Chapter 5

RESOURCES

Help for Teachers

Making Connections with Literature

Using literature as a supplement and enhancement for instruction is good teaching practice because:

- Children learn from everything they experience.
- Children learn more effectively when instruction is associated with positive emotions, such as those evoked by a good book.
- Literacy is key to children's success as learners.
- There are many different learning styles.

We encourage you to incorporate books of all kinds into your work with *Packaging and Other Structures.* We've included an annotated list of quality books of all kinds on the following pages—storybooks in which the uses and design of packaging and other structures are demonstrated, as well as nonfiction books on how to design and create packaging and structures, the functions they serve, and how to make the best use of materials.

But don't stop with these. You know your students and how they learn better than anyone else. When you see a book that might further your instructional goals, interest or challenge a particular student, or evoke feelings that make learning more fun, add it to the books that are available to your students.

Amelia's Road, by Linda Jacob Altman. Lee & Low Books, Inc.: New York, 1995. (Recommended grades: K-5)

Tired of moving around so much, Amelia, the daughter of migrant farm workers, dreams of a stable home. She finds peace at the story's end by planting a treasure box, which is filled with her treasures, beneath a wondrous tree. This book allows older readers to see that families live in all kinds of ways. Her treasure box packages all of Amelia's dreams.

And So They Build, by Bert Kitchen. Candlewick Press: Cambridge, MA, 1995. (Recommended grades: PreK-3)

Students can explore the extraordinary world of animal behavior with descriptions of 12 astonishing animal architects and explanations of why and how they build their marvelous structures. Color illustrations show animals, especially insects, as they work building their structures.

Ant Cities, by Arthur Dorros. HarperCollins: New York, 1988. (Recommended grades: K-4)

A "Let's Read-and-Find-Out" science book that explains how ants live and work together to build and maintain their cities. This literary connection presents the structural problems ants contend with and explores their cooperative working habits.

Art from Packaging, by Gillian Chapman. Raintree Steck-Vaughn: New York, 1997. (Recommended grades: 2-6)

Contains instructions for making prints from bubble-wrap, puppets from cardboard boxes, and other arts-and-crafts projects using discarded packaging materials.

Bad Egg: The True Story of Humpty Dumpty, by Sarah Hayes. Little Brown and Company: Boston, 1987. (Recommended grades: K-2)

Humpty Dumpty sat on the wall. Humpty Dumpty had a great fall. What events happened in between? This true story of Humpty Dumpty, who it turns out, was not entirely blameless. An interesting link to use for introducing packaging to younger students.

The Bag I'm Taking to Grandma's, by Shirley Neitzel. William Morrow & Co.: New York, 1998. (Recommended grades: K-3)

A young boy is packing a bag for a trip to visit his grandmother. He fills a shopping bag with his mitt, cars, space ship, wooden animals, his favorite stuffed rabbit, his pillow, a book, and a flashlight. Then along comes Mom with packing ideas of her own. This literature link utilizes pictures, repetitive phrases, and rebuses to increase the fun for beginning readers, while integrating the theme of packaging.

The Big Box, by Virginia Clammer. Millbrook Press: Brookfield, CT, 1999. (Recommended grades: K-2)

Bill and his little sister Kay enjoy playing in a big box, which becomes in turn a car, a jet, and the engine of a train. This "Level 1 Real Kids Reader" blends phonics with whole language. A beginning controlled vocabulary helps connect packaging with literacy for emergent readers.

A Box Can Be Many Things, by Dana Meachen Rau. Children's Press: New York, 1997. (Recommended grades: K-3)

After their mother tosses out a large box of junk, a girl and her younger brother retrieve it from the garbage. They pretend it is a cave, a car, a house, and a cage. Even when it lies in pieces on the ground, their imaginations lead them to more inventive uses for the box.

Boxes! Boxes!, by Leonard Everett Fisher. The Viking Press: New York, 1984. (Recommended grades: PreK-2)

Enticing rhymes explore all the things a box can be—box-kite, jack-in-the-box, candy box, treasure chest and more. Colorful illustrations transform everyday objects and expand the playtime of young readers and listeners.

The Bridge, by Emily C. Neville. Harper & Row: New York, 1988. (Recommended grades: K-3)

When the old wooden bridge breaks, a young boy is delighted to be able to watch, from his front yard, the many different machines at work building the new bridge across the brook. The new bridge is a dirt road over a culvert. The new structure is more sturdy, but not as unique and memorable as the old rattling wooden bridge.

Bridges! Amazing Structures to Design, Build and Test, by Carol A. Johmann. Williamson Publishing Company: Charlotte, VT, 1999. (Recommended grades: 3 and up)

Each chapter consists of numerous short articles combining historical and technical information on the design and construction of bridges with easy hands-on experiments. It includes analysis of arch, beam, and suspension systems, the "care and feeding" of structures and reflections on bridges of the future. Throughout, there are simple projects involving building, measurement and observation as well as writing poems about bridges. The book concludes with a challenge for young minds to "think outside the box."

Charlotte's Web, by E.B.White. HarperCollins: New York, 1976. (Recommended grades: 3-6)

"Some Pig!" These words that Charlotte spins into her web to describe Wilbur cause plenty of excitement, and ultimately, help save his life. A classic that depicts life and death, the passage of time, and the wonders of nature, and also shows readers that true friendship lasts forever.

Creative Crafts from Cardboard Boxes, by Nikki Conner. Copper Beech Books: Brookfield, CT, 1996. (Recommended grades: K-3)

Crafts are easily created from boxes and transformed into a train, car, ship, or puppet stage with puppets. The same supplies can create a game, a snake, or a wagon from paper cups. The book has no text, only numbered visuals, so no reading is involved.

Creative Crafts from Plastic Bottles, by Nikki Conner. Millbrook Press: New York, 1997. (Recommended grades: K-3)

Provides instructions for making such items as bangles, a rocket, a buggy, and a plant pot from plastic bottles. Wordless instructions and visuals explain each project.

Creative Crafts from Plastic Cups, by Nikki Conner. Millbrook Press: New York, 1996. (Recommended grades: K-3)

Provides a variety of craft projects for young children using plastic cups. There is no text—only numbered, step by step, visual instructions.

Dinosaurs to the Rescue, by Laurie Brown. Marc Brown. Little, Brown & Company: Boston, 1994. (Recommended grades: 1-6)

A guide to protecting our planet. Packed with good advice on how to use less of the earth's precious resources and how to find new uses for old household items. Text and illustrations of dinosaur characters introduce the earth's major environmental problems and suggest ways children can help.

The Great Trash Bash, by Loreen Leedy. Holiday House: New York, 1991. (Recommended grades: 1-5)

The animal citizens of Beaston discover better ways to recycle and control their trash. Young readers learn how to dispose of packaging materials and bash the trash in their own communities.

Houses of Adobe: The Southwest, by Bonnie Shemie. Tundra Books: Plattsburgh, NY, 1995. (Recommended grades: 4-6)

An excellent resource on the adobe structures built by Native Americans in the southwestern region of the United States. It describes the materials used, construction methods, and the uses of these different structures. Good link for integrating geography and packaging, and also a resource for student reports.

How Do They Package It?, by George Sullivan. Westminster Press: Philadelphia, 1976. (Recommended grades: 6+ and Teacher Reference)

Everything you always wanted to know about the world of packaging, as tubes, boxes, bottles, flip-top cans, aerosols, and jars compete for places on supermarket shelves. Different types of convenient, commanding, and colorful packages are described. Discover who created the first tea bag, why we buy milk in cartons and plastic containers. and why they don't package peanut butter in a tube. Though slightly dated, it provides fascinating facts and information for teacher reference and student research reports.

How Insects Build Their Amazing Houses, by W. Wright Robinson. Blackbirch Press: Woodbridge, CT, 1999. (Recommended grades: 5 and up)

Explores how various animals live and what can be learned from studying the types of structures they build. Describes step-by-step how termites build mounds; how wasps build nests; how ants build giant anthills; and how bees build nests, tunnels, and special chambers.

How on Earth Do We Recycle Plastic?, by Janet Potter D'Amato. Millbrook Press: New York, 1992. (Recommended grades: 4 and up)

Discusses the environmental problems caused by the manufacture and disposal of plastic, and presents craft projects that use recycled plastic.

Likeable Recyclables: Creative Ideas for Reusing Bags, Boxes, Cans, and Cartons, by Linda Schwartz. The Learning Works, Inc., 1994. (Recommended grades: 1-6)

Presents an endless array of fun-filled ways on how to decrease the garbage we produce from discarded bottles, boxes, cans, cartons, cups, and tubes, by making toys, games, and other crafts out of items we usually discard.

Little Bear's Trousers, by Jane Hissey. Philomel Books: New York, 1987. (Recommended grades: K-3)

While looking for his beloved red trousers, Little Bear discovers that other animals have found many uses for them: sails for a boat, a container for dog bones, a hump warmer or a hat, a flag, even a cake frosting bag. A very creative resource for the concepts of structure and function.

Look What You Can Make with Paper Bags, by Judy Burke. Boyds Mills Press: Honesdale, PA, 1999. (Recommended grades: K–6)

Each project in this book begins with a paper bag. Full-color photographs of the finished projects motivate children to explore and complete their own projects. From a "Rustic Log Cabin" to an "Autumn Scarecrow" to "Mask Mania," these appealing craft ideas will stimulate the imagination.

Lunch Boxes, by Fred Ehrlich. Penguin Putnam Books: New York, 1991. (Recommended grades: K-3)

The vocabulary is simple and repetitious, making this book appealing for young readers. It's lunchtime at Oak Hill School, and all the children go quietly to the lunchroom carrying their lunch boxes. Once they sit down to eat, their food goes everywhere but in their mouths. Various packaging items can be observed and identified on the lunch table when the lunch boxes are opened.

Maebelle's Suitcase, by Tricia Tusa. Macmillan Publishing: New York, 1999. (Recommended grades: K-3)

One hundred-and-eight-year-old Maebelle (the Pippi Longstockings of the geriatric set) designs and makes hats. She lives in a treetop house and has a lot of bird friends. When her neighbor flies over to borrow a suitcase to fly south, the packing creates a problem, but the resolution is warm and wonderful, just like the book.

Making Gift Boxes, by Linda Hendry. Kids Can Press: Buffalo, NY, 1999. (Recommended grades: 3-6)

Now kids can make their own gift boxes. Excellent step-by-step directions are given for projects that range from simple to challenging. An empty cracker box becomes a fierce-looking monster, or a small milk carton becomes a cozy cottage. Kids learn how to recycle easily found items into beautiful gift boxes. There is a color photo of each finished project.

Mommy's Briefcase, by Alice Low. Scholastic, Inc.: New York, 1995. (Recommended grades: PreK-2)

Look what's inside Mommy's briefcase! Packed inside this hands-on book are special folders containing all the things a working Mom carries in her briefcase. Neat link for introducing emergent readers to packaging.

The Mud Flat Mystery, by James Stevenson. Greenwillow Books: New York, 1997. (Recommended grades: K-3)

When a large box is delivered to Duncan while he is away, the other animal inhabitants of Mud Flat are consumed with curiosity about what might be inside. Is it heavy? Or fragile? Should they guard it? Is it food? Can they solve this mystery? An easy read-aloud book that will help kids along the road toward independent reading.

My Cat Likes to Hide in Boxes, by Eve Sutton. Scholastic, Inc.: New York, 1973. (Recommended grades: K-2)

Delightful book with rhymes about cats from all over the world and "my cat" that likes to hide in boxes! The predictable pattern encourages reading participation, either whole-group or independent. The idea of using boxes and shapes as homes is an early connection to structure and geometry.

Native Dwellings, by Bonnie Shemie. Tundra Books: Montreal, Canada, 1991. (Recommended grades: 2-6)

This is a series of books that includes Houses of Hide and Earth (Plains), Houses of Bark (Woodlands), and Houses of Snow, Skin and Bones, (Northern). Each volume deals with a type of Native American dwellings, including how they are lived in, as well as the building materials, techniques, and tools used to construct them.

Packaging Source Book, by Robert Opie. Chartwell Books: Secaucus, NJ, 1989. (Teacher Resource)

Pictorial guide to packaging design, from 1880 to the present. It chronicles the changes from the ornate and whimsical fancy goods wrapping of the 1880s to the bold packaging ideas that vie for consumers' attention today. This international survey of packaging highlights the innovations made in the design and packaging of everyday products, and the creation of brand images. An excellent resource for teacher reference, and an inquiry tool for independent student reports.

Plastics, by Terry Cash. Garrett Educational Corporation: Ada, OK, 1990 (Recommended grades: 3-6)

This book introduces plastics, showing how everyday things, from bags to tubes, to toys, are made and recycled, and what properties are characteristic of each material. It includes ideas for a variety of simple projects and experiments. An outstanding feature is the integration of questions and suggestions for collecting, observing, experimenting, and comparing.

Plastics and Polymers, by Robert C. Mebane. Twenty-First Century Books: New York, 1995. (Recommended grades: 6-up)

Explores the basic properties of metals, plastics, and polymers. Contains simple demonstrations that require little preparation and utilize easily obtained materials. A resource link for teachers and upper grade students.

The Purse, by Kathy Caple. Houghton Mifflin Company: Boston, 1986. (Recommended Grades: K-2)

Katie keeps her money in a Band-Aid box until her older sister convinces her to buy a purse. Because she uses all her money for the purse, she has nothing left to put in it. She does earn more money and the way she spends it provides a novel twist to the ending.

Pyramid, by David Macaulay. Houghton Mifflin Company: Boston, 1977. (Recommended grades: 5-up)

Text and black-and-white illustrations follow the intricate process of how the great pharaohs' burial places were conceived and constructed. A fabulous book for learning about the pyramids and their mysteries. The text is very reader friendly and illustrations provide visual reinforcement.

Simon and His Boxes, by Gilles Tibo. Tundra Books: Plattsburgh, New York, 1992. (Recommended grades: K-3)

Simon is a little boy who has impossible dreams. He finds some cardboard boxes in the forest and he builds homes, apartments, and cities for the animals. But the animals refuse to join him in his cities, and Simon learns that animals prefer the homes they already have, and that boxes can have other, better uses.

Sitting In My Box, by Dee Lillegard. Penguin Putnam Books: New York, 1993. (Recommended grades: K-2)

With only his imagination for company, a little boy sits alone in a cardboard box, and is soon joined by animal after animal, with hilarious results.

A Special Kind of Love, by Stephen Michael King. Scholastic, Inc.: New York, 1996. (Recommended grades: PreK-3)

Explores the relationship between a father and a son and the unique way in which the father expresses his love. He builds wonderful things for his son—an enormous castle, a colorful kite, and a speedy go-cart, all out of boxes.

Spiders Spin Webs, by Yvonne Winer. Charlesbridge Publishing: Watertown,MA, 1998. (Recommended grades: K-3)

Young readers get a chance to look up-close at a stunning variety of webs from around the world. Rhyming text describes how, when, where, and why spiders spin webs.

Super Structures, by Philip Wilkinson. Houghton Mifflin: Boston, 1996. (Recommended grades: 4-6)

An "Inside Guides" book on amazing feats of engineering and construction. It uses three-dimensional models to explore fascinating structures, revealing their inner workings. Learn what keeps a soaring skyscraper standing, and what record-breaking bridge is nearly twice the size of its nearest rival. Great resource for student project reports and teacher information.

Super Structures of the World, by Stewart Kallen. Abdo & Daughters, 1991. (Recommended grades: 4 and up)

Surveys notable structures built by humans from ancient dwellings to modern amusement parks.

The Statue of Liberty, by Lucille Recht Penner. Random House: New York, 1995. (Recommended grades: 1-3)

This "Step Into Reading – Step 1" book explains the significance of the Statue of Liberty, where it originated, how it was constructed, and how it came to be in America. It describes the size of the structure and the process for building the high pedestal.

The True Story of the Three Little Pigs, by A. Wolf, by Lane Smith, As Told to Jon Scieszka. Scholastic, Inc.: New York, 1989. (Recommended grades: PreK-3)

A retelling of the folktale, by the wolf, who then gives his own outlandish version of what really happened when he tangled with the three little pigs. Being a victim for centuries of bad press, Alexander T. Wolf (you can call him Al), comes forward to give his side of the story. He was framed! It's not his fault if two of the pigs built shoddy houses.

Unbuilding, by David Macaulay. Houghton Mifflin Company: Boston, 1986. (Recommended grades: 1-6)

It is not a work of nonfiction, but a work of fantasy; and not the story of the making of a skyscraper structure, but the story of the dismantling of one—the Empire State Building.

The Very Busy Spider, by Eric Carle. Putnam Publishing: New York, 1995. (Recommended grades: PreK-2)

Pictures to feel as well as to see while you hear or read. Children use their fingers to trace the growth of the spider's structure, the spider's web. The collages are striking, the repetitive phrases and imitative sounds appealing, and the tactile experience of the growing web is educationally rewarding.

Whatever Happened to Humpty Dumpty?: And Other Surprising Sequels to Mother Goose Rhymes, by David T. Greenberg. Little, Brown & Company: Boston, 1999. (Recommended grades: 1-6)

Outrageous gross-out sequels to 20 Mother Goose rhymes present packaging from a humorous point of view. What ever happened to Humpty Dumpty after he fell off that wall? How did Peter the Pumpkineater's wife get back at him for putting her in a pumpkin shell? Teachers will have fun using this book in poetry units.

What's In A Box?, by Kelly Boivin. Children's Press: Chicago, 1991. (Recommended grades: K-2)

A book in the beginning-to-read series, "Rookie Readers," is a good introduction to packaging for emergent readers. It describes different types of boxes, and what they may hold, using both verse and graphics.

When This Box Is Full, by Patricia Lillie. Greenwillow Books: New York, 1993. (Recommended grades: K-3)

Using an empty wooden box and twelve familiar items representing the months of the year, young children engage in inquiry-based activities. These concepts include: empty and full, inside and outside, collecting, counting, sharing, remembering and the passage of time.

Yard Sale, by James Stevenson. Greenwillow Books: New York, 1996. (Recommended grades: PreK-3)

The signs are up, the tags are on, and the animals of "Mud Flat" participate in a yard sale. In ten brief chapters, the many characters sell one another all sorts of packaged items. Very funny, enjoyable reading!

Assessment

Nearly everyone agrees about the importance of assessment, but what exactly is it, and why is it so significant in education? In a very broad sense, education is like a very large design problem and assessment is the method of evaluating the design. However, education has many objectives, not just one, so assessment also includes a complex process of deciding what to assess and how. Another major complication is that many different kinds of people have a stake in the outcome of the educational process. Parents want to know how much their children are learning and how they can best help them. Politicians worry about the backlash from voters if the educational system appears to be "failing," however that term is defined. Administrators fear that they will be held accountable for low test scores in their schools.

Teachers, who have the most sustained and direct involvement of any adults in the educational process, are constantly looking for ways of knowing how well and how much their students are learning. This data can come from both formal and informal assessment methods, and may be either qualitative or quantitative. At the same time, teachers are often held accountable to conflicting requirements that are difficult or impossible to meet. For example, the goal of providing a supportive and welcoming learning environment may be in conflict with the regimentation imposed administrative requirements. Another common concern of teachers is that high-stakes testing will require them to "teach to the test" rather than to support student learning.

Regardless of demands from outside the classroom, a teacher's primary responsibility is to engage students in exploring and understanding the subject matter. Assessment includes any method of finding out how much of this exploring and understanding actually happens. Information gained through assessment is the only factual basis for knowing what students are learning, how to motivate learning more effectively, how and whether to redesign the curriculum, how to tailor it to the needs of individual students, and how and when to involve parents in the process. Assessment is far too extensive and important to be narrowly defined by standardized test results or to be determined by people outside the classroom.

Here are some basic conclusions that follow from this view of assessment:

- Assessment should be based on clear educational goals.
- Many different kinds of information should be collected as part of assessment. Some of the most important assessment data is totally unexpected.
- Assessment should not be divorced from curriculum; every learning activity should also provide information for assessment.
- Whenever possible, students should become involved in assessing their own learning—for example, by evaluating their own designs or predictions.
- Assessment should examine not only what students have learned, but also the opportunities provided by the curriculum and the learning environment.

The following account by Sandra Skea, a fifth grade teacher at Mott Hall School, shows how assessment opportunities can arise during the course of a curriculum unit. Sandra's story of the Portable Storage System appears in Chapter 4 (pp. 119-125).

The construction of a portable classroom storage system was a project we developed to solve a real design problem. We were in need of a storage system to hold shoebox dioramas. Because the class met in several different classrooms during the week, we needed a system that would be portable and manageable.

At the time, we were exploring the properties of rectangular prisms in math class. Some students were having difficulty calculating girth, volume, and surface area from two-dimensional drawings found in the text. Even those who could do the calculations were relying on formulas they might not understand and would not be likely to remember. So aside from giving my students an opportunity to plan and work together as they designed and tested

solutions for our storage problem, my goals included engaging students in using math and in communicating mathematically. I hoped that their desire to solve a design problem would facilitate their desire to understand and own the math involved. I hoped that they would be able not only to read and interpret two-dimensional drawings of three-dimensional objects, but also to understand the math embedded in the formulas.

Initially I had planned to use classroom observations, class discussions, and the final design projects as bases for assessment. I planned to look at and assess how well the students worked together, planned their time, met the design criteria, and used the necessary math. As the project progressed, I discovered many more opportunities for assessment and I also saw many more ways to engage the students in learning and understanding the design process and math.

I used my observations of the students and their reflections at the end of each day to guide me as I created new assessments. For example, I designed homework assignments based on the questions they were asking each other in class:

- *How can we better use our time?*
- *How can we make the box stronger?*
- *Will another kind of adhesive or tape work better?*
- *How do we know ten dioramas will fit in the storage units?*

One day I overheard a student saying, "I could use a system like this to store my toys. My mother says my room is a mess!" I then devised a homework assignment asking the students to report how they could create and use a similar design for use at home.

At another point, I heard a student ask, "Who wants to be the math expert and what is the math expert supposed to do anyway?" I immediately made up a homework assignment asking the students to describe the role of each group member and to explain how the roles were assigned.

Noting how engaged the students became in responding to these homework assignments and in sharing their new ideas led me to explore other assessment methods. Since the students were so clearly proud of their work, I felt there should be a formal way for them to record their accomplishments. I decided to have each student write a final report. Students became very excited about this idea, because it would give them a chance to express the issues and ideas they had discovered. Many students included charts, graphs, and drawings. The students found these reports helpful in planning their group oral presentations.

As I circulated during work time and listened to the daily progress reports, I asked reflective questions. I learned where student understanding of various mathematical concepts was weak or incorrect. Asking students to look at parallel lines, perpendicular lines, angles, faces, and areas created learning opportunities for them and new teaching and assessment opportunities for myself.

For example, looking at a shelf in terms of angles and lines led students to discover that two right angles can combine to make a straight angle, which has l80 degrees. I discovered that a simple design problem presents countless opportunities for teaching geometric concepts, measurement, and number sense.

I introduced peer assessment and self-assessment after the design process was complete. The students evaluated the final projects, as each group presented their storage unit, findings, and ideas to the rest of the class. The student self-assessment questionnaire asked students to reflect on their storage system design, their participation in the design process, and the math and design principles they had learned.

Affording students the opportunity to engage in design and testing allowed me to assess their progress in becoming good problem-solvers. I was able to gain insight into how well they can identify a problem, make a plan, design, redesign, test and evaluate their solutions. These kinds of information are simply not available from a standardized test. A project-based assignment allows students to correct mistakes, and find out the math and design principles they need to solve a real problem. Students become good problem-solvers when they when they are allowed to explore their own solution methods.

The students' progress became apparent when they were later asked to explore the properties of a cylinder. A student suggested that the way to find the volume of a cylinder might be like the formula for finding the volume of a rectangular prism, such as a storage unit:

"If the base of the storage system times its height equals the volume of the box, maybe if we multiply the base of a cylinder times its height we will get its volume." It was clear that this student was able to connect a formula with a concept, and apply both in a new situation.

I learned from this project that we as teachers must be alert for new and alternative assessment possibilities as they arise. My goals for the project became much richer as I saw my students participate in a mathematical community that fostered exploring, interacting, and using math in a real-life context. The educational goals that evolved led to the greatest insight into how my students learn, and how they can use and communicate what they have learned. The key was that I began with a good problem, and that I allowed room for new goals and assessment methods, driven by the students' experiences in becoming good problem-solvers and masters of their own learning.

Educational Goals

In order to assess the learning outcomes of an activity, it is necessary to know what the educational goals were. However, the purpose of a curriculum unit may not be so clear-cut. Any worthwhile educational activity probably has more than one goal. Also, a teacher's goals may (and often do) change as the activity progresses, or there may be unintended outcomes that are far more significant than the original goals.

Sandra's account illustrates how the goals of an extended unit evolve as the unit progresses. Initially, Sandra saw the Portable Storage Units as a means of providing a real-world context for learning some math concepts that were difficult for her students to grasp. As the groups began to work on their designs, Sandra saw many more possible goals.

Students were learning ideas about structures, time management, group work, design and redesign that were at least as important as the original math goals. Consequently, she developed assessment methods to gauge their learning in these other areas as well. At the same time, Sandra felt that her math goals had been achieved. Evidence for this claim came after the project was over, when a student applied what she had learned from the project to a new problem: finding the volume of cylinder.

Rigid adherence to an initial set of goals assumes that the educational process is entirely predictable, which is not the case. Every teacher has both short- and long-term goals for her students, and it is difficult to know in advance when something will happen to advance the long-term goals unexpectedly. As Sandra put it during a discussion on assessment, "You can talk about goals all you want, but what I really care about is that they feel good about themselves and about what they are able to accomplish."

Information from a Variety of Sources

If educational goals are complex and multifaceted, so are the means of assessing to what extent these goals are met. The narrowest view of assessment, most popular in political circles, confines it to standardized tests. A somewhat broader view expands assessment to include all kinds of paper-and-pencil instruments designed specifically for assessment, such as worksheets, homework assignments, tests, and quizzes.

Our view of assessment is broader still. Let's look at the broad variety of assessment methods Sandra employed in the Portable Storage Structures Unit. Each day, at the end of the work session, each group was required to give a short account of their work during the day, and of their plans for the next day. Many of the issues raised during these sessions became the basis for homework assignments for the entire class. These assignments included drawing and reflective writing as well as performing calculations. The project culminated in a written final report by each student, and an oral presentation by each group. Each student also had to write a self-evaluation of his or her contributions to the project.

Part of the attraction of teaching is that much of what happens in the classroom is unpredictable, and some of the surprises are pleasant and even thrilling. Consequently, it is impossible to decide in advance what all of the methods of assessment will be. Often, serendipity provides ways of assessing students' learning that nobody could have anticipated.

Two striking examples of serendipity appear in Theresa Luongo's account of her pre-K/K class in Chapter 4 (pp. 92-99). Children who had been exploring pump dispensers decided to use them to "empty the smelly water from the water table." In other words, they saw the potential of the device to solve a new problem, one it had not been designed for. Even more significant, students who had been testing shopping bags decided to repair the broken bags. This decision led to other repair activities, such as repair of torn book covers. Clearly, these students had learned about more than the strength of bags. They became aware of their own potential as problem solvers and redesigners.

Curriculum as a Source of Assessment Data

In order to maximize the amount of information available, the curriculum itself must be seen as a rich source of assessment data. Verona Williams' story includes an account of how her students struggled with classifying bags of different types. Samples of their work are shown in Figures 4-14 through 4-19, accompanied by Verona's commentary on each student's work (pp. 102-104). There is wide variation in what they did. Some students used more than one set of categories, but did not show how they are related, such as big and little plus paper and plastic. Another student mentioned a variety of categories, and also drew large and small bags, but did not count the bags in other categories. Another gave clear descriptions of the uses of three different kinds of bags, but did not sort bags or classify them. The one student who drew a bar graph of different kinds of bags did not use real data. The one accurate bar graph was of dolls, not bags. Each of these worksheets provides Verona with a window into a student's reasoning process, while also serving as a valuable learning experience.

Students Assess Their Own Learning

Should the audience for assessment data include students themselves? Obviously, students need to know how well they are doing, so they can gauge their own efforts and develop realistic goals for their own learning. However, traditional assessment is usually presented to students in an adversarial manner, in the form of test grades and report cards that frequently undermine rather than enhance their motivation for learning. In traditional forms of assessment, students are always evaluated by adults rather than by themselves, and the outcomes of assessment often have high stakes. Both of these factors contribute to the view of assessment as an antagonistic process. How can students gain access to candid data about their own learning?

Some examples of peer- and self-assessment appear in Chapter 4. Christine Smith asked each student to fill out an evaluation sheet, which included both a self-evaluation and also a rating of each group member. Sandra Skea asked students to evaluate one another's oral group presentations, as well as daily reflections on the group process and a final self-evaluation form at the end.

In Sandra's and Michael Gatton's classes, there was an element of self-assessment that is rarely found in school settings. Both classes undertook projects intended to solve problems that were real to the students: the need for storage space. Both teachers remarked that the students had designed and constructed structures that were of real use to them, and that had actually solved their problems. The students could evaluate their own work by seeing these devices in daily use.

Assessing Teaching, Curriculum, and Environment

Like anybody else who designs or plans anything, most teachers engage in informal assessment of their work on an ongoing basis. They ask themselves, "Is it working?" This question is really one of self-assessment: "What is the quality of the learning opportunities I have provided for my students?" Some of this self-assessment by teachers is based on student learning outcomes of the many kinds described above. At the same time, teachers also assess learning opportunities on the basis of their own perceptions and experiences. Chapter 4 has several good examples of self-assessment and redesign of learning environments by teachers. At the end of her unit on packaging, Verona Williams saw several ways to improve it:

- Integrate sorting and classifying bags with a math unit on making charts and graphs;
- Replace some of the invididual activities with group activities;
- Provide time for examining how and where the bags broke during bag testing; and
- Include an activity on redesign of the bags to make them stronger.

Similarly, both Minerva Rivera and Christine Smith redesigned their packaging units in midstream to deal with classroom management issues. Minerva divided her class in two, and found another activity for those who had not become engaged in testing paper bags; while Christine devised an activity to engage those students who had already conducted their tests of pump and spray dispensers.

Sandra Skea has described at some length how she revised and extended Portable Storage Units, originally developed as a math activity, into something considerably more ambitious. Michael Gatton, by contrast, began with a very ambitious project, which he found he had to scale down to make it manageable. His concluding reflections include suggestions for trimming the project even further.

The Institutional Context

Every school is different. Each one offers both resources that can be helpful in implementing a new curriculum, and barriers that can make it difficult. It is useful to analyze both carefully, with an eye to mobilizing and extending the resources and overcoming the barriers. In this section, we will look at how some teachers have gained crucial support from school staff, parents, other teachers, and administrators as they developed new programs in science and technology.

The Custodian

The custodian is a key person in the success of any new program, which may take students outside of the classroom and into the rest of the building. The custodian is probably more familiar with the physical layout of the building than anyone else. He or she also has the best access to discarded materials, such as cardboard, waste paper, or wood, that can be very useful. A cooperative custodian can also offer suggestions about additional storage space, and can insure that projects in process will not be thrown out.

The custodian's involvement can also lead to exciting surprises, as the following story illustrates. A second-grade teacher and her class were studying the water supply system of a school in the South Bronx, New York City. They began with the water fountain just outside their classroom. The children were convinced that the water for the fountain was stored in the wall

just behind it. Then somebody noticed that there were pipes leading to the fountain. They followed the pipes along the ceiling and realized that they came from someplace else in the building. At this point they went to another floor and noticed a similar pattern of pipes. Eventually, their investigation led them to the basement. There they met the custodian, who gave them copies of the blueprints (maps) of the building, and showed them how the water came into the building. The following day, he gave them an opportunity to turn on the boiler, so they could see how the hot water was heated! The outcome of this investigation was a working 3D model of the building's water supply, in which the pipes were represented by straws and the reservoir by a basin held above the highest floor.

The Parents

Parents can also be critical to the success of a curriculum project. A number of teachers have involved parents in investigations of the community around the school. One ESL teacher in East Harlem, New York City, whose students were recent immigrants from various parts of Latin America, engaged her students in a study of the casitas in the community. A casita (literally, "little house") is a small building constructed by community residents on a vacant lot, which may serve as a club house or a religious shrine, or which may be used to house livestock. Several parents who were very familiar with the community accompanied the class on their field visits and facilitated their discussions with the users of the casitas.

How does a teacher get parents involved in the first place? Some teachers have organized parent/child workshops, after school or on Saturdays, as a way to inform parents of what their children are doing and to solicit their support. One strategy that has worked is to have a parent/child workshop a few weeks after children have begun a project. In the workshop, parents and their children are encouraged to pursue a hands-on project that is similar to what the children have already been doing in school. Because the children have already started the project, they will often take the lead in explaining the material and offer their parents advice on how to proceed. At the same time, parents will provide their own experiences and expertise, and some may become excited enough to volunteer additional support. Parent volunteers can provide the additional adult presence needed for taking the class outside the building.

Other Teachers

Just as children often require peer interaction to pursue a project, so peer support can be essential for teachers too. Another teacher can be a springboard for ideas, a source of advice on overcoming difficulties, and a friend to turn to when everything seems to go wrong. There are many models for teacher/teacher collaboration, each of which can work in some circumstances. Ultimately, the collaborators have to figure out for themselves what works best for them. Here are some examples of ways in which teachers in the same school have worked together:

- An experienced teacher gave workshops in the school, in which she engaged other teachers in some of the same activities she had been doing in her classroom. Several of the other teachers became interested and sought advice on pursuing these activities in their own classrooms.
- An experienced special education teacher mentored a less experienced special ed teacher, offering her assistance in some of the same projects she had done in her own classroom.
- A science cluster teacher met with a classroom group during a "prep" period twice a week. She enlisted the students' classroom teacher in pursuing some of the same projects as part of their regular classroom work.
- A fifth grade teacher and a kindergarten teacher decided to work together. After the fifth-graders had pursued some of their own investigations, several of them became the facilitators in helping the kindergarten children do similar studies. Besides being a collaboration among teachers, this project was also a collaboration between older and younger children.

Collaboration among teachers may be actively discouraged by the culture of the school. Even in the best circumstances, collaborations can be difficult to sustain. Just as every school is different, so is every classroom. Ideas and strategies that work in one classroom may or may not be directly transferable to another, and it is important to remain sensitive to differences in chemistry and culture from one room to the next. The most important ingredient in a collaboration among teachers is the commitment to work and learn together, regardless of the outcome of any particular project or idea.

School Adminstration

A major component of a teacher's setting is the culture of the school administration. A principal, assistant principal, or other supervisor can make or break an innovative curriculum project. Some teachers are fortunate enough to find themselves in environments that nurture innovation; others are not so lucky. For better or worse, the tone set by the administration is a major factor that every teacher has to deal with. Even without initial support, however, there are a number of strategies for bringing a skeptical (or even a hostile) administrator on board. Here are some methods that have worked.

One teacher, who was a participant in an in-service inquiry science program, had a roomful of upper-elementary students engaged in long-term science investigations, largely of their own design. She decided to encourage them to enter their projects in the school science fair. She immediately ran into the opposition of her principal, who insisted that all of the material on the display boards be "professionally done." The teacher knew that her students were invested in their projects, and perfectly capable of creating their own displays, but unable to type the material or produce fancy graphics. To make the displays for them would be to undermine all of their efforts and enthusiasm. So she presented the situation to her children, without any suggestion about what they ought to do about it.

The next time the principal visited their classroom, the students let him know that they wanted to enter the science fair, and they believed they could make display boards which would be perfectly readable. In any case, they would be around to explain anything the judges didn't understand. With the teacher standing by silently, the principal reluctantly gave in. At the fair, it became clear that these were the students who had the best grasp of their own projects, although there were others that had nicer-looking boards. Neither the children nor the teacher were surprised when they won first, second and third prizes, and went on to the District fair! Equally important, the teacher felt that this was a turning point in her relationship with the principal. Afterwards, he interfered much less with her efforts at innovation.

It is far more effective to mobilize children, parents, other teachers, and staff than to confront an administrator directly. He or she will have a much harder time saying no to children, parents, or a group of teachers, than to a individual. Also, successful programs speak for themselves. Outside authorities, such as science fair judges, funding sources or important visitors, can make even the most reluctant principal sit up and take notice. Most important, innovation succeeds best when innovators lay the seeds quietly over time, and exploit opportunities to overcome resistance.

Resist the temptation to take on every adversary, every time. Focus instead on the resources that are available to you, and learn how to mobilize them effectively. Wait for opportunities to let your efforts speak for themselves.