Professional Development Workshops Guide

The Science of Teaching Science

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Professional Development Workshops Guide

The Science of Teaching Science

An Eight-Part Workshop Series for K-8 Teachers of Science

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Table of Contents

Series Overview

The series focuses on new science teaching methods and examines various issues or dilemmas that arise and how to resolve them. It provides an opportunity for teachers to get together and exhange ideas, share experiences, and support one another's efforts.

The workshops look at eight different aspects of teaching science. Each workshop takes an in-depth look into another teacher's classroom to help us focus on the issues. These teachers are heroes, brave and generous. They have permitted cameras to come into their classrooms and film them during their science lessons. These situations are unscripted and unrehearsed. They show real teachers in real classrooms doing their actual teaching. Observing other teachers teaching is something we rarely get to do, and it provides many wonderful insights.

We look at the teaching process from beginning to end. The first lesson focuses on a problem that is especially challenging to elementary school teachers – lack of science background. The remaining programs are relevent and of potential interest to both elementary and secondary school teachers.

WORKSHOP 1: Preparing to Teach Science
How can we prepare to teach science when we have little or no background in the subject?

WORKSHOP 2: Eliciting Students' Prior Knowledge
How do we find out what students already think and use that information in designing our lesson plans?

WORKSHOP 3: Creating a Context for Learning
Why is it important to begin a lesson by observing a relevant phenomenon?

WORKSHOP 4: Supporting Good Data Collection
What kinds of tools can we provide to support good data collection?

WORKSHOP 5: Summarizing, Comparing, and Interpreting Results
How can we help students reflect on their observations, draw conclusions, and build a consensus model of events?

WORKSHOP 6: Special Considerations
How do we create a classroom environment that meets the needs of *all* students?

WORKSHOP 7: Specific Instructional Strategies
What are some of the different kinds of strategies and tools we can use to support and promote student learning?

WORKSHOP 8: Assessing Student Understanding
How do we find out what students really understand and know at the end of a lesson?

About the Content Guide and Host

Content Guide

Kathleen M. Fisher earned her Ph.D. in molecular genetics from the University of California-Davis, and her Bachelor of Science degree from Rutgers University. She is a Professor of Biology and a member of the Center for Research in Mathematics and Science Education at San Diego State University (SDSU) where she teaches biology to prospective elementary school teachers. Her research focuses on conceptual learning of biology and how it might be enhanced with a Macintosh-based learning tool, SemNet ®.

Before coming to San Diego State University in 1987, Fisher was on the faculty at the University of California-Davis. She was also a member of two graduate groups at the University of California-Berkeley, the SESAME Graduate Group in Science and Mathematics Education and the Education in Mathematics, Science, and Technology Program (EMST), where she supervised graduate students in biology education. She has been a Program Associate with the National Science Foundation, a Senior Fulbright Lecturer, and an Atomic Energy Postdoctoral Fellow. Fisher is Director and managing partner of the SemNet Research Group, and developer of the SemNet ® knowledge analysis software.

Host

Terez Waldoch received her Ph.D. from the University of Massachusetts in May 1994, specializing in children's thinking in science. She teaches fourth grade at a suburban elementary school in western Massachusetts. Throughout 23 years of teaching, Waldoch has worked as the science curriculum coordinator and currently co-chairs the Curriculum Overview Committee.

During her career as a classroom teacher, Waldoch has presented science workshops to local teachers and at the National Science Teachers Association conventions in 1984 and 1992. She has also presented research conducted with other classroom teachers at the New England Educational Research Organization in Portsmouth, NH, in 1993. As part of her on-going professional development, Waldoch participated in the Harbor Explorations Project, a summer course in oceanology for teachers. In the fall of 1993, Waldoch was recognized with the Presidential Award for Excellence in Science Teaching in the Commonwealth of Massachusetts.

Workshop Components

Guest Teachers

Several teachers from schools in the Boston area will appear throughout the workshop series. These teachers will engage in group discussions throughout the workshop just as you will discuss ideas with participants at your own school. This guide lists the names, grade levels, and schools of the guest teachers at each workshop.

Featured Teachers

In each workshop, we will take an in-depth look at the classroom of one or more featured teachers. These situations are unscripted and unrehearsed, and are part of a series called Video Case Studies in Science Education, produced by the Harvard-Smithsonian Center for Astrophysics and funded by the Annenberg/ CPB Math and Science Project. We will also see videoclips of teachers from the Science Images series, produced by the North Central Regional Education Lab. These excerpts are intended to provide examples, both successful and not so successful, of a variety of approaches to science teaching. The featured teachers are part of our studio panel. You have in this guide background information for each of the featured teachers in each workshop.

Questions for Discussion

Throughout each workshop, the content guide will pose questions for you to think about and discuss with the other participants at your site. The questions will be displayed on the screen for approximately 15 seconds. If you are watching the workshops on videotape, we suggest that you pause the tape when these questions come up, and take about 5 or 10 minutes to discuss the posed questions with your colleagues. If you are watching a direct broadcast, we have printed the questions in this guide so that you can come back and think about them when the workshop is over.

Assignments

At the end of each workshop, the content guide will present an assignment for you to do in preparation for the following workshop. Instructions for these assignments are listed in this guide.

Journal

We recommend keeping a journal throughout this workshop series. This journal should be a record of and commentary on your own learning. As the series progresses, pay particular attention to changes in your thinking and the implications of those changes. If you're stuck for what to write about, we have provided some "Questions for Thought" for each workshop.

WORKSHOP 1:
Preparing to Teach Science

Most K-8 teachers have not had many science and math courses, and they often feel as though they didn't get much out of the courses they did have. How can they be expected to teach science topics for meaningful understanding when they themselves are not sure they understand the topics? We'll look at a variety of strategies teachers use to learn as much as possible about a science topic before they teach it.

Guest Teachers

(all teachers are from Boston area schools unless otherwise noted)

Ewald Charles	Grades 6 and 7 science	Boston Renaissance School
Hamid Gharooni	High school science	Madison Park High School
Rob Snyder	High school science	Brookline High School
Sharon Soucy	Kindergarten	Tatnuk Magnet School
Zevey Steinitz	Grades 3 and 4	Cambridge Port School
Audrey Sturgis	Grade 8 science	Solomon Lewenberg Middle School

Featured Teacher

NAME:	Audrey Sturgis
EXPERIENCE:	13 years
GRADE/SUBJECTS:	Year 1 – Grade 8, Science and Social Studies; Year 2 – Grade 7, Science
SCHOOL:	Solomon Lewenberg Middle School (Mattapan, MA)
DEMOGRAPHICS:	Middle school in an inner city setting
CLASSROOM:	3 sections, 90 students total; 90% African-American and Hispanic
SCIENCE TEACHING:	90 minute sessions on alternate days of the week
CURRICULUM:	Developed by the teacher
OTHER:	Third year teaching middle grades; background in elementary education

Questions for Discussion

1. What are you hoping to get out of this series?

2. What skills and strategies does Audrey use to engage her students in science learning?

3. Are content and process equally important?

Content
the scientific principles and concepts that the teacher wants to get across to the students

Process
the activities the students are engaged in as they build concrete knowledge that will support their understanding of the scientific principles and concepts

4. How do you prepare to teach a science topic? What strategies do you find particularly useful?

Questions for Thought

1. What are some strategies that you can use to make connections between science and students' lives?

2. Where do you think a knowledge of science fits into the real world that confronts students today?

3. How would you develop a curriculum in which you were as much a science learner as your students?

Assignment

In preparation for Workshop 2, please interview two to five of your students. Have some boiling water available at the beginning of each interview. Say that you are boiling water, and that you would like the student to tell you what is in the bubbles that form at the bottom of the pot, beaker, or flask. Then ask the student how he/she thinks that substance has formed.

Record the results of your first question in the following chart:

Grade Level	Oxygen	Substance in Bubbles		
		Hydrogen	Water Vapor	Other (what)
Student 1				
Student 2				
Student 3				
Student 4				
Student 5				

After the interview, tell the student that the correct answer is water vapor. The reason the water vapor bubbles form at the bottom of the pot is because that is where it is the hottest, and they rise because they are lighter than water. Then they go into the air and we can't see them anymore because water vapor is invisible.

WORKSHOP 2:
Eliciting Students' Prior Knowledge

Why begin a lesson by eliciting students' prior knowledge? It is essential to know what students believe at the outset in order to provide the instruction necessary to help them move toward a more scientific understanding. There are many ways of eliciting prior knowledge, including strategies such as concept mapping, pre-tests, and student interpretation of a demonstration. This program will examine many of these strategies.

Guest Teachers

(all teachers are from Boston area schools unless otherwise noted)

Ingrid Allardi	Grade 1	Potter Road Elementary School
James Carter	High school physics	Saugus High School
Ron Cutraro	Grade 6	Heath School
Mary DiSchino	Grades 3 and 4	Graham & Parks Alternative Public School
David Joseph	Grade 6 science	Brooks Middle School
Patreka Wood	Grades 6 and 7 science	Boston Renaissance Charter School

Featured Teachers

NAME:	Dorcas Gonzales-Lantz
EXPERIENCE:	3 years
GRADE/SUBJECTS:	Grade 6 science
SCHOOL:	Otto Middle School (Lansing, MI)
DEMOGRAPHICS:	Inner city middle school
CLASSROOM:	29 students (3 special needs, 5 ESL)
SCIENCE TEACHING:	55 minutes every day
CURRICULUM:	District specified
OTHER:	Language arts, social studies major

NAME:	Ingrid Allardi
EXPERIENCE:	2 years
GRADE/SUBJECTS:	Grade 1 — all subjects
SCHOOL:	Potter Road School (Framingham, MA)
DEMOGRAPHICS:	Suburban elementary school
CLASSROOM:	21 students
SCIENCE TEACHING:	50 minutes, twice per week
CURRICULUM:	District specified — life, earth, and physical sciences
OTHER:	Child psychology major

NAME:	Terez Waldoch
EXPERIENCE:	31 years
GRADE/SUBJECTS:	Grade 4 — all subjects
SCHOOL:	Wildwood School (Amherst, MA)
DEMOGRAPHICS:	Elementary school in small college town
CLASSROOM:	22 students (7% special needs, 5% ESL)
SCIENCE TEACHING:	1 hour, three times per week
CURRICULUM:	District specified — life, earth, and physical sciences
OTHER:	Doctorate in science education
	Presidential Award for Excellence in Science Teaching, 1993

Questions for Discussion

1. How does Dorcas elicit students' ideas?

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2. Imagine you are standing in front of a mirror so you can see only your head and chest. Now back up ten paces — how much more of yourself do you see in the mirror?

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Questions for Thought

1. What are the trade-offs between activities focused on teachers' objectives and those allowing students to explore their own ideas?

2. How might you interpret a situation in which, at the culmination of a unit, consensus among students regarding a difficult idea is reached? Where consensus is *not* reached?

3. Does it make sense to teach about the states of matter in grades K-2?

Assignment

In preparation for Workshop 3, please think of and describe three different, simple lessons you might use to teach your students about the sense of sight (or lack of it).

WORKSHOP 3: Creating a Context for Learning

In our videotapes of teachers in classrooms, we sometimes see a teacher open a science kit and ask students to start working on it without any framing or introduction. Students need time to assimilate a problem and make it their own. It helps if they can relate the problem to experience in their everyday lives, and it's even better if they can formulate the questions. We will see video clips of teachers trying to incorporate students' questions into their lessons.

Guest Teachers

(all teachers are from Boston area schools unless otherwise noted)

Jennifer Cataldo	Grade 5	The Ambrose School
Chris Collier	Spec. ed. inclusion teacher	Indianapolis Public Schools
David Joseph	Grade 6 science	Brooks Middle School
Robert Tai	Physics teacher and education researcher	Day Middle School

Featured Teachers

NAME:	Christine Collier
EXPERIENCE:	17 years
GRADE/SUBJECTS:	Grades 3-4, interdisciplinary based on science
SCHOOL:	School #92 (Indianapolis, IN)
DEMOGRAPHICS:	Elementary "school within a school" in an urban setting
CLASSROOM:	24 students in multicultural setting; 3 special ed students
SCIENCE TEACHING:	Incorporated into curriculum each day
CURRICULUM:	City-wide guidelines; teacher-designed curriculum
OTHER:	Special Education Inclusion teacher

NAME:	Sister Gertrude Hennessey
EXPERIENCE:	21 years
GRADE/SUBJECTS:	Grades 1-6, science
DEMOGRAPHICS:	Suburban elementary parochial school
CLASSROOM:	24 students
SCIENCE TEACHING:	45 minutes, 5 times per week
CURRICULUM:	Teacher-designed, research-based curriculum
OTHER:	Doctorate in science education

NAME:	Robert Tai
EXPERIENCE:	Student teacher
GRADE/SUBJECTS:	Grade 7, science
SCHOOL:	Day Middle School (Newton, MA)
DEMOGRAPHICS:	Suburban middle school
CLASSROOM:	20 students
SCIENCE TEACHING:	45 minutes every day
CURRICULUM:	District curriculum
OTHER:	Graduate student working on Ph.D.

Questions for Thought

1. Eliciting what students already know has implications for flexibility in the classroom — instead of following a fixed lesson plan, a teacher adapts and makes modifications as a lesson progresses. How do you think this would work in your classroom?

2. Teachers who are familiar with common misconceptions about a topic are better equipped to elicit prior knowledge. Why?

3. One approach to summarizing students' alternative theories is:

   - Write the contrasting theories on the board.
   - Have a discussion with the class about what each one means.
   - Ask for a show of hands to determine how many students believe in each theory.
   - Tell students that it is okay to change their minds.
   - Repeat this surveying of the class several times during a lesson.

What are the advantages of this approach?

Assignment

Pretend that you are going to be teaching a lesson to second-graders and you've planned the following experiment:

You are going to give your second-graders an eyedropper, a container of clean water, and a penny. Their job is to *estimate* and then *count* how many drops of water they can put on the head of the penny.

Your task is to design a data sheet for these young children to record their data. Be sure to leave space for both their *estimates* and their *observations*.

[You might want to try the experiment yourself so you can learn something about the range of values you might expect.]

WORKSHOP 4: Supporting Good Data Collection

One of the things that sets science activities apart from other endeavors is the care with which observations are made and data is recorded. If it is possible and relevant, a scientist will measure and quantify: How long did it take? How many are required? etc.

Children need support in collecting careful data. Thinking through the entire process in advance and making sure to provide the students with good tables and charts prepared for data collection can make the task much more manageable. We will look at ways to do this.

Guest Teachers

(all teachers are from Boston area schools unless otherwise noted)

Carl Johnson	Earth science	South Boston High School
Malik Latif	Physics and chemistry	Jeremiah Burke High School
Fran Ludwig	K-5 science	Lexington
Sarah Novogrodsky	Grade 5	Longfellow School

Featured Teachers

NAME:	Sarah Novodgrodsky
EXPERIENCE:	5 years
GRADE/SUBJECTS:	Grade 5 — all subjects
SCHOOL:	Longfellow School (Cambridge, MA)
DEMOGRAPHICS:	Outer city elementary school in university community
CLASSROOM:	23 students (35% special needs, 55% ESL)
SCIENCE TEACHING:	1-hour sessions twice per week
CURRICULUM:	Life, physical, and earth sciences; "kits" adopted by district
OTHER:	Lead teacher for professional development in the use of kits which are prepackaged curriculum including teachers' guides and materials and supplies for an entire class

NAME:	Joanne Hurley
EXPERIENCE:	18 years
GRADE/SUBJECTS:	Grade 2 — all subjects
SCHOOL:	Burgess Elementary School (Sturbridge, MA)
DEMOGRAPHICS:	Suburban elementary school
CLASSROOM:	23 students
SCIENCE TEACHING:	45-minute block for science and social studies every day
CURRICULUM:	Teacher developed, theme-based using GEMS and AIMS
OTHER:	Science teacher leader for district

NAME:	Doug Kirkpatrick
EXPERIENCE:	35 years
GRADE/SUBJECTS:	Grade 8 — physical science
SCHOOL:	Foothill Middle School (Walnut Creek, CA)
DEMOGRAPHICS:	Middle school in suburban community
CLASSROOM:	30-32 students (2-3 special needs)
SCIENCE TEACHING:	54-minute periods, 6 out of every 7 days (rotating schedule)
CURRICULUM:	Designed by teacher working with group at the University of California, Berkeley
OTHER:	Received Feminist of the Year Award from National Feminist Majority Foundation in 1991 for getting girls involved with science

Questions for Discussion

1. What advice would you give to a student teacher concerning how to design data sheets?

2. Predict the conditions of a carrot and some raisins left overnight in fresh water and in saturated salt water, and give the reasons for your predictions.

Questions for Thought

1. What purpose is served by having students explore a phenomenon and collect data without a specific hypothesis or prediction to test? What is the advantage of having students commit to predictions? When would you use general exploration, and when would you use prediction?

2. Should you provide students with pre-designed data collection forms, or have them make their own? What are the advantages and disadvantages of each strategy?

3. Is it best when each student can collect his or her own data, or should data be collected by groups of students? What are the reasons for having students report their data to the whole class?

Assignment

In preparation for Workshop 5, please complete the following assignment:

Imagine that your students are collecting data on water along a river. The data they are gathering is the temperature of the water and the pH of the water, and they are collecting this data at 6 different locations along the river. You have 26 students, and they are working in groups of three or four (i.e., 7 total groups).

Your task is to design an instrument (a form or chart) for summarizing the data from the whole class. What will you use — a map? a bar graph? a line graph? a table? What will your instrument look like?

Your variables are: temperature, pH, 6 locations, 26 students in 7 groups.

WORKSHOP 5: Summarizing, Comparing, and Interpreting Results

Although students generally work together in small groups in hands-on science classes, there are times when all-class discussions are valuable. Summarizing, comparing, and interpreting often involves the whole class. We will see examples of teachers using both small-group and whole-class approaches to teaching science, and will discuss when each may be appropriate.

Guest Teachers

(all teachers are from Boston area schools unless otherwise noted)

Viriato Goncalves	Grades 7 and 8, bilingual	Deerborne Middle School
Dotty Herd	Grade 6 and 7 science	Ten Mile Elementary School (TN)
Jennie Paretti	Grade 2	Maplewood Elementary School
Rob Snyder	Earth and space science	Brookline High School

Featured Teachers

NAME:	Dotty Herd
EXPERIENCE:	23 years
GRADE/SUBJECTS:	Grade 6 (and several grade 7 students) — all subjects
SCHOOL:	Ten Mile Elementary School (Ten Mile, TN)
DEMOGRAPHICS:	K-8 school in a rural district
CLASSROOM:	25 students (4 special ed.)
SCIENCE TEACHING:	30-45 minutes daily; science integrated into curriculum
CURRICULUM:	Derives from the Tennessee Valley Project (previously built around objectives for state standardized test)

NAME:	Jennie Paretti
EXPERIENCE:	20 years
GRADE/SUBJECTS:	Kindergarten — all subjects
SCHOOL:	Maplewood Elementary School (Malden, MA)
DEMOGRAPHICS:	Elementary school in an urban community
CLASSROOM:	21 students (A.M. session); 22 students (P.M. session)
SCIENCE TEACHING:	Integrated into daily activities; science center available daily
CURRICULUM:	Teacher-developed
OTHER:	Masters degree with concentration in whole language development and process writing

NAME:	Richard Haller
EXPERIENCE:	20 years
GRADE/SUBJECTS:	Grade 2 — all subjects
SCHOOL:	Burgess Elementary School (Sturbridge, MA)
DEMOGRAPHICS:	Suburban elementary school
CLASSROOM:	24 students
SCIENCE TEACHING:	45-minute block for science and social studies daily
CURRICULUM:	Teacher-developed; theme-based using GEMS and AIMS (previously built around objectives for state standardized test)
OTHER:	Science teacher leader for district

NAME:	Doug Kirkpatrick
EXPERIENCE:	35 years
GRADE/SUBJECTS:	Grade 8 — physical science
SCHOOL:	Foothill Middle School (Walnut Creek, CA)
DEMOGRAPHICS:	Middle school in suburban community
CLASSROOM:	30-32 students (2-3 special needs)
SCIENCE TEACHING:	54-minute periods, 6 out of every 7 days (rotating schedule)
CURRICULUM:	Designed by teacher working with group at the University of California, Berkeley
OTHER:	Received Feminist of the Year Award from National Feminist Majority Foundation in 1991 for getting girls involved with science

Question for Discussion

1. How would you use these data summarizing techniques in your teaching?

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Questions for Thought

1. What do students gain from having to present their findings to other students or other classes instead of reporting only to the teacher? What are three different ways in which this can be arranged?

2. If a student presenting findings to the whole class says something that's clearly wrong, what are some of your options? Which option would you be likely to choose, and why?

3. Present arguments for and against using computers to help summarize data. How can the advantages be maximized while the disadvantages are minimized?

Assignment

In preparation for Workshop 6, please ask a few of your colleagues (a mini-interview) the following questions:

To teach science more effectively to girls, do we need to use different teaching approaches than we do with boys? Why or why not? Does this vary with grade level?

WORKSHOP 6: Special Considerations

Hands-on science classes involve all the challenges of regular classrooms, and add some additional challenges, too. This program will focus on some of the things we must think about in teaching science:

1. Working with diverse student populations
2. Stimulating interest in science among minorities and girls
3. Using scientific vocabulary only when necessary
4. Helping students believe their voices are valued
5. Promoting student discussion, yet keeping it focused
6. Eliminating sexism and racism
7. Treating students with respect
8. Facilitating learning with multiple learning modalities

Guest Teachers

(all teachers are from Boston area schools unless otherwise noted)

Tom Hocker	K-5 science specialist	William Monroe Trotter School
Heather Hurley	Grade 1	Thoreau Elementary School
Raquel Jacobson-Peregrino	Grade 7, earth science	Boston Latin School
Marie Joseph	Grades 2-4, bilingual	Graham and Park School
Joyce Newhouse		MassPEP, Inc.

Featured Teachers

NAME:	Raquel Jacobson
EXPERIENCE:	6 years
GRADE/SUBJECTS:	Grade 7 — earth science
SCHOOL:	Boston Latin School (Boston, MA)
DEMOGRAPHICS:	Urban school requiring admission test
CLASSROOM:	150 multi-ethnic students
SCIENCE TEACHING:	42 minutes (3 days); 30 minutes (2 days); Use of lab room (1 day)
CURRICULUM:	Middle grades earth science curriculum, with textbook as a guide
OTHER:	Undergraduate and graduate study in geology; Ed.M. in Teaching and Curriculum

NAME:	Donna Fosberg
EXPERIENCE:	22 years
GRADE/SUBJECTS:	Grade 5 — all subjects
SCHOOL:	Weitzel Elementary School (Flagstaff, AZ)
DEMOGRAPHICS:	Elementary school in a small city/rural district
CLASSROOM:	25% Native American; 25% Mexican American
SCIENCE TEACHING:	Approximately 6 hours per week
CURRICULUM:	Teachers free to make choices in an integrated curriculum

Questions for Discussion

1. What are your strategies for including underrepresented students in your science class?

2. Do you need to water down the curriculum to promote diversity?

Questions for Thought

1. In this time of increased diversity among children in the areas of culture, gender, and learning abilities, how do you think your classroom reflects this change? Have you had to change your teaching style? If so, how would an outsider notice the changes in your classroom?

2. What are the learning issues facing children with languge barriers? How do they present themselves in a classroom?

3. How do girls approach science activities? Do you notice any behavioral differences between boys and girls? Should girls be taught in separate sections for science?

4. What strategies have you found successful with diverse groups of students?

Assignment

In the next workshop, you will hear the term "constructivism" being used. What does constructivism mean to you?

In preparation for Workshop 7, please think about what kinds of constructivist teaching strategies you use (if any) in your own classroom.

WORKSHOP 7: Specific Instructional Strategies

We will discuss problem-based learning as one way to approach science teaching in the context of student interests. The problems may range from finding particular information in the library, to examining the effects of pollution on animal and plant life.

Guest Teachers

(all teachers are from Boston area schools unless otherwise noted)

Pat Coleman	Grade 8 science and social studies	Thurston Middle School
Tom Hocker	K-5 science specialist	Trotter Elementary School
Heather Hurley	Grade 1	Thoreau Elementary School
Teresa Keung	Chinese bilingual math and science	C.R. Edwards Middle School
Zevey Steinitz	Grades 3 and 4	Cambridgeport School

Featured Teachers

NAME:	Terez Waldoch
EXPERIENCE:	31 years
GRADE/SUBJECTS:	Grade 4 — all subjects
SCHOOL:	Wildwood School (Amherst, MA)
DEMOGRAPHICS:	Elementary school in a small college town
CLASSROOM:	22 students (7% special needs; 5% ESL)
SCIENCE TEACHING:	1-hour sessions, 3 times per week
CURRICULUM:	Life, physical, and earth science; district-specified
OTHER:	Ed.D.; Presidential Award for Excellence in Science Teaching (1993)

NAME:	Pat Coleman
EXPERIENCE:	21 years
GRADE/SUBJECTS:	Grade 8 — life science and social studies
SCHOOL:	Thurston Middle School (Westwood, MA)
DEMOGRAPHICS:	Middle school in a suburban town
CLASSROOM:	48 students (20% special needs), divided into two sections
SCIENCE TEACHING:	Two classes (40-minute periods, twice per week)
CURRICULUM:	Integrated science "spiraled" curriculum; district-specified
OTHER:	Shares classrooms with other teachers (doesn't have his own room)

Question for Discussion

1. How do you use portfolios in your classroom?

Questions for Thought

1. How could portfolios be used in science units?
2. What are the advantages and disadvantages of keeping subject matter portfolios?
3. How can journals be used most effectively in the classroom?

Assignment

In preparation for Workshop 8, please ask your students to tell you how they feel about the ways in which you evaluate their learning. What do they like best?

WORKSHOP 8: Assessing Student Understanding

Embedded assessment means building assessment into the activities and classroom processes in an integrated and natural manner. We will see teachers integrating many different forms of assessment into their lessons.

Guest Teachers

(all teachers are from Boston area schools unless otherwise noted)

Tom Banaszewski	Grade 5	Maria Hastings School
Candace Dunlap	High school biology	Malden High School
Jean Huff	Grade 3	Burr School
Alma Wright	Grades 1 and 2	Trotter School

Featured Teachers

NAME:	Jean Huff
EXPERIENCE:	19 years
GRADE/SUBJECTS:	Grade 3 — all subjects
SCHOOL:	Burr School (Newton, MA)
DEMOGRAPHICS:	Elementary school in a suburban city
CLASSROOM:	22 students (15% special needs; 10% ESL)
SCIENCE TEACHING:	3 times per week (approx. 120 minutes total)
CURRICULUM:	District-specified
OTHER:	Ed.M. in Elementary Education; teaches in an "open" school

NAME:	Tom Banaszewski
EXPERIENCE:	First-year teacher
GRADE/SUBJECTS:	Grade 5 — all subjects
SCHOOL:	Hastings School (Lexington, MA)
DEMOGRAPHICS:	Suburban school in affluent town
CLASSROOM:	26 students (10% special needs)
SCIENCE TEACHING:	50-minute sessions, twice per week
CURRICULUM:	Life, physical and earth sciences; district-specified
OTHER:	Shares teaching responsibilities with another first-year teacher who was initially brought in to assist with special needs students

Questions for Discussion

1. Have each person at your site take 5 items out of his or her pockets.
   Put all of the items in the center of the table and categorize them (e.g. by size, color, function).
   Summarize the categories on a pie chart by labeling each slice and placing the items in slices.

2. Suppose that you are a fifth grade teacher. You asked your students to classify a variety of artifacts and report their frequencies in a pie chart. How would you design a scoring rubric for this task, if the entire task is worth 10 points?

3. What are some of the issues surrounding frameworks and standards? Do you agree with the benefits and liabilities of frameworks?

Questions for Thought

1. What are some strategies you could use to involve students in their own assessment?

2. Many embedded assessment techniques produce qualitative data. How do you incorporate this data into a letter or number grade at the end of a lesson, unit, or semester? (i.e., How do you qualify embedded assessment?)

APPENDIX A:
Teaching for Meaningful Understanding

This workshop series will look at various facets of teaching for meaningful understanding. It may be useful for you to have this overview for reference. The description below may also clarify for you what we mean by terms such as "meaningful understanding," "personal knowledge construction," and "constructivism," which are likely to be mentioned in the workshops.

To make sense of ideas, students need to put those ideas together in their own minds and in their own ways. This is the process of personal knowledge construction. Teaching that promotes knowledge construction by students is often described as constructivist. Among the features of a lesson that contribute to creating a constructivist orientation are the following:

1. **Framework.** Lessons are organized into a coherent framework that aims to build bigger ideas over time. Sequence and connection are important.
2. **Lessons.** Each lesson is selected to illustrate an important idea. It is also useful if the lesson gives an outcome that is surprising or unexpected to students, and therefore gets their attention and challenges their assumptions.
3. **Framing.** The teacher begins each lesson by asking students to summarize what went on before and what was learned. The teacher draws links that lead students from the previous lesson(s) to the current one.
4. **Prior Knowledge.** Before doing a lesson, it is important to find out what the students already know about the topic. This is often done via whole class discussion, with the teacher eliciting ideas from students and organizing them on the board. Solid starting points, gaps in knowledge, disagreements, and important alternative conceptions can be identified in this way.
5. **Prediction.** Students are asked to predict outcomes before performing activities, to discuss their predictions with their group, and to write down their predictions. This prompts students to build a mental model of the event, run a simulation, and commit themselves to the anticipated outcome. In this way, they become invested in observing the actual outcome.
6. **Group Work.** Working in groups (typically of three or four students each) involves students in collaboration and dialog. They struggle to formulate and express their ideas to one another, listen to one another, and negotiate meanings. They teach to and learn from each other.
7. **Context.** Each lesson involves students in observing a phenomenon or event. This provides a concrete illustration of the key scientific principle being studied. It also draws students into the problem, generating interest and motivation, and gives students an opportunity to think of their own questions. The phenomenon provides a context in which the scientific ideas make sense.
8. **Embedded Questions.** Questions are inserted throughout a lesson to prompt students to focus on key issues and think about deeper levels of interpretation.
9. **Data Collection.** Support is provided to guide students in making observations and collecting data. Although they work in groups, students are expected to keep their own notes and record the relevant data about each lesson.

10. **Data Summary.** At the end of a lesson, data from the whole class is summarized on the board or on transparencies. This allows teacher and students to assess the accuracy of the data. Generally there is a high level of agreement among all groups. This is valuable because when students' observations disagree with their expectations, they have a strong tendency to conclude that "I did the experiment wrong." That is, they hang onto their ideas and dismiss their observations. However, when students see that the whole class got the same results, they tend to be more willing to reconsider their ideas. Sometimes students do not obtain the same results, and then an effort is made to identify the reasons.
11. **Data Manipulation.** It is often useful to manipulate the data after it is collected, as in calculating survival rates or summarizing changes over time in a line graph. This manipulation of the data is intrinsic in science.
12. **Post Knowledge (Data Interpretation).** One hears a great deal these days about eliciting prior knowledge. But it is equally important to elicit post knowledge. What have students learned from the lesson? The conclusion may seem obvious to the teacher, but do the students see it? How many still believe their naive ideas? A whole class discussion of the data and its interpretation is essential to find out what was achieved in the lesson and what still needs to be addressed.
13. **Links to Everyday Knowledge.** Throughout the lesson and especially during the post knowledge discussion, students are prompted to bring in examples from everyday life, as well as to apply their knowledge in interpreting everyday situations brought up by the teacher.
14. **Reflection.** One good rule of thumb is that students spend at least as much time making sense of a lesson as they do in performing the activity. Students are typically engaged in organizing their ideas into larger frameworks and making the connections between their ideas explicit, through activities such as concept mapping, semantic networking, writing, or making presentations.
15. **Safe Environment.** When students are treated with respect, as thoughtful young adults, that is how they behave. Creating an environment conducive to thoughtful discussions is often challenging for teachers who have learned the art of 'controlling' their classes. Among the strategies of successful teachers are: talking softly, talking in an authentic and thoughtful way, listening carefully to students' ideas and responding with interest, encouraging students to respect one another's ideas, getting to the same physical level as the students to talk to them, and giving interesting and challenging assignments.
16. **Embedded (on-going) Assessment.** Teachers use each phase of the lesson to assess students' progress, identify problems in understanding, and alter instruction as needed. They monitor groups, listen in on conversations, review journal comments, and ask probing questions.
17. **Authentic (summative) Assessment.** At the end of a lesson, teachers try to devise assessments that reflect the kinds of activities and skills used in the lesson, and that focus on deep understanding of larger issues rather than small details. Multiple choice items are used much less frequently, and when used, are often two-tiered. The first item is a content question (e.g, Where does most of the weight of dry wood come from, a) soil, water, & sun, b) CO2, water & sun)? The second item is a reason question (e.g., The reason this is true is because a) this is what the plant needs to grow, b) these are converted into sugar in photosynthesis, c) a gas couldn't possibly make up the weight of a tree).

APPENDIX B: Suggested Resources

List assembled in part by and comments by Maria Varelas Dept. of Curriculum and Instruction, College of Education, M/C 147, Univ. of Illinois at Chicago, 1040 W. Harrison St., Chicago, IL.

Champagne, Audrey B. & Hornig, Leslie E. (1985). *Science Teaching: The Report of the 1985 National Forum for School Science.* Washington, DC: American Association for the Advancement of Science. (ISBN 0888-4358, ISBN 0-87168-286-9).

Driver, R., Squires, A., Rushworth, P., Wood-Robinson, V. (1994). *Making Sense of Secondary Science: Research into Children's Ideas.* New York: Routledge.

Esler, W. E. & Esler, M. K. (1985). *Teaching Elementary Science.* Belmont, CA: Wadsworth Publishing.
A book filled with hundreds of lessons plans for elementary teachers.

Fensham, Peter, Gunstone, Richard, & White, Richard. (1994). *The Content of Science: A Constructivist Approach to its Teaching and Learning.* Washington, DC: The Falmer Press (ISBN 0 7507 0221 4, paperback).

Harlen, Wynne, Ed. (1985). *Primary Science: Taking the Plunge.* Oxford: Heinemann, ISBN 0-435-57350-0.
I like the approach to the book a lot and some students have just raved about it. I like the specific information and insights it provides about student thinking and action.

Lemke, Jay L. (1993). *Talking science: Language, Values and Learning.* Norwood, NJ: Ablex Publishing Company. (ISBN 0-89391-566-1, paperback).

National Center for Improving Science Education. (1990). *Elementary School Science for the 90s*, available from The Network, Inc., 300 Brickstone Sq., Suite 900, Andover, MA 01810.
Book found very helpful with teachers and other leaders.

Osborne & Freyberg, Eds. (1985). *Learning in Science: The Implications of Children's Science.* Auckland, NZ: Heinemann.

National Standards and Goals for Science Teaching

American Association for the Advancement of Science. (1983). *Benchmarks for Science Literacy*. New York: Oxford University Press.

American Association for the Advancement of Science Project 2061. (1989, 1990). *Science for All Americans*. New York: Oxford University Press.

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

National Science Foundation. (1993). *Beyond National Standards and Goals: Excellence in Mathematics and Science Education K-12* (NSF Publication No. 93-70). Washington, D.C.: National Science Foundation.

Alternative Conceptions

Helm, H. & Novak, J. D. (1983). *Proceedings of the International Seminar: Misconceptions in Science and Mathematics June 20-22, 1983.* Ithaca, NY: Department of Education, Cornell University.

Novak, J. D. (1987). *Proceedings of the Second International Seminar: Misconceptions and Educational Strategies in Science and Mathematics July 26-29, 1987.* Vol. II. Ithaca, NY: Department of Education, Cornell University.

Novak, J. D. (1993). *Proceedings of the Third International Seminar: Misconceptions and Educational Strategies in Science and Mathematics*. Vol. III. Ithaca, NY: Department of Education, Cornell University.

Pfundt, Helga & Duit, Reinders. (1994). *Bibliography: Students' alternative frameworks and science education, Fourth Edition.* Institut fur die Padagogik der Naturwissenschaften (Institute for Science Education), an der Universitat Kiel, Ofshausenstrasse 62, D-2300 Kiel I, Federal Republic of Germany.

World Wide Web URLs

Fisher, Kathleen M. (1997). **Biology Lessons.** **www.BiologyLessons.sdsu.edu.**
This consists of constructivist-style biology experiments using mostly off-the-grocery-shelf materials. Aims to address many common misconceptions and foster strong conceptual development through many embedded questions. Includes specific assignments for creating SemNet-based semantic networks after each exercise. SemNet software and SemNet files available free.

Los Angeles County Office of Education, Teams Distance Learning, K-12 Lesson Plans.
http://teams.lacoe.edu/documentation/places/lessons.html
A resource for finding many different sites.

Science and Math Initiatives (SAMI). **www.learner.org/sami**
A database of Web resources for science and math teachers. Features an online teacher help service.