science (ISI-Science) curriculum

Reflection Questions

- How much time do you really spend teaching science? Would you teach science more frequently if you could also consider this part of literacy instruction time?
- How do you assess your students’ science knowledge and literacy skills? Do you use this information to differentiate or individualize instruction for students with different skills and interests? Do you think some of the methods described in this paper would work in your classroom?
- How might you use some of the ideas for teaching literacy skills, such as text structure, during your science instruction time? What about in other content areas, such as social studies?
- In this article, there are a number of strategies for encouraging student discussion. What are some other methods that you use?
- Were you surprised by how much progress the students in this study made in their science and literacy skills? Why or why not?

described in the following section. Individualized or differentiated reading instruction has been shown to be effective for improving first graders’ reading comprehension (Connor et al., 2007), so we hypothesized that ISI-Science would generally support students’ science and literacy learning, regardless of their initial science knowledge or literacy skills.

ISI-Science Curriculum

Because we are located in Florida, we began with the Sunshine State Standards for Science (Florida Department of Education, 2008) to select the overall topic, objectives, and content for the science unit, *Why Is Soil Important?* The unit rationale was,

Students will learn about soil, earthworms, plants, and erosion in order to understand the components and

processes of the natural world. The importance and functions of soil will be taught as a means to provide students with knowledge about how the composition of the soil contributes to the environment and provides an ecosystem for many living things. Earthworms and how they affect the soil, while also needing the soil to live, will be investigated. Students will explore how the soil provides an important habitat for earthworms and how, in turn, earthworms make soil richer and better for plants. Children will also investigate plants and how plants rely on soil to live. They will investigate in what types of soil plants grow and do not grow. Erosion will be studied in the context of natural processes that affect the Earth around us and how plants can help to control erosion. (Connor, 2009, p. 1)

This particular unit included five lessons, with each lesson lasting three to six days. To structure the lessons within the unit, we used the 5-E Learning Cycle, which is a model that has been used successfully for over a decade (Bybee, 1997). The 5-E Learning Cycle provides a mnemonic that supports inquiry-based activities, class discussion, and use of expository text. The five Es are engage, explore, explain, elaborate, and evaluate.

The challenge remained how best to individualize science instruction within the framework of the 5-E Learning Cycle. We decided to individualize lessons in three ways: First, we used strategic flexible grouping of students that would allow the teacher to provide extra scaffolding for students who required support. After trying a number of grouping strategies, the teachers agreed that grouping the students by reading comprehension and oral reading fluency (ORF; Good & Kaminski, 2002) provided groups that could work well together and varied in their science topic knowledge. Students were assigned to one of three levels: orange, green, or blue. At the orange level, students were reading below grade expectations and were not very fluent (ORF words correct/minute < 75). At the green level, students were reading fairly fluently (ORF > 76) and their reading comprehension skills were around grade expectations, or their reading comprehension scores were somewhat above grade expectations (grade equivalent [GE] between 2.3 and 2.5) and then ORF was not considered. For the blue level, students' reading comprehension skills were above grade expectations (GE > 2.5) and their fluency was not considered.

The total number of groups was determined by each teacher, with a maximum of six groups per class, which teachers agreed helped them effectively

facilitate and manage the classroom. Across participating classrooms, there was usually more than one group of students at two of the levels of reading (e.g., two orange groups, three green groups, one blue group). Leveling of groups by reading skills allowed the teachers to provide extra support, scaffolding, and attention to students who were less independent, with the goal of fostering greater independence while ensuring that the students were learning critical science knowledge and literacy skills. Teachers had the opportunity to move students between different groups; however, for our study, we encouraged them to use the recommended skill-based groups so that we could evaluate this particular grouping strategy.

Second, we individualized the reading materials by using leveled texts. Most of our texts came from the Seeds of Science/Roots of Reading curriculum (Lawrence Hall of Science & Regents of the University of California [LHS/RUC], 2007), which provides well-written and coherent texts. In some instances, we wrote or adapted text so that students reading below a second-grade level (i.e., orange level) could still read independently.

Third, each child had a scientist notebook (Palincsar & Magnusson, 2001), which is a loose-leaf binder in which they collected and organized observation records, lab worksheets, resource materials, and other handouts. The notebook became a reference providing the students ready access to information they had accumulated from their observations, readings, and discussions. The lab worksheets themselves were adapted for each of the three group levels. For example, in Figure 1, the lab sheet for each group asked the same questions, Why do you think earthworms help soil? and What have you observed or learned about your earthworms?, but the expected number of responses varied by group level: two for the orange groups, three for green, and four for blue.

We explicitly taught students how to read expository text, including attending to headings and highlighted words, using tables of content, reading charts and graphs, and writing procedural text. Plus, we used several well-established comprehension strategies, including graphic organizers and compare and contrast. Teachers used two strategies to encourage greater student participation: brainstorming and think-pair-share. During brainstorming, students were encouraged to share and write ideas (Rawlinson, 1981). During think-pair-share (Lyman, 1992), students were asked a probing question, asked

to think about it, and then asked to discuss it with a partner or small group. Once students had time for discussion, students were asked to share answers with the larger group. Additionally, teachers provided explicit decoding instruction, such as how to spell multisyllabic words. For example, if students asked how to spell a word such as *earthworm*, the teacher discussed with them that it was a compound word composed of two simpler words, along with strategies about how to sound it out and then spell the word.

A Detailed Description of One Lesson in Our Unit

The entire unit included five lessons: (1) What types of soil are there and why is soil important? (2) What are earthworms and how do they help the soil? (3) How do we help earthworms live? (4) What do plants need to grow? and (5) Erosion: How does soil help plants and how do plants help the soil? Each lesson used a three- to six-day format to complete one 5-E Learning Cycle. Lessons were interconnected and built on one another. Later in this section, we present the third lesson, How do we help earthworms live? The objective for this lesson was for students to learn how earthworms move and breathe by exploring habitat characteristics that help them live. (The complete lesson is available from the author upon request.)

Engage

The teacher and students began the engage segment by completing a K-W-L (i.e., what you *know*, what you *want* to know, what you *learned*) chart about earthworms and how they help the soil. Students brainstormed what they knew about earthworms' diet, movement, and the type of soil they live in.

The key to the brainstorming process is that the teacher and students do not judge ideas. This allows students to begin free-flowing thought processes that will help them during the subsequent elaborate phase of the earthworm lesson, when they design and build an earthworm habitat. The teacher recorded their responses on the K-W-L overhead transparency, and the students received a copy of the K-W-L chart for their scientist notebooks. The engage segment segued into a discussion of the definition of habitat and its relevance for the earthworms.

Figure 1
An Example of Lab Worksheets That Students Complete and Save in Their Scientist Notebooks

The figure shows three overlapping lab worksheets titled "My Earthworm Hypothesis" for different groups: Blue, Green, and Orange. Each worksheet is divided into two main sections. The first section, "Why do you think earthworms help soil? Write your hypothesis or prediction below," contains numbered lines for students to write their hypotheses. The second section, "What have you observed or learned about your earthworms?", contains numbered lines for observations. Each worksheet also includes a header for the student's name and a date section indicating "Unit 1 Lesson 2" and "Part 1 Day 2" and "Part 2 Day 3".

Note. The lab sheet is completed on two separate days. First students make their hypotheses and then, based on their observations, decide if their hypotheses were correct or incorrect.

Explore

Students sat in flexible learning groups as the teacher distributed test tubes filled with soil and worms, one for each group. Students were reminded about the proper handling of scientific equipment and specimens and were encouraged to work with their group members to carefully observe the worms as they completed their observation lab sheets (see Figure 1). They were reminded that "scientists collaborate," and students were to think and then discuss with their group how earthworms help the soil. The lab worksheets were designed to set high expectations but with greater scaffolding for students with weaker skills (orange group) and increasingly less

scaffolding for students with stronger skills (green and blue groups). The teacher observed the groups as they worked together and provided attention and support as needed, understanding that the students in the orange groups might need additional support.

Explain

In the explain phase, students used expository science books to learn more about earthworms. This phase started by reviewing the hypotheses students developed and recorded on the left half of the lab sheet during the explore lesson about earthworms. In this way, connections from the previous activity were explicitly discussed. Then, within their groups, students read two different books about earthworms. The teacher assigned a different number of pages in the book *Earthworms Underground* (Beals, 2007) for the orange and green groups. The blue group read a more difficult book, *Handbook of Forest Floor Animals* (Bravo & Hosoume, 2007). The teacher worked closely with the orange group while carefully monitoring interactions within the green and blue groups.

Using the texts in their groups, students completed their lab sheets about earthworms. This lab sheet, which also became part of the scientist notebook, was also differentiated based on skills; the blue group was expected to provide more ideas than the other groups. Students in the orange and green groups were encouraged to come up with as many ideas as they could with a focus on quality over quantity. During this phase of the lesson, the teacher explicitly taught students how to use book headings. For example, the *Handbook of Forest Floor Animals* provided information on many animals in addition to earthworms. Thus, students were taught to use the table of contents and headings to find information specific to earthworms. Groups then shared with the entire class the earthworm information they discovered in their books.

Elaborate

In the elaborate phase, the class built an earthworm habitat terrarium. While students sat with their groups, the teacher called on one student from each group to share with the class which soil type (learned during lesson 1) the group hypothesized should be used in building an earthworm habitat. Students were encouraged to refer to their scientist

notebooks and the lab sheets and notes completed in the engage, explore, and explain phases of the lesson. The teacher asked each student to provide a rationale for the soil type, stressing the importance of sharing their reason for selecting a certain material. For example, one student pointed out that the bottom layer might be sand or pebbles to “keep the soil from getting too moist, because earthworms will not be able to breathe if the soil is too wet.” Notice how the student used both *moist* and *wet*. Students first learn everyday words when concepts are introduced and then more advanced vocabulary (Brown & Ryoo, 2008; Brown & Spang, 2008). Students’ responses were recorded on an overhead transparency (although a computer with a projector could also be used) that showed an empty terrarium with unlabeled layers. The purpose of the activity was for students to think about what function each soil layer might serve, the order of the soil layers, and what this might mean for earthworms’ habitat. As a class, students began to design the earthworm habitat, which would be constructed the following day.

The elaborate phase continued the next day as students worked in groups and reviewed their plans for building the habitat. The students decided which materials (e.g., sand, pebbles, soil, leaves) to include and in which order. Then, as a class, the students (with their teacher’s help) decided on a final plan, referring to the overhead transparency completed the day before and the plans created by each group. They then built an earthworm habitat as a class, following the final plan, and recorded their initial observations on the earthworm observation lab sheet in their scientist notebooks. Over the next four weeks, students used these lab worksheets to record their observations about the differences they saw in the earthworms and their habitat.

Evaluation

Evaluation was embedded throughout the lessons. For example, the teachers assessed whether students were learning key concepts by listening to students’ questions and comments during whole-class and small-group discussions. The teachers also examined the students’ scientist notebooks and lab worksheets. This information was used to redesign lessons and provide review as needed.

The Study

To investigate whether implementing the ISI-Science curriculum unit contributed to second graders' science and literacy learning, we conducted a four-month study using a pre- to posttest design asking four research questions:

1. Did students' knowledge of science content improve from pretest to posttest?
2. Did students show greater gains from pretest to posttest on questions directly related to the unit content (i.e., target content) compared with gains on questions about natural resources (i.e., nontarget content)?
3. Were students who showed the lowest level of science knowledge on the pretest (i.e., at or below the 25th percentile) able to make the same gains in target content knowledge as students with higher pretest scores (i.e., above the 25th percentile)?
4. Did students improve in literacy skills, as measured by the change in quality of written responses to open-ended questions from pretest to posttest?

Method

Participants. The study included five second-grade classrooms located at one school in northern Florida. Eighty-seven students participated in this study (47 boys, 40 girls), with 16 to 18 students per classroom. About half of the students lived in high-poverty homes (i.e., qualified for free or reduced-price lunch). Slightly more than half were African American, about 40% were white, and the remaining students belonged to other ethnic groups. Classroom teachers and research-funded teachers were all fully certified. The five classroom teachers helped design the curriculum, and two of them had participated in the research project the previous year. The three research-funded teachers were highly qualified and pursuing their doctoral degrees in teacher education (one in elementary education and the others in reading and language arts).

Procedure. The first unit of the ISI-Science intervention focused on exploration of a central question: Why is soil important? Throughout this five-lesson unit, students investigated earthworms, plants, roots,

and soil erosion. Research-funded teachers taught the first lesson (Unit 1, Lesson 1) in all five classrooms, while the classroom teacher observed and assisted. For the rest of the lessons (Unit 1, Lessons 2–5), responsibility for teaching each lesson alternated systematically between research-funded teachers and classroom teachers. When a classroom teacher implemented lessons, a research assistant was always present in the classroom to help her. We used this method so that teachers could be actively involved in developing the curriculum and so that there was consistency in instruction across classrooms.

Assessment. Student learning was assessed by a science knowledge unit test completed the week prior and the week following the six-week unit. This unit test was designed by the researchers to assess student science learning in areas of instruction (i.e., target content) as well as in related areas that were not directly taught (i.e., nontarget content). The test included 12 multiple-choice questions (10 target content) and three open-ended response questions (two target content). For example, one multiple-choice question stated, "In what environment would an earthworm MOST like to live?" Response choices were "A. Above ground, B. Underground, C. In a tree, D. In the water." A nontarget question asked, "Which one of the following is NOT a renewable resource?" with answer choices "A. Sun, B. Water, C. Oil, D. Trees." One open-ended target question was, "Describe in your own words how erosion happens."

By examining written responses to the open-ended questions, we were able to assess gains in basic literacy skills, including the number of sentences, the number of words spelled correctly, and the number of multisyllabic words used. The unit test was created by the authors, who include literacy and science education experts, based on the lesson content and materials. Each item was evaluated during team meetings with the contributions of research-funded teachers and research assistants. The test generated an α reliability coefficient of 0.95. A scoring rubric was created for three open-ended items, each of



which was scored by three of the authors to ensure inter-rater reliability. On items for which the authors initially disagreed, scoring was discussed until the researchers reached consensus.

Results

Research Question 1: Did Students Learn Science Content? The graphs in Figures 2 and 3 allow us to compare student scores from pretest to posttest on multiple-choice target content questions and for each of the open-ended response questions (see also Table 1). They show an average increase of 30% in the number of science content questions answered correctly following the ISI-Science intervention. Further, they show that students were able to provide generally more accurate and thorough responses to each of the open-ended questions.

We used paired sample *t*-tests, which showed whether there was a significant increase in students' scores or whether the increases seen in the graphs in Figures 2 and 3 were due to chance. When we examined the *t* values (see Table 1), we found that it was highly unlikely that students would have made these gains by chance. In all cases, our *p* value was less than .004 for target questions.

Research Question 2: Were There Differences in Scores on Target Versus Nontarget Content Questions?

The gains in students' science scores may have been related to other instruction the students received in the classroom or at home. To check this, we again used paired sample *t* tests to see if students made significant gains on questions related to natural resources. On the multiple-choice questions, students made gains on both target and nontarget questions (see Table 1). However, their gains were greater for the target questions. For the open-ended questions (see Figure 3), we saw a similar pattern. Students made significant gains on the two target open-ended questions, but the slight gains observed on the nontarget open-ended question were not significant (very small *t* value, $p = .33$). Thus, students generally showed greater gains on the science topics that were explicitly taught during the unit than on related topics that were not explicitly taught.

Research Question 3: Effect of ISI-Science for Students With Initially Lower Science Scores.

The ISI-Science curriculum was designed to support science and literacy learning for all students, including those who began the school year with lower levels of science knowledge. To examine this, we first

Figure 2
Pre- and Posttest Scores of Multiple-Choice Questions on Target Science Content

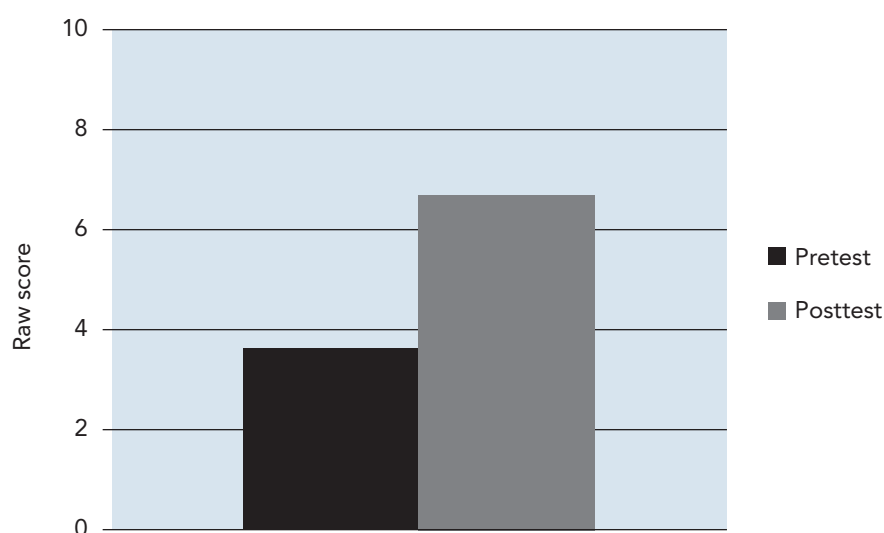
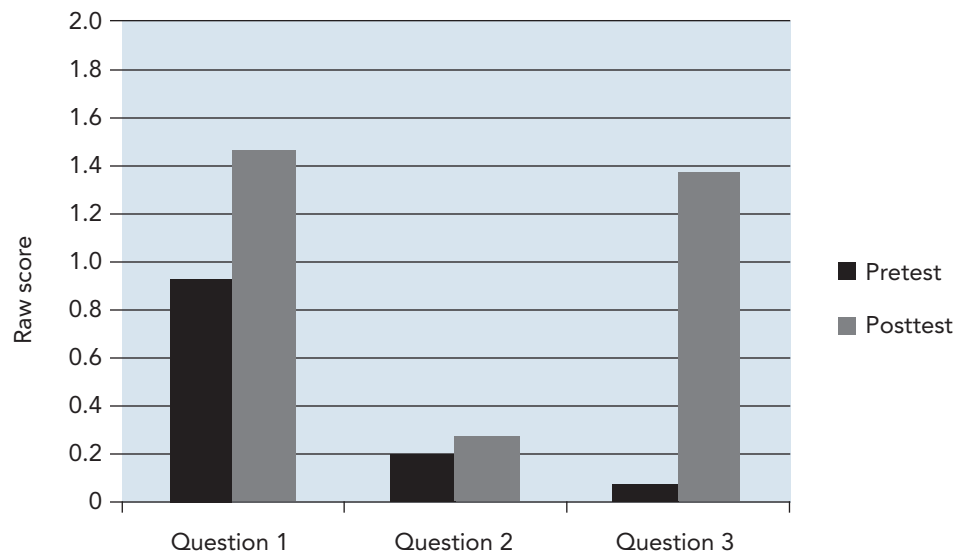


Figure 3
Pre- and Posttest Scores of Open-Ended Response Questions on Science Content



Note. Questions 1 and 3 assess target content on soil and erosion, respectively. Question 2 is on a related topic (natural resources) that was not taught.

Table 1
Science Content Scores on Pretest and Posttest

Science content	Pretest mean (SD)	Posttest mean (SD)	Mean gain score ^a	t
<i>Multiple-choice questions</i>				
Total correct of target content	3.65 (1.32)	6.67 (1.96)	3.02	13.18*
% correct of target content	36.46 (13.18)	66.71 (19.57)	30.25	
Total correct of nontarget content	0.48 (0.59)	0.90 (0.64)	0.42	4.57*
% correct of nontarget content	23.78 (29.63)	45.12 (32.02)	21.34	
<i>Open-ended responses</i>				
Question 1 (target content)	0.93 (0.70)	1.46 (0.83)	0.53	4.82*
Question 2 (nontarget content)	0.20 (0.55)	0.27 (0.65)	0.07	0.97
Question 3 (target content)	0.07 (0.31)	1.37 (1.25)	1.30	9.50*

Note. The means and standard deviations (in parentheses) are presented for the Unit 1 test.

^aThe mean gain score was calculated by subtracting the pretest mean from the posttest mean.

*Indicates a significant difference from pre- to posttest at $p < .004$ level.

identified 42 students who achieved a pretest score of 4 or less, which is low (i.e., about the 25th percentile) for the students in this study. One thing to keep in mind is that these students were in all three group levels, since grouping was based on reading skill not

science knowledge. Although most were in the orange group ($n = 25$), 11 were in the green group, and seven were in the blue group. We used paired sample t tests to compare the science gains made by students with lower and higher pretest science scores.

Regardless of students' science pretest score (lower or higher), on average, they made the same gains (i.e., any differences in mean gains were likely due to chance, $p > .05$). The mean gain for students with low scores was 5.43 points ($SD = 3.25$), whereas the mean gain for students with higher pretest scores was 5.28 points ($SD = 2.97$).

We also compared pre- to posttest science gains for students with low scores versus higher scores on the pretest open-ended questions using the literacy measures (e.g., number of words correct, number of multisyllabic words). Again, there were no significant differences ($p > .05$) in gains in science scores for students with lower initial literacy scores compared with those with higher initial literacy scores (3.7-point gain compared with 3.4-point gain).

Research Question 4: Did the Quality of Students' Written Responses Improve? One of the central goals of the ISI-Science intervention was to enhance students' literacy skills while at the same time increasing science content knowledge. Examination of students' written responses on the three open-ended questions allowed us to examine the quantity (i.e., number of words and sentences) and quality (i.e., spelling and use of multisyllabic words) of writing. Table 2 and Figure 4 present a comparison of students' scores at pretest and posttest on these four literacy skills. Students wrote an average of 17.55 more words in their test responses following the intervention and spelled an average of 10% more words correctly. Paired sample t tests confirmed that the gains from pretest to posttest were statistically

significant for all four skills, as was the ratio of correctly spelled words to total number of words written.

Discussion

Although more research is needed, our results indicate that we were able to successfully develop and implement a second-grade science curriculum that supported students' science and literacy learning. Teachers were able to implement the ISI-Science curriculum effectively as designed and, indeed, contributed important ideas and extensions so that it worked better in the classroom.

What is particularly encouraging is that even students who began the unit with weak science and literacy skills generally made gains in science content learning that were as great as students who began the unit with stronger skills. This was the case even though the school served many students living in poverty. This is an important finding, because traditionally, students living in poverty and students from minority groups, who frequently do not have the opportunity to develop important vocabulary, background, and early literacy skills, typically but not always fail to achieve as well as their more affluent majority peers (NAEP, 2007). Based on this and other research (Connor et al., 2009), it is possible that individualizing instruction by using formal and informal assessment data to create flexible learning groups and continually monitor students' progress may help close the well-documented achievement gap (Jencks & Phillips, 1998).

Table 2
Literacy Scores on Pretest and Posttest

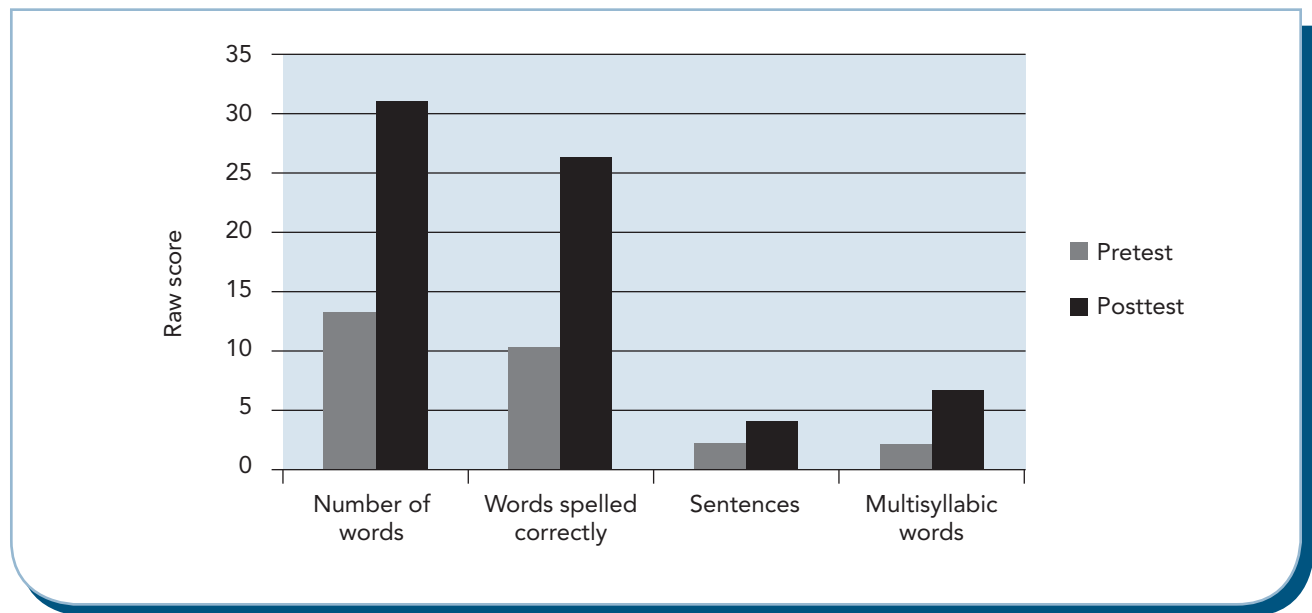
Literacy skills	Pretest M (SD)	Posttest M (SD)	Mean gain score ^a	t
Total number of words	13.41 (7.59)	30.96 (19.32)	17.55	8.93*
Correctly spelled words	10.35 (7.08)	26.39 (18.56)	16.04	8.99*
Ratio of correct to total words (%)	71.48 (27.98)	81.69 (16.01)	10.21	3.94*
Number of sentences	2.29 (1.37)	4.10 (2.19)	1.81	7.38*
Number of multisyllabic words	2.12 (2.16)	6.67 (5.62)	4.55	8.98*

Note. The means and standard deviations (in parentheses) are presented for written responses on the Unit 1 test.

^aThe mean gain score was calculated by subtracting the pretest mean from the posttest mean.

*Indicates a significant difference from pre- to posttest at $p < .004$ level.

Figure 4
Pre- and Posttest Literacy Scores



It is important to keep in mind that we did not attempt to show that this curriculum or way of teaching science and literacy was more effective than other curricula or using other strategies; we compared only the pretest and posttest scores of students who received our curriculum. In our future research, we will compare the ISI-Science curriculum to the core science curriculum used in the schools by randomly assigning teachers to teach science using either ISI-Science or the school curriculum. Nevertheless, our results so far are encouraging.

Adapting science instruction to use the structures and strategies we describe here should be relatively simple. Our goal was to keep lessons to no more than 30 to 40 minutes for three to four consecutive days, but we did have some lessons that lasted six days over two weeks. Based on feedback from our teachers, this was a reasonable amount of time to dedicate to science given the other curricular demands on class time. The 5-E Learning Cycle lent itself well to integrating text and using peer instruction in small groups. We have already developed a second unit, Properties of Matter, and again found that students showed significant gains from pretest to posttest and students with weaker science knowledge at the beginning of the unit made gains that were, on average, the same as those of students with stronger scores.

The specific discussion and comprehension strategies we used were confined to those with research evidence (National Institute of Child Health and Human Development, 2000), those that were used frequently by many teachers, and those that fit well with science. For discussion strategies, we used brainstorming and think-pair-share. For comprehension strategies, we used questioning, compare and contrast, predicting, and graphic organizers. We also used K-W-L. Although there is less rigorous research on K-W-L, it is widely used in classrooms, including by the teachers who helped design the curriculum. These strategies were easy to integrate into science, encouraged students to share their ideas, and appeared to support their science and literacy learning as evidenced by student gains from pre- to posttest.

Perhaps the most challenging aspect of developing the curriculum was finding science expository texts that were appropriate for the wide range of literacy skills our second graders displayed. Unfortunately, many of the books provided by the science core curriculum were not well written, were not coherent (i.e., did not use *because* or other linking words that help students make connections), and did not cover the content in sufficient depth. We successfully used the texts in the Seeds of Science/Roots of Reading curriculum (LHS/RUC, 2007), but we had to

adapt some of the texts to meet the needs of some of the students with weaker reading skills.

Based on our observations, the aesthetic appeal and relevance to students' experiences made texts such as those in the Seeds of Science/Roots of Reading curriculum inherently interesting to our second graders. When looking for texts for teaching science, the most important consideration should be accuracy of content. Research has shown that students tend to accept information presented through texts in science class as accurate, whether or not the ideas are, in fact, correct (Rice, 2002). Misconceptions and erroneous ideas may be communicated not only through what students read but also through pictures, illustrations, and diagrams that convey information about size, proportion, distance, and other physical relationships. Anthropomorphism, as well as gender and racial stereotyping, are also factors to consider in selecting texts for science class. Well-chosen literature, even fiction texts, may be used to assist students who have weaker reading skills in learning science as well as to engage the interests and support the learning of all students.

Although some early elementary teachers may hesitate to teach science, either because they do not feel qualified or because they feel that reading and math take priority (Marx & Harris, 2006), schools and teachers are becoming increasingly accountable for their students' content area learning. Moreover, our previous research on reading development shows that, especially at higher poverty schools, students seem to be developing stronger decoding skills than comprehension skills. As students move from learning to read to reading to learn (Chall, 1967), explicitly integrating the use of text and comprehension strategies in the learning of science content offers a promising approach to supporting students' comprehension and science learning.

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