Third Misconceptions Seminar Proceedings (1993)

Paper Title: **USING CHILDREN'S LITERATURE TO ACCESS AND CHALLENGE YOUNG CHILDREN'S IDEAS ABOUT SCIENCE**
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Keywords: concept formation,learning strategies,learning motivation,,,,,,
General School Subject: science
Specific School Subject:
Students:

Macintosh File Name: Shymansky - Children Literature
Release Date: 4-17-1994 F, 11-8-1994 I

Publisher: Misconceptions Trust
Publisher Location: Ithaca, NY
Volume Name: The Proceedings of the Third International Seminar on Misconceptions and Educational Strategies in Science and Mathematics
Publication Year: 1993
Conference Date: August 1-4, 1993
Contact Information (correct as of 12-23-2010):
Web: www.mlrg.org
Email: info@mlrg.org

A Correct Reference Format: Author, Paper Title in The Proceedings of the Third International Seminar on Misconceptions and Educational Strategies in Science and Mathematics, Misconceptions Trust: Ithaca, NY (1993).

original publication of this proceedings was supported by a grant from the National Science Foundation, and the transformation of this collection into a modern format was supported by the Novak-Golton Fund, which is administered by the Department of Education at Cornell University. If you have found this collection to be of value in your work, consider supporting our ability to support you by purchasing a subscription to the collection or joining the Meaningful Learning Research Group.
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USING CHILDREN'S LITERATURE TO ACCESS AND CHALLENGE YOUNG CHILDREN'S IDEAS ABOUT SCIENCE

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Overview

Our primary purpose in this paper is to describe a strategy of using language arts activities, especially children's literature, as a platform for teaching and learning science in the early grades. The strategy represents one facet of a more comprehensive effort, working with the notion of using children's ideas as the focus of teacher enhancement and instructional planning. Thus, we have included background on our initial "Focus On Children's Ideas about Science" (FOCIS) project and its sequel, "Parents, Activities and Literature" (Science PALs), the two projects on which this paper is based.

The FOCIS Project

In the FOCIS project, student ideas about selected topics in science were used to focus enhancement activities for middle school (grade 4-9) teachers. The idea in the project was to promote a deep understanding of the targeted concepts in science among teachers by having them study their own students' ideas about those same topics.

The FOCIS project was advertised to middle school teachers as an opportunity to develop a special instructional unit based on student ideas about a selected topic. The emphasis from the start was on researching the structure, origin and evolution of student ideas. As a result, teachers participating in the inservice did not enter or ever view the experience as a science course. Thus, they felt no great pressure to master any particular body of science knowledge nor the normal anxiety and learned helplessness many teachers associate with science courses.

The inservice was set up in three distinct segments. There was an initial two-weekend segment in which teacher topic teams met with a science expert and science educator to establish the parameters of the science topic around which the unit would be developed, to learn how to make concept maps, to establish procedures for interviewing students in their home schools, and to make concept maps of their own knowledge about the unit topic. Concept mapping and clinical interviewing were introduced primarily as tools for gathering and monitoring student ideas, but in fact provided the medium in which the teachers' science and content pedagogical knowledge were enhanced, while the students' understanding and the science unit development established a relevant problem-centered context.

The second inservice segment consisted of a two-week summer workshop in which student ideas gathered by the teachers via concept mapping and clinical interviews were analyzed and instructional units were prepared. Again, a science expert was involved. At this stage the teacher/expert teams had to tease out and evaluate the science in the student ideas. A snapshot of activity taken at this stage of the inservice would have looked like one of any number of other science workshops except that when activities occurred they were driven by a problem-centered need to evaluate the merit of the student ideas for unit planning, not by the need to learn science to pass a workshop test.

In the final segment of the inservice, teachers implemented the science units on which they had worked that previous summer. Prior to, during and following the implementation, each topic team met with their science expert to continue the analysis of student ideas. To maintain the focus on studying student ideas, all the topic teams monitored student understanding in their classes using concept maps and a set of special tests constructed for their units. Along with anecdotal data gathered by the teachers, the concept maps and test data served further to focus discussions in the final meetings.

Throughout the inservice, the science expert served as a collaborative resource person, not as a lecturer. Prior to the start of the inservice, all the experts were briefed on the "using student ideas to plan instruction" theme of the inservice and given training on how to interact with the teachers. For example, they were told that their primary function was to assist the teachers in evaluating the merits of the student ideas and to make suggestions to teachers on how to probe, engage and challenge those ideas. They were told they could explain, demonstrate and set up labs related to the student ideas brought by the teachers, but were discouraged from approaching the experience as if it were a "short course" on the topic. This mode of interaction was new to most of the science experts enlisted, but all seemed to accept and adapt to the challenge very well.

A formal evaluation of change in teacher understanding of science concepts related to the topics studied by each team was performed in the project. Concept maps generated by individual teachers at three points during the six-month inservice and scored blindly at the end allowed us to monitor changes in mean scores for various groups using standard statistical procedures. But more importantly, the three observations and the richness of the data provided in the concept maps allowed us to study qualitative changes in understanding of the individual teachers across the inservice. In that sense, our study was also a collection of single subject/small group case studies.

Each teacher constructed a personal map of his/her target science topic at the end of the first spring weekend session; at the end of the summer workshop; and again at the end of the fall implementation phase. Directions for constructing the maps were very "open-ended": ["construct a concept map which reflects what you think are the most important ideas related to ... (substance abuse, simple circuits, ecology, heredity, weather, ...")]; no standard set of key concepts was given to the teachers for any of the three concept mappings.

Concept maps were rated blindly by teams of two content specialists. Each science expert who worked with the teacher teams during the inservice was asked to generate an outline of the major science ideas explored. From those outlines, the concept map rating team for the topic generated a set of valid propositions and a set of potentially invalid propositions. To investigate the level of teacher understanding expressed in the maps, we computed two weighted composite scores for each map—one for the valid propositions and one for the invalid propositions identified. Changes in the weighted composite scores for valid propositions and invalid propositions were analyzed.

Not surprisingly we found that the teachers, like their students, harbored a variety of erroneous ideas about the science topics and were inclined to hold onto them (Shymansky, et al., in press). However, we did not expect what we found when we studied both the topic group means and the individual map profiles. Repeated measures analysis of the weighted valid proposition scores between mappings showed that the change in teacher understanding between successive mappings was positive overall and significant.

Extending the FOCIS Approach

The FOCIS project involved middle school teachers from grades 4-9. In FOCIS we relied heavily on concept map and interview data from the students to access relevant science ideas and direct the enhancement activities. While these techniques proved generally effective as idea-gathering tools for middle school teachers, we observed an apprehensiveness, a certain reluctance among the elementary grade level teachers about incorporating concept mapping strategies into their daily teaching regimen. In the late stages of the FOCIS project, it became clear that we would have to come up with a more user-friendly strategy to get at students' ideas if we wanted K-6 teachers to continue using a student-idea based program of hands-on science instruction after their formal participation in the project had ceased. Our solution was to use language arts as a basis to explore science concepts and to involve parents as instructional partners to get at students' ideas. The language arts focus provides a comfortable context for elementary school teachers that has an established instructional priority and frequently serves as a common interface among students, parents and teachers.

The Science PALs Project

The FOCIS approach to teacher enhancement is based on more than a decade of research on conceptual change teaching/learning (e.g., Osborne & Wittrock, 1983; Driver, 1990). The basis of conceptual change research is constructivist theory, which holds that understanding is not an either/or state of mind, nor is it a simple accumulation of ideas. Rather, human understanding moves between states of conceptual equilibrium and disequilibrium as new ideas and experiences are encountered. Critical to constructivist theory and the resulting conceptual change models are the interaction among task, learner and context and the way an individual networks or links ideas/images/models/explanations at any point in time. Teachers who use conceptual change to teach science attempt to create instructional situations which cause learners to modify their conceptual networks to be more consistent with those held by the scientific community. The research on changes in teacher understanding of science ideas indicates it is neither smooth nor uni-directional (Shymansky, et al., in press).

Figure 1 illustrates the basic principle of conceptual change teaching/learning. At the heart of the model and the enhancement approaches lie the learner's ideas about a selected science topic (represented as C_i, C_2, ... C_5) and the scientifically held ideas (C_s). What one understands at any point in time reflects one's organization of ideas. Understanding progresses, regresses, or remains unchanged as reflected by the jagged line. Changes in understanding occur when the learner's ideas are challenged and extended through direct experience, as the learner interacts with others and as he/she reflects on his/her own ideas.

Figure 2 shows how student ideas from the teachers' own students serve as the vehicle for the inservice work in the FOCIS approach. In this middle school enhancement project, teachers learned how to use concept maps and interviews to tap into that stream of student conceptions (which were usually the same as the teachers'); then science experts worked with the teachers to analyze the science underlying the students' ideas and design hands-on activities to engage, challenge and extend those ideas. The Science PALs enhancement study of K-6 teachers addresses scientific concepts through the use of language arts activities (children's literature, writing activities, drama, and visual arts media which are embedded with science ideas) and by engaging parents as partners to tap into that stream of learner conceptions. The hands-on science activities are used to challenge and extend student ideas in the classroom. The backbone of the learning model and the enhancement approach are (1) the collaborative analysis of children's science ideas accessed by science-based literature, (2) the collaborative preparation of science activities to engage, challenge and extend children's science ideas, and (3) the teacher-authored science-based children's literature. The language arts activities are intended to provide a medium through which students can engage, express and polish their ideas and teachers can access and monitor student conceptions. Authoring, selecting and using children's literature provides a highly-valued, low-anxiety, supportive context in which teachers' science understanding can be engaged realistically and enhanced naturally.

Why Focus on Students' Ideas?

There is a considerable body of research evidence which suggests that students come to school harboring explanations and ideas about science that differ considerably from those held by scientists (Osborne & Freyberg, 1985). These ideas are more or less resistant to change based on how central a given idea is to a student's thinking (Linn, 1986). Teaching strategies aimed at effecting "conceptual change" in students necessarily require that a teacher know how to access, challenge, and extend a student's central ideas. How well a teacher understands the science ideas related to a topic effectively places an upper limit on the conceptual level at which he/she can engage students in that topic. While it is true that extensive subject matter knowledge alone does not guarantee good teaching, without a deep understanding of a topic, a teacher is hard-pressed to do much more than "manage" the science classroom (Linn, 1987). Effective teaching appears to involve content knowledge, pedagogical knowledge and the specific intersection of these domains—content pedagogical knowledge. The advantages of doing hands-on activities are greatly enhanced when a teacher understands enough about the topic and children learning science to pose challenging questions that probe student ideas and provide a supportive scaffolding on which students can restructure their knowledge. It follows from the importance of content pedagogical knowledge that preservice and inservice teacher education should focus on helping teachers learn how to access, challenge, and extend student ideas specific to the science topics being studied in their classrooms.

Student ideas related to topics targeted for instruction provide the ideal vehicle for helping teachers better understand the science they are expected to teach. Using student ideas for teacher enhancement is efficient—inservice activities can be targeted to the specific science topics and ideas that teachers plan to teach—and non-threatening—teachers are more willing to work with a science expert on the relevant problem of what their students don't understand than on the threatening problem of what the teachers themselves don't understand. In effect the students' ideas serve as the "I've got a friend (student) with a problem" ("straw man") through which the teachers' conceptual problems can be addressed and their understanding enhanced.

Why Use Language Arts in Science?

What student can resist a good adventure story with some puzzle to be solved or mystery to be unravelled? The elementary school science classroom is a natural setting for adventure because so much in the immediate environment is a mystery to young students. Data from every "NAEP" study consistently have shown that student interest in science is very high in the early grades but drops off dramatically by late middle school. Though the reasons for the drop in interest are surely complex, the usually dry, expository text materials and often-times seemingly pointless, cook-book hands-on activities are likely culprits in the turn-off. Introducing science ideas in more exciting, personally relevant formats has the potential to provide both the context and motivation for doing hands-on activities and for seeking additional information and explanations from expository sources both inside and outside the classroom (Butzow & Butzow, 1988; Coonrod, Rusher & Miller, 1991; Kinghorn & Pelton, 1991; Martin & Miller, 1990; Smardo, 1982).

Using language arts activities (e.g., stories, storytelling, drama, visual arts, etc.) as scaffolds for building science concepts is supported by research in both language arts and science education (Yore & Shymansky, 1991). Elementary school-aged children are often exposed to new ideas through written, oral and visual media and tend to use these forms of expression as a way of providing structure to ideas (Lawrence, Skoog & Simmons, 1984). Young students need to learn how to think about, work with, and express science ideas through a variety of language, visual, and tactile modes; and they need to do these things early and often. Writing-to-learn science and reading-to-learn science embedded in an experience-rich integrated language arts/science environment has significant potential.

There are other reasons for using language arts activities to access and challenge student ideas about science and to stimulate hands-on science activities. It is well documented that:

_ Elementary school teachers spend almost six times as much time on language arts as on science in a given school day (Goodlad, 1984).

_ Language arts is often an area of strength for elementary teachers providing a “comfort zone” from which they can deal with the more intimidating area of science (Butzow & Butzow, 1988).

_ Elementary school teachers lament not doing a better job of teaching science, but feel that of all the instructional areas, science is the one they are least prepared to teach and most intimidated by (Weiss, 1987).

The reality of elementary school life is that language arts is perceived as the most important area of the curriculum. Even those teachers who are enthusiastic about science often do not feel they have enough time to devote to it. When they do teach science, they tend to rely too much on the textbooks. Hands-on activities, when used, are often over-structured in order to save time. K-6 teachers must be shown how hands-on science activities can be used in conjunction with language arts activities to develop skills of problem focus, identification of main ideas, argument patterns based on evidence, example, contradiction, etc.—skills which are critical to understanding science. If science learning is presented in a more familiar and comfortable context, teachers are more willing to take time from language arts to do hands-on science activities (Saul, Baker, Bird, & Mandell, 1990). Romance and Vitale (1992) demonstrated that the integration of hands-on science activities and language arts instruction results in significant gains in both science and reading.

Why Use Parent Partners?

It is well known that parents play a key role in children’s success in schools—especially at the elementary school level. Parental involvement in a child’s school experience dramatically and positively affects a child's motivation and attitude and increases academic achievement as well (Chavkin, 1989; Edwards, 1990; Fullan & Stiegelbauer, 1991; Swick, 1991). Not surprisingly, these positive results have been observed in a wide range of socioeconomic, racial and ethnic groups (Davies, 1991; Edwards, 1990). As the earliest and most influential teachers, parents are a source of strength for schools. In the words of one expert, “Trying to educate the young without help and support from the home is akin to trying to rake leaves in a high wind” (Gough, 1991).

Though there is general consensus that teachers appreciate parent involvement, research suggests that very few teachers make a systematic effort to establish specific learning goals with parents or provide special instructions to help them be more effective (Fullan & Stiegelbauer, 1991). The teacher's attitude and willingness to provide direction make the difference in whether parents are productive partners in their children's education (Epstein, 1988). Given directions from teachers, parents can be very effective instructional partners (Fullan & Stiegelbauer, 1991). The success of this partnership must consider the parents’ “comfort zones,” societal values and the goals of science. The integration of language arts and science provides a learning context that maximizes each of these considerations.

Writing to Learn

Analyzing students’ ideas, authoring and instructional planning experiences provide the seductive context for the teacher enhancement. These problem-centered situations provide relevant opportunities for science experts to influence the teachers’ science understanding. Writing-to-learn science is a promising cognitive strategy for enhancing the science understanding of the writers who are attempting to address the conceptual problems of the reader. Current research indicates that writing provides a window into the writer’s understanding; that early stages of writing require exploration, restructuring and integration of knowledge; and that writing to communicate with an uninformed or misinformed audience enhances the writer’s own understanding, quality of arguments, and communication skills (Fellows, in press).

A Pilot Project

In April, 1992, we conducted a pilot project at Longfellow Elementary School in Iowa City to get a sense of the viability of using language arts activities to stimulate teacher and student interest in doing meaningful hands-on science. We were also interested in finding out how a teacher might benefit from the experience and how parents would respond to being actively involved as partners. A primary grade teacher from Longfellow volunteered to teach the science topic “sink/float” in her 1st/2nd grade classroom. A parent workshop was held; the teacher and the parents collected the students’ science ideas; and a science consultant provided science enrichment for the teacher as they analyzed the student ideas and designed specific language arts and hands-on activities to challenge and extend student ideas about the concept of sink/float. (Appendix)

After extensive planning, teacher and the pilot project staff conducted a special coaching session at the school for the parents of the teacher’s students. We named our project, “Science PALs” (Parents, Activities and Literature) to emphasize the substantive role of the parent in the instructional process and the use of language arts to stimulate interest in science. We made special buttons for parents showing a Science PALs logo and including the inscription: "(first name) is a Science PAL." One or both parents of every student in the teacher’s class attended the session. Students were also invited to make it easier for parents to attend. The students engaged in some hands-on science and language arts activities in a separate room while the parents met with the teacher and the project staff. Parents were given background on the pilot project, instructions on how to gather their child’s ideas through the at-home activities, and directions on how to report to the teacher. The pilot was successful in the following ways:

_ The teacher’s understanding of the science related to the sink/float hands-on activities improved significantly based on informal evaluations of the science expert working with her across the two weeks.

_ She developed and employed teaching activities and strategies using the students’ ideas—activities and strategies that, by her own admission, she had never tried before.

_ She expressed a newly found level of comfort with teaching science. The language arts activities (reading, story-telling, writing stories, etc.) and the at-home and in-class hands-on activities were very effective in helping the teacher frame questions about the science ideas which she and her students did not understand.

_ Parent participation was 100% and their response was overwhelmingly positive.

A compilation of parent responses to a questionnaire used at the evening session to survey parents' interest in working as "Science PALs" is provided in the appendix. The responses suggest a strong parent interest and willingness to help with their child's science learning and the teacher's development. Many parents verbally congratulated the teacher, the school principal, and project staff on their plan to involve parents in a substantive way.

Potential Problems with Literature in Science

The current trend at the elementary school level is to break down traditional subject boundaries and teach "across the curriculum." Science publishers (e.g., Scholastic, Macmillan and Silver Burdette) have seized the opportunity to showcase children's stories in their science bookbags in an attempt to capture the reading-conscious, science-shy elementary school teacher. Constructivist learning theory is also in vogue among the science publishers. Many claim to have programs that build on student ideas. But what kind of science is being promoted in the stories accompanying these programs? Are children's ideas really being used?

An examination of the science trade book literature and newly published science programs reveals two serious problems:

- The stories often promote bad science (misconceptions).
- There is a pervasive acquiescence to science experts (authority).

An example of the first problem is found in the popular children's book, Who Sank the Boat? (Allen, 1983). The story describes the boarding of a boat by a group of animal friends. The boat finally tips over as the last friend, a tiny mouse, jumps on board. The illustrations in the story clearly show the boat tipping—a problem with equilibrium, not sinking. But many young children confuse the principles of balance and buoyancy. It is common to observe young children attempt to make a foil boat float by placing it carefully on the water even after previous attempts to float the same boat showed that the boat's displacement was inadequate.

Acquiescence to authority is a problem that strikes directly at the foundation of constructivist learning theory and the preparedness of teachers who teach science. Many elementary school teachers feel insecure about their own science knowledge and rely on printed materials to reveal the correct answers. But "giving the answer" in text greatly diminishes the role of children's ideas in the teaching-learning process. For example, in one of Silver Burdette & Ginn's Horizons Plus Science Stories, after demonstrating the "trick" of an egg sinking in tap water but floating in salt water, "Alvin the Magician" explains the behavior of the two systems in terms of densities. Unlike the illustration of the mouse tipping the boat, the comparative densities explanation is correct. But by giving the explanation, the story renders moot the children's ideas about why the egg behaved as it did. Motivation to investigate and find out about the discrepancy is diminished. It can be argued that such stories do little more than deliver information, albeit in a more colorful fashion than traditional expository texts, and are no more likely to stimulate or facilitate hands-on investigation than an expository text.

A New Kind of Children's Science Literature

The idea of using literature in science at the elementary school level has practical and pedagogical merit. On the practical side, elementary school teachers see themselves first and foremost as teachers of language arts. If children's literature can be used as a hook to persuade teachers to teach science, the opportunity should not be squandered. But not all literature is equally effective for teaching science. The fact that a story has a science theme or deals with something scientific does not make it a good science instructional tool. However, if composed properly, a science story can capture the true nature of science. As Martin and Miller (1990) explain:

> The scientist seeks more than isolated facts from nature. The scientist seeks a story. Inevitably the story is characterized by a mystery. Since the world does not yield its secrets easily, the scientist must be a careful and persistent observer.

In other words, science as a search for understanding should be more like an adventure into the unknown than a review of what is known. For years science texts have been written as reviews rather than adventures. Student texts serve as repositories of what has been found by scientists and capture very little of the mystery and controversy which surrounded the adventure. When authors have attempted to recreate some of the adventure, however (e.g., the historical readers in the Harvard Project

Physics program), their efforts were seen as interesting but inefficient as an instructional medium.

Science based children's literature must be more than an interesting story about science if it is to be an effective instructional medium for elementary school (or any level for that matter). A crucial ingredient in a science adventure is carrying out an investigation to solve a mystery or settle a controversy—the hands-on part of the adventure. As interesting as the feature articles in National Geographic are, most fail the hands-on test. Even though mysteries are unfolded in dramatic style in the articles, the reader (student) is drawn into the drama vicariously at best. A highly skilled and science-competent teacher could involve students directly, but this is beyond the talent and time of most classroom teachers.

For science literature to be classroom effective, the following conditions must be created:

_ Students must be drawn into a mystery or controversy in which the story characters reveal and students are given opportunity to express alternative ideas.

_ Students must be challenged to solve the mystery or resolve the controversy through active investigation.

_ Students must be given opportunity to share their initial ideas and resolutions with other students in the classroom.

The primary role of such science literature is to challenge students, not to inform them. Thus, this literature is not intended to compete with traditional expository sources, but to complement them. Another key characteristic of the literature is that investigations seek to settle arguments and controversy rather than confirm something already established as true. The investigations are woven into the fabric of the story, not appended to it. In effect, the story provides both reason for doing investigations and context for explanations.

The character of "challenge science literature" is best explained with a specific example. In the following section, excerpts from a specially developed series of children's stories are presented as the literature would be used to teach primary grade students about some basic properties of matter and sinking and floating.

The Beaver Chronicles

The Beaver Chronicles is a series of stories about a beaver family who encounter a variety of problems associated with their home in a dam. In the first story, Bonnie Beaver, one of the story's main characters, accidentally solves the problem of a dropping water level in the family's beaver pond. She and other characters in the story are puzzled by the series of events, and student readers are invited to help solve the mystery. The numbered sections which follow describe the instructional sequence paralleling the story's development.

1. The story targets specific science concepts which are age appropriate for the children.

   Example: Matter takes up space.

2. The story creates a problem, mystery or controversy which serves as context for the science concepts and motivation for subsequent investigation.

   Example: *"Hmmmmmm..." thought Gramps. "I remember back when I was a kit. The water in our beaver pond got so low the entrance to our lodge was out in the open so we couldn't swim into it anymore."*

   "Oh, Gramps!!" wailed Bonnie. "What did you do?"

   "Well," said Gramps, "we had to move our whole family to another pond."

   The water level in the beaver pond is dropping. The beaver family may have to move because the entrance to the beaver lodge will be exposed and a mountain lion might attack the family.

3. A solution to the problem is revealed, but no explanation is given.

   Example: *And as suddenly as they had started, the rocks stopped sliding. Some really big ones landed in the beaver pond. Lucky for Bonnie she only got a few bumps from the sliding rocks.*

   "Look, look, everybody!! The water level has gone back up!! It's halfway back up the measuring stick." Bobby yelled.

Gramps checked the entrance to the beaver lodge. It was back underwater again. The beaver family was safe.

The rockslide had dumped some large rocks into the pond causing the water level to rise covering the beaver lodge and protecting the beaver family from the mountain lion.

4. Characters (and students) offer alternative explanations for the rise in the water level.

Example: *Bonnie was quite proud of herself. She had helped save her family's home. "I'm sure glad I caused that rock slide," said Bonnie. "The rocks sure seemed to make the water level go up—but I wonder why??"*

"I'm certainly happy, too, that the pond level went back up," agreed Mother Beaver, "but I think it was the air that came in with the rock slide that caused the water level to rise—not the rocks."

"Didn't either of you see the big splash from the rock slide?" yelled Bobby. "It was so cool. I think it was the push from the splash that made the water level come up—not the rocks or the air."

The story characters voice a number of different explanations for the rise in water level—a mystery and argument are created. This is an opportunity for the teacher to ask students for their ideas about what made the water level rise.

5. The story segment ends with a question and a challenge.

Example: *"Well," said Gramps. "It looks to me that we have three different ideas about how the landslide made the water level go up. Let's see if we can find out if any of them can explain what happened in our little beaver pond."*

The story ends with an unresolved question/controversy. The teacher can then invite students to share their own explanations and ways to find out which explanation is best.

At this point in the instruction, the teacher can utilize sink/float activities which deal with displacement of objects submersed in fluids. The key, however, is to encourage students to think about how their investigations relate to and resolve the controversy raised by the story characters or classmates. The teacher should also require students to share their investigation results in various forms (language arts).

Closing Remarks

For at least the last thirty years, science educators have been grappling with the problems of not enough science being taught and too much reading about and not enough doing science. In that time, instruction has oscillated between the highly structured, didactic and open-ended discovery approaches. Today there is considerable interest in the theme, “less is more” and in organizing curriculum around “science, technology and society,” and it is very much in vogue to talk about constructivism. Underlying all these themes and strategies is an attempt to make science accessible and meaningful for students. Recent efforts to break down subject barriers in the curriculum have the potential to improve science instruction. But there is danger that science may lose ground rather than gain status in the cross-curricular approach. We support the use of children’s literature as a platform for elementary science. But the cornerstone of science still lies in active participation in the process—in doing science. We believe that specially designed “challenge literature” can maintain that sensitive balance in the science/language arts marriage.

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Appendix 1

Sinking and Floating Activities

1. Testing objects to see which float and which sink.

1.1 Give the children an assortment of small objects such as plastic buttons, nails, tacks, rubber stoppers, cork stoppers, marbles, etc. Have them build a chart that has them list each object by name, tell what material it is made of, predict whether it will float or sink, then test whether it floats or sinks and record observations (see data recording sheet).

1.2 Allow children to collect their own objects for testing and have them make a chart similar to the one above.

NOTE: The predictions could be a group activity in which the teacher records predictions on a chart on the blackboard. Students can then do the tests individually or in pairs or small teams. The students can keep personal records of the test to be compiled on the chart by the class at the end of the activity.

Questions to children

A. Can you make some kind of rule to predict which objects will float and which will sink?

B. What causes an object to float? Sink?

2. Objects that float can also sink. Objects that sink can also float.

2.1 Give children a clay ball and have them put it in water to see if it floats or sinks. Have them roll the clay ball out flat with a rolling pin or pound it flat with their hands and fashion it into a boat shape to see if they can make it float.

2.2 Give children an aluminum pop bottle screw cap and have them float it in water. Then have them pound it with a hammer or black of wood until it is flat. Have them try to float it again.

Questions to Children

A. What happened to make the sinking object float - the floating object sink?

B. Did the weight of the objects change?

C. Did what the objects were made of change?

3. Who Sank the Boat?

Give the students a small plastic boat and ask them to use objects from the activity to see how many objects they can fit in the boat before it sinks. Ask them to try different combinations of objects.

Questions to Children

_______A. What happens to the boat when you begin adding objects to it?

B. Does it matter what order you put the objects in the boat?

4. When an object is submerged in water there is a force pushing it up.

4.1 Give the children a collection of various sized balls that can float--from small plastic balls to soccer balls. Have the children push the balls into a pail of water. Start with smallest and work up to the largest.

Questions to Children

_______A. What does it feel like when you push the object into the water?

B. What is pushing back? Why? How?

4.2 Tie a brick onto a short (3 foot) length of cord. Have the child hold the loose end of the cord in her outstretched hands and pick the brick up off the floor. Then put the brick into a bucket of water and ask the child to try and lift it again.

Questions to Children

A. Is there any difference?

B. What is causing the difference?

5. When an object is submerged in water, it displaces some of the water causing the water level to rise.

5.0 "The Crow and the Pitcher." Read the Aesop Fable, "The Crow and the Pitcher," to the class and then recreate the physical situation for the students using a tall narrow vessel (like a graduated cylinder) that is half filled with water. Have the children add pebbles to the vessel and observe what happens to the water level in the vessel. Have them continue to add pebbles until the water is right up to the top of the vessel where it would be easy for the crow to drink.

Questions to Children

________A. Why did the water level rise?

B. Was any water added to the vessel to get the water level to rise?

C. What did the rocks do?

5.1 Give the children a collection of different sized objects that sink. Have them arrange these objects in order of increasing size. Starting from the smallest object and working to the largest, have children put the objects into a transparent container of water and have them observe what happens.

Questions to Children

________A. What happens?

B. Why? What causes it?

5.2 Have children repeat activity 5.1, but also mark the water level on the side of the container before placing the object in the water. Then after submerging the object, they can measure the difference with a ruler and make a chart of their observations and measurements.

5.3 Have the children do the same activity again using the overflow container. With this device, the water level will not rise; instead, the displaced water will run out of the spigot and be collected in a separate container. The volume of this water can then be measured using a measuring cup or graduated cylinder. Have children keep a chart of their measurements. These can be compared to the measurements in 5.2 above.

Question to Children

A. What is the relationship between the size of the objects and the amount of water displaced?

6. The weight of the water displaced can be compared to the weight of the object submerged in the water.

6.1 Give the children a collection of objects that both sink and float. Activity 4.3 can be repeated and both the objects and the water displaced can be weighed. For the objects that float, have the children carefully push them into the water so that they are just barely totally submerged. Have the children group the objects by floating or sinking and make charts **comparing the weight of the objects and the weights of the displaced water.**

Questions to Children

A. What is the relationship of the weights of the objects to the weight of the water for all the sinking objects? For all the floating objects?

6.2 Have the children put each floating object into the water so that it just floats but is not pushed down under the water submerged. Have the children weigh the water displaced and compare to the weight of the object.

7. Density Comparisons

7.1 Have the children take two or three objects that have the same volume and place them in displacement tanks to verify that they have the same volume. Then weigh them.

Questions to Children

If objects take up the same space but have different weights, what is different about them?

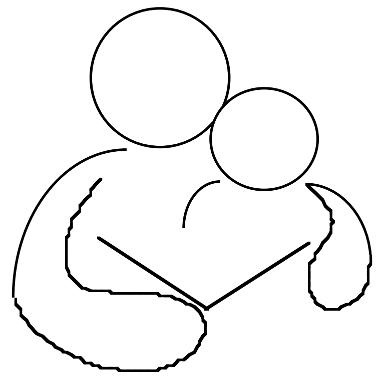
7.2 Have children use the data collected in 5.3 above and do a simple density calculation by dividing the weight of the object by its volume (the volume of the displaced water).

7.3 Ask children to make a chart comparing the densities of all the objects that float to all the objects that sink.

8. Application Activities

8.1 Give the children a mixture of sand and cork bits. Get them to brainstorm about how they might separate them. Have them dump the mixture into a jar of water. The sand sinks, the cork floats. They can skim the cork off the surface and dry it out and pour the water out to collect the sand.

Appendix 2



Science PALs Project
(Science, Parents, Activities and Literature)

Parent Questionnaire

		Percent				
		Agree	---		Disagree	
	As a parent, I . . .	5	4	3	2	1
1.	Am comfortable when talking to my child's teacher.	67	22	11	__	__
2.	Feel it is not my place to be a part of my child's school learning experiences.	__	6	__	__	94
3.	Feel my child's teacher is interested in my thoughts andideas.	56	22	17	__	__
4.	Feel that my child's teacher really listens to my concerns.	61	28	11	__	__
5.	Feel that a close working relationship with my child's teacher/school is necessary for optimal student growth.	67	33	__	__	__
6.	Anticipate parent/teacher conferences with pleasure.	50	39	11	__	__
7.	Feel there is open and enough communication with my child'steacher.	50	22	22	6	__
8.	Am as involved with my child's education as I would like to be.	22	11	44	17	6
9.	Consider myself a partner with the school in my child's education.	56	11	33	__	__

10.	Would work at home with my child if I had specific directions from the teacher.	89	11	__	__	__
11.	Feel that science is important at the early elementary level.	83	11	6	__	__
12.	Clearly understand my role as a Science Pal as explained in the preparation workshop.	83	17	__	__	__
13.	Feel the Science Pal preparation workshop was a positive experience.	83	17	__	__	__
14.	Think there needs to be more parent-school interaction.	72	6	11	11	__

On the reverse of this sheet, please write any suggestions or comments about the Science PALS Project and/or your workshop experience.