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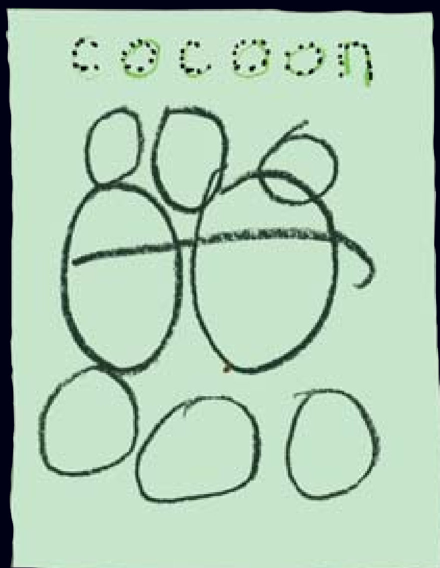
Teachers' Innovations in K–8 Science, Math and Technology

Connect®

INSIDE



THIS ISSUE'S FOCUS

Communication

Let's talk!

A small child adds antennae on a careful drawing of a silk moth; two friends negotiate whether to use cards or dice to move a marker along a game board; middle school students present and defend their findings about toxins to a community of teachers, scientists and peers; a Web page erupts from the nimble HTML commands of a lone designer. All of these examples show the importance and variety of communication in the context of learning math, science and technology. In this issue we see relationships formed, connections made, and the media employed that fulfill the Standards in math and science in rich and meaningful ways. So, read these articles, and we'll talk (or draw, or write, or sign, or IM, or . . .)!

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Student Researchers

An Environmental Science Symposium

by Greg De Francis and Rachel Van Houten

On the morning of the symposium, nervous participants file into a large room and set up their research posters on large, rectangular tables before pouring a glass of orange juice and making small talk with researchers from other institutions. They have convened to share their findings on the toxic effects of sodium chloride, sodium hypochlorite, and nitrogen fertilizers on aquatic and terrestrial organisms.

Their posters contain data tables and graphs, texts explaining experimental protocol, and photographs of test tubes and Petri dishes containing various chemicals. The audience consists of other researchers who have come to present their own findings and learn what others have discovered in their investigations. The only difference between this morning and a professional conference is the fact that these participants are in middle, not graduate, school.

Students presenting their findings at a Student Symposium

The work before the symposium

The symposium is the annual culminating activity of the Environmental Detectives curriculum project, a unique collaboration between the Montshire Museum of Science, Dartmouth College and five middle schools in Vermont and New Hampshire. Supported through a National Institute of Environmental Health Sciences research grant, this science program emphasizes student-designed investigations related to environmental toxicology research.

Students are first introduced to environmental sciences through case studies of real environmental issues and problems drawn from local and regional newspapers and other media. These case studies introduce major concepts in toxicology, chemistry, ecology, and geology. Students begin to see how the different sciences are connected in the real world, and that they can begin to study the interrelationships among the physical and living environment through their own experiments.

By the time the students participate in the symposium, they have spent up to eight weeks learning how substances such as road salt, fertilizers, and pesticides move in surface water and ground water through the environment. They have talked with visiting researchers in their classrooms and have read about local environmental problems in newspaper and magazine articles. They will have set up and tested water filtration systems of their own design, and learned how to design a “dose-response” experiment using organisms such as daphnia, radish seeds, and brine shrimp.

After eight weeks, students have a better understanding of the big picture of how we all impact the environment as well as the environmental issues in their own neighborhoods. They craft a research question that they can answer through a dose-response experimental protocol of their own design.

Dr. Carol Folt, Professor of Biological Science, Dartmouth College, discusses experimental design with middle school students.

Connecting with adult researchers

. . . teachers and students need to be more closely connected to real world problems, real research and research scientists.

The premise of the Environmental Detectives program is that teachers and students need to be more closely connected to real world problems, real research and research scientists. To connect to real problems, students read articles about topics such as the relationship between childhood asthma attacks and traffic patterns, fertilizer use on golf courses and water quality of nearby ponds, or old mine tailings and acid run-off into nearby stream ecosystems.

Scientists visit the students' classrooms and create a connection to real research. While designing their own experiments to determine the effects of salinity on radish seed germination, students meet with university scientists who are involved in similar toxicology research, but at a professional level.

We have found that student engagement and interest in a visiting scientist's presentation is greatly increased when the students and scientists are sharing similar research problems. The dialogue between the two is simply fascinating, with researchers sharing their solutions to experimental protocol problems the students may be struggling with, and the students communicating novel ideas to researchers about how they can use simple materials to carry out fairly sophisticated experiments in a middle school classroom.

Students at the symposium

The Environmental Detectives Symposium provides an opportunity for teachers and students from five different school districts to meet and share their learning with others. Students see that their research projects are not isolated assignments, but part of a larger network of students doing similar work, much like a professional community of scientists. Teachers gain insight into the ways that their peers in other schools deal with the challenges inherent in doing real research with middle school students. Also in the audience, simultaneously learning and teaching, are researchers, school administrators, project staff, professors, parents, and community members. The students receive immediate feedback from this diverse audience via questions and observations.

The question-and-answer portion of the presentation is the true test of what the students have learned—they have no idea what questions will be asked, and their answers demonstrate deep understanding of their experimental design and how it connects to their lives. In one presentation, a student research team had run an experiment testing the effect of the insect repellent DEET on the heart rate of daphnia (using heart rate as an indication of physiological stress). A student's hand popped up in the audience. The question she asked was "Will you use DEET now that you have seen this effect?"

In another presentation, the students ran a dose-response experiment on the affect of salinity on grass seed germination. When a graduate student in the audience from Dartmouth College asked the students how they came up with this research question, they responded, "We noticed a lot of dead grass along the sides of the road and we were wondering if the amount of salt put on the roads during the winter might be the reason. Then we decided to use germination as the response since we don't have enough time to see if there is a difference in the growth."

Many of the researchers in the audience were from Dartmouth's Center for Environmental Health Sciences and were very interested in the particulars of the methodologies employed by the students in their experiments. When one researcher asked a pair of students how they determined the number of replicates and the sample size they used in an experiment investigating the toxic affects of fertilizer on brine shrimp mortality, the students gave a wonderful, thoughtful response: “We were hoping to have five brine shrimp in each replicate, and five replicates at each dose. But with four different doses to test and our control, that would have added up to 125 brine shrimp! Although that might have been better than what we did, we had to share the few brine shrimp we had in the class with other research groups – so we were limited by the amount of brine shrimp our teacher was able to raise. We would like to repeat the experiment to see if we get the same results.”

Answering these questions from teachers, researchers, and project staff in the audience allowed the students to demonstrate their understanding of the scientific processes and content they have been learning over the past eight weeks. The *National Science Education Standards* for Grades 5–8 emphasize developing student abilities necessary to do scientific inquiry, from the first standard that calls for, “identifying questions that can be answered through scientific investigations,” through the whole process to, “communicating scientific procedures and explanations.” In addition to the “Science as Inquiry” standard, students also are developing their understandings within the standards for “Life Sciences” and “Science in Personal and Social Perspectives.”

Meaning far beyond the classroom

A student symposium provides students the opportunity to demonstrate their learning in an authentic environment. This particular model capitalizes on the fact that multiple schools within a one-hour travel radius are working with the same curriculum facilitated through a Museum-University-School collaboration. However, the model can work within a school. The role of the audience, which includes scientists, teachers, school administrators, parents and other community members is what makes for a meaningful experience. The different backgrounds and levels of expertise among audience members create an intellectually exciting—and somewhat intimidating—presentation for all involved. Through this symposium experience, the science curriculum breaks out of the walls of the school and embraces the students’ community. The students can then recognize that adults, other then their teachers and parents, are interested in their work, and that it has meaning outside their classroom.

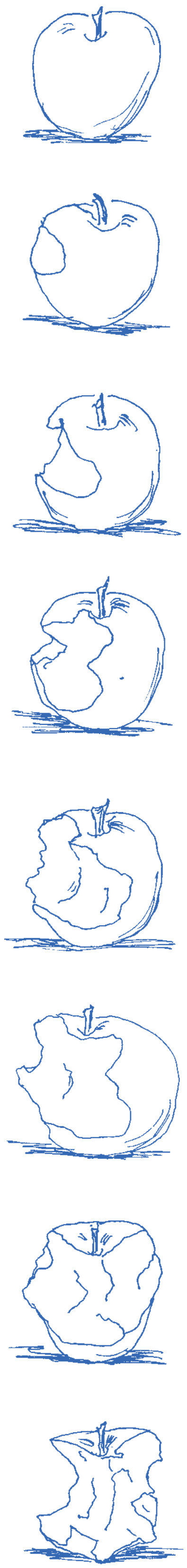
Dartmouth students and community members ask two students from Orford, NH, about their dose-response experiment data after their presentation.

Greg De Francis has spent the last 15 years helping students and teachers throughout Vermont and New Hampshire investigate science as a science teacher at the Montshire Museum of Science in Norwich, Vermont. When not actually playing with science or teaching, he manages various large educational projects and grants as part of his position as Director of Education at Montshire.

Rachel Van Houten is a science teacher and program manager at the Montshire Museum of Science, in Norwich, Vermont. Rachel has supported teachers and taught in six different schools in Vermont and New Hampshire developing and piloting the Environmental Detectives curriculum project. Previously, Rachel taught at the New England Aquarium and Lake Champlain Maritime Museum.

Sketching as a Science Tool

by Lorie Topinka and Diane T. Sands



"The most important thing we can teach our young people is to observe well."
—Ernst Mayr

At an all day workshop for teachers on common fouling organisms found on dock pilings around San Francisco Bay, we began with an overview describing the sketching activities and techniques. Participants would use these to help them understand this overlooked world of animals just under the surface of the Bay. These workshops, offered through the California Academy of Sciences as a part of the *SF Bay 2K* project, bring teachers and researchers together to enhance the understanding of marine organisms.

A teacher's hand shot up. "I know that sketching is an important tool for enhancing observation and understanding in the science classroom, and I do use it, but I don't know how to grade assignments. My students soon learn this and don't take the assignments seriously. How do I grade student sketching assignments?" In order to integrate sketching into the classroom, teachers must consider grading, standards, and measurability. The checklist presented here helps document the science observation in a way that is measurable and can be tracked to benefit both students and teachers.

Sketching discovery

Beyond the use of sketching in the classroom to achieve curricular goals, sketching and recordkeeping is essential to the careers of field scientists. Many field biologists develop the habit of keeping journals to record information in the field and, in many instances, augment field notes with detailed sketches.

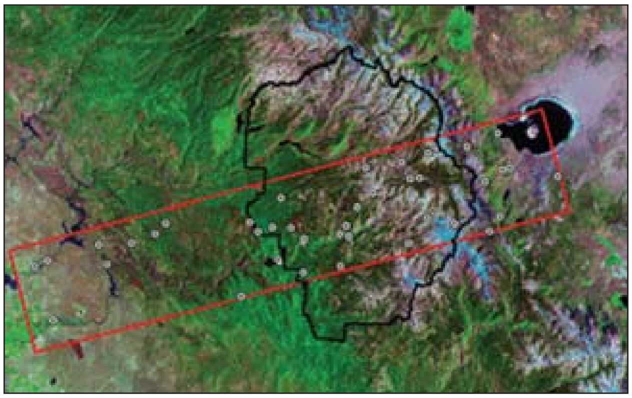
For scientists of all kinds, keeping a field journal enhances learning by providing a platform for the integration of experimental data. The sketchbook is a place where the details of research and experiments can be recorded, and hypotheses considered. By making connections on the pages of a sketchbook, scientists link observation and memory.

Two researchers, Tim W. Gallagher (Editor-in-chief of Living Bird, the Cornell Lab of Ornithology's award-winning quarterly magazine) and Bobby R. Harrison (Associate Professor of Art and Photography at Oakwood College in Huntsville, Alabama) have been looking for years for the thought-to-be-extinct Ivory-billed woodpecker. A very brief sighting of the bird on February 27, 2004, in Arkansas' Cache River National Wildlife Refuge did not give either man time or opportunity to use available camcorders. Independently, both made field notes and sketches of a large bird showing the identical pattern of white and black on the wings and back that is diagnostic of an Ivory-billed woodpecker. These field observations have become part of the supporting online material for their recent article in Science about the rediscovery of the Ivory-billed woodpecker.

Gallagher and Harrison made good use of their visual memories in producing their sketches. Observation is, of course, more than "seeing." It refers to skills associated with collecting data using all of the senses, and is influenced by the assumptions and theoretical knowledge of the observer. Gallagher and Harrison both combined their well-developed visual memories with their observational skills to sketch identical diagnostic patterns.

Capturing knowledge

Biologists, botanists and zoologists keep field journals to record what they see when they study their subject in its habitat. Field layouts, experiment set-ups, and pre-



The Yosemite Transect:
(http://mvz.berkeley.edu/Grinnell/Yosemite.html)
The transect (box), National Park (black outline) and main sampling sites (white dots).

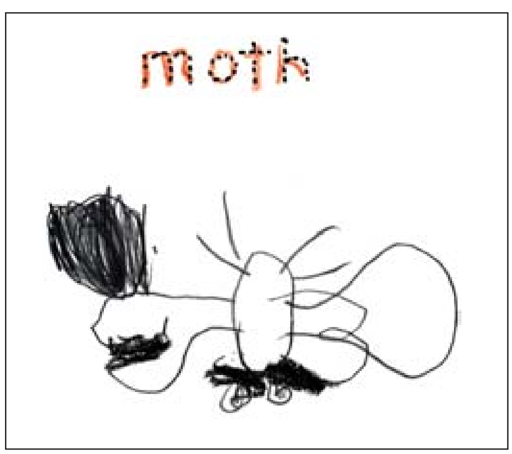
liminary results are often more easily recorded using quick sketches, diagrams, and charts than words. These field sketches can even be of use to future scientists.

Between 1914 and 1920, Joseph Grinnell and colleagues surveyed mammals, birds, reptiles, and amphibians in a transect across part of California that included Yosemite National Park. The survey included detailed field journals and accompanying sketches. The University of California Berkeley Museum of Vertebrate Zoology is resurveying this same "Yosemite Transect" to find out how occurrence and abundance have changed in the course of a century. Dr. James L. Patton, professor emeritus in the Department of Integrative Biology, UC Berkeley, and an expert on small mammals has been leading the summer survey teams. In a recent presentation, Dr. Patton related that because of the detailed and accurate field sketches made by Charles Camp in 1915 of camp and collection sites in Lyell Canyon, his team was able to revisit and collect at exactly the same places that Grinnell's team had collected at 90 years ago.

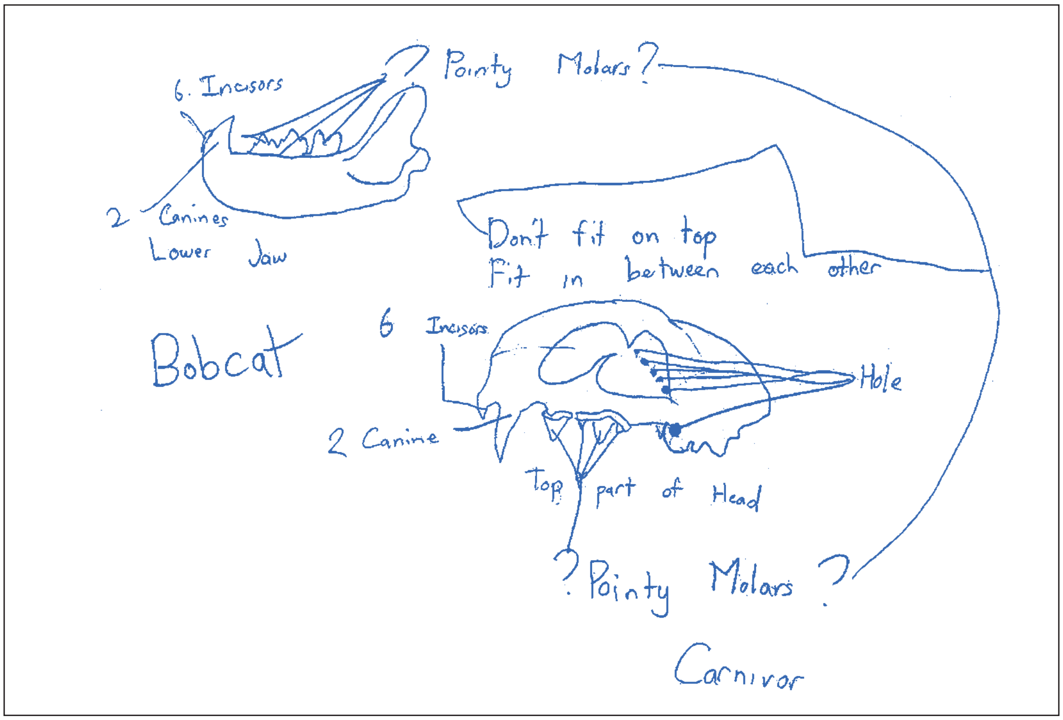
Habits of observation and a questioning mindset

For students, we are trying to develop the habit of skillful observation as a way to enhance their understanding of science. The act of sketching most often requires longer observation of a subject or object than students who are not sketching are willing to do. When first introducing sketching as an observational tool, it helps to use assignments that by their nature require many sequential observations of the same object. A favorite is the assignment to draw an apple, take a bite, draw it again, take another bite, and draw it again and again, adding lengths of paper and sketches, until the apple is just a core. Students become so interested in capturing the diminishing apple that any reluctance to sketch vanishes and time spent observing increases. By repeatedly using sketching activities with clear assignment goals that a checklist provides, students become habituated to slowing down and looking.

Sketching activities can be incorporated in the science curriculum at all ages. A kindergarten class was fortunate to have a silk moth for study and observation. When asked to sketch the silk moth, one boy first drew a simple, but unremarkable sketch, and then, after a long look at the silk moth, was observed vigorously using his black crayon to make large, black, feathery antennae. This sketch is an excellent record of his observation.



By making connections on the pages of a sketchbook, scientists link observation and memory.



We advocate the use of sketching . . . to develop the questioning mindset that is part of scientific inquiry.

We advocate the use of sketching not only to enhance observation, but also to develop the questioning mindset that is part of scientific inquiry. Students using the checklist are usually required to write down at least one question they have about the subject as they sketch it. In an elementary class studying the differences between herbivores and carnivores and the relationship between the structure and function of their teeth, one third-grader made very careful observations that are nicely revealed by the sketch, question, and comment.

One can "see" his thinking about the skull and the teeth he is sketching. He correctly labels the canines and incisors, but asks, in apparent disbelief, about the, *"?pointy molars?"* Additional comments reveal his observations that the molars, *"don't fit on top . . . fit in between each other."* He was observing that the carnassial teeth of the true carnivore are sharp and pointed and work by shearing instead of grinding. He made the correct observation that the molars from the upper and lower jaws of a carnivore don't come together as do the molars of an herbivore.

Sketchbooks combine drawing with written information to convey the entire exercise. In her popular book, *Drawing on the Right Side of the Brain*, Betty Edwards talks about the five skills needed for creating art. These skills, she emphasizes, are not drawing skills. They are perceptual skills. Journals are popular as learning tools because they reach across curricula, they are accessible to students with a variety of learning styles and abilities, and they develop a diversity of skills. The checklist makes the introduction of sketchbook techniques into the classroom work for the sciences as well as opening the door to integration with literature, math and current events.

Using the sketching checklist

Students need to be encouraged to approach their observations and sketches with method and rigor. By using this checklist, which structures the sketching exercise and gives points based not on quality of art but on careful inclusion of detail, students are encouraged to approach the study of science with a scientific mindset. The checklist helps students break down a complex visual outcome into steps that they can understand. It also serves as a reminder of the complexity of the assignment.

Teachers choose from the list of possibilities only the items relevant for each assignment. The checklist can be used all year

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Diane T. Sands is a naturalist, illustrator, cartoonist, librarian and the Archivist for the Guild of Natural Science Illustrators. She uses the sketchbook as a medium for recording the movements of the world around her.

long and the choice of relevant items varied to fit the nature of the assignment. By introducing students to sketchbook techniques and using a checklist tool, teachers make science observation through sketching measurable and easy to track. A sixth grade teacher who took a workshop at the California Academy of Sciences on *Sketching for the Science Classroom* quickly integrated the checklist into her assignments and reported back, "It makes the students take the assignment more seriously." ✐

Resources

Edwards, Betty. *Drawing on the Right Side of the Brain*. Jeremy P. Tarcher, Inc., 1989.

Fitzpatrick et al. "Ivory-billed Woodpecker (Campephilus principales) Persists in Continental North America." *Science*, 308 (2005), 1460-1462.

Grinnell, Joseph, and T. I. Storer. *Animal Life in the Yosemite*. University of California Press. 1924.

SKETCHING ASSIGNMENT

Check the items that the teacher tells you to include in your sketching assignment.

____Date (1 point)
____Place (1 point)
____Weather/temperature (1 point)
____Time (1 point)

Sketch

_____Likeness of object (1 point)
____Detail of interesting part (1 point)
____Label parts (1 point *or more* ____)
____Color or notes about color (1 point)
____Identify object sketched (1 point)
____Notes and descriptions (1 point)
____Habitat sketch (1 point)

Measurements

____Indicate size of object sketched (1 point)
____Indicate any part of sketch that is life-sized (1 point)
____If magnified, indicate magnification (1 point)

Other Things to Include

____Connections (1 point)
____Questions (1 point)

Total points *possible* for today_______

Now review your sketch for today. If you completed a checked item in your sketch, circle the point or points. Add up your points. *Or have a classmate score your sketch and you score their sketch.*

Total points for today ___________

Name ________________________________ Date _________________________

Developed by Lorie Topinka, Manager of Teacher Services, California Academy of Sciences

Picturing Conduction

by Sarah Davis

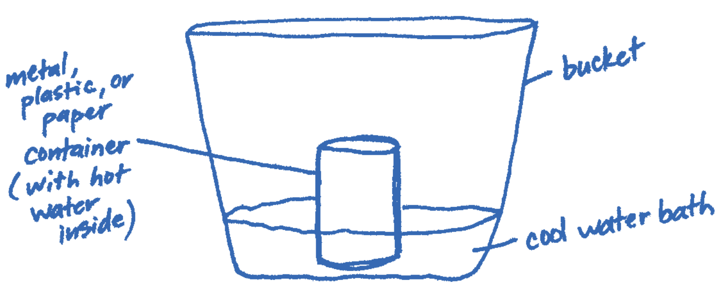
. . . multi-step drawing experiences can lead to more articulate verbal expression down the road.

Elementary school teachers often ask their students to express their scientific ideas by drawing pictures. As students learn to write, however, written explanations come to the fore, and drawings can sometimes dwindle at the middle school level. This is unfortunate! Over the years, I have started to rely more and more on drawings as learning and assessment tools for sixth, seventh, and eighth graders.

I have found that drawing can actually help students develop and refine their understanding of scientific ideas, and multi-step drawing experiences can lead to more articulate verbal expression down the road. Here is one assignment I have used when students are learning about the concept of conduction; this assignment combines both drawing and writing.

Making ice cream

In my sixth grade classroom, students learn about conduction through a unit called *Ice Cream Making and Cake Baking*.[1] A little background on the unit will help set the scene for the drawing assignment. In *Ice Cream Making*, students use experimental results to choose the optimal materials for a homemade ice cream chamber. First, students must decide on the container that will hold the ice cream ingredients; this container must allow the cream to cool quickly. Instead of wasting expensive cream and sugar in the testing process, students fill the three candidate cups—metal, plastic, and paper—with hot water. Then they place the containers in cool water baths. Every thirty seconds, students track the temperature of the hot water in the three containers and the temperature of the cooler water in the bucket. Students anxiously watch as the hot water cools and the cool water warms over time.



After students determine that the metal cup is the best performer, I ask them to explain how the heat gets from the hot water inside the cup to the cooler water outside the cup. The concept of conduction—the idea that molecules transfer heat energy by direct contact—is difficult to discuss with words alone. The idea lends itself to pictures.

I first ask students to draw a picture of what they think is happening inside the ice cream chamber. We use these initial ideas to spark discussion about the direction and process of heat flow. After modeling conduction using our bodies as molecules, students take on a more rigorous drawing assignment: create a six-frame cartoon that shows how heat is transferred from the hot water to the cooler water.

Importantly, students' cartoons undergo at least two revisions before we are done. First-draft drawings are typically quite simplistic. Just as language arts teachers guide students through multiple drafts of essays of increasing complexity, science teachers must be ready to guide students through multiple drafts of increasingly detailed drawings. I find that the cartoon format, because it is so friendly and familiar, gains some student buy-in for the teacher; students invest in the cartoons and are less likely to balk at the process of multiple revisions.

A visual text about heat transfer

The format of a cartoon works particularly well for the concept of heat transfer because it forces students to break the process into steps and pay attention to fine details. They must show the gradual spread of heat energy (from the hot water to the container, from the container to the cool water) and this leads to some fine-tuning discussions. For example, one frequent debate is about how most effectively to show molecular vibrations. Common ideas include straight lines, squiggly lines, lightning bolts, or spring shapes around each molecule.

Students often begin arguing about what looks the best, or which is most visually appealing. I ask students, "Is the hot water always vibrating the same amount from the start to the end of the cartoon?" This question reminds students that the hot water cools over time, and their drawings must show changes in kinetic energy in a semi-quantifiable way. Many students eventually decide that straight lines or squiggles are best because they can vary the number of lines or squiggles to clearly communicate varying intensities of molecular vibration. This is an important discussion, because as we are talking about drawing, we are also clarifying our understanding of what happens as fast-moving molecules collide with slow-moving molecules.

Other discussions have focused on distinguishing between the different molecules involved in the heat transfer process. Some students argue that the hot water molecules, the metal can molecules, and the water molecules in the cool water bath should all be different colors because then you can tell them apart. Others contend that this leads to misconceptions because hot water and cool water are both composed of water molecules, and so they should be the same color. While focusing on how to draw, we are hashing out scientific ideas. In his book, *I See What You Mean*, Steve Moline asserts that, "…the process of drawing provokes questions and invites clarification."[2] I have found this to be very true.

Adding the written word

After the drawings are fine-tuned, students add dialogue to the cartoon. Each frame must include at least one molecule "speaking." It's important to say here that I initially held back from giving the molecules voices and personalities, for multiple reasons. However, as I describe below, I found some distinct advantages to grounding students in the informal language of dialogue.

I begin by telling the students that the dialogue must convey what the molecules are experiencing. On the first attempt, I typically get a lot of, "Hi, Joe!" and "How's it going, Bob?" I show examples of this dialogue to the whole class, and ask them, "What do these words tell me about what is going on scientifically?" After the obvious answer, I ask, "How can we write dialogue that is scientifically rich, but is not dry or boring?" Through practice and revision, students generate countless creative and often humorous ways to tell the story of the bumps, collisions, and passing vibrations that they have drawn. An example of one cartoon frame is shown on the next page. Students find that they can communicate important ideas through casual, comical, and very informal quotes.

I find that cartoons, again because they are friendly and inviting, allow students to "grow into" more advanced verbal explanations of the process of conduction. They allow students to use their own ways of speaking to make sense before and while developing more advanced language.

Later, students can eloquently explain to me that when "fast-moving molecules collide with slow-moving molecules, heat energy is transferred from the faster molecules to the slower molecules, causing the slower molecules to move faster." The *first* step toward this explanation might be a cartoon quote that says, "Hey! That guy keeps smashing into me! Now I'm really shaking too!"

Individual feedback is essential during the process of creating the cartoons. I review and comment on each student's dialogue, and students peer conference with one another. During the peer conference, reviewers must write down quotes from peers' cartoons that clearly convey essential ideas such as "the hot water molecules are vibrating fast," or, "the cool water molecules are starting to vibrate more." These checkpoints focus reviewers on the scientific content of the cartoon quotes. Of course, reviewers are also encouraged to comment on creative or humorous dialogue, and to pinpoint dialogue that is not yet clear.

Work in progress!

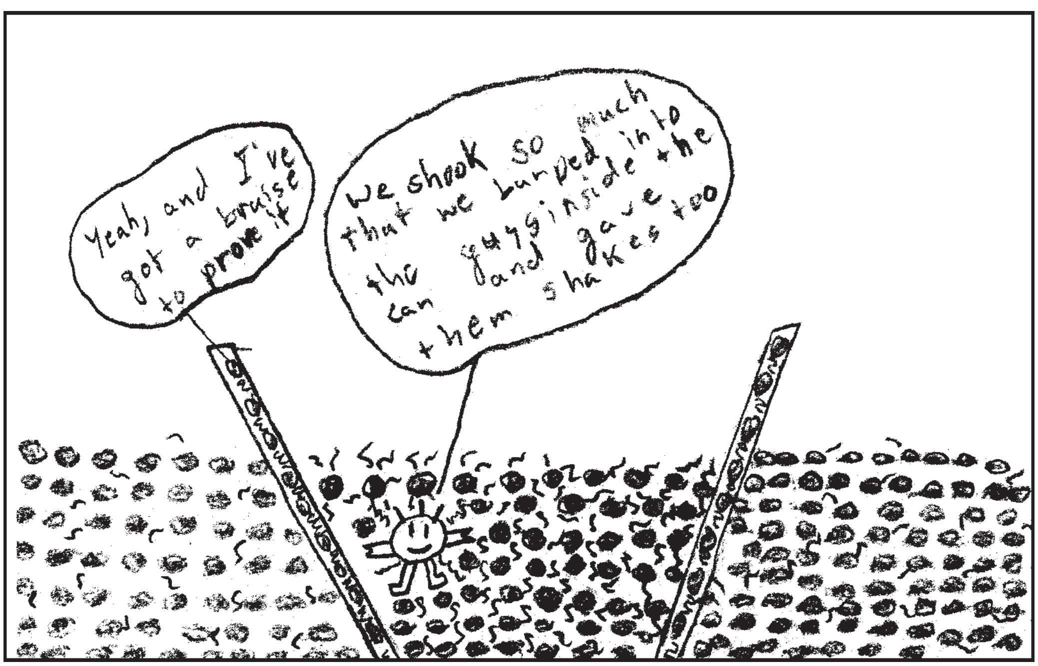
The multiple drafts of these "conduction cartoons" are intriguing records of emerging understanding and verbal expression. I know that students are learning as they make decisions about how and what to draw, and I know that they are starting to speak about complex concepts through informal cartoon dialogue.

The cartoons are definitely a work in progress for me. I wonder, could I leave the dialogue out, and would the drawings and the discussions about the drawings get students to the same point of clarity about conduction? Could this be a "pure" drawing assignment? How would it affect student investment in the project? I anticipate that my approach to the cartoon will continue to evolve over the next few years as I experiment with multi-step drawing projects.

Sarah Davis currently teaches middle school science in Hudson, Massachusetts.

NOTES

1. Bernie Zubrowski, *Ice Cream Making and Cake Baking*. (Cuisenaire, 1994).
2. Steve Moline, *I See What You Mean*. (Pembroke Publishers Ltd., 1995).



Adventures in Communication

MATHEMATICS AND ENGLISH LANGUAGE DEVELOPMENT

by Grace Coates

"The ability to read, write, listen, think, and communicate about problems will develop and deepen students' understanding of mathematics."

—The Communication Standard in *Principles and Standards for School Mathematics*, NCTM 2000

A utopian vision

The first time I tried to get my seven to eight year old students to communicate, not just mathematically but academically, I envisioned lively bilingual chatter, smiling faces, and deep thoughtful expressions as my students explored the scientific and mathematical ideas set before them.

I had just spent a summer learning about cooperative learning, science and mathematics, and how to best meet the needs of students acquiring English language. I knew and understood the research, I read what Edward De Avila had written about children learning from one another, Elizabeth Cohen's work on cooperative groups, and Steven Krashen's work on how children acquire language and use it in meaningful contexts. I placed the chairs in the recommended groups of five. I was ready for this!

In preparation

I removed every desk in the room and replaced them with kidney-shaped tables my principal had provided. He was looking forward to this as well since his own child was in my class. "OK, let me know when I can come and see the transformation," he chided me as we placed the last table.

So, what happened?

Well, let me just say that my first experience in my new Utopian classroom was not what I had envisioned. Where I had imagined cooperative dialogue, there was bickering and arguing over materials. Where I had envisioned smiles, many students wore sullen looks. A few wore triumphant smiles as they managed to take over the work or materials. Where I had hoped for thoughtful curiosity, there were pleading looks saying, "What do I do?'

I was so disappointed by these results, and my inability to change things in a way that would get my students working productively, that I brought the desks back in. I explained to my class that this was temporary, and that as soon as we learned how to make the table groups work, I would bring the tables back in.

As I thought about what had happened and how my class had behaved in the new groups, I realized they did not know how to communicate. They lacked the social experiences needed to talk to one another to get things done, explained, or shared. They did not understand what it meant to explore ideas independently. On my part, I assumed that by assigning them roles, providing wonderful mathematics explorations, and creating groups everything else would take care of itself.

A new beginning

So, we started from the beginning. In our new rows of desks we practiced asking for items from our neighbors. As we practiced, the children who did not understand English learned the names of typical classroom items like pencils, books, paper, and scissors. The monolingual English speakers learned to say, " Please," "Thank you," *"A rhombus is like a stretched-out square, shaped like a kite."*

and the name of the person they were addressing. In about a week, we were fluent with these and I paired up the desks. It was so successful the students even noticed and said how great their classroom was. So we wrote on a large sheet of paper about the ways in which our class was wonderful. Everyday I would thank them for being so awesome as I read one of the items on that public list, which kept growing as the year progressed.

Stating expectations and modes of response

Soon, we were ready to move pairs of desks together, and we became groups of four.

"As we work together today," I announced. "I will be listening for the names of the polygons we're studying this week. Before we start our work, let's review what they are. Please just call them out 'popcorn' style." This meant they could just say the words without raising their hands. "As you name them, I will write them on the chart."

Students called out the names and as I heard them I wrote hexagon, square, triangle, trapezoid, rhombus, rectangle. Students who did not speak English fluently repeated the names as they heard their classmates say them. Just to be sure everyone knew what each one meant, I taped a model of each next to the corresponding word. As promised, I set out to listen to conversations and to record what I heard. As I passed his table, Rigo looked at me sheepishly and repeated, "Rombus, rhombus, rhombus . . ." "Thanks," I smiled, "Now use it to tell me something about it." I gave him a moment and he said, "A rhombus is like a stretched-out square, shaped like a kite."

In their groups, I assigned them each a polygon to talk about. Each group would report on their polygon. Each group's assignment was to tell three true things about their polygon. "As you discuss your polygons today, I will be looking for active listeners." I reminded them. We discussed briefly what active listening looked like, and proceeded with the polygon talks.

Here was my reward for rewinding my class and starting anew.

Students were listening; I saw eyes on the speaker, heads nodding in agreement, and children asking questions. As I walked from table to table, I heard the following conversations:

Table 1

Student A: "Hexagons remind me of stop signs."

Student B: "Yeah, and bee homes."

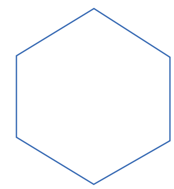


Table 2

Student A: "Triangles have three sides."

Student B: "And three corners, oops sorry." (For the interruption)

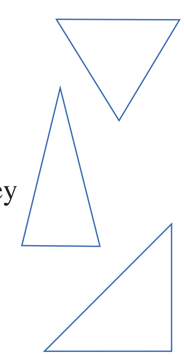
Student A: "It's OK."

There is much more, but you get the idea. Throughout the lessons we continued to listen to the words, think about our words, to practice verbally and to share publicly. We wrote public notes and referred to them daily. Our math assignments became more complex and the ideas more challenging and abstract.

THE TIGER GROUP'S PUBLIC NOTES

The Tigers' Triangles

- Triangles have three (3) sides
- Triangles have three corners
- Some are wide or they can be thin
- Some triangles have a corner like the square's corner



Extra information: Triangles remind us of baseball diamonds, but are a different shape. Some street signs look like triangles—as does a paper hat or a pyramid.

I provided primary language support for students acquiring English as a second language, and I modeled language, made expectations clear, and gave them time to try out their new skills as they explored mathematical ideas. As they worked with their peers they heard English language models, and practiced the words related to the work at hand as they reported the results of their group's findings.

What I did to bring about the change:

- modeled appropriate vocabulary and processes where needed;
- stated clear expectations and expected modes of response;
- provided open-ended mathematics investigations;
- asked questions to extend student thinking;
- allowed time for thinking and reflection;
- adapted questions to students' level of English fluency;
- established a pattern of listen, think, talk, share;
- created public notes, advance organizers, and charts to provide visual cues;
- referred to the public notes and other visual cues on a consistent basis;
- connected their language to mathematical language in meaningful contexts.

When it was time to move into groups of five we were ready. Students were on task (most of the time) and continued to develop socially and academically. Along with talking about mathematics, our discussions became laced with words like, "compared, discussed, created, agreed, disagreed," and other verbs from the cognitive domain.

There was still more to do, but this year, these students had taught me that communication was not just about my lesson plan, or even just about strategies. I learned about each child and where that child was in her development, understanding, and experience in communicating.

Grace Dávila Coates is the Director of FAMILY MATH, an international program dedicated to bringing families together for the purpose of investigating mathematical ideas, raising awareness of the role of mathematics in education, and opening doors to mathematics understanding and appreciation. She is the primary author of FAMILY MATH for Young Children *and* FAMILY MATH II.

To contact her please visit the EQUALS website at: http://www.lawrencehallofscience.org/equals/.

To inquire about becoming a FAMILY MATH site please call her directly at 510-643-6350.

Along with talking about mathematics, our discussions became laced with words like, "compared, discussed, created, agreed, disagreed" and other verbs from the cognitive domain.

Resources

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Cummins, J. "Knowledge, Power And Identity In Teaching English As A Second Language," in F. Genesee (ed.) *Educating Second Language Children: The Whole Child, The Whole Curriculum, The Whole Community* (pp. 33-58). Cambridge University Press. 1994.

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Licon Khisty, L. "Making Mathematics Accessible To Latino Students: Rethinking Instructional Practice." In Trentacosta, J. (ed.), *Multicultural and Gender Equity In The Mathematics Classroom: The Gift Of Diversity*. Yearbook series editor: Kenney, M.J. The National Council of Teachers of Mathematics, Inc. 1997.

The *Principles and Standards for School Mathematics*. The National Council of Teachers of Mathematics, Inc. 2000.

Weaving Your Own Web(site)

by Peter Selfridge

Nobody has to explain, least of all to middle school children, about the Internet and the World-Wide Web. Children have literally grown up with it as a source of information (browsing) and peer-to-peer communication (email and messaging). But while most kids and grownups alike take the Web for granted as a source of information of all kinds, far fewer have used the Web as a publishing medium. This represents a wonderful opportunity for education because creating Web pages is both easy and fun, and can augment traditional learning methods by giving kids a great way to communicate the results of their learning.

Not only are Web pages a familiar and powerful way to communicate, but the act of designing an effective Web page forces the child to organize the presentation of his or her material in a medium that allows for rapid feedback, easy experimentation and group learning.

The key to effective Web publishing is to learn *HTML* (Hyper Text Markup Language) directly. While one can create a Web page from Microsoft Word or any number of other applications (like Frontpage or Dreamweaver), learning HTML directly has many benefits. The most important of these is a direct understanding of the mechanism of Web page construction and Web browser operation. This understanding of the "nuts and bolts" of the Web demystifies this ubiquitous technology and creates a solid foundation for learning other Web technologies. Once HTML is mastered, so-called "authoring" tools are much easier to teach. But the biggest benefit, in our experience, is that learning HTML is fun because what is going on is so crystal-clear and the feedback is direct and instantaneous. This clarity makes the learning and the teaching process particularly rewarding.

HTML is easy to learn and to teach. This article describes the basics of HTML and Web publishing so that any adult, with a little practice, should be able to sit down and create multiple, linked Web pages with text, tables, and images, and should be able to incorporate Web publishing in their lessons. (Note: the instructions in this article are appropriate for PC-based computers running Windows.)

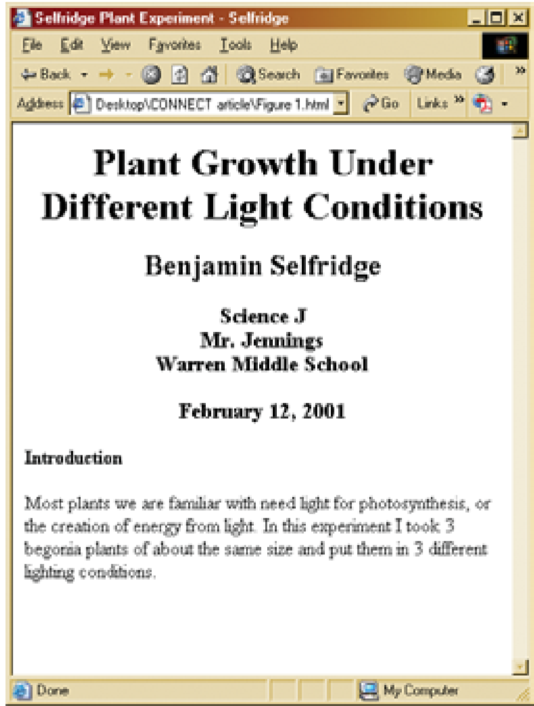
Some basics

So what is a Web page, exactly, and how is one created? A Web page is a computer file that has content (text, images, etc.) along with a set of instructions for how that content should be displayed on the computer. Web pages are viewed in a Web *browser* like Microsoft Explorer (there are others) by providing the browser with the address of the file, either on the computer or on the Internet. This address is called a *URL* or Universal Resource Locator and often looks like this: www.mywebsite.com.

On your computer, if you use Notepad to create a file with some text in it and then save it with the extension .html, you should see the file *icon* change to look like the icon of a web page. (Changing the extension can be a little tricky: in the "Save As" form you have to change the "Save as Type" selection to "All Files".) If you do this properly, when you double-click on the file it will open up a Web page in a browser and you're off and running!

HTML consists of a set of formatting instructions called *tags* that are enclosed in angle brackets ("<" and ">"). Most tags have a start tag (for example: "<h1>" tells the browser to display the text that follows as a large heading) and an end tag with a forward slash that stops the formatting (for example, "</h1>" will stop the head-

```
<html>
<head>
<title>Selfridge Plant Experiment</title>
</head>
<body>
<center>
<h1><b>Plant</b> Growth Under Different Light Conditions</h1>
<p>
<h2>Benjamin Selfridge</h2>
<p>
<h3>
Science J
<br>
Mr. Jennings
<br>
Warren Middle School
<p>
February 12, 2001
<p>
</h3>
</center>
<b>Introduction</b>
<p>
Most plants we are familiar with need light for photosynthesis,
 or the creation of energy from light. In this experiment I took
3 begonia plants of about the same size and put them in 3
different lighting conditions.
</body>
</html>
```



*Some basic HTML tags: The heading tags (h1, h2, h3) create headings of different sizes, the <p> tag skips a line, and the
 tag starts a new line of text. The <b> tag makes the text bold, and the <center> tag centers the text.*

ing format and return to normal text display).

Sticking for now to just text, you can use a surprisingly small number of tags to make your Web page look quite fancy. You can center text in the page, change the size and color, and even change the font.

More tags

Once you have the idea that HTML tags tell the browser how to format the content in the file, you're well on your way. But text is only one kind of content, so here we briefly describe how to display images, lists, tables, and links.

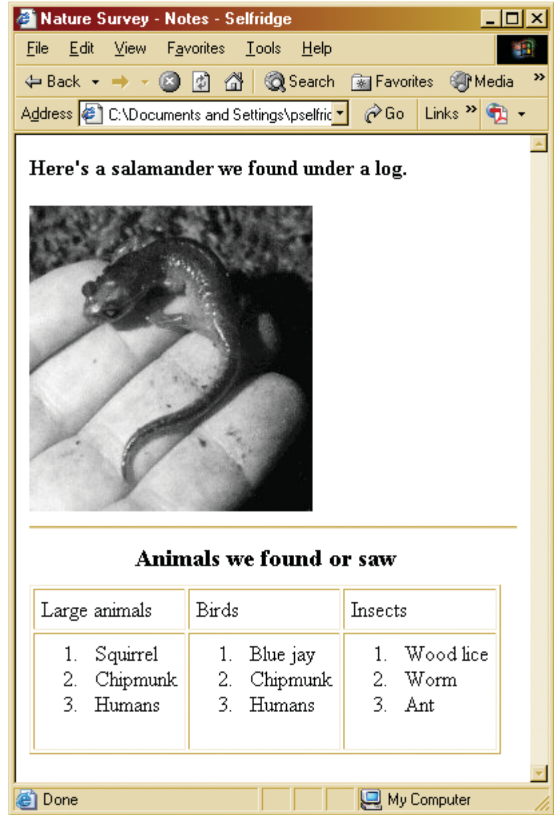
Let's say you have an image called "Image1.jpg" on your computer and you want to put that on your Web page. To do that you use the <img> tag with the "ref" *attribute* (an attribute augments a tag with additional information), as here: <img src="Image1.gif"> and the picture will be placed in the Web page.

Lists are also straightforward. There are several kinds of lists, with their own tags, but the idea is to start a list using the <ol> tag (think "open list") and then separately identify each list element using the <li> tag (think "list item").

Tables are somewhat similar to lists but have more structure and, as a result, a few more tags to keep track of. Basically, you start out with a <table> tag that says you're going to create a table. Then, you can add a caption using the <caption> tag. Finally, for each row of the table, you start with a <tr> tag ("table row") and then use the <td> ("table data") tag for each piece of content for that row.

Finally, links are parts of a Web page that when you click on them, take the browser to another page (or another part of the same page). Links can be words or images, and are created using a somewhat arcane notation. The <a> tag tells the browser that this is a link, and the href attribute indicates the URL of the link when it is clicked. What follows then is the text (actually, it could be an image!) of the link.

```
<html>
<head>
<title>Nature notes</title>
</head>
<body>
<b>Here’s a salamander we found under a log.</b>
<p>
<img src=”Image1.jpg”>
<hr>
<table border cellpadding=5>
  <caption><h3>Animals we found or saw</caption>
  <tr>
        <td>Large animals</td>
        <td>Birds</td>
        <td>Insects</td>
  </tr>
  <tr>
        <td>
          <ol type=1>
            <li>Squirrel
            <li>Chipmunk
            <li>Humans
      </ol>
        </td>
        <td>
          <ol type=1>
            <li>Blue jay
            <li>Chipmunk
            <li>Humans
          </ol>
        </td>
        <td>
          <ol type=1>
                <li>Wood lice
                <li>Worm
                <li>Ant
          </ol>
        </td>
  </tr>
</table>
</body>
</html>
```



Images, tables, and lists: This is an example of a Web page with an image, several lists, and a table. Just to show you that you can combine these tags together, the table itself contains the three lists. Note that the HTML is indented for readability but that this does not affect the layout in the browser.

Organizing and publishing your web content

Once you are comfortable with creating Web pages and linking them together, the next step is to think about how to organize a set of related Web pages. For example, let’s say you have asked your students to each create a report using HTML. The students are to design and create their report as one or more linked Web pages and can use text, images, tables, and lists. Now you want to combine all of the Web pages into a single combined site. Further, let’s say that each student’s content is in a folder with his or her name all on a single classroom computer, and that you have two different classes that you want to combine.

Organizing content like this is a little like creating a table of contents, but where each table entry is a link to the content itself. And, since you have two classes, you can first create links to two pages each of which holds the content for one of the classes. Each page will then point to the individual pages that each student has created.

So far we have described creating Web content that sits on the local classroom computer. Actually putting content on the public Web where anyone can visit it (including students at home and their parents and friends) is another step. The key word here is *hosting* which means putting Web content onto a Web *server*. A server is a computer that is registered with the Internet and has a known URL. You may be able to publish classroom content on

```
<html>
<head>
<title>My links</title>
</head>
<body>
<h2>Here are some of my favorite Web sites:</h2>
<a href="http://www.disney.com">Disney</a>
<br>
<a href="http://www.html-for-kids.com">Html-for-kids</a>
<br>
<a href="http://www.Google.com">Google</a>
<br>
<a href="http://www.Myschool.com">MySchool</a>
<br>
</body>
</html>
```

An example of HTML tags used to create links

your school's Web site. The alternative is to purchase a *domain name* and a hosting service yourself. While not free, it is not very expensive.

Suggestions for the classroom

Using Web pages as a publishing and communications medium has many benefits, including forming a solid foundation for how the Web really works, how other Web tools work, an introduction to computer programming (HTML is a simple form of programming, and our book describes a little bit of JavaScript which really is computer programming), and a sense of power and understanding of computers. Once you have become familiar and comfortable yourself with creating Web pages using HTML, you can consider incorporating it into your teaching. Here are some additional advantages and things to think about as you do so:

- Kids usually love sharing their work, which is why you probably have lots of "kid content" on the walls of your classroom. Creating Web pages is just an advanced form of sharing, and kids love it!
- Emphasize the design aspect of a Web page. It's a little like PowerPoint (which you've probably used) in that there are a multitude of presentation choices and which affect the impact of the work. Have your students actively think about and share design choices, not just content.
- Children usually learn best in the context of a project. Creating Web pages is perfect for project learning because it's a publishing medium. Furthermore, you can create projects to encourage Web content creation, like creating an on-line text or photography journal.
- It's straightforward to have teams of students create Web content for a joint project. This can be especially rewarding because students can both contribute in their strong areas and also learn from their team mates.

Many more avenues

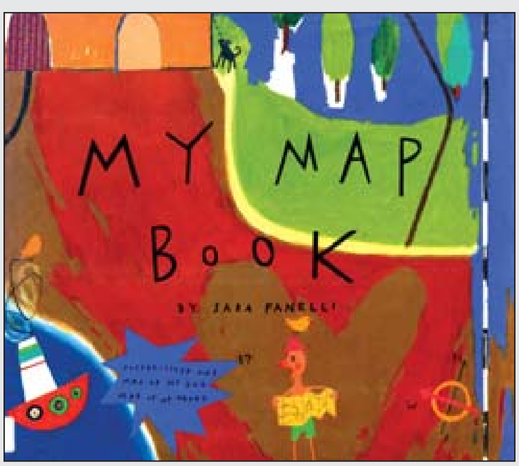
HTML is just the beginning. While novices can easily create effective content, there is a whole world of technology out there that can be explored. XML, Flash, embedding videos and music into a Web page, JavaScript, you name it! Learning how to create Web content by learning HTML directly gives students confidence and understanding that can be used to extend their learning in technology and communications. Since the Web is how so many students already gather information about the world, they can experience a whole new aspect of a world they already know!

Peter Selfridge is a computer scientist with a life-long interest in learning and teaching. When his son Benjamin was 12 years old (he is now 15, summer 2005), he taught himself HTML and had the idea of writing a book "for kids, by a kid." A Kid's Guide to Creating Web Pages *was published in September 2004 by Zephyr Press.*

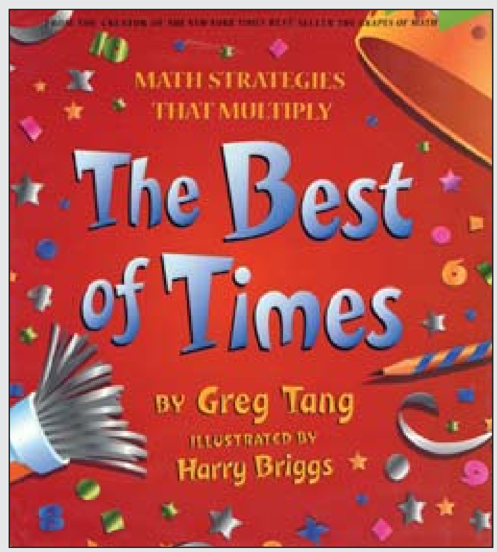
Literature Links

Top Secret: A Handbook of Codes, Ciphers, and Secret Writing, by Paul B. Janeczko (Candlewick Press, 2004), is an excellent resource written for children interested in making and breaking codes and ciphers. Drawing from historical sources, literature, and kids' games, this book covers many different ways of concealing messages. The author suggests keeping a codemaker's field kit (including notebook or journal) and a friend to work with sending and receiving messages. Organized in two sections, codemaking and codebreaking, the book outlines over twenty-seven methods. Each has examples and practice challenges with answers at the back of the book. This is an excellent opportunity for integration of language and math. Invisible ink recipes could work well in an introduction to chemical reactions. Fourth through eighth graders would enjoy this book.

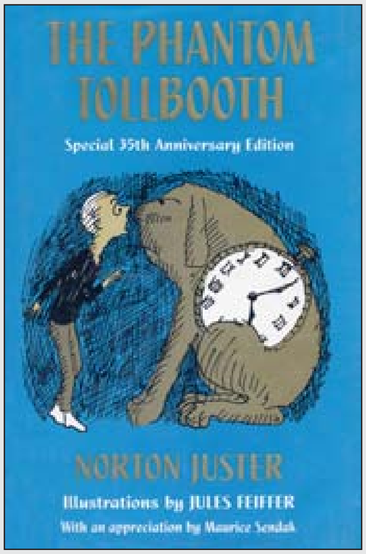
My Map Book, by Sara Fanelli (Harper Collins, 1995), is a quirky example of visual representation. Each spread of pages is a different map: a map of "my neighborhood," "my family," "my day," "my favorite foods," and "my heart." Each is stylized as if done by small children, using pencil, collaged words and letters, paint and chalk. The illustrations stand alone; there is no text other than titles and labels. This book offers many examples of various ways to show or communicate places, values, and ideas. It could be used when talking about mapping (either places or ideas) with kindergarten through fourth-graders.



The Best of Times, by Greg Tang (Scholastic Press, 2002), is a title by the same author as *The Grapes of Math*. Bright, crisp, whimsical computer designs by Harry Briggs illustrate different ways of thinking about the times tables. Zero and one are fairly straightforward; multiplying by two just means doubling a number. For threes, double the number plus one more of the number. For fours, double twice, etc. While these strategies might be helpful to certain learners, this would be used best as an alternate, not replacement to memorizing times tables. Students would need to have proficiency in repeated addition and basic concepts of multiplication before making good use of this book.



The Phantom Tollbooth, by Norton Juster (Random House, 1961), still holds up as a classic adventure for fourth- through eighth-graders. "It seems to me that almost everything is a waste of time," says Milo, the hero of the story. He receives the gift of a tollbooth and because there's nothing else to do, travels through the tollbooth in a toy car. He first enters Dictionopolis and picks up Tock, the

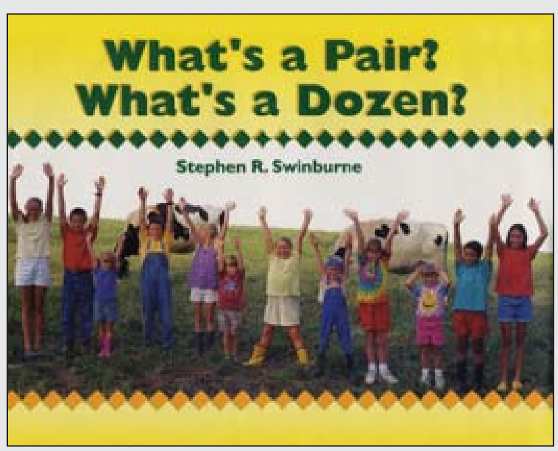


watchdog who ticks. They continue along a route visible on a map printed on the end papers of the book. In Dictionopolis, they meet the Spelling Bee, the Humbug, and Faintly Macabre, the not-so-wicked Which. Many conventions of time, space, logic, computation and expression are playfully rearranged in this tale. (The Island of Conclusions may only be reached by jumping. At one point, the Humbug wants to travel via miles because it's quicker, but Milo wants to travel in inches because it's shorter.)

If the World Were a Village, by David J. Smith (Kids Can Press, 2002), is a beautifully illustrated, large format book examining issues of population growth, cultures, distribution of wealth and resources. What if the whole world consisted of a village of just 100 people? "By learning about the villagers . . . perhaps we can find out more about our neighbors in the real world and the problems our planet may face in the future." How many villagers would speak English? How many villagers would get to eat every night? While the lists of items provide fodder for conversations about percentages, fractions, and comparative statements, the content of the lists offers the chance to explore issues beyond the classroom. "More than half the people in the global village come from the 10 most populated countries . . ." Representing amounts using manipulatives such as unifix cubes and referring to a handy map are just two simple ways to integrate these important issues into everyday math and science lessons.

Sketching Outdoors in Spring (Lothrop Lee & Shephard Books, 1987) and ***Secrets of a Wildlife Watcher*** (Lothrop, Lee & Shephard Books, 1983), both by writer and artist Jim Arnosky remain some of the best resources for helping children to look closely and record their observations. Both books feature a blend of facts about wildlife and landscapes in general, with many helpful tricks for capturing phenomena, creatures, thoughts and questions on paper. *Secrets* is a much more comprehensive "how-to," with recommendations of the best tools to use and how to use them: Keep pencils less than sharp to better convey values; always carry binoculars; get low to the ground to draw tiny things (like ducklings). These books are inspirational and even young children (not yet reading proficiently) would benefit from looking at the pictures as models of sketching.

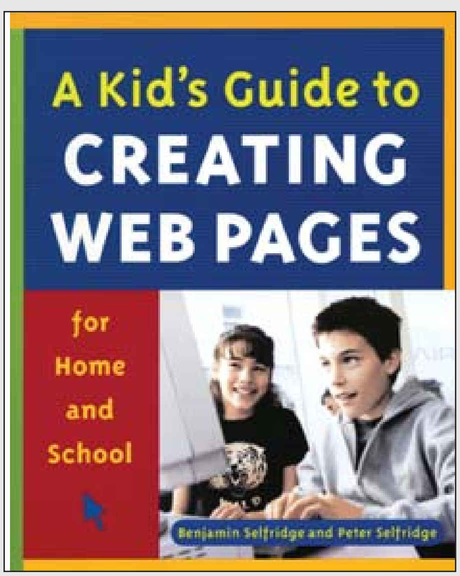
What's a Pair? What's a Dozen? by Stephen R. Swinburne (Boyds Mills Press, 2000), uses photos of school children engaged in various everyday activities to talk about numbers. Single, first, and uni- are all related to the value of one; two of something can be called a pair or could be called a couple. The concept of odd and even is introduced here, as well as general quantities such as several and many. The simple language and large text makes this a great book for early readers. This would be a good introduction to counting and number values in kindergarten through second grade.



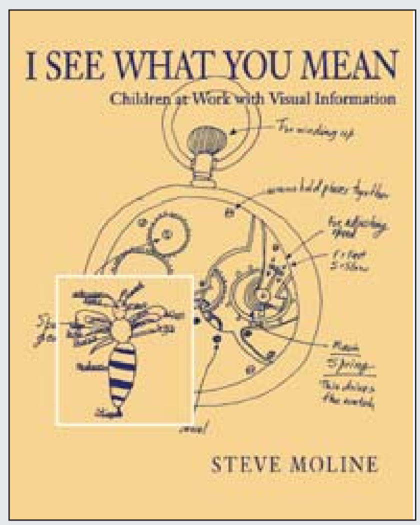
Resource Reviews

A Kid's Guide to Creating Web Pages for Home and School, by Benjamin and Peter Selfridge, is a great introduction to HTML as a basic and important tool in Web page design. Although written exclusively for PC's, this step-by-step guide is easy to follow and encouraging for those just starting out in creating Web sites. These explorations include using colors, fonts and photos to augment designs, how to link to other Web sites, using an online journal, and uploading to the Internet. There are challenge questions and tasks that test new knowledge in a non-threatening way. This book was written for eleven to sixteen year olds, but younger children with a high interest in this topic would also gain much from it. One unique aspect of the book is that Benjamin Selfridge was thirteen years old at the time of writing the book. For more about HTML, see Peter Selfridge's article on page 14 of this issue. 128 pages.

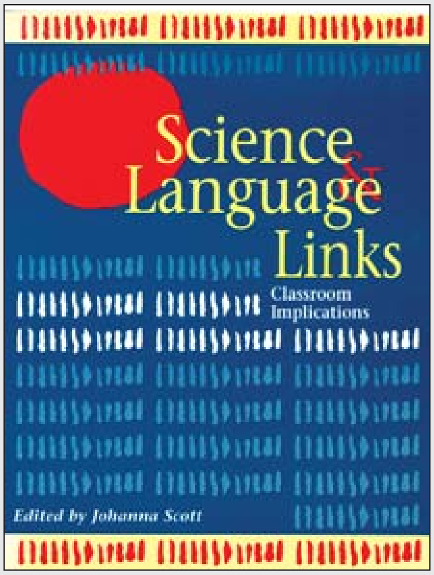
A Kid's Guide to Creating Web Pages for Home and School *($19.95), is a Zephyr Press title available from Independent Publishers Group, 814 N. Franklin St., Chicago, IL 60610. Call 800-888-4741, online at* http://www.ipgbook.com.



I See What You Mean: Children at Work with Visual Information, by Steve Moline, is a ***Connect*** favorite and has appeared in this column before. It is written from the perspective of literacy, but has many applications in communication of mathematical and scientific ideas, K–6. Moline's examples include simple, analytic and synthetic diagrams, graphs, time lines, maps, tables and graphic design. He emphasizes that the purpose of using visual information is not to "do a graph" but to make meaning in a way that is accessible, memorable, concise, and clear to readers. The author recommends combining explicit instruction and an extensive practice using a wide variety of experiences to teach students about representing data. The book has over 100 student examples and many ideas for activities. This is a useful and provocative book for teachers. Visit Steve's Web site to learn more about visual literacy for K-8 teachers: http://www.k-8visual.info/. 148 pages.



I See What You Mean: Children at Work with Visual Information *($22.50), is available from Stenhouse Publishers, PO Box 11020, Portland, ME 04104-7020. Call 1-800-988-9812, online at* http://www.stenhouse.com.



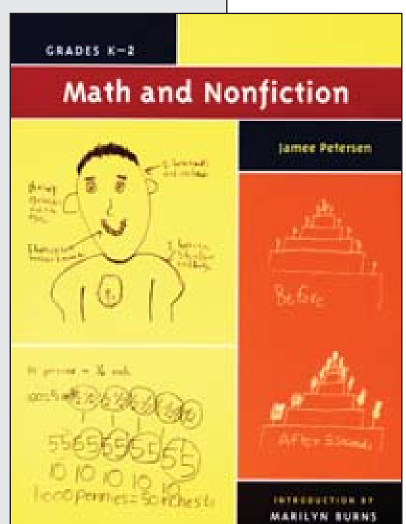
Science Language and Links: Classroom Implications, edited by Johanna Scott, is a wonderful resource that examines how language can further science learning and how science can further language learning. The text collected from several teacher/authors is broken into three distinct sections: science and talking, science and writing, and science and reading. Filled with student examples, each point is clearly stated and thoroughly investigated. Chapter 2 addresses learners of English in science classrooms. While originally published in 1992, this is still a valuable resource with many helpful questions to ponder and activities to explore. 106 pages.

Science and Language Links: Classroom Implications *($16.50), is available from Heinemann Publishing, PO Box 6926, Portsmouth NH 03802-6926. Call 800-225-5800, on line at* http:// www.heinemann.com.

Linking Mathematics and Language: Practical Classroom Activities, by Richard McCallum and Robert Whitlow, is a bare-bones but very useful collection of over thirty activities, some of them classics. Written for teachers of five to twelve year olds, the games and experiences offered here are for partners and small groups. The activities cover geometry, logic, measurement, number sense, and probability/statistics. Some background information and philosophy is given in the first section of the book. An emphasis is placed on communication between players, connecting mathematics to everyday life, and engaging in fun activities that promote critical thinking. The descriptions of activities include adaptations and extensions. 150 pages.

Linking Mathematics and Language: Practical Classroom Activities *($17.50), is available from Heinemann Publishing, PO Box 6926, Portsmouth NH 03802-6926. Call 800-225-5800, on line at* http:// www.heinemann.com.

Math and Nonfiction: Grades K-2, by Jamee Petersen and ***Math and Nonfiction: Grades 3–5***, by Stephanie Sheffield and Kathleen Gallagher, are two of a series of books from Marilyn Burns' Math Solutions group. They promote the idea that, ". . . children's books can be effective vehicles for motivating children to think and reason mathematically." (p. xi). Nonfiction books offer children a different way of listening when the stories are read aloud, and a different way of interacting with a book. Instead of reading from cover to cover, one might only read a potion of the nonfiction book. Each lesson is conveyed in a conversational tone, with plenty of reflective narration from the author. As well, children's drawings and quotes from journal entries and discussions are prominent. Each lesson describes detailed steps and suggestions. In short, these are of the same fine caliber we have grown to expect from Math Solutions. 220 pages.



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Using Data and Modeling Tools to Improve Communication in the Classroom

by

BOB COULTER

For at least the past decade, schools have sought to leverage the communication potential of the internet, video conferencing, and other technology resources. Great efforts have been made to have students communicate with peers at distant schools and with far-flung experts. Comparable efforts have been undertaken to help students communicate their ideas through web pages, PowerPoint presentations, and other tools. Since these efforts are so well documented, I'd like to explore alternative ways in which technology-enhanced representations can support communication.

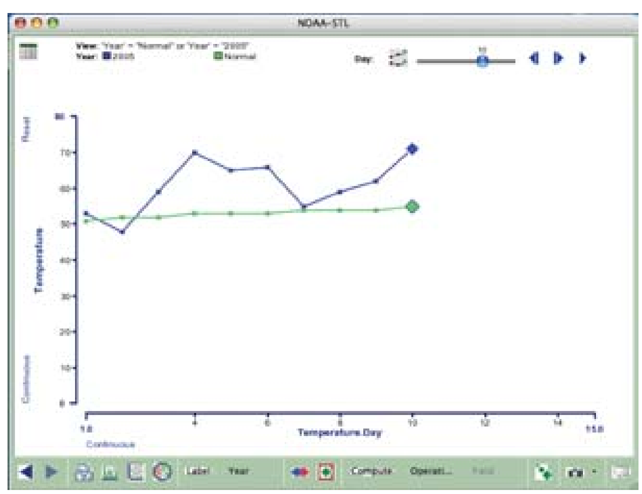
In a classroom filled with rich investigations, judicious use of data tools and modeling software can play a vital role in advancing student communications. Innovative new data tools can go well beyond the capacities of a spreadsheet to help students organize, manage, investigate and present their data. Complementing these efforts, modeling tools can help students explore phenomena that they cannot manipulate directly. Both of these approaches can enrich the quality of the dialogue happening in the classroom, which in turn can help students achieve a deeper and more nuanced understanding of what they are investigating.

To explore these complementary functions, I'll be using two new software programs—one an updating of a long-standing student data analysis tool and the other a tool for modeling the Earth system processes that drive the seasons. *Tabletop 2* is a major updating of a program that broke new ground in its first iteration in the mid-90's, with the new version offering a streamlined interface and new functions such as showing how data changes over time. *Seasons 2*, an enhanced version of an earlier program from Riverside Scientific, supports a great deal of interactive "what if?" investigations of how local and global climate patterns are affected by the Earth's position in the solar system.

Tabletop software and uses

Tabletop™ enables students to rapidly produce graphic representations of data they and others have collected, and more importantly, change the graphs instantly in response to questions that inevitably arise in the course of a rich discussion of the data. Just click on an axis label and choose the variable you want to graph. Similarly, functions such as color-coding or labeling the data, or viewing a subset of the data (such as all of the 10-year olds in the data set) require at most a few mouse clicks. At each step in the discussion, the representation the students just created can be further modified in response to new questions that emerge.

Traditional spreadsheet tools that walk the user through a 5-step wizard to generate a fixed graph simply don't facilitate this flexible use of data to develop a questioning frame of mind among students. Having to walk through the process each



Bob Coulter is director of Mapping the Environment, a program at the Missouri Botanical Garden's Litzsinger Road Ecology Center that supports teachers' efforts to enhance their science curriculum through use of the Internet and geographic informations system (GIS) software. Previously, Bob taught elementary grades for 12 years.
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time to generate a new graph poses a significant disincentive to wonder. Aided by the right tools and your support, students will develop their communication skills as they engage with data as a resource that can be questioned, debated and explored freely in pursuit of important patterns.

One of the most powerful features in the new version of *Tabletop* is the ability to "replay" data that reflects change over time. One of the sample data sets that comes with the software shows plant height measurements like those students would collect in a standard botany investigation. Just like the frame-advance function of a VCR or DVD player, you can "walk" the graph forward to reveal each day's measurements, looking for broad trends and outliers. Color-coding the data for specific growing conditions (such as high or low levels of watering) makes results for the different experimental treatments stand out.

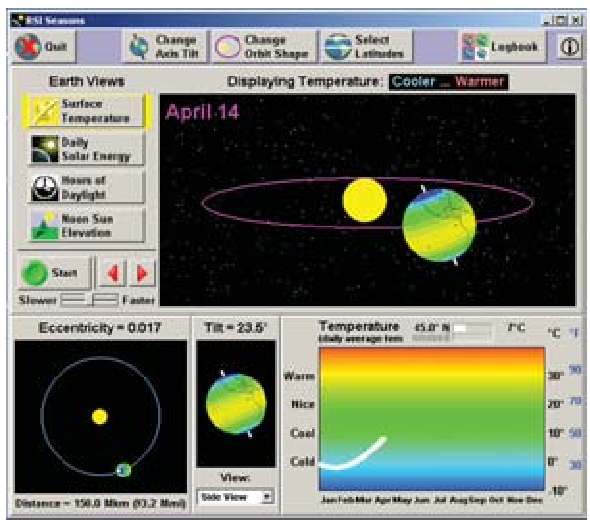
Similarly, other data—such as weather—that plays out over time can be represented in this manner. Many natural phenomena respond to annual variations in temperature. Warmer or colder temperatures can alter the timing of events such as flowers blooming, leaves emerging, and animals migrating. In the screenshot, you can see how the data for St. Louis in the first half of April, 2005 compared with "normal" data. Just as with the plant data, clicking on the forward arrow button advances both the current year and normal graph lines by a day. In this way, your students can see the season unfold in a powerful representation. Depending on the specific learning goals the data for the current year could be compared to normal, or if it better fits your learning goals, the pattern of this data over the past several years can be observed to see how much annual variation there is relative to what is "normal."

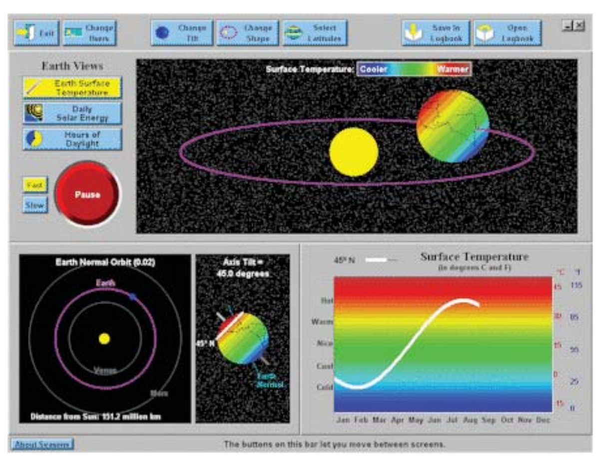
These representations provide powerful tools with which students can see data patterns, discuss and debate with their peers what they observe, and make public presentations of data as one element of a larger communication of their research findings. In the end, both their communication skills and content knowledge will be enhanced.

Using *Seasons* software with students

While *Tabletop* offers a generic data management tool, *Seasons* is an example of the potential for content-rich modeling tools. In this program, students can observe how annual climate patterns vary seasonally by location on Earth. As the model Earth revolves around the sun, the data are represented geographically (through changing color-coded temperature bands across the globe) and graphically (with line graphs showing temperature change over the course of the year at a given location).

Using the *Seasons* software, students can readily observe these patterns for their own area and investigate the seasons at different locations. In this way, important patterns are communicated using a variety of representations. Well-orchestrated discussions can help students come to appreciate the benefits and limitations of each form of representation. As they do this, students will be developing their understanding of





climate, their data literacy skills, and their oral communication skills as they formulate their growing concepts and listen to their peers' points of view.

Beyond this basic representation, the power of modeling tools as a communication method comes to the fore as students manipulate variables that cannot be altered in real life. How does the climate pattern in your community change if the tilt of the Earth's axis were more or less vertical than 23.5 degrees? How would an altered orbital path around the sun change climate patterns on Earth? The common misconception that winter results from the Earth being more distant from the Sun can be explored as these variables are manipulated on-screen with just a few mouse clicks.

As with the more basic investigations with *Seasons*, important communication is happening both directly with the technology as your students compare and contrast the different representations, and with the ensuing discussions and writing assignments that can grow out of the representations. For example, students could write science fiction about life in your community if the earth shifted its orbit or its tilt. How would they be affected directly through changed temperature patterns, and how would they be affected by changes elsewhere on the planet? Would food sources be altered? Would new shelter and fuel sources be needed?

These examples are just a few starting points from which student communication skills can be enhanced through judicious use of technology resources. Other programs will offer similar but slightly different opportunities. The key in judging the merits of a particular tool is to assess the quality of the representations made possible with the software, and the likelihood that these representations will help you to facilitate meaningful dialogue among your students. ✐

Resources

The new version of *Seasons* should be available from Riverside Scientific (http:// www.riversci.com) by September of 2005.

Tabletop 2 is in beta testing right now. The developers at TERC have told us, "We are accepting beta testers now and are interested in good beta testing this fall." You can contact them at: http://www.tabletop.terc.edu.

Games: Playing Around with Communication

by Jennifer Manwell

I am a self-proclaimed game nut: card games, board games, games with dice or spinners, strategy games, math games, new games, old games—you name it! As an educator, I love games because they offer my students ways to interact and build relationships with their peers and teachers, as well as the academics imbued with the game. While playing games, children find themselves clarifying rules, discussing content, teaching and learning from their peers, negotiating the social landscape of the class, thinking critically about strategies, and questioning each other about aspects of the game. Additionally, using board games in the classroom:

- Encourages children to *listen* to each other;
- Necessitates *negotiations* between peers: Will the game be played on the floor or on a table? Will it be played as a cooperative or competitive game? Who will start? How can disagreements be solved? What if someone new wants to join in part-way through the game?
- Promotes *differentiated learning* because a student can engage with content on varied levels and also play the games most appropriate for his or her learning;
- Enables teachers to *assess* children's problem-solving strategies, knowledge of the content, communication style, and

negotiation abilities as students *describe* what they are doing and thinking as they play games.

This list pertains to the use of existing games. Now consider the process of actually *creating* a game. Recently during Circle Time in my multi-aged classroom of seven to nine year olds, we were discussing the sources of fibers used to make textiles. We had looked at plants and animals as our two main categories, though we could have included minerals. One of my students asked, "Are we going to make a game about this?" We had spent several months perfecting a board game about grains so when I teasingly answered, "I wasn't planning on it, but that's a great idea," I was expecting to hear groans of agony. Instead, the boy who had mentioned it looked quite pleased with himself for having the idea. His peers started shooting up their hands to offer suggestions.

"We could have facts on the spaces like, 'The power loom was invented in 1784, move ahead 4 spaces.'"

"It could be like *The Grain Game*, but about weaving."

"No, that would just be duplicating what we've already done."

"How about matching cotton cloth to a picture of a cotton plant and wool to a sheep?"

And so another game idea emerged.

That same week, a student, wanting to avoid his assigned "Centers" work, asked, "May I make a game like *Creepy Cave* to help the kindergartners read better?" Little did he know there would be much more problem solving and critical thinking involved in creating a language arts game than there would be in the money activity he was trying to avoid. We made a deal, work on math for 10 minutes and then start the game.

Creating board games is, of course, not all fun and games. Teachers need to provide time, computers, art supplies, space, an organizational structure, patience for increased activity levels, and probing questions as students brainstorm ideas,

research information, make first drafts, and revise their games. It takes time on the teacher's part to plan how to proceed effectively with each step.

Inviting volunteers into the classroom can help offer the students (and the teacher) more support as they work on the different aspects of the game. However, the quality of communication—in the form of problem-solving, negotiating, revising, creative and logical thinking, strategizing, and clarifying—provides a powerful classroom experience. There is much more learning taking place than just the research related to the topic of the game.

Steps to creating a quality board game

1. Students should have experience playing many different types of games.
2. Teacher introduces the topic.
3. The class brainstorms elements of the topic.
4. The class brainstorms possible structures
   - Path game
   - Use of fate cards
   - Short cuts
   - Matching, collecting, trading cards
5. Students create a rough draft of the board.
6. The teacher frames research questions for the students to use as they gather information about the topic.
7. Students conduct their research.

(continued)

Jennifer Manwell teaches in an arts rich, multi-age classroom at The Neighborhood Schoolhouse in Brattleboro, Vermont. During the summer she works at The Creative Arts at Keene summer program in Keene, New Hampshire. She has been using and creating games for 13 years in her child-centered classrooms.

Games: Playing Around with Communication

(continued)

8. Teacher helps students organize the information into a fun format based on the chosen structure.
9. Keystroke the information as needed.
10. Students draw pictures to illustrate the game.
11. Students try out the game.
12. Students offer suggestions to improve the game.
13. Repeat steps 11 and 12 as often as necessary.
14. Teacher provides opportunity for peers, parents, or community members to play the game(s).

"The Grain Game," in which players try to be the first to get five different types of grain cards before getting to the grange for the community brunch.

The creation and use of board games is a fun (and educational) way to promote communication within the classroom. Board games provide an engaging method for introducing new information, reviewing previously taught skills, and assessing students' understandings of content. Children become energized about academic topics when they can create a meaningful product from which others can benefit. They become invested in teaching their parents, siblings, and friends how to play games they have made. Games can therefore offer parents an avenue for discussing otherwise evasive classroom experiences with their children.

A classroom that incorporates games in its curriculum is one that has the healthy buzz and the nose-down-bottom-up look of children who are engaged in conversations about what they are doing, how they are doing it, and even why they are doing it. Let's play!

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