FIELDWORK

NOTES FROM EXPEDITIONARY LEARNING CLASSROOMS

MAY 2004 VOLUME XII, NUMBER 3

1,261 Worms and Counting:

Scientific Inquiry with First Graders

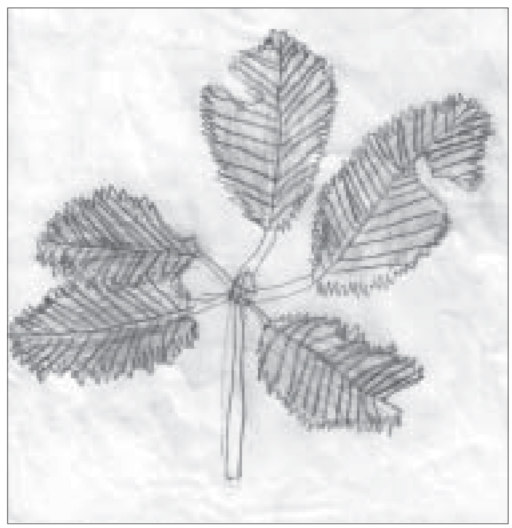
By Peter Thulson

Editors Note: For several articles in this issue, we include examples of the authors' use of effective instructional practices as well as indicators of teaching inquiry-based science from the Expeditionary Learning Core Practice Benchmarks (see www.elob.org/aboutEL/practices/html)

My first graders have been counting worms. After the New Year, one of my students brought a colony of Red Wigglers that had worn out their welcome in her mother's kitchen. They came with oozing vegetable scraps in perforated Tupperware.

They did not attract much attention for a week or so, but when students grew more interested we moved the worms into an 18-gallon Rubbermaid bin. We began feeding them banana peels and apple cores from snacktime, and coffee grounds from the teachers' lounge here at the Rocky Mountain School of Expeditionary Learning in Denver, Colorado. The worms joined two turtles, a gecko, a small forest of tree seedlings, and a dozen or so fish in our classroom.

I have been trying to increase the quality and quantity of my mathematics instruction, especially the kind integrated with my students' daily routines and with their study of an expedition topic. I started this last year after attending a workshop on data sets led by Ron Berger, a teacher and Expeditionary Learning consultant. Now my students collect data



Mason Fling, a first grader at Rocky Mountain School of Expeditionary Learning in Denver, Colorado, drew this leaf of a Buckeye tree as part of a tree study.

continued on next page

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1,261 Worms, continued from page 1

about weather on our calendar and about the growth of our tree seedlings in a logbook. Soon after Devin brought in the worms from her mother's kitchen, I decided to have students collect data from a periodic worm census.

COUNTING AND REPRESENTING THINKING

On January 11, my students counted the worms. I scooped the soil from the tub onto each of our six teams' round tables. Students noisily exclaimed at incidental observations and asked questions as they picked through to find and count the worms. Each team reported its findings. Together, we totaled the results. We found 126 worms.

We are really studying trees. We are gearing up for a large tree planting project. Worms are just among the things turned up along the way. Connections present themselves. Occasionally the worm team will feed a failed seedling to the worms. As an experiment, we repotted several seedlings in worm castings instead of potting soil. The worms show how lives draw on past lives and contribute to future ones.

We kept track of questions as students brought them up for discussion or further investigation. How long do the eggs take to hatch? What food do they like best? Which end is the front? In addition to the mathematics goals, I wanted to cultivate an understanding of life cycles and skills in scientific inquiry.

To record the results of our census, we used Unifix cubes to represent the worms. Each team built a color-coded tower with a cube for each worm in its count. Students' built their understandings at different levels of sophistication.

> "They were 1000 percent slimy! I did see a lot of pink on the worm. It had black things, kind of circlish. They were inside the worm and you could see right through the worm. I thought it was very cool."
>
> *Elise, first grader*
> *Rocky Mountain School of Expeditionary Learning*

Jay is younger than his classmates. It was not long ago his writing had a real-time, one-to-one correspondence not to his words, but to the actual events in the story. The marks he made on paper had a more magical than phonetic relationship to his story. The Unifix cubes retained some of that concrete magical relationship to the worms they stood for.

"I wanted to just grab every single block to make a big huge tower that's more than our stuff, maybe a hundred or something," Jay said. "I pushed myself to how much I wanted to do for the worms and each block makes a worm, so we were, like, putting together worms, like, killing them and putting them together, but we didn't really kill them, we just didn't use worms, we used something else."

As time went on, our representations became more abstract. By the fourth census, we had scrounged all the Unifix cubes in the building. Students cut and taped together strips of colored paper equal in length to their teams' Unifix cube towers. Our 936 worms had provoked the interest of several high school students in our school. They were using curve-fitting strategies to predict the outcomes of each census with amazingly accurate results. Their visits provoked more confidence and sustained effort in first graders.

> Good practices foster character by inspiring each student to develop craftsmanship, perseverance, collaborative skills, and responsibility for learning. They promote critical thinking by asking that students make connections, perceive patterns and relationships, understand diverse perspectives, supply evidence for inferences and conclusions, and generalize to the big ideas of the discipline studied.
>
> *Expeditionary Learning Core Practice Benchmarks, p. 18*

PREDICTING, ANALYZING, AND BUILDING THEORIES

The practical necessity (running short of cubes) seemed to help students' readiness to

continued on page 5

Whose Questions Are They?

Inquiry-Based Teaching and Learning in Science

By Scott Gill

Silence. What an awkward moment for a teacher who has just asked a question. A basic question and they should know the answer. Yet, silence.

"What type of rock do you think this is?" Silence.

I know they know. I know they studied geology in fourth grade. Perhaps they were preoccupied with the thought of rappelling down the face of the cliff. But I want them to know something about the rock they will be rappelling down.

"There are three major categories of rocks named by the manner they were formed. Which group of rocks would this belong to?" Now it was feet shuffling silence as the group of sixth graders stood at the base of the limestone cliff.

How often in my many years of teaching science did the questions come from me and fall on deaf, tuned out ears? Even our experiments were cookbook in approach—students followed the step-by-step procedure and got predictable results. After completing the experiment, students would then answer the questions on the publisher's consumable lab sheet. Boring!

Camp Ewalu in early May and the sun feels warm as it penetrates the developing squirrel's ear-sized leaves budding on the oak trees. As part of a three-day, science-based outdoor education experience for sixth graders at Table Mound School in Dubuque, Iowa, I had agreed to teach a session on rappelling.

The last student was making her way down the cliff when I heard the next group heading my way. A group of about 20 students every 90 minutes. Think, Scott. How can I get the questions to come from the students instead of from me?

There was a time in my career when I would not have asked this question. Through Expeditionary Learning I have experienced the value and power of personal as well as peer critique and revision. Using effective instructional practices, as described in the Expeditionary Learning *Core Practice Benchmarks*, has taken my practice to a new level of active pedagogy that really engages students.

In Expeditionary Learning science classrooms, students are doing scientific research, inquiry, and problem solving. As teachers, we need to ask our students to represent and reflect on their thinking, take and defend positions, and consider multiple perspectives. As teachers, we need to reflect on our practice and ask ourselves, as I did at Camp Ewalu, how to make the required science topics compelling for students to learn.

The exciting times in my classroom were when the questions came from the students. When students were faced with a discrepant event, something that did not make sense. Trying to make sense out of something, that is when learning accelerates.

"Before we go rappelling, it is important that we know more about the rock in front of us. Without talking, I want you to go up to the rock, look at it closely, and think of two or three questions you have about the rock." The students wandered to the face of the rock and stood around. Most stared nervously at the rope dangling to the base of the cliff. After a couple of minutes, I called them back together. "What are your questions?"

They asked a few questions

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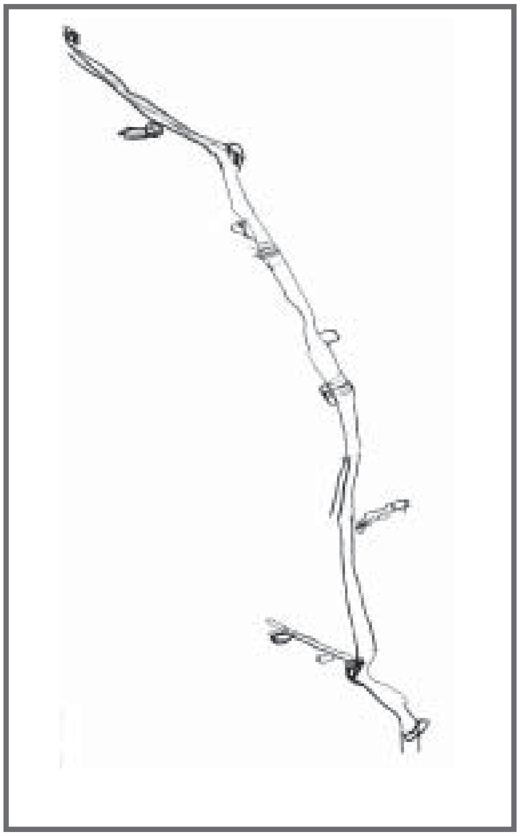
Molly Morein, a first grader at Rocky Mountain School of Expeditionary Learning in Denver, Colorado, sketched this winter twig from a London Planetree.



Whose Questions, continued from page 3

such as "What kind of rock is this?" and "How can those plants grow from the rock?" But, unfortunately, the most compelling question was "Is that the cliff we are going to rappel down?"

Hmm … better, but still not there. As I assisted the students into the harnesses, I realized I needed a better strategy. So, how do I get the content-rich questions coming from the students? What instructional strategies cause a student to wonder, to think, to make sense? As I discovered at the rappelling cliff, I needed to have the students look, analyze, and come up with their questions. But even when I asked students to think of questions, it was obvious that the dangling rope competed for attention.

One more group to rappel after lunch, more time to strategize. While hiking back to the lodge for lunch, I passed another limestone outcropping. Looking closer, I found a small broken piece of rock on the ground with shell fossils. This might be it–this might be the hook.

After lunch I hurried to the rappelling site. I left the rappelling equipment out of sight, the rope still coiled at the top. When the students arrived, I was sitting, looking at the fossil. The students just gathered around and were inquisitive about what I was studying. As they sat around me, I passed the fossil around and questions started to erupt. Without answering the questions, I asked them to partner up and head to the rock, then without talking, individually come up with a couple of things they noticed and caused them to wonder about. Then with the partner, share the thoughts and as partners decide on one good question they would like answered about the rock.

How often in my many years of teaching science did the questions come from me and fall on deaf, tuned out ears?

Part of the success of the strategy is to have students first give thought individually and then pair up and discuss their wonderings. By expecting each pair to respond with one good question, students learn to evaluate their questions, determine importance, and use the power of persuasion to come up with an agreed upon question.

Even then, my tendency has been to answer the students' inquiries rather than turning to the group and prompting them to respond by asking another question. By turning to the group, I discovered my ability to check for understanding, prior knowledge, and the need for explicit instruction on the points where there is not group knowledge or where there may be misunderstanding.

Off they went, inquisitive eyes searching for something, anything. Then in pairs, talking, discussing, even arguing about what the one question should be.

We were sitting in a circle at the base of the rock and they began. The question almost leapt from Josh's mouth. "We think this is limestone, but we want to know what caused the holes in the rocks." "What makes you think it is limestone?" I replied. "I know!" Andrea almost interrupted my question. "Because we found a fossil over here." "You did?" "Yeah, want to see?"

I smiled as the group sprang from the circle to follow Andrea and Stephanie to the rock. I even had to bring the "rock talk" to a conclusion so that all of the students would have a chance to rappel before their 90-minute session was up.

Scott Gill is the field director with Expeditionary Learning in the Southwest region.

EXAMPLES OF ACTIVE PEDAGOGY

~ Questioning and Following Student Thinking

~ Using Exemplars and Models

~ Multiple Drafts, Revision, and Critique

~ Reflecting and Debriefing

Expeditionary Learning Core Practice Benchmarks, p. 19

1,261 Worms, continued from page 2

leave the one-worm, one-cube representation for a next step of abstraction. Students enjoyed predicting how far our enormous horizontal bar graph would wrap around the corner along the next wall. They all seemed clear on its connection to the fertile worms in the tub.

After students had written about the counts and discussed the implications, I showed several how to reproduce their data tables as spreadsheets on the computer. Then they had the computers chart the data (two clicks). The resulting bar graphs made perfect sense to them—in ways they would not have without the intermediate steps. They began to reason more flexibly with the data.

After interviewing individual students, I became interested in their theory building and use of evidence. Jay provoked a lot of discussion after he insisted there were no more worms than when we began.

His theory seemed to spark thinking about other questions. From the beginning, I started each census by scooping roughly equal amounts of soil from our tub onto each of the six teams' tables. Different teams ended up with different numbers of worms, a fact they eventually questioned. When we discussed the discrepancy recently, three explanations arose.

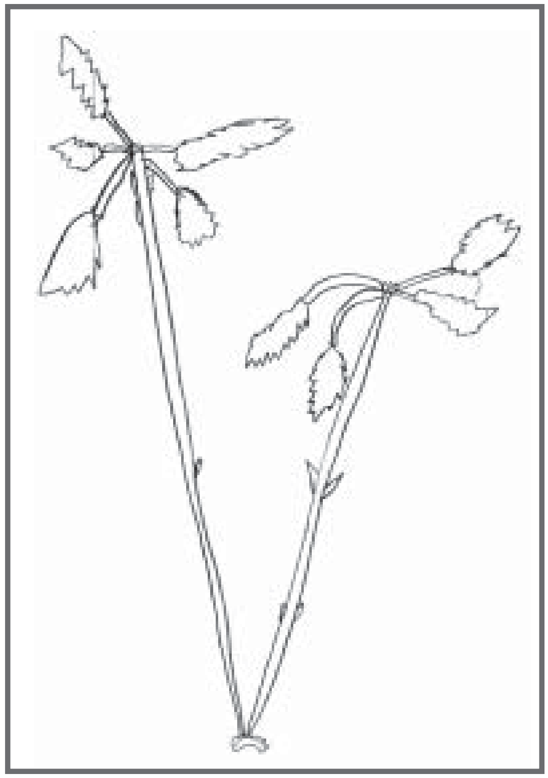
Emma spoke right up. She is a precocious reader and thinker with extensive background knowledge on most topics. "God," she said. "It's because God just, decided, this team should get more, this team should get less, this time." I restated Emma's explanation and several heads nodded.

Then Devin spoke up. "The worms like to stay at the bottom. Peter took scoops from the bottom sometimes and sometimes he took scoops from the top so they didn't get the worms as much."

Molly proposed a third explanation. "I think maybe some teams counted wrong. When we counted, some of the worms were really small and somebody could have not seen them. They counted wrong, but not my team."

I restated all three explanations. A little more than half the students favored Devin's explanation. The rest split fairly evenly between God and Error. Could we find the truth?

Jay provoked a lot of discussion after he insisted there were no more worms than when we began.



This Northern Red Oak seedling was drawn by Corey Nuechterlein, a first grader at Rocky Mountain School of Expeditionary Learning in Denver, Colorado.

FURTHER INVESTIGATION

The question of whether and why worms preferred the bottom of the tub engaged all three parties. Explanations revealed differing levels of sophistication.

"They don't like it when the scoop touches them or when your hand touches them," Enzo said. " When your scoop comes, they say, 'Go down! 'cause they didn't like it and the little worms say, 'Wormie see, Wormie do!"

Enzo's anthropomorphic explanation is typical of young children, but it accounts in a sophisticated way for the fact that not all the worms in subsequent counts could have learned from past experience with the scoop. He provided for the worms' transmission of knowledge between generations.

Other children ascribed the worms' preference to wetter conditions at the bottom or to the fact that we usually put juicy scraps back into the bottom of the tub. Eventually, Phoebe proposed a test of Devin's theory. She proposed counting worms in scoops from the top and from the bottom of the tub. Almost everyone

continued on page 10

Investigating Maple Syrup:

A Slice of an Expedition

By Sally Kent

Over winter break I made my own artificial maple syrup. When I served it over pancakes to my 12-year-old daughter Margaret and her friend, they dubbed it delicious. That is when I knew I had my work cut out for me. I wanted my sixth-grade science students at Framingham Middle School, in Framingham, Massachusetts, to care about pure, local maple syrup, and by extension Massachusetts sugaring farms. Lousy artificial syrup would have been a great start.

I am bracing myself for them to determine that the artificial is easier and still tastes really good.

Our team's yearlong multidisciplinary expedition, *Do Small Farms in Massachusetts Matter?*, has had many seasonal components, including harvesting, preserving, and in-depth studies and experiments on photosynthesis. With spring arriving, I am getting ready for a two-night stay at the Farm School in Athol, Massachusetts, with my 30 students and teammate, humanities teacher Patrick Colonna.

At the farm, they will prepare meals, take care of animals, tap maple trees for their sap, and produce maple syrup. Learning the process of sugaring is a very natural and field-based approach to covering the required curriculum of natural cycles, and continuing our study of photosynthesis and respiration and the reason for seasons. Also, by instilling a scientific interest, or even a passion, for natural maple syrup before farm school, I am hoping the students will connect more personally with the experience, and perhaps even come to their own conclusion that small sugar farms in Massachusetts matter.

During my mid-course planning, I determined that my students needed to understand the difference between natural and artificial syrup before our stay at the farm. After brainstorming and doing research, I decided to set up a scenario where the students could become taste experts or taste critics.

On the Internet, I came across examples of how to do taste testing, including a discrimination test and a quality test. I also found out that the Natick Army Research Lab (10 minutes from our school) performs sensory tests professionally to prepare meals for soldiers. I contacted the lab and set up a date for the students to visit and receive training in quality sensory testing.

Students are given multiple opportunities to engage in complex, problem-based activities, labs, and investigations, and to represent and analyze data.

Expeditionary Learning Core Practice Benchmarks, p. 27

PREPARING FOR FIELDWORK

First, the class needed to experiment a bit on their own to gain some background knowledge for their fieldwork experience. One morning my students walked into the classroom to see the tables covered with tablecloths and set with plates and cups. They would experience their first test—a discrimination/triangle test of three different artificial syrups. The students rotated in pairs through eight stations. Each station had two of the same and one different syrup in identical, labeled cups.

Their task was to identify which two syrups were the same at each station. Circling through, they only talked to their partner, smelling, tasting, pouring, recording, and dropping their anonymous answer into a box. Next, each pair selected a station and I gave a quick mini-lesson on preparing a frequency graph of the results to determine the most likely two syrups. This helped students realize that the more individuals that sampled them, the more likely they would be to get the correct answer. We also talked about how their decisions may have been influenced by their partners. The class generated many research questions that day, some about natural syrups and some about artificial syrup.

VISITING THE LAB

At Natick Research Lab, our hosts, scientists Armand Cardello and Alan Wright, instructed us on how quality testing is done when selecting foods developed for the soldiers. They also discussed the discrimination test. The students felt reassured that they had already done a test similar to what professionals do. Cardello, a research psychologist, and Wright, a food scientist, trained us in how to test for sweet, sour, bitter, how to smell for off odors (offensive odors) and natural odors, how to look for thickness, and so on. We learned about the importance of observing silence and not communicating during testing.

Next, we did the testing ourselves. We each sat in an isolated booth and completed a computerized survey designed to rate the quality of a generic artificial syrup, Aunt Jemima syrup, and a natural maple syrup. Each student received samples of the three syrups, one at a time, through a tiny door in the booth, tested it and then rated it and recorded the answers to 10 questions on the survey (Is it sweet? Does it have a natural maple odor?, and so on).

Before we left, our hosts displayed our results in beautiful, colorful bar graphs on a large overhead projector. The graphs demonstrated that the students preferred the familiar taste of Aunt Jemima to the generic artificial, or to the natural maple syrup. The students returned to school motivated and excited, but admittedly starting to dread that maple flavor! And, it was just the beginning.

CONDUCTING OUR OWN TEST

The following day they began preparing to make their own syrup. Over the next few days, students found recipes on the Internet, and figured out how to prepare and make their own artificial syrup. Ingredients such as cartons of brown sugar, bottles of corn syrup and artificial maple extract came from home. They adapted the recipes and carefully recorded ingredients and procedures, including temperatures and times.

The class prepared their own survey sheet based on the questions from the Army Research Lab survey and set up stations for more than 100 schoolmates to circulate through. The testers each rated between two and five of the student-made syrups. This time, the students created more complex frequency graphs and averaged and calculated percentages to determine the most popular syrup. This led them to think about changes they should make in their ingredients or procedure for making syrup.

During the preparation of the syrups, we generated many questions and posted them in the classroom. While students will pursue many of the questions at farm school, we answered others with experiments during science class.

The team is almost ready to leave for farm school. The students have been working on this expedition in every subject, and have raised enough money through service projects so that each student will only have to pay $50 for the trip. They will truly understand there is a big difference between artificial and natural syrup. I am bracing myself for them to determine that the artificial is easier and still tastes really good (they got a lot of compliments on their syrups in their surveys).

I will need to help them understand all of the processing that took place in the ingredients of their artificial syrup and compare that to the natural. They might create a map that begins with the final product and traces the ingredients back to their geographic origins. The natural will be easy, but the artificial will be quite complex, some ingredients may possibly come from different countries. *Do small sugar farms in Massachusetts matter?* Will they have answered a piece of their question?

Sally Kent teaches sixth-grade math and science at Framingham Community Charter School in Framingham, Massachusetts.

IN PURSUIT OF ANSWERS

One student unexpectedly brought in a gallon of maple sap from home. Our research had already determined that there is a 40:1 ratio of sap to syrup, so we discussed what that meant and what happens when we boil it. What is the purpose of boiling? Was it just to sterilize? Some were wondering why the sap hardly had an odor and why it looked like water. We discussed what happens when it boils. We agreed unanimously that we needed to confirm our 40:1 research, so the class began measuring volume, boiling, and timing.

—Sally Kent

Whose Bones Are These?

Building Curiosity and Knowledge through Literacy

By Cyndi Gueswel

We kept glancing at our watches. We were behind, but we simply could not interrupt. The participants in our conference session conversed intently as they rearranged the photos of skulls, explained their reasoning, questioned one another, picked up a skull and puzzled over it again, brows furrowed.

The participants had completely immersed themselves in a workshop on teaching inquiry-based science that I facilitated with fellow school designer Tony Altucher at the National Conference in Seattle, Washington, in March. We wanted to provide an experience for educators that demonstrated building curiosity and background knowledge, and integrating literacy instruction into science content. Our hope was that these educators from across the country could take back content and tools to use with their upper elementary, middle, or high school students.

A FOCUS ON LESSON DESIGN

~ Teachers sometimes start a lesson or an investigation with a complex or provocative problem...

~ Teachers activate and build upon students' prior knowledge.

~ Students use manipulatives as tools for thinking and representing.

~ Each lesson incorporates strategies to build curiosity and has a sense of urgency and purpose.

~ Every student has a role and/or a responsibility for producing something that shows his or her thinking.

~ ...students do the thinking and the work.

Expeditionary Learning Core Practice Benchmarks, p. 19

We had asked our class to examine 10 different pictures of skulls or skeletons copied on cardstock and work with a partner to place them in chronological order. Participants filled out a two-sided recording form, tracking the inferences they were making, the evidence they were using to make those inferences, and their questions (see example on website). Also, they recorded the agreed upon order as well as the features they had used to determine that order.

REACHING CONSENSUS

Next, in groups of four, the participants had to come to consensus on the order of the skulls and skeletons. Tony and I defined consensus as everyone in the group understanding, agreeing, and being able to explain their thinking. We stressed the importance of consensus, so participants took it to heart.

One team went beyond the request to put the bones in simple chronological order; they were building a phylogenetic tree (similar to a family tree, a diagram showing related groupings). Another team not only discussed features used to determine age, but also mused about the age of the person at death and the cause of death, knowing that these facts would also have an impact on order.

About 45 minutes later, each group finally reported out its order, reasoning, and questions, all of which we scribed on large anchor charts. It was time to reveal the answers. We had saved a final column on the anchor chart for the true chronology showing each group's responses, so they were easy to compare. To build the drama, we wrote up the answers with the chart facing away from the participants, and then spun it around. Exclamations of surprise and confirmation let us know that indeed, they were hooked.

Discussing the discrepancies and new information (name, classification, age, and location) led us to a new round of questioning. We revisited our original list of questions, answered what we could, and proceeded to revise other questions and add scores of new ones. In a classroom, this is exactly what you hope for with your students: that the immersion work you do drives their need to know, their urgency about a topic. In an actual classroom, those questions would have guided our next steps in the expedition, determing areas where we needed to build further knowledge, and clarifying topics the students were highly motivated to investigate deeply.

CONTROVERSY AND DEBATE

For this session, Tony and I had chosen to leap into a specific issue. Guided by the overarching question "Whose bones are these?" we delved directly into the controversy surrounding Kennewick Man, a skeleton discovered in 1996 on the banks of the Columbia River, near Kennewick, Washington. Five tribes have claimed him and wish to repatriate his remains. Archaeologists want to retain him, seeing a great loss for scientific study if he is reburied.

We used an editorial from *The Denver Post* entitled "Balancing Science, Culture: Do Scientists Have Rights to All Finds?" (11/29/1998) by Vine Deloria Jr. to continue building curiosity and background knowledge and intentionally incorporate literacy instruction. We modeled looking for persuasive language by doing a think-aloud using the first paragraph of the article.

Next, participants finished reading the article on their own, highlighting persuasive words and phrases. In our group debrief, we discussed not only Deloria's opinion (that Kennewick man should be repatriated), but also how he chose to convey his opinion and whether or not he was persuasive. The curiosity was continuing to build; not only was a debate forming over the issue, but participants were alert to techniques employed to persuade.

The final step of the workshop would have been to read the epilogue of James Chatters' book, *Ancient Encounters: Kennewick Man and the First Americans* (Simon and Schuster, 2001), a compelling argument for the other side of the issue. Finally, participants would have used the two texts to record evidence for and against the statement "Kennewick Man should be repatriated to the tribes." Alas, we were out of time. Clearly, we had underestimated just how in-depth the participants would go with their thinking and discussions. Not the worst of dilemmas in a learning environment!

It was time to wrap up. We had to bring the session back around to our purposes and to the core practice benchmarks. The group reported that ordering and grouping items is a simple task, yet the thinking is complex, making for a nice balance. Also, they were intrigued by the new questions and the complexity of the controversy over Kennewick Man.

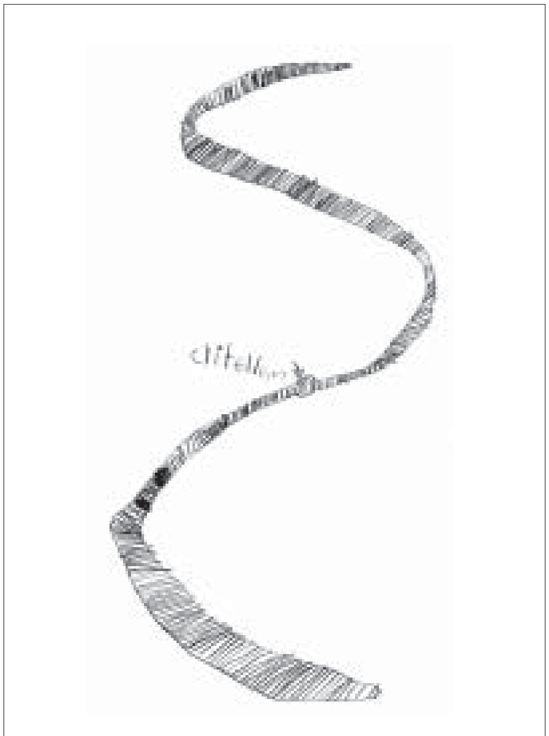
In what ways had literacy been incorporated? All four ingredients were present: reading, writing, speaking, and listening. They had applied the comprehension strategies of inferring, asking questions, and determining importance. They had read with a purpose, re-read, and text coded. They were learning content through carefully chosen text, scrutinizing it for structure, author's purpose, and meaning.

The participants plunged directly into interesting issues and critical thinking; they had become archaeologists and paleontologists. These aims could not have been successfully met without the social construction of meaning and effective group participation. The group had indeed brought the core practice benchmarks of inquiry-based science, reading across the disciplines, and effective instructional practices alive.

Thanks to school designers, Barbara Waxman and Mary Jo Swartley, for originally developing these materials and ideas for the Northwest Regional Literacy II Institute.

Cyndi Gueswel is a school designer in the Northwest region with Expeditionary Learning.

We revisited our original list of questions, answered what we could, and proceeded to revise other questions and add scores of new ones.



First grader Phoebe Bawmann observed and sketched this drawing as part of an investigation of worms at Rocky Mountain School of Expeditionary Learning in Denver, Colorado.

1,261 Worms, continued from page 5

found the results convincing when her teammates counted eight worms in the scoop from the top and 28 in the scoop from the bottom.

This test and the details of students' experience with worms established the plausibility of Devon's explanation. The other explanations seemed harder to test. Emma seemed to feel her explanation was compatible with Devin's, though she could not articulate the idea. Molly still thinks errors in counting explain the differences. She has even begun to voice support for Jay's theory that the worm population is not changing at all—that we keep counting wrong and should keep trying until we get the same answer three times.

The differences in development in my students' thinking make specific learning objectives for the whole class problematic. Jay's magical thinking, Enzo's anthropomorphism, and Molly's awareness of human fallibility lead them to errors that are constructive. Developmentally appropriate practices avoid inducing correct answers that short circuit real understanding.

This study is incidental but relevant to our study of trees. Making it part of our routine in class over six weeks has let a rich variety of concepts simmer—or rather breed—in the backs of students' minds. It continues. Last week we counted 1,261 worms and listed a new set of questions. Among other things, we have separated six groups of 100 worms and have begun differentiating and recording the food given to each group.

After reading of worms' role in soil building and aeration, students also decided each of the saplings we plant on the school grounds this spring will receive a gift of worms to help establish its root system.

In our lessons in scientific inquiry, I have told students there are three main places to look for answers to questions that come up when you study something: observation (look closer and longer), experiment (test an idea), ask an expert (read in a book or phone a specialist). This inquiry made me realize I had left out the most important source: thinking.

Peter Thulson loops with his kindergarten and first graders at Rocky Mountain School of Expeditionary Learning in Denver, Colorado.

EXAMPLES OF ACTIVE PEDAGOGY

TEACHING INQUIRY-BASED SCIENCE

~ Students are given multiple opportunities to engage in complex, problem-based activities, labs, and investigations, and to represent and analyze data.

~ Teachers ask students to articulate their theories, explanations, and understandings.

~ Teachers ask students to represent and reflect on their thinking (e.g., create analogies, make graphs, create pictures, build models).

~ Students are asked to apply knowledge in diverse and authentic contexts, explain ideas, interpret texts, predict phenomena, and construct arguments based on evidence (instead of focusing exclusively on predetermined "right answers").

~ Students are asked to take and defend positions and to consider multiple perspectives.

~ As part of ongoing assessment, teachers look for misconceptions and create experiences that challenge those misconceptions.

Expeditionary Learning Core Practice Benchmarks, p. 27

Science as a Segue to Math

By Myra Parks

"I hate math!" How often have we heard those frustrated words as teachers? Many students suffer from a very real math anxiety. They shut down when they are in traditional math classrooms and teachers struggle, often unsuccessfully, to help them build confidence and take risks with their mathematical thinking.

This was the situation I faced last year in teaching my math/science block at The Crossroads School in Baltimore, Maryland. The feeling of math anxiety pervaded my relationships with my students and lowered my confidence in my own abilities as a teacher. I even began to doubt that I could teach math well enough to benefit my students. As a result, I opted to teach only science this year.

I can remember the exact moment when I looked around the room and realized that my seventh-grade science students were enjoying doing math and having success with it. They were revising their fitness project results and helping each other check their statistical data. "Your median can't be right because it's not in the center of your data set!" I heard one student explain to another. Why had it taken me this long to figure out that I was on to something?

Students simply need to forget that they are learning math in order to truly learn it. Who doesn't love doing science experiments and projects? I guess I am biased on that account as a science person, but it seems to me science is a subject most students love. Science is where they can forget that they are doing math. My fitness project students demonstrated this—they just needed an authentic context in which they could apply their math knowledge. A compelling topic had to be driving their learning and demonstration of math skills.

My students and I recently finished the first part of our human body expedition. The idea for this topic came from my participation in the Physiology and Fitness Summit last summer. Although I loved the expedition that I was immersed in while I was in Colorado, I realized that the same exact expedition would not work for my own classroom. I had to modify it to meet the needs of my own students and the needs of my school, particularly with the Maryland State Assessment program rapidly approaching.

With some adjustments, I found that the students could cover most of our data and statistics outcomes with this one project, as well as my science content on the human body and scientific method. Data and statistics were actually a key to students learning the scientific method through true inquiry, trial, and error.

The students chose their own variables to test, such as "How does walking and climbing stairs affect my heart rate?" We collected data, organized it into tables, calculated the mean, median, mode, and range of the data, and graphed it to look for patterns and trends. Some students met with failure along the way.

One student collected data on the effect of exercise on her body temperature for one week before realizing from her data that one minute of exercise was not long enough to change her body temperature. Although she had to redo her procedures for the experiment and start over, I now

continued on next page

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Science as a Segue, continued from page 11

am certain that she will give more thought to her procedures in the future.

Another student only collected three days worth of data and was unable to find a conclusive pattern. He finally realized that the more samples he collected, the more valid his data set became. Many students learned first hand the value of organizing data. They also understood why I was always nagging them to remember to label their answers. They were no longer just practicing math and science, they were doing it!

Despite the fact that this human body expedition was loaded with opportunities to explore math, upon deeper reflection I have realized that there were many missed opportunities along the way. We started with a mini-unit on nutrition, where students calculated the percent of fat and sugars in various foods. During the nutrition unit, we could have studied misleading graphs. For example, low fat foods tend to be extremely high in sugar, which is rarely demonstrated.

While learning about cardiovascular fitness, students could have explored functional relationships. They could have determined the effect that smoking has on breathing rate and lung capacity. Science is full of opportunities to explore these deeper math concepts, not just data and statistics. One simply has to be looking for those chances and take advantage of them!

I now look forward to finding ways in which I can incorporate authentic math into my expeditions instead of dreading it, or doing it because I know the students need more math practice. My thinking is not far off from my students in that respect.

I am sure my new understanding that math can be taught through science is not something new. However, it was my own epiphany and growth as a math/science teacher. I believe I can truly use that title now.

Myra Parks teaches sixth-and seventh-grade math and science at The Crossroads School in Baltimore, Maryland.