Journal of Elementary Science Education, Vol. 20, No. 2 (Spring 2008), pp. 23-37.

Elementary Students' Retention of Environmental Science Knowledge: Connected Science Instruction Versus Direct Instruction

Bhaskar Upadhyay, University of Minnesota
Cristina DeFranco, University of Minnesota

Abstract

This study compares 3rd-grade elementary students' gain and retention of science vocabulary over time in two different classes—connected science instruction *versus* direct instruction. *Data analysis yielded that students who received connected science instruction showed less gain in science knowledge in the short term compared to students who received direct instruction. On the other hand, the growth curve demonstrated a lower rate of loss of science knowledge among students in connected science classes compared to students in direct instruction classes.*

We believe that two of the main goals of elementary science are (1) to lay the foundations in science content and skills for further learning and (2) to foster the development of science concepts and science process skills in students. In addition, elementary science provides motivation and context to children for authentic and rich experiences in reading, mathematics, and social studies (National Research Council [NRC], 1996). Data show that knowledge of science improves the mathematics and reading scores of elementary students. Therefore, the processes of learning and retaining science and science-related vocabulary are connected to the greater goal of scientific literacy and to future successful endeavors in the field of science (American Association for the Advancement of Science [AAAS], 1990).

Most studies related to elementary science and elementary students focus on short-term gains in science knowledge and vocabulary (e.g., Klahr & Nigam, 2004; Knapp & Barrie, 2001; Semb & Ellis, 1994; Stahl & Clark, 1987). This paper addresses the need for research focusing on elementary students' long-term retention of science knowledge and vocabulary.

We started our research with the question, *How does the use of connected science instruction affect the retention of environmental science knowledge and vocabulary by 3rd-grade students?* In this study, we consider connected science instruction to be present when teachers design and implement science instructions that connect students' funds of knowledge (Moll & Gonzalez, 2002) with the science content of their lessons. We determined that prior knowledge counts as funds of knowledge because both originate as a result of students' interactions in school and in the community.

We draw upon the idea of connected science instruction based on the work of Moll and Gonzalez (2002). According to these scholars, the notion of funds of knowledge is a variant of connected science instruction. Individuals gain knowledge through the historical, cultural, and social interactions in which they participate. Individuals also learn many skills and cultural practices in their home and school environments (see Velez-lbanez & Greenberg, 1992). When they are encouraged to use their funds of knowledge in classrooms, students use the skills, experiences, and ideas learned at home to understand and engage in science at school (Basu & Barton, in press). Students contrast new concepts with their funds of knowledge, and these contrasting relationships also help students strengthen older concepts (Barton, 2000; Bouillion & Gomez, 2001; Moll & Gonzalez, 2002).

Bouillion and Gomez (2001) used real-world problems and school-community partnerships to provide a context for connected science instruction. In their study of urban elementary students, Bouillion and Gomez found that when teachers connected science to students' cultural, social, and home environments, students learned science better and successfully completed their science curriculum. Similarly Barton (1998) and Fusco (2001) discovered that urban students learned science better if students believed that the science they learned was useful and connected to their everyday experiences. In addition, Hammond (2001) found that when teachers designed an elementary science curriculum based on students' lived experiences, parental and student participation in school science activities increased. Many students also demonstrated an improved recall of science knowledge in later assignments. Hammond further discovered that elementary students and parents believed that they had positive science learning experiences in those classes. Delpit (1995), Ladson-Billings (1994), and Thao (2003) make similar arguments: If students are to succeed in science, teachers must help them connect subject content with home experiences. Further, when teachers view "households as repositories for knowledge that can be drawn out to shape [science] curriculum" (Messing, 2005, p. 184), science teaching becomes connected in a meaningful way to students' lives and experiences. Therefore, connected science instruction allows students to bridge classroom knowledge with community knowledge. Research clearly emphasizes that for learning to occur, new information must be integrated with what the learner already knows—that is, with their funds of knowledge (Rumelhart, 1980; Tierney & Pearson, 1985).

Importance of Prior Knowledge in Retention

When teachers link new information to a student's prior knowledge, they activate the student's interest and curiosity and infuse instruction with a sense of purpose (Barton, 1998; Falk & Adelman, 2003; Tobias, 1994). They can link curriculum, instruction, and assessment to students' experiences, language, and culture. By tapping into students' prior knowledge in science, teachers can plan lessons that will clarify incomplete or problematic prior knowledge, decide on the appropriate pedagogy for the topic, and make necessary adjustments to activities and assessment materials. Hands-on experiments and discussions during instruction allow students to gain and retain more knowledge because students have more opportunities to connect prior knowledge, practice, and relearn new knowledge (Burkhardt & Schoenfeld, 2003; Hake, 2004; Semb & Ellis, 1994). We believe that one of the keys to achieving long-term memory may be the richness of the connections between students' prior knowledge and new knowledge. The more connections, the easier it is to remember. We believe when new information gets hooked up with a particularly rich and well-organized portion of memory, it inherits all the connections that already exist. This is why it is much easier to learn new science concepts that are connected to experiences than to learn decontextualized concepts.

Importance of Alternative Conception on Learning

In our research, we recognize the importance of alternative conceptions in science learning. We believe that alternative conceptions originate from students' funds of knowledge, which are gained through their lived experiences in different settings, and which become a part of prior knowledge. Sometimes, alternative conceptions can hinder the science learning. A familiar example from elementary school is students' understanding of the relationship between the Earth and the Sun. While growing up, children are told by adults that the "Sun is rising and setting," giving them an image of a sun that moves about the earth. This alternative conception can make it difficult for students to learn the correct scientific explanation of "sunrise and sunset."

On the other hand, many elementary students are familiar with bean sprouts, either bought from grocery stores or grown in homes. Many Hispanic and Hmong students know that when bean sprouts are grown at home, the sprouts are exposed to very little or no light (Upadhyay, 2006). These Hispanic and Hmong students experience that less light prevents the sprouts from turning green. The students gain the alternative conception that continuous lack of light makes the sprouts not turn green. Teachers can use the relationship between light and bean sprout conception to teach concepts such as sun energy and plant food relation and sun energy and plant growth. This alternative conception can help Hispanic and Hmong students to learn the connection between sun energy and plant growth.

When teachers' science instructions allow students to confront, challenge, and utilize their alternative conceptions, teachers may observe removal of wrong alternative conceptions in students, thus allowing for meaningful understanding of the science content to occur (Bahrick, 1984; Semb, Ellis, & Araujo, 1993). This kind of classroom context represents "naturalistic settings in which content memory [is] enhanced" (Semb & Ellis, 1994, p. 254). Often, alternative conceptions can occur in students' understanding of scientific methods (i.e., getting a correct answer in an experiment); organization of scientific knowledge; scientific vernacular (i.e., meaning of the word *work* in physical science); and scientific fact (i.e., plants breathe carbon-dioxide). When teachers use these alternative conceptions to teach science, students seem to learn, enjoy, and engage in science better (McDermott, 1991; Wandersee, Mintzes, & Novak, 1994).

Science Vocabulary and Retention

The research on science vocabulary learning and retention shows that elementary and middle school students learn, understand, and retain science vocabulary better if the classroom instructions are discussion-oriented (Rosenshine & Stevens, 1984; Stahl & Clark, 1987; Stahl & Vancil, 1986). An increased level of understanding of science vocabulary among these students can be attributed to the fact that discussion-oriented instructions provide opportunities for students to generate personal meanings and connections to science learning. This idea is further supported by theories of Vygotsky (1978) and Leont'ev (1981), who posit that culturally structured social activities and connections have a substantial impact on memory. Further, instructions that support interactive engagements promote student learning in conceptually difficult areas (e.g., Hake, 2004; Lowery, 2003; Shavelson & Towne, 2000). Works of Steffe and Gale (1995) argue that knowledge constructed in classroom environments that encourage and employ instructions that connect students' lives and experiences are more stable (e.g., Sweller & Cooper, 1985).

Our goal in this paper is to find out the relationship between connected science instruction (as previously defined) and elementary students' retention of science knowledge. We chose environmental science lessons as our context for research because the subject provided better opportunities for teachers to implement connected science instruction. In addition, environmental science is the major component of the 3rd-grade science standards, so we could conduct our research without jeopardizing normal science course progress.

Research Questions

1. What is the effect of *connected science instruction* on 3rd graders' acquisition and retention of environmental science vocabulary?
2. What is the effect of *direct instruction* on 3rd graders' acquisition and retention of environmental science vocabulary?
3. What are the different outcomes in student knowledge of environmental science vocabulary when these two methods of instruction are compared?

Methods

Pine and Oak Elementary Schools both have a majority of White students (88%). The schools belong to two large urban school districts in the midwestern United States. Almost one-quarter of the students qualify for reduced or free lunch under Title I. For this study, we chose two 3rd-grade classes from each of the schools. All four classes were comparable in size, demographic makeup, and general lessons covered. We wanted to assume consistency across all classes in order to remove possible confounding effects of other variables from the effect of our test variable. The four teachers who taught the classes were all female, one was Hispanic and three were White. Each teacher had been teaching in the school for an average of 12 years. Participants in the study included a total of 108 3rd-grade elementary students. Teachers administered a researcher-developed environmental science survey instrument (see Appendix A) to all the students in their science classes during the same week.

Research Designs

Environmental Science Teaching Workshop and Resources

We provided Pat (Pine Elementary) and Kris (Oak Elementary), whose classes were designated as treatment groups, with various resources related to teaching environmental science using a connected science approach. We designed supplementary materials that gave teachers content knowledge and pedagogy to teach environment science. The supplementary materials included instruction and resources for dioramas such as river and lake habitats, and school yards; examples of everyday community activities such as gardening and farmers' markets; and materials to do hands-on activities.

Two three-day workshops helped Pat and Kris to design, develop, and implement the dioramas in their instruction. During the workshops, Pat and Kris were encouraged to connect science to their students' lives and experiences through habitat needs, the food chain, pollution, farmers' markets, gardening, grocery stores, and farming. As most of our students had outdoor experiences in farms, farmers' markets, woods, lakes, and rivers, we decided to discuss with the teachers the five following questions: (1) Why do farmers use fertilizers?; (2) How do fertilizers affect water and fish?; (3) Why do farmers rotate crops and how is that beneficial for soil?; (4) Why are farmers' markets important and how do these markets help communities?; and (5) How does the weather (i.e., sun, water, snow, and air) affect plants? We believed that posing these questions would help our teachers connect science to students' experiences during hands-on activities as well as discussions.

Significant time was spent with teachers discussing the student diorama projects. In the workshop, Pat and Kris created a river diorama and presented it to us. During the presentation, researchers role-played as parents, students, and other schoolteachers to help Pat and Kris envision how the diorama project could be handled better. Over a two-month period, students in treatment groups would collect information about various land, river, and lake systems as a part of their diorama project. Each group would use these observations to prepare their dioramas, and teachers would provide logistical and material support. Groups of four or five students would complete and present dioramas to the class at the end of the environmental science unit. Finally, these dioramas would be presented to the school and the parents.

Liz (Pine Elementary) and Sue (Oak Elementary), the control group teachers, did not participate in any of the workshops. We instructed Liz and Sue to teach environmental science through direct instruction methods. Liz and Sue were asked not to connect science to students' lived experiences but to teach in a teacher-centered method. We also asked the teachers to do hands-on activities in which they would provide all the instructions to students, including the answers to the activities.

In consultation with all four participating teachers, we selected environmental science content that would allow them to keep up with their regular curriculum. The research design required all four teachers to teach four units consisting of lessons on "Design a Habitat," "Food Chain Tag," "Ecosystem," "Environmental Effects," and "Predicting Futuristic Environment." For "Design a Habitat," students listened to a story about an aquatic habitat and a land habitat. Later, they were given the opportunity to create their own aquatic habitat diorama using the materials contributed by students, teachers, and researchers. In "Food Chain Tag," students became members of an aquatic ecosystem and had to find the correct ratio of species in order to balance that ecosystem. All the teachers spent eight weeks (September through November 2005) teaching environmental science units. All the teachers used Full Option Science System (FOSS) materials and resources as the baseline. Finally, all the teachers were asked not to teach environmental science while teaching other subjects.

Survey

A pre-/post-survey design was used to collect data for this study. The first, or pre-instruction, survey was given to students before the exposure to environmental science units. The second, or post-instruction, survey was given to students immediately after the completion of the environmental science units, gauging students' gains in knowledge. The third, or retention, survey was given three months after the post-instruction survey to measure the retention of science knowledge learned during the research period. The pre-survey consisted of 12 environmental science content questions. The post and retention surveys consisted of the exact same 12 content questions as in the previous surveys.

We purposefully constructed the items to assess students' understanding of environmental science content. We completed content-validity of all the items in the survey. The items were refined after suggestions from two environmental science experts, two elementary science educators, two elementary teachers, and two 3rd-grade students. The content-validity addressed the following five issues: (1) items reflected environmental science contents accurately, (2) items discriminated between conceptual understanding and content knowledge, (3) item difficulty was appropriate for the grade level, (4) language was easy and understandable, and (5) items matched the content taught. We scored the surveys and tabulated the total correct scores for each student in *SPSS*™ data software.

Environmental Interviews

We conducted four focus group interviews with four students from treatment groups and four from the control groups. The focus group lasted for about one hour for each group in their respective classrooms. During the focus groups, we sought explanations for questions such as "What do you like about learning environmental science?," "What don't you like about your science class and activities? (give examples)," "Do you think environmental science is related to your lives? Why or why not? (give examples)," "How easy is it for you to answer the science questions in the survey (and why)?," "Can you explain how every living and nonliving thing is connected to each other? (give examples)," and "What did you talk about with your friends who were in Pat or Kris's class?" Responses to these questions gave us further insight into what students learned and what they retained.

Similarly, we conducted two focus group interviews with Pat and Liz and two focus group interviews with Kris and Sue at their respective schools. Each focus group interview lasted for one hour. During that time, we asked questions such as "What changes did you see in your students' ability in science and attitude towards science?," "What were some challenges during connected science instructions?," "What science skills do you believe the students learned or struggled with?," and "Why do you believe that your students will retain most of the science knowledge after three months?" Teachers' responses gave us further understanding about what worked and what did not work in their classes.

First, we will present quantitative results from our repeated measure ANOVA analysis, followed by descriptive statistics based on our data from 100 students. Second, we will present evidence from qualitative data analysis, which will further help us explain our findings from the analysis of quantitative data.

Data Analysis and Results

The control group consisted of 51 students, and the treatment group consisted of 57 students who received three months of connected science instruction in environmental science. The demographic profile revealed a predominantly White sample (control group, 88%; treatment group, 89%).

Sporadic missing data (n = 8) occurred because students missed the class for various unforeseen reasons beyond the control of the study. The missing data were not specific to any particular group of students, thus the nature of the absence was completely random. Therefore, we had 54 students in the treatment group and 46 students in the control group, with a total of 100 students who had complete data for all three surveys. In addition, in our analysis, we assumed that the number of participants in both the groups was equal.

Retention of environmental science vocabulary among elementary students was analyzed using a repeated-measure ANOVA with pre-/post-survey scores (pretest, posttest, retention) as within subject factors, and treatment versus control (connected science instruction versus direct instruction) as between subject factors. In this study, all statistical analyses are set at $p = 0.05$. According to Mauchly's test, assumption of sphericity was met at $p > 0.05$. The main effect of time on the retention of environmental science vocabulary was significant between control and treatment groups (Table 1), $F(2, 196) = 3.896$, $p = 0.022$.

Table 1. Repeated Measure ANOVA for Scores at Different Times and Treatment

Source	Type III Sum of Squares	df	Mean Square	*F*	*p*-Value	Partial Eta Squared
Within Subject Effects						
Score	11.77	2	5.89	3.896	0.022	0.038
Score*Treatment	11.01	2	5.51	3.644	0.027	0.036
Error	296.12	196	1.51			
Between Subject Effects						
Treatment	49.24	1	49.24	23.280	<0.001	0.191
Error	207.31	98	2.12			

Treatment Group (Connected Science Instruction)

We further analyzed the scores (pre versus post and post versus retention) of treatment and control groups using paired sample *t*-tests to determine if the ANOVA main effect was because of the treatment. The *t*-test yielded no significant gain in scores in the treatment group over three time periods. For the treatment group (Table 2), the posttest score increased from a mean of 7.85 (SD = 2.21) at pretreatment to a mean of 7.89 (SD = 1.98) immediately following the treatment, $t\ (53)_{pre/post} = 0.086$, $p = 0.466$. The retention score decayed to a mean of 7.72 from the posttest mean of 7.89 (SD = 1.70) and $t\ (53)_{post\text{-}retention} = 0.832$, $p = 0.207$.

Table 2. Means and Standard Deviations (in Parentheses) for Science Vocabulary Survey

		Science Vocabulary Score (0-12)		
Condition	***n***	**Pretest (Time 1)**	**Posttest (Time 2)**	**Retention (Time 3)**
Treatment	54	7.85 (2.21)	7.89 (1.98)	7.72 (1.70)
Control	46	5.91 (1.64)	6.85 (1.55)	6.48 (1.24)

Control Group (Direct Instruction)

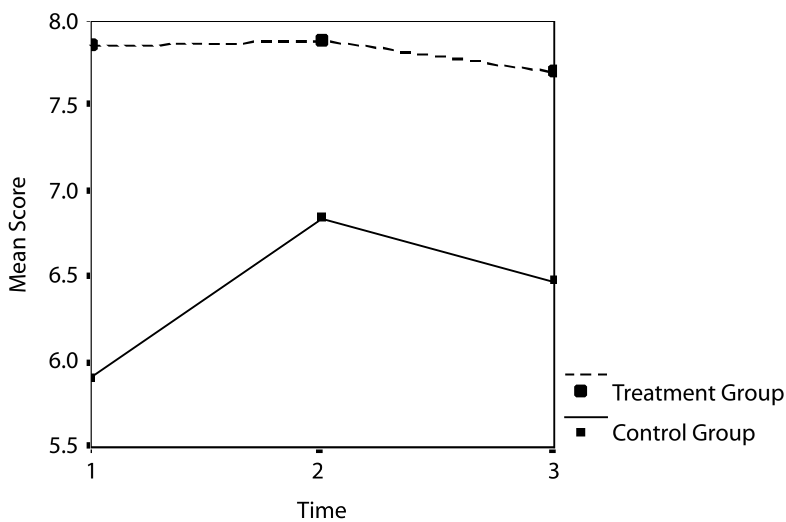
In the case of the control group, the paired sample *t*-test yielded significant gain in environmental science vocabulary score in the pre-/post-phase. The posttest score (Table 2) significantly increased from the pretest mean of 5.91 (SD = 1.64) to a mean of 6.85 (SD = 1.55) and $t\ (45)_{pre/post} = 3.079$, $p = 0.002$. The retention mean decayed to a mean of 6.48 (SD = 1.24) and $t\ (45)_{post\text{-}retention} = 1.326$, $p = 0.096$.

Overall Effect (Treatment and Retention Interaction)

ANOVA (Table 1) yielded a significant interaction between environmental science vocabulary scores over time and treatment, $F(2, 196) = 4.080$, $p = 0.018$. Also, between subjects ANOVA (Table 1) yielded that the treatment factor was significant, $F(1, 98) = 22.331$, $p < 0.001$. However, small values of partial Eta squared for both the main effect (Eta squared = 0.038) and Score*Treatment interaction (Eta squared = 0.036) indicated that both were weak effects in retention of environmental science vocabulary. Therefore, the effect of treatment on science vocabulary gain (score) accounted for only about 4% (partial Eta = 0.038) of the total (effect + error) variability in the retention of environmental science vocabulary.

Further, the growth curve graph (Figure 1) indicates the effect of instruction over time (represented by *Time* variable) on the environmental science vocabulary score gain (represented by *Mean Score* variable). Looking at the two lines, *treatment* and *control*, we see that although there was a dramatic increase in environmental science vocabulary scores for direct instruction students from Time 1 (pretest) to Time 2 (posttest), the connected science instruction didn't produce much of a change in the environmental science vocabulary scores of treatment group students. Therefore, the rate of gain in vocabulary is much higher in control group students compared to treatment group students.

Figure 1. Mean Score of Treatment and Control Group at Three Different Times



On the other hand, the growth curve indicates that the rate of the loss of environmental science vocabulary in the control group is higher than the treatment group as indicated by the segments of growth curves representing the loss (between Time 2 and Time 3).

Qualitative Data Findings

Interviews provided insights as to why students liked or disliked learning in a connected science instruction environment versus direct instruction. Almost all the students interviewed in the treatment group said they enjoyed the connected science approach because they “got to be out in the [community] and learn and have fun.” They mentioned different reasons for liking connected science instruction such as having fun, hands-on activities, connection to what they do at home, work in groups, and presenting their work to parents and other friends. Many other students from this group did not like this approach to learning because they were confused about “what [they] need[ed] to learn and memorize and what [was] not [necessary]. [Therefore, they] couldn’t answer some of the questions [in the survey].”

Yet, many students liked connected science instruction because they had opportunities to work as investigators trying to connect things they “saw and knew” from their experiences at “home and at school.” One of the students commented, “In this class, I got to work with my friends to [figure out all] we see outside [related] to science. This class show[ed] me [how] what we eat and grow [was connected] to science [concepts] in class.” Another student added, “In class, we learn[ed] to look at many things, [observe] [at] home and in the school fields carefully, and [take detailed] notes.” The comments illustrate that students were very satisfied and engaged in the learning. Students were also learning and perfecting skills such as observation, note taking, critical questioning, and sharing, all of which are very important skills for success in science.

On the other hand, students in control group classes mentioned that “they [missed] doing a lot of experiments [in the field] and [they] [dis]liked that part of their class.” These students also felt that they “missed many fun things . . . [which made them enjoy class less].” One of the students in the control group believed that not getting to do field work “made [him look] less able and less intelligent.” He strongly argued, however, that “I’m better [than] many in [Pat’s] class in [science]. I would have enjoyed doing science like they [friends in Pat’s class] did.” However, most of the students shared the view that direct instruction was “easy to [follow] and [they] knew what [was] important [and] what [they could] forget.” One student mentioned, “I [didn’t] see how science and home [were] related. I need to know that, I guess?” Another student said, “the test was easy because I [knew] what the right answer [was] . . . [but] I wish we had more [field] experiments to do like the other class.”

Students in treatment and control groups mentioned that they “[would] talk [about] what [they] learn[ed] in [their respective] science classes.” Control group students also mentioned that they got all the answers from teachers but appreciated when a “teacher ask[ed] [them] to think about examples [that came] from [their] home [experiences].”

Teachers in the treatment class observed that “Students were very talkative about their work with dioramas. They were excited that they could present their work to parents and the school.” Even so, teachers felt that many students had a hard time deciphering science knowledge and concepts from the connection part of the instruction. They believed that students might have been confused about what science knowledge to retain and what to forget. Despite showing poor performance in the survey scores, treatment group students could “explain and converse about environmental science” issues quite well.

Teachers in control group classes observed that "Students were less engaged in looking at the larger picture like how science affects their lives." The teachers found that students missed doing more investigative work. However, students "knew what [was] important science knowledge . . . and felt confident about answering questions in the [survey]. [Students in this group] should do well in science [memorization] tests."

Discussions, Conclusions, and Implications

The results of the study revealed that the treatment group students showed lower environmental science vocabulary gain (pretest to posttest) from connected science instruction compared to the control group students who received direct instruction. Such results are in line with the findings of other research in mathematics, science, and cognition (Kilpatrick, Swafford, & Findell, 2001; Klahr & Nigam, 2004; Mayer, 2004; Sweller, 2003). The loss of environmental science vocabulary was greater among students who received direct instruction compared to those who received connected science instruction.

Further, the growth curves showed that the students who had higher prior environmental science vocabulary, as shown by their pretest scores, also scored higher in the posttest, and vice versa. This finding supports earlier findings that prior knowledge can be a predictor of how well students will learn science vocabulary, thus indicating that teachers should use prior knowledge (e.g., lived experiences, cultural and social knowledge, etc.) to teach science (Fusco, 2001; Lundberg & Moch, 1995). Another important finding demonstrated by the growth curve is that the rate of loss of environmental science vocabulary was higher for the students who received direct instruction compared to connected science instruction. Such results are in line with earlier research showing that participatory instruction promotes better opportunities to relearn and practice science knowledge and skills (Knapp & Barrie, 2001; Kyllonen & Lajoie, 2003; Stahl & Clark, 1987).

Connected science instruction attempts to capitalize on students' funds of knowledge and prior knowledge gained through lived experiences and active involvement in the learning process. Students learn and remember new information best when it is linked to relevant prior knowledge or experiences. The qualitative data from this study and other studies showed that students enjoy and engage in science when they feel that their ideas are valued and science is meaningful to them (Barton, 1998; Lundberg & Moch, 1995; Moll & Gonzalez, 2002; Tobias, 1994). In addition, the qualitative data from this study also indicates that students prefer direct instruction from their teachers so that they don't get confused about the relationships between science and their funds of knowledge and lived experiences. For example, the studies of Klahr and Nigam (2004) and Mayer (2004) with elementary and middle school students show similar results.

Our findings imply that educators should design science instruction that supports immediate significant gain in science knowledge and helps retain that gain for a longer period of time. Science teachers must carefully balance direct instruction with connected science instruction, however. Both approaches make important contributions to teaching science to elementary students. Findings also support the incorporation of students' lived experiences and ideas into the science curriculum; this kind of science instruction has the potential to lower the rate of loss of science knowledge in the future. As elementary science teachers and educators, we may need to rethink how we teach science in the new era of high-stakes tests because the consequences for students and teachers are critical.

We conducted this study by taking into consideration the limits of our participating teachers (i.e., time, access to resources, high-stakes test) and what they could do in their classrooms. We also believe that our student population was not diverse enough to generalize the findings to more diverse urban settings. Also, we were not able to randomly select two groups of students who engaged in connected science instruction and direct instruction classes. In addition, our definition of connected science instruction was limited to funds of knowledge, prior knowledge, and connecting students' lived experiences and homes, but it did not include the content integration (i.e., science and mathematics, science and social studies, etc.) aspect of connected instruction. Therefore, additional lines of inquiry are necessary to gain a more complete understanding of the retention of science knowledge and how connected science instruction influences that outcome. By providing a comparison of two different approaches to the teaching of science, this study contributes to our understanding of how students respond and, even more importantly, how they retain science knowledge in order to build on it in the future.

All the names of the participants and schools are pseudonyms to retain the anonymity.
Contract Grant Sponsor: DNR, Minnesota, Grant number: A48693 w.o.#44. The opinions, views, and conclusions expressed in this article may not reflect those of the funding agency.

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Appendix A

Please circle the best answer.

1. What are the four basic needs that all living things need to survive?
   A. Water, cover, space, and friends
   B. Food, water, cover, and space
   C. Muscles, food, water, and trees
   D. Food, muscles, trees, and friends

2. A food chain . . .
   A. gives off light energy that plants can use to make food.
   B. is an organism that gets its food energy by eating other plants or animals.
   C. is a tiny plant or animal that lives in the water.
   D. shows how plants and animals get food energy.

3. Which of the following is not a type of cover?
   A. Piers
   B. Water
   C. Fallen logs
   D. Docks

4. The process plants use to make food energy is called ______________.
   A. plankton
   B. producers
   C. photosynthesis
   D. predator

5. Which of the following is true?
   A. Predators hunt and capture prey.
   B. Prey hunt and capture predators.
   C. Predators hunt and capture producers only.
   D. Producers hunt and capture prey only.

6. All energy for food chains starts with ______________.
   A. decomposers
   B. consumers
   C. producers
   D. the Sun

7. What might a fish use for cover in a lake?
   A. Bait
   B. Aquatic plants
   C. Oxygen
   D. Nets

8. Producers . . .
   A. use gills to get oxygen out of the water.
   B. eat other animals.
   C. use photosynthesis.
   D. break down dead plant and animals into nutrients.

9. Which of the following is true about anglers?
   A. Anyone who fishes is an angler.
   B. Anglers are not very common in Minnesota.
   C. Anglers can only be boys
   D. Anglers are a kind of bait to use when fishing.

10. How do predators help to keep habitats balanced?
    A. Predators don't eat prey from the same location.
    B. Predators stay on opposite sides of the habitat from each other.
    C. Predators keep the numbers of prey animals from getting too high.
    D. Predators are "in charge" of their habitats.

11. If an aquatic habitat is polluted or damaged _______________.
    A. bluegills will leave
    B. predators will leave
    C. fish may not survive
    D. fish may survive

12. What is a limiting resource?
    A. A physical characteristic that helps fish to swim.
    B. A large predator fish.
    C. The amount and quality of a habitat that determines if fish will survive.
    D. The greatest number of plants and animals that a habitat can take care of over time.

Correspondence regarding this article should be directed to

Dr. Bhaskar Upadhyay
University of Minnesota
Curriculum and Instruction
125 Peik Hall
159 Pillsbury Drive, SE
Minneapolis, MN 55455
upadh006@umn.edu

Manuscript accepted January 29, 2007.