Exemplary Science in Grades PreK-4

Standards-Based Success Stories

Robert E. Yager
and
Sandra K. Enger, Editors

NSTA press
NATIONAL SCIENCE TEACHERS ASSOCIATION
Arlington, Virginia

NSTA press®
NATIONAL SCIENCE TEACHERS ASSOCIATION

Claire Reinburg, Director
Judy Cusick, Senior Editor
J. Andrew Cocke, Associate Editor
Betty Smith, Associate Editor
Robin Allan, Book Acquisitions Coordinator

ART AND DESIGN, Will Thomas, Jr., Director

PRINTING AND PRODUCTION, Catherine Lorrain, Director
Nguyet Tran, Assistant Production Manager
Jack Parker, Electronic Prepress Technician

NATIONAL SCIENCE TEACHERS ASSOCIATION
Gerald F. Wheeler, Executive Director
David Beacom, Publisher

08 07 06 4 3 2 1

Library of Congress Cataloging-in-Publication Data
Yager, Robert Eugene, 1930-
Exemplary science in grades PreK-4 : standards-based success stories / edited by Robert E. Yager and Sandra K. Enger.
p. cm.
Includes bibliographical references and index.
ISBN-13: 978-0-87355-261-5 (alk. paper)
ISBN-10: 0-87355-261-X (alk. paper)
1. Science--Study and teaching (Early childhood) I. Enger, Sandra K. II. Title.
LB1139.5.S35Y34 2006
372.3'5--dc22
2006023089

NSTA is committed to publishing quality materials that promote the best in inquiry-based science education. However, conditions of actual use may vary and the safety procedures and practices described in this book are intended to serve only as a guide. Additional precautionary measures may be required. NSTA and the author(s) do not warrant or represent that the procedure and practices in this book meet any safety code or standard or federal, state, or local regulations. NSTA and the author(s) disclaim any liability for personal injury or damage to property arising out of or relating to the use of this book including any recommendations, instructions, or materials contained therein.

Contents

Implementing the Changes in PreK–4 School Programs Envisioned in the National Science Education Standards:

Where Are We Ten Years Later?

Robert E. Yager, Editor
University of Iowa

How This Book Came About

Ten years have elapsed since the 1996 publication of the National Science Education Standards (NSES) (NRC 1996). The critical issues in science education now are these: How far have we progressed in putting the vision of the NSES into practice? What remains to be done? What new visions are worthy of new trials?

The four monographs in the NSTA Exemplary Science monograph series seek to answer these questions. The monographs are *Exemplary Science: Best Practices in Professional Development; Exemplary Science in Grades 9–12; Exemplary Science in Grades 5–8;* and *Exemplary Science in Grades PreK–4* (the book you are reading).

The series was conceived in 2001 by an advisory board of science educators, many of whom had participated in the development of the National Science Education Standards. The advisory board members (who are all active and involved NSTA members; see pp. xi–xii for their names) decided to seek exemplars of the NSES *More Emphasis* conditions as a way to evaluate progress toward the visions of the NSES. The *More Emphasis* conditions provide summaries of the NSES recommendations in science teaching, professional development, assessment, science content, and science education programs and systems. (See Appendix 1 for the six *Less Emphasis/More Emphasis* lists.) The board sent information about the projected series to the NSTA leadership team and to all the NSTA affiliates, chapters, and associated groups. A call for papers on exemplary programs also appeared in all NSTA publications. In addition, more than a thousand letters inviting nominations were sent to leaders identified in the *2001–2002 NSTA Handbook,* and personal letters were sent to leaders of all science education organizations.

After preliminary responses were received, the advisory board identified teachers and programs that it felt should be encouraged to prepare formal drafts for further review and evaluation.

The goal was to identify 15 of the best situations in each of the four areas—professional development and grades 9–12, 5–8, and PreK–4—where facets of the teaching, professional development, assessment, and content standards were being met in an exemplary manner.

The most important aspect of the selection process was the evidence the authors of each article could provide about how their programs affected student learning. This aspect proved the most elusive. Most of us "know" when something is going well, but we are not well equipped to provide real evidence for this knowing. Many exciting program descriptions were not among the final titles—simply because little or no evidence other than personal testimony was available in the materials forwarded. The NSTA advisory board chose the 14 elementary school models that make up this monograph as the best examples of programs that fulfill the *More Emphasis* conditions; each has had a clear, positive impact on student science learning.

The History of the National Science Education Standards

Before discussing the contents of this book at greater length, I would like to offer a brief history of how the National Science Education Standards came to be.

Most educators credit the National Council of Teachers of Mathematics (NCTM) with initiating the many efforts to produce national standards for programs in U.S. schools. In 1986 (10 years before the publication of the National Science Education Standards), the board of directors of NCTM established a Commission on Standards for School Mathematics with the aim of improving the quality of school mathematics. A draft of these standards was developed during the summer of 1987, revised during the summer of 1988 after much discussion among NCTM members, and finally published as the *Curriculum and Evaluation Standards for School Mathematics* in 1989.

The NCTM standards did much for mathematics education by providing a consensus for what mathematics should be. The National Science Foundation (NSF) and other funding groups had not been involved in developing the math standards, but these groups quickly funded research and training to move schools and teachers in the direction of those standards. Having such a "national" statement regarding needed reforms resulted in funding from private and government foundations to produce school standards in other disciplines, including science.

NSF encouraged the science education community to develop standards modeled after the NCTM document (1989). Interestingly, both the American Association for the Advancement of Science (AAAS) and the National Science Teachers Association (NSTA) expressed interest in preparing science standards. Both organizations indicated that they had made a significant start on such national standards—AAAS with its Project 2061 and NSTA with its Scope, Sequence, and Coordination project. Both of these national projects had support from NSF, private foundations, and industries. The compromise on this "competition" between AAAS and NSTA leaders led to the recommendation that the National Research Council (NRC) of the National Academy of Science be funded to develop the National Science Education Standards. With NSF funding provided in 1992, both NSTA and AAAS helped select the science leaders who would prepare the NSES. Several early drafts were circulated among hundreds of people with invitations to comment, suggest, debate, and assist with a consensus document. A full-time director of consensus provided leadership and assistance as final drafts were assembled. Eventually, it took $7 million and four years of debate to produce the 262-page NSES publication in 1996.

There was never any intention that the Standards would indicate minimum competencies that would be required of all. Instead, the focus was on visions of how teaching, assessment, and content should be changed. Early on, programs and systems were added as follow-ups to teaching, assessment, and content.

The NSES and the Elementary School Classroom

The NSES suggest changes across the board for elementary levels K–4. Teachers of these grade levels are often poorly prepared in the quantity and quality of collegiate work they have completed in science. In fact, the typical elementary school teacher is quite frank in reporting that he or she never liked science in high school, experienced little in his or her own elementary school program when a student, and completed only minimal science courses as part of the elementary education major in college.

Further, science has never been emphasized as a core part of the elementary school curriculum—certainly not as one of the basics like reading and mathematics. Too many administrators, parents, community leaders, and politicians are content to focus on the skills related to reading and mathematics with the belief and assertion that these skills are needed before doing science. Of course their view of science is that it is information that has amassed concerning natural world objects and events and that the important ideas of these can and should be given to students via textbooks, worksheets, and teacher directions. Also, in that view, assessment focuses upon student ability to recall, report, and recite on what has been covered.

The National Standards advocate the use of real-world contexts in which the skills of science are needed—as opposed to deciding for the students what they will need and giving them the information to develop those "needed" skills without helping them first establish the relevant context.

Elementary students start with skills and curiosity about the objects and events in the natural world in which they find themselves. The sadness is that this natural interest and curiosity declines the longer students study science in a traditional way—with teachers giving directions and determining what will be studied and how.

Elementary teachers know their students and how eager they are to learn. However, these teachers' reservations about their own abilities in traditional science make them less likely to spend even minimal time on science. Often science is an afternoon class, and often it is scheduled before recess. Too often, too, the science class focuses on vocabulary in the belief that students need a special vocabulary before they can do science. A focus on vocabulary, unfortunately, does little to encourage students to pursue their own interests and questions and leads students to believe that science is strange, with complicated terms that are never used except in science classes. Although they learn the definitions to get good grades and impress their teachers and their parents, they rarely see any other use for their efforts and the things they are directed to do by teachers.

Elementary teachers need more confidence. They need experience with the real meaning of science as a human endeavor. They need to realize that they can and do know science; it just is not the science from most of the courses in their own K–16 experiences. Elementary teachers are often the most successful in staff development programs, especially when they find the fun of doing science. They also can learn readily that their own students can help determine the content, help identify sources of information, can work cooperatively with other students, and can use their science learning in their daily living and in improving their own schools and communities.

The 14 exemplary programs in this book will be seen, I hope, as models for other teachers—not just to copy, but as templates for ways of approaching science and encouraging their students to do more of what they like. The best students become experts; they learn by doing rather than by remembering or duplicating what texts and teachers tell them.

The Standards have probably done more to change science at the elementary school level than at the other grade levels. It has been hard to change high school programs, most likely because of the great focus on college preparation and the discipline-bound curriculum that frequently has little connection or relevance across grade levels.

Elementary teachers often become enthused about teaching science when they understand the visions outlined in the NSES. When both teachers and students are inspired, curious, and involved, science becomes central to the lives of students and others in the community and can give the subject relevance in the real world.

References

Harms, N. C., and R. E. Yager, eds. 1981. *What research says to the science teacher, Vol. 3*. Arlington, VA: National Science Teachers Association.

National Council of Teachers of Mathematics (NCTM). 1989. *Curriculum and evaluation standards for school mathematics.* Reston, VA: Author.

National Research Council (NRC). 1996. *National Science Education Standards.* Washington, DC: National Academy Press.

National Science Teachers Association (NSTA). 2003. *NSTA handbook.* Arlington, VA: Author.

Weiss, I. R., E. R. Banilower, R. A. Crawford, and C. M. Overstreet. 2003. *Local systemic change through teacher enhancement, year eight cross-site report.* Chapel Hill, NC: Horizon Research.

Wiggins, G., and J. McTighe. 1998. *Understanding by design.* Alexandria, VA: Association for Supervision and Curriculum Development (ASCD).

Acknowledgments

Members of the National Advisory Board for the Exemplary Science Series

Hans O. Andersen
Indiana University-Bloomington
3240 Wright Education Building
Indiana University
Bloomington, IN 47405-1006

Charles R. Barman
Indiana University School of Education
504 Pheasant Run
Zionsville, IN 46077

Bonnie Brunkhorst
California State University-San Bernardino
6288 Alegre Court
Riverside, CA 92506

Rodger Bybee
Executive Director
B S C S
5415 Mark Dabling Blvd.
Colorado Springs, CO 80918

Audrey Champagne
State University of New York
Educational Theory & Practice
ED 122, 1400 Washington Ave.
Albany, NY 12222

Fred Johnson
8890 Bridlewood Lane
Cordova, TN 38016

Roger Johnson
University of Minnesota
Dept of Curriculum & Instruction
60 Peik Hill
Minneapolis, MN 55455

Mozell Lang
Pontiac Northern High School
1051 Arlene St.
Pontiac, MI 48340

LeRoy R. Lee
Executive Director
Wisconsin Science Network
4420 Gray Road
De Forest, WI 53532-2506

Shelley A. Lee
Science Consultant
Dept. of Public Instruction
804 Brook St.
De Forest, WI 53532-3210

Gerry Madrazo
The University of North Carolina at
Chapel Hill
Cb #3345
Chapel Hill, NC 27599-3345

Dick Merrill
Science Curriculum Specialist, Retired
Mount Diablo Unified School District
Concord, CA

Nick Micozzi
Plymouth Public Schools
253 S. Meadow Road
Plymouth, MA 02360

Edward P. Ortleb
Science Consultant
5663 Pernod Ave.
St Louis, MO 63139

Jack Rhoton
Professor of Science Education
East Tennessee State University
601 West Valley View Circle
Kingsport, TN 37664

Gerald Skoog
Texas Tech University
15th and Boston
College of Education
Lubbock, TX 79409-1071

Emma Walton
2014 Crataegus Circle
Anchorage, AK 99508

Sandra West
Southwest Texas University
P.O. Box 1441
Canyon Lake, TX 78130

Karen Worth
Senior Scientist
Education Development Center
55 Chapel St.
Newton, MA 02458

Assistant Editor at the University of Iowa
Mary Ann Mullinnix

About the Editors

Robert E. Yager—an active contributor to the development of the National Science Education Standards—has devoted his life to teaching, writing, and advocating on behalf of science education worldwide. Having started his career as a high school science teacher, he has been a professor of science education at the University of Iowa since 1956. He has also served as president of seven national organizations, including NSTA, and been involved in teacher education in Japan, Korea, Taiwan, and Europe. Among his many publications are several NSTA books, including *Focus on Excellence* and *What Research Says to the Science Teacher.* Yager earned a bachelor's degree in biology from the University of Northern Iowa and master's and doctoral degrees in plant physiology from the University of Iowa.

Sandra K. Enger has been an exemplary teacher of biology in Arkansas. She became initially involved in the NSTA Scope, Sequence, and Coordination project in which she assisted many teachers from all levels in developing new and more inclusive assessment efforts. Currently she is an associate professor of science education at the University of Alabama—Huntsville. She has edited a volume on *Assessing Student Understanding in Science* (Corwin Press). Enger earned bachelor's and master's degrees in biology from Winona State University and a doctoral degree in science education from the University of Iowa.

Building On the Natural Wonder Inherent in Us All

Becky Fish
Gladbrook-Reinbeck School District

Setting

The Gladbrook-Reinbeck School District is located in Iowa, a state of just over three million people. The rich farmland that surrounds our district produces corn, beans, cattle, swine, and proud hardworking people. Naturally, many of the businesses in our area are farm related. The parents of the children in our district are farmers, laborers and blue-collar workers, and college-educated professionals. Our district has two sites, one in Gladbrook and the other in Reinbeck. The Gladbrook facility houses an elementary and a middle school. In Reinbeck, there are two buildings to serve the Gladbrook and Reinbeck students: another elementary school and the high school. Our school district provides an education for 800 students in the entire K–12 program.

There are plenty of rich educational opportunities for teachers in this area. Our Area Education Association (intermediate service units between the Iowa Department of Education and the more than 300 local school districts in our state), the University of Northern Iowa, and the University of Iowa are all within 90 miles of Gladbrook. The leaders in these institutions keep us up-to-date with educational practices that are research based and developmentally appropriate.

My classroom is located at the Gladbrook site. Gladbrook is a rural community of about 1,000 people. I teach kindergarten. The kindergartners in our district meet in an all-day, every-day program. With the help of our county conservationist, we've planted a little prairie just outside the west windows of our kindergarten room. There is a large grassy, tree-filled playground to the north of our room. Both areas allow us to explore, question, experiment, and learn.

Emphasizing the NSES in My Kindergarten Classroom

I'm in the process of becoming the teacher I want to be by incorporating the visions embodied in the National Science Education Standards (NSES) into my science teaching. I'm sharing my story to encourage other regular education elementary teachers to gain the courage to step out of their common routines, learn more about constructivist teaching, and begin to include inquiry-based teaching in their curriculums.

Because of my participation in recent science and math workshops and extensive conversations with my teaching peers who have been working to develop the same kinds of constructivist programs, I've embraced several National Science Education Standards. I'm now purposefully providing many occasions for my students to create and follow through with their own inquiries, consciously working to develop chosen concepts over an extended period of time, encouraging collaboration, leading discussions that help my young students discuss some real science social issues, and helping them record and organize their observations and draw conclusions. I know that I'm nurturing our future scientists, and learning in general, by giving my students many opportunities to be involved in the inquiry process.

Keeping the Wonder Alive: Our Gladbrook Prairie

The tall grass prairie area that the elementary students and teachers planted outside the kindergarten room has become a major teaching aid. I'm learning that the area is not only fertile ground for the native grasses and flowers of our midwestern section of the country but also a rich educational resource for our students, stimulating them to learn more about the process of inquiry. Through inquiry my students practice lifelong learning skills.

The Gladbrook prairie area.

Through an "aha" experience in our little prairie, I learned that in the fall our prairie is filled with dozens of giant black-and-yellow garden spiders building webs and making egg sacs. I still remember the first time I discovered them—they were everywhere. My heart began to pound, and, let me tell you, I jumped back to get out of their way. After I stood there for awhile, noticing their color, the way they moved, and their environment, I felt a need to learn more about them. I'd become a learner once more. Slowly, I walked closer so I could get a better look. I had questions. What kind of spiders were they? What were they so busy doing? My senses and emotions were engaged. I felt the urge to hurry inside to share my wonderful discovery with my teaching buddies.

In reflecting on this encounter with the beautiful garden spiders, I realized that an engaging classroom inquiry experience would feel a lot like this. There would be joy and challenge, exploration, discovery, observation, questioning, sharing, and making a plan to learn more. I knew what I wanted to do for my kindergartners. I was eager to create learning opportunities for my students that would replicate my experience in the prairie. Lessons in which my students would be encouraged to think about topics that are connected to their world. Experiences that would put them in control of their own learning. The kind of encounters for which details become important and memorable. Learning they could apply to their lives right now. I began to build an inquiry-based classroom.

How Do I Put It All Together?

That's a good question. I'm still learning. I've found that the destination is always the same, even though the path I take to reach that destination is different every year. These are the goals I work toward. I want to mold confident young scientists who

- have encountered real science experiences,
- are comfortable with the science process,
- have had the chance to be in charge of their own learning,
- have had countless opportunities to engage in higher-level thinking, and
- have developed scientific knowledge by meeting our district's standards and benchmarks.

The direction I take to help my students reach these goals depends on the prior knowledge, skills, and the interests of the children I am working with. Because of that, I always find myself taking a zigzag, instead of a straight, path to reach those important end goals.

If the path to reach this destination is different every year and the children do a big share of the planning, you might wonder, "How does a teacher prepare?" There are some constants to my job as a teacher of inquiry. They are to

1. gather background information with regard to the Standard/benchmark about to be addressed.
2. set out the stimuli to capture interest and engage the senses.
3. be equipped with good questions myself that will allow me to help my students
   - identify the questions that are important to them,
   - discover processes that will help them answer their questions,
   - persist through their struggles,
   - connect experiences together to make meaning, and
   - follow through to use the information they have gained.
4. consider materials needed and
   - provide a clipboard and paper, and science journal to gather data,
   - provide easy access to classroom accumulation of different science materials, and
   - provide time for students to brainstorm lists of needed materials.
5. step back and observe students interactions to determine when group discussions would be beneficial to students. The purpose of discussion could be to
   - form, collect, and record questions;
   - teach, model, and discuss process skills used;
   - make plans for next steps;
   - notice connections with other investigations, understandings, and concepts;

- talk over what has been learned—details, the big picture;
- discuss ways we will communicate to others what we've discovered; and
- evaluate the learning experience (did our tests answer our questions?).

6. Plan for the challenge of assessment (evidence that students can use the information and skills in new situations). Details come later in the chapter.

Excerpts From Kindergarten Inquiry Experiences

Here are a few examples of what my students have accomplished with inquiry.

The Life Cycle of the Butterfly

The first experience I will share, "The Life Cycle of the Butterfly," is common in early childhood programs. I found that the topic offered me an opportunity to develop a true inquiry experience and supported real social debate as encouraged by the NSES. I had led my children through this unit many times before with hands-on strategies. But, because I realized the value of the inquiry process, I decided to raise the bar for myself and go beyond the hands-on approach. I would try to create a classroom environment in which my youngsters could not only learn scienctific facts but also begin to think like scientists and take more responsibility for their own learning.

I had the scientific background knowledge of the topic *butterflies,* so my next step was to think about the stimulus. Sometimes I plant the invitation to learn, but this time I was sure that someone would bring in a caterpillar or butterfly to share. So, my next step was to just wait. I wasn't the one to set the date to begin instruction; the children now acquired that job. As predicted, the larva of the monarch butterfly arrived in room 110. We were ready to begin.

Instead of using the beautiful caterpillar as an impetus to share my knowledge with the children as I used to do, I stayed in the background, listened to their conversations, and took notes. I heard some accurate facts, some incorrect understandings, and some questions. I was very much aware of their interest and had gained a good understanding of their level of knowledge. My students had opened the door. I was ready to lead the way.

Equipped with questions and a basic plan of where I hoped to go with this first group meeting, I organized a large-group discussion. "I heard you talking about the caterpillar. It sounds like you are interested in that little caterpillar. Are you? Would you like to spend some time finding out more about him? Tell me what you're wondering about." The children and I talked about the things they thought they knew and the questions they had about caterpillars, chrysalises, and butterflies. Their understandings and questions were recorded on chart paper to refer back to.

They asked, "Where did the caterpillar come from? I wonder what caterpillars eat. How long does it take to change to a butterfly? Should we keep the butterfly or let him go? I wonder what will happen next? What should we feed the butterfly? How many wings does a butterfly have? How does a butterfly eat?" By themselves, they listed all of the objectives I had included in my lesson plans. Instead of giving the children an oratory on the life cycle and structure of the butterfly, and maybe an additional few minutes sharing my own personal opinion on the release of the butterfly, I asked them to think of ways they could learn more to answer their own questions.

In the past—the plain old hands-on way—I would have immediately corrected their misunderstandings and moved on with the lesson plan. But one of my new goals was to help them think and reason. So, without pointing out exactly what was right or wrong with their thinking, I told them that we could work together to plan ways they could prove or disprove the information they had. It's very important to help my students understand that it is good when they are able to change their minds about a previous understanding. I tell them that if the evidence proves otherwise and if there are many who value that new evidence, it might be wise to consider the new facts and change your mind. That's what scientists do.

The interactions in our initial discussion helped us identify, narrow, and record our questions. Our interactions also began to instill in my young students a sense of what it's like to be a scientist.

The unit continued for three to four weeks with the children leading the way. The anticipation was great. The children learned about habitats that were friendly to the butterflies. The prairie allowed them to identify the plant where the monarch liked to lay its eggs. They learned about the body structure and coloring of the larva that crawled out of those eggs. They watched as the larva made its chrysalis, and they waited for the butterfly to emerge. A fews days of debate ended in the release of our butterflies. All the time we were asking questions, observing, predicting, collecting data, communicating, drawing conclusions, asking more questions, and considering new ways to answer those questions. With inquiry the children learned more than facts about butterflies. They also had the opportunity to learn how it feels to be a scientist.

Composting

In the following inquiry experiences, composting helped the children to develop more NSES. They collected, recorded, organized, and reflected on relevant data. The kindergartners had the opportunity to see an investigation through the fall, winter, and spring before all of their questions were answered.

Friends Investigating Pumpkins

In the fall, after our many inquiries about pumpkins, my students noticed that our pumpkins were beginning to rot. They wondered what that "yucky" stuff was inside the pumpkins. And what was that awful smell? Here was another chance for me to use their curiosity to develop logical habits of mind.

Change was the big concept for the year. Now was the perfect time, when the pumpkins were dramatically displaying their life cycle, to ask my young scientists if they could think of ways the life of the pumpkin plant was like the life of the butterfly. Could they connect the two learning experiences? Most of the students looked puzzled. They responded with, "They both were alive." "I loved the butterflies, and I love the pumpkins." Both of those answers were fine, but I wanted them to think deeper. I couldn't get them to the next step, so I began to hum a song the children had learned in September that emphasizes cycles. They recognized the song, "Love Goes Round In

A Circle," recorded by The Bat Chorus. In a short amount of time they did make the connection I was hoping for. They recognized that the life cycle of the pumpkin went around in a circle—seed, vine, flowers, pumpkins, seed, vine, and so on—just as the life cycle of the butterfly did—egg, larva, chrysalis, butterfly, and so on. Both living things, the plant and the animal, went through predictable changes. The children illustrated the life cycle of the pumpkin on our white board and then recorded their new understanding in their science journals. My students were becoming more aware of change and the cycles of things. I also found that, when I offered more opportunities for them to think more deeply and made an extra effort to identify connections to prior learning, their successful responses increased. I was often surprised and pleased by the examples of cycles and change they detected in their everyday lives.

Before we put the pumpkins in the compost bin, several children decided that they wanted to watch them rot. They put a big chunk of a pumpkin in a plastic bag so that we couldn't smell it and left a similar-sized piece right out in the open air. The rest of the pumpkins went outside in the compost bin. They watched with interest—and disgust—to see what happened to the chunks inside and to the pumpkins outside. We of course compared the changes that were occurring in the pumpkins and made journal entries often. When the piece of pumpkin exposed to the warm air of the classroom began to get juicy, the children and I wanted to get it out of the room. I asked them if they'd ever thought about how they could stop the pumpkin from decomposing. They talked about it, but couldn't come up with anything that would help them find the answer to that question. I wanted to jump right in and offer some ideas to consider but resisted and simply suggested that we just keep thinking about it.

The children wondered why the pumpkins in the compost bin didn't decompose as quickly as the ones in our room. My next question was, "Is there anything different about the pumpkins outside and the pumpkins inside?" That led us to talk about the differences in environment, which included temperature. There were so many great opportunities for reasoning. And so it continued, until the children eventually concluded that things decompose more quickly where the temperature is warm and more slowly where the temperature is cold.

A January Visit to Our Compost Bin

The watchful eyes of the children kept track of those pumpkins through the snowy winter and into the warm spring. They entered data from each visit to the compost bin into their pumpkin journals. Over time, the entries revealed more accurate reporting, more detail, and more understanding of decomposition.


The Gladbrook students visit the compost bin.

Guess what these children found when they came back to school in September? You're right. They witnessed the full life cycle of the pumpkins. Long vines, with yellow flowers, and small pumpkins, were growing from that compost bin. More observing. More questions. Happy kids! Happy teacher!

"Balance"

I've found that it is possible to work science inquiry into my existing curriculum. I have a special unit that the children and I love. We call it "Our Circus Extravaganza." It provides many opportunities to develop physical, emotional, social, and academic growth. Language, math, social studies, and the arts found priority spots in my lesson plans. But I began to wonder how I could incorporate science into this already invigorating unit.

Several years ago I was introduced to some great science kits. I'd acquired a FOSS "Balance and Motion" kit and used it in the prescribed way. The children had great experiences and found success. But, again, I wanted to take those preplanned experiences to the next level to make it a richer encounter with inquiry. Balance would fit perfectly into this circus theme. The content and teaching of the NSES could be addressed. I would be connecting science to other school subjects, and, while learning more about balance, I would be providing challenging, age-appropriate opportunities for all of my students to do science.

I used Jack Prelutsky's book *Circus* (1989), which has wonderful illustrations and explanations of various circus acts. Several pages pertain to balance: clowns balancing plates on sticks, acrobats balancing on one another's shoulders, and seals balancing balls on their noses. When sharing the book with the children, I stopped on those pages and said "Wow," and we talked about the amazing tricks that were pictured there. I asked if anyone in our class was good at balancing things. Some said, "Not me"; others said, "Yes, I can balance." My next questions were, "Would you like to try to balance some objects? Would like to learn more about balance?" Everyone said, "YES!"

The children needed a definition of the word *balance*. They decided that, for a good balancing trick, they couldn't hold on to the object they were balancing and that the object they were trying to balance could wobble a little, but it could not fall down. One child pointed out, and we all agreed that, for an object to be truly balanced, the bigger object needed to be on top of something smaller—pretty good thinking.

We built background knowledge with more books and a video. Some of the children became teachers by describing circus acts they had seen. We brainstormed materials we would gather for our exploration. This was the time I offered the children the materials from the science kit, "Balance and Motion." I didn't give any instructions on how to use the items. We were almost ready to begin to explore the phenomenon of balance.

I needed to stop and reflect on the goals to be accomplished in these balance investigations. What were the essentials of this experience? In addition to another chance for students to become more familiar with the joy of doing science, I wanted to provide experiences with which they could begin to think about what the center of gravity is. The investigations were also an opportunity for me to introduce the value of persistence, present the fact that our experiments with balance needed to be assessed, and begin to explain the advantage gained when scientists work together to find answers to their questions. Most young learners don't know how to get to their next stage of learning. They need a teacher to lead them and find natural ways to introduce these processes, skills, and values.

Time to let the learning continue. When we began experimenting with balance, the children were full of energy, laughing, groaning, moving, and talking. Some were finding success, and some were struggling. After ample time for exploration, we had a group meeting. My questions and comments to them were, "What should we do when our experiments don't work out the way we want them to? Who could we go to, to learn more? You know, scientists learn from each other. Did you notice anything that was the same with every trick where the object was really balanced?" The students buddied up to share our successes and struggles with classmates and then made plans to explore again.

With many opportunities to develop a balancing trick, eventually everyone was ready to share their tricks with their classmates. We circled up, tricks in hand. Each child had a chance to be the ringmaster and introduce an act, and each child had a chance to be in the center ring to amaze their classmates with his or her balancing trick.

It is important for students to be included in the assessment of their own thinking and experimenting.

After every performance, and using the children's definition of balance, I took the opportunity to help each child evaluate his or her trick. I asked, "Did it really balance? Do you know why or why not? Is there anything about your trick that you would like to change to make it balance better? What would that be? Why?"

That year no one chose to do a balancing act in our production of "The Greatest Circus Extravaganza in Gladbrook, Iowa," but everyone did have one more opportunity to be in charge of his or her own learning, think like a scientist, and through their explorations learn more about the phenomenon of balance. They were learning how to learn. Isn't that what an education is truly all about?

Assessing the Ingredients of Science

Assessment is interwoven with instruction. It is ongoing and diagnostic. Teachers must keep track of which students understand the basic ideas, which students can perform the identified skills, and which students are struggling. The results of daily assessments help modify the content, process, depth, and pace of tomorrow's instruction. Teachers must also step back to assess the environment the students are working in. There may be interventions necessary to create the safe, stimulating setting necessary for optimum learning. At this grade level, most of the assessments can be done informally and need not take a teacher a great deal of time to complete.

I've gathered a checklist of objectives that are directly observable and that relate to both subject matter and science process skills. I keep the checklist on my science clipboard, identify the exact skill or understanding that I'm assessing, and, as I informally assess the children, I can jot down the date and a few words to describe the specific instance by the skill or understanding that was successfully demonstrated. I don't often get the time to assess every child during a science lesson. I've found, however, that with this checklist it's quick and easy for me to document the growth of many of my students either during the learning experience or after reflecting on the lesson later in the day.

ASSESSMENTS OF INQUIRY
What it means "to do" science and understand concepts in the kindergarten classroom.

NAME____

Generate questions?
Make associations?
Interpret findings?
Willing to change mind in light of findings?
Show evidence of understanding the concept?
Systematic with the procedure?
Notice anything significant in the investigation?
Generate a new idea/possible solution?
Use trial and error?
Use scientific vocabulary?
Drawing/writing complete enough to be recognized by someone else?
Engaged and persistent with the task?
Respectful of others in the group?
Share the work?
Manage materials well?

Teacher Comments:

Examples of Student Assessments

There are daily opportunities for meaningful, authentic assessments. Some of the assessments follow that I use to help myself plan appropriate content, processes, and products so that my students can continue growing.

1. Observations—One of the best times to learn about the development of processes, skills and understandings is when the children are engaged in an investigation. In this example, the lesson, "Fall Visit to the Prairie" had a twofold purpose. The children wanted to examine the seeds of the different prairie plants. I wanted to be able to step back and observe the interactions and abilities of the children. It was early in the kindergarten year, so the ability of my students to stay on task was limited and their skill development was still immature. Accomplishing both goals would be difficult for me without help. The third-grade teacher and I frequently have our kids buddy up. This was a time my youngsters needed some one-on-one assistance, so I asked my teacher friend if her class would like to join us. Her students were familiar with the prairie and also enjoyed the responsibilities given them. The "big buddy" was to stay with his or her "little buddy," help the little buddy stay focused on the task, and help the little buddy pick just one seed head from a variety of plants to put in a collection sack. The teachers and children reviewed what scientists do and the goals of their investigation. Then, with their collection sacks in one hand and their friend's hand in the other, the buddies headed out to the prairie to explore and learn.

I carried my science clipboard to the prairie, ready to make brief notes concerning ability to stay on task, share the work, exchange ideas, and ask questions. The dynamics of each group of children differed. By stepping back to watch both individuals and the group as a whole, I could assess their progress toward our long-term inquiry goals and then determine what my next steps should be. It would take more than one visit to the prairie for me to gather all of the information I wanted. The children found the prairie irresistible and did not hesitate to comply with my request to return soon.

2. Discussions—Sometimes I hear children cite examples of scientific understandings outside of science class. I cherish those comments the most because they tell me that the child is applying what he or she learned from classroom inquiry activities to everyday experiences in the real world.


Kindergartners and third graders buddy up.

Let me share one such experience with you. The children and I had spent several weeks working with a motion unit. On our way to lunch, Brady noticed that the floor slants down a bit just as we enter the lunchroom. He turned to me and said, "Hey, Mrs. Fish, this is an inclined plane. It would be fun to bring our cars down here to see how far they will roll." My return comment was, "This is a steep inclined plane. You are thinking like a scientist, Brady. I agree. It would be fun to bring our cars to the lunchroom. We will have to talk about it and see if the class is interested. If they are, we can make plans to do just that." I knew that he was engaged in higher-level thinking because he was applying his new science understanding to his everyday life. When we got back to the classroom, I recorded Brady's observation, comment, and understanding on his inquiry assessment sheet.

3. Journaling—In the curriculum section, I shared a little about our composting project. In that narrative I mentioned that we often made journal entries. Here are two pieces of journaling work I collected from those composting investigations. Both journal entries are evidence of growth in science skills and understandings. They also show development in each student's ability to use reading and writing skills in meaningful situations.

Five-year-old Morgan completed her entry in November. She titled and dated her work. The investigation involved the solid pumpkin shell that was placed in a plastic bag in October. The children wanted to watch it decompose. As time passed, it had changed from a solid to a liquid. The drawing in Morgan's journal entry showed me that she recognized and understood that a change had occurred. Her work was complete and was a good representation of the decomposed pumpkin in the plastic bag. She used temporary spelling to record what she observed about the liquid in the plastic bag. I knew who had completed this particular data report because she remembered to put her name on her work. I noticed that she consulted the word bank to spell pumpkin and November.

What was next for Morgan? Morgan was gaining confidence as a scientist and as a writer. I complimented her on the accuracy of her drawing and the word she chose to describe what was in the bag. I encouraged her to keep using the science word bank and her ability to hear the sounds in words to write a complete sentence. It only took a few minutes at the end of the day to note Morgan's growth on her inquiry assessment sheet.

The work that Tyler produced in January was evidence that he is growing in many areas. His observation skills are acute. On our January visit to the compost bin he observed that a spider had left a little white egg sac on one of the top boards of the bin. Tyler noticed the snow in the bin and the sunny day. He included each of those observations in his drawing and writing. He wrote a compound sentence, complete with an end mark, and included the title and date in his entry. Tyler forgot his name, but sometimes that happens. He will try to remember next time. It was quick and easy to use the inquiry assessment sheet to credit Tyler with his accomplishments.

What was next for Tyler? He was still very much a five-year-old. He was very social and, even though his skills were advanced, would not want to be off working alone on a project. Still, I wanted to take advantage of his interest and give him more opportunities to develop a taste for the joy of discovery. I asked him what he wanted to investigate next. He chose to go out to the prairie to dig in the snow and try to find the few pieces of pumpkin shell we'd placed on the ground outside our kindergarten window. Anticipating the usual snowy winter, the children had placed a big rock beside the pumpkin shells so that they would be easy to find. With a friend at his side and wondering if those pieces of pumpkin had decomposed, Tyler headed outside. It was another chance for both of them to be in charge of their own learning. Their understanding of decomposition would grow, and, maybe most important, they would increase their awareness of what it means to be a scientist.

Assessment is a central ingredient of science, so it also should be central with science teaching and learning. Students and teachers need to understand that science is not science without evidence and interpretations that are assessed, validated, and accepted by others. By thoughtfully using the assessment data collected, a teacher can modify lesson plans to meet the current needs of her students.

Building on the Natural Wonder

Over the years many good things have happened in my classroom, but I've been able to see great things happen since inquiry and constructivist teaching have become fundamental components of my kindergarten curriculum. Challenge, real learning, joy, added independence, and freedom have found a home in my room. Letting my students know exactly what they should know, understand, and be able to do has increased their success. It's essential that the investigations the children—and I—design are fun and engaging. If real learning is to result, the inquiry must also be purposeful. When the environment, teachers, and students work together toward a specific, identified purpose, learning is more likely to get to long-term memory. Wonder, ample opportunities for the children to plan ways to find the answers to their questions for themselves, and shared objectives have supported my efforts to make learning meaningful and consequently long-lasting.

Keep the wonder alive. Invite inquiry into your classroom.

References

Lobel, A., and J. Prelutsky. 1989. *Circus.* New York: Simon & Schuster.

National Research Council (NRC). 1997. *Introducing the National Science Education Standards.* Washington, DC: National Academy of Sciences.

National Science Foundation (NSF). *Inquiry: Thoughts, views, and strategies for the K-5 classroom,* Vol. 2 of Foundations. A monograph for professionals in science, mathematics, and technology education. Available at *www.nsf.gov/pubs/2000/nsf99148/start.htm*