Assessing Instruction for Inquiry: A Workshop

Session Overview

In this session, teachers access their prior knowledge of teaching through inquiry and assess several activities including their own teaching for essential features of facilitating classroom inquiry.

Assessing Instruction for Inquiry Session At-a-Glance:

Phase of Instructional Model	Session Activity (Participants will:)	Suggested Time
Engage Learner connects past and present learning experiences and organizes own thinking toward learning outcomes of this session	Brainstorm and chart in response to "What are the characteristics of inquiry based teaching?" and "What tools and strategies have you used in the past to assess Inquiry-based teaching?"	30 minutes
Explore Concepts, processes, and skills are identified and developed	Participate in and "watch" an activity which facilitates understanding of inquiry. Compare evidence from the activity with charted characteristics of inquiry. Develop skill using the Inquiry Instruction Rubric.	60 - 90 minutes
Explain Learners demonstrate their conceptual understanding, process skills, or behaviors.	Using the Inquiry Instruction Rubric, demonstrate skill by scoring one video clip of teaching through inquiry. Discuss findings after viewing.	45 minutes
Elaborate (Explore - explain loop included here) Extend conceptual understanding and skills; new experiences allow for deeper understanding, more information, and adequate skills.	Using the Inquiry Instruction Rubric, score 2 or 3 additional video clips of teaching through inquiry. Discuss findings after each viewing.	1 - 1 1/2 hours (30-45 minutes per video + discussion)
Evaluate Learners assess own understanding and abilities.	After assessing your own ability to use the Inquiry Instruction Rubric, score a video clip of your own teaching through inquiry.	60 minutes (may be done post-session)

Assessing Instruction for Inquiry: A Workshop

Intended Audience:
Classroom Teachers

Essential Questions:
What are the characteristics of inquiry teaching? How can I assess the extent to which teaching reflects the characteristics of inquiry?

Objectives:
Teachers will engage in an assessment process of inquiry-based teaching behaviors AND assess their own teaching using the NLIST Inquiry Instruction Rubric.

Conceptual Learning Sequence:
The prerequisites for this professional development session are experience with Instructional Materials Rubric and knowledge of what *scientific inquiry* means (i.e. the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work, page 1, Inquiry and the NSES). If teachers are not familiar with the Instructional Materials rubric or to scientific inquiry, then time must be planned for them to attend prerequisite workshops.

If, as a result of this session and assessing their own teaching, teachers want to work on modifying their own instructional strategies and teaching behaviors, they can review next steps to modify their teaching towards a more inquiry-focused approach.

This session targets teachers who are at the consequence, collaboration, and refocusing stages of concern about their teaching in terms of inquiry; i.e. teachers who are asking, "How is my teaching through inquiry affecting my learners? How can I refine my teaching to have more impact?"

In a series of follow-up sessions in learning groups, teachers can work with others asking, "How can I relate what I am doing to what others are doing?" Eventually, teachers may reach the point where they say, "I have some ideas about something that would work even better." (Inquiry and the NSES, page 146)

Session Overview:
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Grouping:
Participants will work individually, in pairs, in groups of four, and as a whole group.

Materials:

- video clips of inquiry-based teaching (see Facilitator's Resource #1); at least one clip of exemplary inquiry-based teaching
- VCR and monitor(s) to accommodate room size
- copies of all hand-outs and transparencies
- copies of Instructional Materials Rubric and the Inquiry Instruction Rubric
- chart paper/markers
- transparency pens
- one copy of Professional Development Rubric (If your audience is professional developers.)
- one copy of appropriate standards matching the content presented in the selected videos

Transparencies/Hand-outs:

1. Session-at-a-Glance
2. T-chart for note-taking
3. Session evaluation form
4. Comparison of Section Headers on the Instructional Materials and Inquiry Instruction Rubrics

Facilitator's Resources:

1. A multi-page annotated list of videos for use in this session. Many clips were filmed in K-12 classrooms.
2. Possible responses for brainstorming (steps 3 and 12)
3. Inquiry Activity #1 from pages 66-73 from Teaching About Evolution and the Nature of Science

Procedure:

1. Welcome participants and review housekeeping items (norms, "parking lot" chart, breaks, locations of restrooms and fire exits, etc.).

2. Share session overview (including the idea that this process leads to self-assessment) and session-at-a-glance **(Hand-out #1/Transparency #1).** The session-at-a-glance can be used as an agenda for this session. Explain that this is one section of the Advancing Science as Inquiry packet. Share the content explanations for the other sections. Share the Professional Development Rubric if your audience is professional developers. Option: Create a chart for the wall of Hand-out #1/Transparency #1.

ENGAGE

Learners connect past and present learning experiences and organize their thinking toward outcomes of current session.

3. Lead participants in a brainstorm with the following prompt.

    "What are the characteristics of teaching through inquiry?"

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Using hand-out #2, record your responses in the left column of a simple
T-chart with characteristics in left column and evidence as header for
right column. Leave the right column empty for now.
```

Chart responses on a transparency or on chart paper in the left column of a simple T-chart with **characteristics** in left column and **evidence** as header for right column **(Transparency #2/Hand-out #2)** as participants record.

4. Distribute session evaluation form **(Hand-out #3/Transparency #3)** modeling the metacognition of the facilitator's planning. Respond to any clarifying questions.

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When I planned this session, I wanted to ensure that I am modeling
inquiry. Have I used the features of inquiry-based teaching as I planned
this session? I set up the session using the five phase instructional
model (the 5E's) and developed the evaluation form specifically to help
me determine if this session does indeed include the NSES
characteristics of inquiry teaching. These five components of learning
experiences for teachers are not aligned with the 5E's.  Let's take a
few minutes to discuss these components.  What do they mean to you?

Please feel free to complete this form as we proceed through this
session.
```

Option: Use any session evaluation form you choose, e.g., the 4 quadrants (1) expectations. (2) gots, (3) needs to implement this process, (4) more I need to know. It is suggested that whichever form is used, that it be distributed at this point or at the start of the session.

EXPLORE

Concepts, processes and skills are identified and developed by the learners.

5. Present a classroom activity using inquiry (such as the one suggested below), which facilitates the learners' understanding of science inquiry. Ask participants to "watch the lesson from the balcony" taking notes in the evidence (right) column on their T-chart, as well as participate in the activity. [Check for understanding on these directions. Participants may not have "multi-tasked" like this before.]

Complete Activity #**1**, Introducing Inquiry and the Nature of Science, through the second cube. From pages 66-73 from Teaching About Evolution and the Nature of Science, National Academy of Sciences, National Academy Press, Washington, DC, 1998. (also available on-line at www.nap.edu/readingroom/books/evolution98)

See Facilitator Resource # 3.

6. Debrief the inquiry activity. Lead a discussion soliciting feedback on each of the characteristics the group charted above in step 3.

   How did the facilitator's behavior noted on your T-chart align with the charted characteristics from step 1? Explain your evidence using any notes in the evidence column taken during the activity.

7. Re-familiarize participants with the Instructional Materials Rubric, if necessary. Discuss the development (the fact that it's based on the Instructional Materials Rubric, etc.) of the Inquiry Instruction Rubric. Introduce the Inquiry Instruction Rubric showing the headers first and comparing with the headers of the IM rubric**. (Hand-out #4/Transparency #4**) (See Note below.)
   As on the IM rubric, not every activity scores at a level 4 nor necessarily should it. Appropriateness of variation is determined by the professional in the classroom in response to the unique needs of the learners.
   Allow participants time to read the Inquiry Instruction Rubric and the definition of inquiry on the first few pages of the rubric. Explain that both rubrics were based on this definition. If participants have experienced the Science as Inquiry workshop, explain that, the Inquiry Instruction Rubric, allows for assessing teaching in a user-friendly format without having to match phrases from the definition of inquiry.

   Which characteristics charted in step #3 are found on the Inquiry Instruction Rubric?

   How would you "score" the facilitation of the activity you just participated in?

   Allow time for participants to score the activity using the Inquiry Instruction Rubric and time to discuss their findings.

   Note: Part A of the Instructional Materials Rubric deals with science content. That section has been deleted from the Inquiry Instruction Rubric. A clarification of science content (content and process) may be helpful here. (See Achieving Scientific Literacy and Science for All Americans)

EXPLAIN

Learners demonstrate their conceptual understanding, process skills, and behaviors.

8. You've just used the Inquiry Instruction Rubric on a "live" activity. Now you'll have a chance to use it with some video activities and to demonstrate your skill using the Inquiry Instruction Rubric.

While viewing a video clip of exemplary inquiry-based teaching, participants use the Inquiry Instruction Rubric to "score" the instruction. (If no video is available, the facilitator may present another inquiry-based lesson.)

Option: An explanation of the science standard(s) being addressed in each video may facilitate the "scoring" process.

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Mark on the Inquiry Instruction Rubric the variation that matches what
you observe.  Make notes of the teacher and student behavior you observe
that matches that variation.
```

(Facilitator may choose to model this scoring process as video begins. This necessitates pre-viewing the video.)

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As you watch the clips, remember you are keeping your own teaching in
mind and thinking about where you would put yourself on these continua.
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9. After the clip and scoring ends,

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Discuss the "results" of your scores with a partner.
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Compile responses by tallying scores from the group. With the whole group, freeze-frame the video and discuss pre-selected examples of "effective" inquiry techniques and "not so effective" techniques and how those might be improved.

ELABORATE
Extend conceptual understanding and skills; new experiences allow for deeper understanding, more information, and adequate skills.

10. While viewing a second video clip, participants "score" the instruction using the Inquiry Instruction Rubric then discuss their scores with a partner. Two pairs team up to discuss their "results" after scoring. Freeze-frame (whole group) discussions of examples of "effective" inquiry techniques and "not so effective" techniques and how those could be improved

11. While viewing a third video clip, participants score individually the instruction. Freeze-frame (whole group) discussions of examples of "effective" inquiry techniques and "not so effective" techniques and how those could be improved

12. Facilitate a whole group discussion charting responses to the prompt,

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"What are the characteristics of inquiry based teaching?"
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(The same prompt from step #3.) Compare with the chart from beginning of the session generated in step #3.

13. Facilitator models a metacognitive reflection of this session using a set of prompts developed from the Inquiry Instruction Rubric (and Professional Development Rubric if your audience is professional developers). Use a "think aloud" strategy for this self-reflection. Ask some questions without answers. Use chart from step 12 compared to chart in step 3 as evidence for group's learning. Use the Inquiry Instruction Rubric (and the Professional Development Rubric if appropriate) as this is played out.

    When I planned this session, I wanted to ensure that I am modeling inquiry. Have I used the features of inquiry-based teaching as I planned this session? I set up the session using the five phase instructional model (the 5E's) and developed the evaluation form specifically to help me determine if this session does indeed include the NSES characteristics of inquiry teaching.

    Did I reach my goal? What does the evidence from the two charts tell me? Who did I score on the Inquiry Instruction Rubric? I wonder what variations I would have received for my teaching?

14. Facilitator leads de-brief of her/his own facilitation after participants complete the session evaluation form (**Hand-out #3**). Specifically ask for examples of evidence to substantiate (or not) each of the 5 sections of the evaluation form.

    Please complete your session feedback/evaluation form.

    What components of inquiry were evident and which were not evident in the session? What is the evidence to substantiate your conclusions? Science isn't science without evidence.

EVALUATE

Learner assesses own understanding and abilities.

15. Ask,

    "Are you ready to assess your own teaching? Have you mastered these skills of matching observable behaviors with the descriptors on the rubric? Do you feel confident to assess your own teaching after successful demonstration of skill development? What are your personal next steps to assess your own teaching?"

    Allow participants time to reflect for themselves as they record their next steps. When ready, participants view and score a video of their own teaching. They may choose to partner with another teacher to do peer observation and peer review of videos. If they choose to modify their teaching based on their assessment of their own teaching, they may select next step for suggestions.

Transparency #1/Hand-out #1

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Evaluate Learners assess own understanding and abilities.	After assessing your own ability to use the Inquiry Instruction Rubric, score a video clip of your own teaching through inquiry.	60 minutes (may be done post-session)

Transparency #2/Hand-out #2

Characteristics of Teaching through Inquiry	**Evidence** of Teaching through Inquiry

Transparency #3/Hand-out #3

Assessing Instruction for Inquiry session evaluation form

Professional development for teachers of science requires integrating knowledge of science, learning, pedagogy, and students; it also requires applying that knowledge to science teaching. Learning experiences for teachers of science must: Use inquiry, reflection, interpretation of research, modeling, and guided practice to build understanding and skill in science teaching. [NSES Professional Development Standard B (NSES page 62+)]

Include evidence from the session in your responses to the following:

To what extent did today's session effectively use:

	not effectively			**very effectively**
inquiry				
Evidence				
reflection				
Evidence				
iterpreting research				
Evidence				
modeling				
Evidence				
guided practice				
Evidence				

Transparency #4/Hand-out #4
(Note: This page will need to be edited if the section headers for the rubrics change or the names of the rubrics change.)

Section Headers on Instructional Materials Rubric	Section Headers on Inquiry Instruction Rubric
A. Increase Understanding of Science Subject Matter	
B. Increase Understanding of How Scientists Study the Natural World	A. Increase Understanding of How Scientists Work
C. Develop the Ability to Conduct Investigations	B. Develop the Ability to Conduct Investigations
D. Develop the Habits of Mind Associated with Science	C. Develop the Habits of Mind Associated with Science

Facilitator resource #1 This is a multi-page annotated list of video resources.

Annenberg
1-800-LEARNER
http://www.learner.org

Learning Science Through Inquiry
Inquiry-based teaching, central to the National Science Education Standards and the Benchmarks for Science Literacy, should not be an isolated occurrence, but comprehensive and ongoing approach. However, many teachers hesitate to teach science through inquiry because they did not learn this way themselves, when they were students or during their preparation to become teachers. This workshop shows inquiry teaching and learning in action, with real teachers and students in real classrooms. Whether you have already experimented with inquiry teaching and want to enhance your practice, or are new to the approach and want to know how to make it work, this workshop will help you understand the process and how it benefits students, and give you strategies to use in your classroom.

Workshop 1. What Is Inquiry and Why Do It?
This introductory workshop presents an overview of why inquiry is such a powerful approach to teaching and learning science how it enables you to assess and meet the needs of a wide range of learners, how it taps children's natural curiosity, and how it deepens their understanding of science.

Workshop 2. Setting the Stage: Creating a Learning Community
At the heart of inquiry teaching and learning is a positive environment that encourages and supports students on their learning paths. This program looks at what is needed for building that foundation and preparing your students for inquiry investigations.

Workshop 3. The Process Begins: Launching the Inquiry Exploration
To inquire into specific scientific phenomena, students need to draw upon a foundation of experience. This program shows how you can encourage students to share and discuss what they already know, and to explore the materials and phenomena in an open-ended manner.

Workshop 4. Focus the Inquiry: Designing the Exploration
Students' open exploration leads to a range of interests and questions that lead in turn to deeper investigation. This program looks at the design process how you can guide students to plan and begin their investigations.

Workshop 5. The Inquiry Continues: Collecting Data and Drawing Upon Resources
This program explores ways that inquirers collect and record first-hand data, just as scientists do, and observe, raise questions, make predictions, test hypotheses, and develop understanding. It also examines how other resources and outside expertise can help your students formulate patterns and relationships.

Workshop 6. Bring It All Together: Processing for Meaning During Inquiry

Making meaning from investigations and experience requires that you guide student dialogue, encouraging your students to make connections, draw conclusions, and ask new questions. This program looks at the rationale for this kind of processing, and strategies that can help students construct new mental frameworks.

Workshop 7. Assessing Inquiry
Assessment is an ongoing process in the classroom. This program looks at a variety of assessment strategies that range from the very informal formative assessments to formal summative assessments, and explores the purposes each can serve.

Workshop 8. Connecting Other Subjects to Inquiry
This program explores how to use subjects like mathematics and language to further scientific inquiry and understanding of science concepts, and conversely, how science can aid learning in other subjects. It also reiterates the benefits of learning science through inquiry and explores your "next steps" along the inquiry journey.

Science K-6: Investigating Classrooms

Science K-6: Investigating Classrooms shows how teachers are incorporating genuine inquiry into their classes. See experienced teachers create supportive learning environments, structure small groups for cooperative learning, and draw out and interpret what students are thinking and learning. Classroom and discussion videos cover grades K-2, 3-4, and 5-6.

Introduction
Provides an overview of the library.

Food for Thought
A fifth-grade class in Huntsville, Alabama explores food chemistry. (50 min.)

Completing the Circuit
A fourth-grade class in Castro Valley, California investigates electrical circuits. (50 min.)

All Sorts of Leaves
A first-grade class in Boynton Beach, Florida studies biodiversity by taking a close look at leaves. (50 min.)

Food for Thought: A Conversation About Teaching
Practicing teachers and science education professionals reflect on the issues raised in Food for Thought (55min.)

Completing the Circuit: A Conversation About Teaching
Practicing teachers and science education professionals reflect on the issues raised in Completing the Circuit (55 min.)

All Sorts of Leaves: A Conversation About Teaching
Practicing teachers and science education professionals reflect on the issues raised in All Sorts of Leaves (55min.)

Teacher Workshop
Sixteen inservice teachers engage in professional development using: Completing the Circuit. (40 min.)

Parents Open House
Teachers, parents, and administrators discuss how different today's classroom science looks from that of the past. (25 min.)

Teaching High School Science

Asking questions, making discoveries, gathering data, analyzing explanations, and communicating scientific arguments are key ingredients in a classroom where vibrant inquiry is taking place. The Teaching High School Science library will help new and veteran science teachers integrate national science standards and inquiry learning into their curricula. Showing science classrooms around the country, the modules cover topics in life science, physical science, Earth and space science, and integrated science. They also show a range of teaching techniques and student/teacher interaction.

Introduction

Thinking Like Scientists
Classroom footage and new footage of scientists in the field explain and illustrate the concept of inquiry.

Chemical Reactions
Students in a ninth-grade Principles of Science and Technology class formulate and explore their own questions about a chemical reaction.

Investigating Crickets
Ninth-grade biology students design and conduct experiments about crickets.

Exploring Mars
Students in an 11th-grade integrated science class explore how the Mars landscape may have formed.

The Physics of Optics
An 11th- and 12th-grade physics class looks at light, lenses, and the human eye.

Science IMAGES

Meet eight elementary and middle school teachers who focus on scientific thinking. These unscripted programs capture several days in their classrooms, complete with the normal changes-of-plan and interruptions, to show inquiry-based science instruction as it unfolds. Each program begins with a science concept and a teacher explaining his or her goals. You'll then see the lesson in progress as students observe, analyze, develop theories, and reach conclusions. Finally, each teacher gives a candid review of the class response and an evaluation of his or her lesson.

Overview
Provides an overview of the video library and coordinated print guides, and how they can be used.

Darlene Norfleet, 1st Grade
Working through a unit on the human body, students compare and contrast features of their own bodies.

Sister Gertrude Hennessey, 2nd Grade
Students develop a theory about force and motion by working with various moving objects.

Chris Collier, 3rd Grade
The class engages in a variety of activities and keeps journals of data and their thoughts while examining the five senses.

Marc Heuer, 4th Grade
Research about water facts and the water cycle, including where the town gets and purifies its water, engages students.

Linda Hallenbeck, 5th Grade
Population data gathered from gravestones in the local cemetery helps students examine the processes of scientific inquiry.

Dorcas Gonzalez-Lantz, 6th Grade
Students learn about matter and molecules as they investigate the relationships between energy and changes of state by observing water change from ice to steam.

Kathy Brown, 7th Grade
An actual case history of a Chicago patient in 1904 who suffered from fatigue teaches students about the human circulatory system.

Doug Kirkpatrick, 8th Grade
Students use computers during a lesson on "What happens to light as you move away?" to observe, graph, and analyze data, then confirm their predictions via e-mail with university scientists.

Physics by Inquiry

Teachers from around the country work toward deepening their understanding of what it means to learn and teach science by inquiry. This video program takes viewers inside the six-week National Science Foundation (NSF) summer institute in physics and physical science. Through carefully sequenced questions and experiments, K-12 teachers are guided in constructing some of the basic concepts required to teach science effectively. Viewers can observe the process of guided inquiry as it unfolds. The program features teachers engaged in discussions with the instructors and with one another as they develop important scientific concepts and reasoning skills. Through direct experience, they begin to recognize and resolve some of the difficulties that are commonly encountered in the study of science. One ninety-minute video program.

Scienceline

Scienceline is a video series that models effective standards-based learning strategies, taking you into classrooms to observe inquiry teaching and learning. Sit with a kindergarten class in Florida; multi-age classes in the Midwest; and suburban and urban third, fourth, and fifth grades. Meet seven extraordinary elementary school teachers whose students investigate the world by linking personal concepts and questions to concrete experiences. Developed in collaboration with the National Science Teachers Association.

Michael Beason
Location: Apopka, Florida kindergarten classroom
Part 1: Michael Beason facilitates an investigation of worms, and the life science concept of living vs. nonliving.
Part 2: Student-directed inquiry leads "Mr. B" and his kindergarten to an unplanned activity! Terrific for exploring solutions to managing the inquiry classroom when the lesson takes an unexpected turn.

Christine Collier
Location: Indianapolis, Indiana classrooms, grades 4-5
Part I: Christine leads students on a long-term investigation of decomposition, a content area she does not fully understand.
Part II: Students in Christine's classroom are confused by the data they collect and are arriving at many misconceptions. She discusses how she addresses this situation.

Lisa Nyberg and Jane Morton
Location: Springfield, Oregon classroom, grades 3-4
Lisa uses the process of guided inquiry into the world of sound to move from a teacher-directed to a student-directed classroom.

Jane Morton
Location: Bellevue, Washington classroom, grades 3-4
Jane and her students identify mystery substances in a geology investigation. See how she incorporates resources beyond her classroom, including the Internet and ecological resources.

Tim O'Keefe
Location: Columbia, South Carolina classroom, grade 3
Part I: Tim O'Keefe models different approaches to inquiry, playing both teacher and learner with his third graders as they explore botany activities. Great for picking up good questioning skills!
Part II: Tim illustrates how to integrate plant-related inquiries with math, language arts, music, and social studies into the inquiry classroom.

Kathryn Mitchell Pierce
Location: Clayton, Missouri classroom, grades 1-3
Part I: Kathyrn shows how to blend inquiry with her Missouri school district's mandated physical science curriculum.
Part II: Students devise tools and strategies to answer their own questions about how scientists predict weather.

Garnetta Chain / Assessment
Location: New Brunswick, New Jersey classroom, grade 3
Part I: Garnetta follows her students on an inquiry about weathering rocks, which begins on their urban school playground.
Part II: Seven elementary school teachers explore multiple strategies for assessing student understanding in an inquiry environment. What's more, they discuss the importance of constant self-assessment of their facilitation role and techniques.

Visualizing Growth: Changing the Way We Teach Science

Follow the professional development of elementary teachers who have partnered with curators at a local science museum, and go exploring with them in the field. Then visit the classrooms where teachers share this new way of learning science with their students, encouraging their curiosity about the natural world as a springboard to scientific inquiry. Embedded in each story are important issues of science teaching, such as assessment and helping students develop inquiry skills.

Introduction
This short sampler offers a comprehensive overview of Visualizing Growth with clips from the library and ideas for forming local partnerships.

Can A Worm Lift an Elephant?: Building Science Confidence
Third-grade teacher Delores Dahn works with a museum curator to better understand physical science, giving her the confidence to present simple machines to her special needs students. A field trip to a local construction company provides students with a valuable connection between school and the outside world, and allows Delores to assess her students' understanding.

Finding Patterns From the Past: Developing Inquiry Skills
An archaeologist introduces a group of teachers to the proper techniques used at an excavation. As a way of understanding the meaning of artifacts and the patterns they create, the group travels to a reconstructed Indian village. In a sixth-grade classroom, Wayne Smith and his students observe, record, and analyze data gathered on a neighborhood field survey. Students conduct research to answer questions about their
community and its past.

Ducks Can Fly?: Bringing the Field to the Classroom
Teachers use their own fieldwork to provide authentic field experiences for their students. After traveling to a gull colony with a curator, first-grade teacher Carol Stewart takes her students to a nearby duck pond. Students observe and explore this natural setting, gathering information for continued exploration in the classroom.

Click, Buzz, Whirr! Insects Are Everywhere: Forming New Partnerships
An entomologist shares his knowledge of insects with teachers, as well as his enthusiasm and respect for living things. Teachers Donna Kellum (first grade) and Carm Perri (fifth grade), along with their students, collect and observe insects at a local park, while others conduct fly-trapping experiments in the classroom. Finally, teachers and the entomologist discuss the outcome of their lessons and share ideas to improve them.

Planting the Seeds for Teacher Growth: Cultivating Reflective Partnerships
This program explores the relationships formed when museums partner with schools, and when teachers partner with other teachers. Mentor and kindergarten teacher Margaret Somerville and third-grade teacher Kathy Casalinuvo work with a botanist at a local nature preserve. The two teachers learn from each other as they build a mutual support system, with self-reflection playing an important role.

Stepping Stones to Inquiry: Learning From a Collection
With a museum geologist, Marianne Rotolo and Ruth Major, third and fifth grade teachers at the same school, use fossils as the basis for learning through inquiry. Students collect fossils and work together to categorize, identify, and assemble their collections, together they visit a museum to seek answers to their questions.

Seasons Don't Go Backwards: Assessing Student Learning
A team of elementary teachers are committed to sharing and developing their ideas through collaborative planning and teaching. They struggle to find new ways to improve student learning as they work with new materials and teaching methods. On-going assessment of student learning leads them to expertise found at the local science museum.

A Garden in the City: Unifying the School Community
Preschool teacher Judy Fix works with parents, colleagues, and the community to build an outdoor learning center. Judy uses her schoolyard laboratory for student exploration and the study of ecology. Over the course of a year, Judy's growth as a teacher parallels that of her students and the garden is used as an educational resource by more teachers.

Building a Better Learning Community: Systemic Change - A Closer Look
The Buffalo, New York, educational community wants to move toward more interactive, inquiry-based learning. Project TEAM (Teacher Education at the Museum) was developed at the science museum to foster new partnerships within and beyond the school system. This documentary talks about the program's accomplishments and the challenges it still faces.

IOX Educational Research and Development
(503) 275-0457
iox@loop.com

Two videos, Why Won't You Tell Me the Answer? Inquiry in the High School Classroom and How Do You Spell Parallel? Visiting Middle School Mathematics,
highlight Northwest teachers who are successfully implementing strategies called for by national and state standards in science and mathematics. The videos include conversations with teachers about their struggles and successes as they work to provide all students with high quality science and mathematics education.
The videos are available for loan to Northwest educators (Alaska, Idaho, Montana, Oregon and Washington). More information about the videos, including how to request a loan for How do you spell parallel? Visiting middle school math and Why won't you tell me the answer? Inquiry in the high school classroom is available by following those links, or by contacting us: (503) 275-0457, or math_and_science@nwrel.org. Others may purchase the videos for $165 each through IOX Educational Research and Development at (310) 822-3275 or online iox@loop.com.

Facilitator resource #2

Possible responses to prompt in step #3 and step #12.

Characteristics of Teaching through Inquiry	**Evidence** of Teaching through Inquiry
Characteristics of teaching through inquiry may include: 〈 teacher frequently asks more questions than imparts information 〈 levels of questions vary from knowledge to analysis 〈 facilitation strategies are used more than presenting strategies 〈 learners are probed to think more deeply about concepts 〈 communication with the teacher is two-way 〈 discourse among students is orchestrated 〈 students are challenged to accept and share responsibility for their own learning 〈 every student is encouraged to participate 〈 skills, attitudes and values of scientific inquiry are modeled by the teacher, including openness, curiosity, skepticism 〈 teachers use evidence gathered from student assessment data to guide their teaching 〈 the setting is created for student work that is flexible and supportive of scientific inquiry 〈 tools, equipment, and technology is available to students 〈 diverse ideas and skills are respected 〈 collaboration among students is nurtured	

Facilitator Resource #3

Activity #1, Introducing Inquiry and the Nature of Science, through the second cube. From pages 66-73 from Teaching About Evolution and the Nature of Science, National Academy of Sciences, National Academy Press, Washington, DC, 1998. (also available on-line at www.nap.edu/readingroom/books/evolution98) Visit this website to download the PDF files of the cubes for this activity.

ACTIVITY 1

Introducing Inquiry and the Nature of Science

This activity introduces basic procedures involved in inquiry and concepts describing the nature of science. In the first portion of the activity the teacher uses a numbered cube to involve students in asking a question—what is on the bottom?— and the students propose an explanation based on their observations. Then the teacher presents the students with a second cube and asks them to use the available evidence to propose an explanation for what is on the bottom of this cube. Finally, students design a cube that they exchange and use for an evaluation. This activity provides students with opportunities to learn the abilities and understandings aligned with science as inquiry and the nature of science as described in the *National Science Education Standards.* Designed for grades 5 through 12, the activity requires a total of four class periods to complete. Lower grade levels might only complete the first cube and the evaluation where students design a problem based on the cube activity.

Standards-Based Outcomes

This activity provides all students with opportunities to develop abilities of scientific inquiry as described in the *National Science Education Standards*. Specifically, it enables them to:

- identify questions that can be answered through scientific investigations,
- design and conduct a scientific investigation,
- use appropriate tools and techniques to gather, analyze, and interpret data,
- develop descriptions, explanations, predictions, and models using evidence,
- think critically and logically to make relationships between evidence and explanations,
- recognize and analyze alternative explanations and predictions, and
- communicate scientific procedures and explanations.

This activity also provides all students opportunities to develop understanding about inquiry and the nature of science as described in the *National Science Education Standards*. Specifically, it introduces the following concepts:

- Different kinds of questions suggest different kinds of scientific investigations.
- Current scientific knowledge and understanding guide scientific investigations.
- Technology used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations.

- Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories.
- Science distinguishes itself from other ways of knowing and from other bodies of knowledge through the use of empirical standards, logical arguments, and skepticism, as scientists strive for the best possible explanations about the natural world.

Science Background for Teachers

The pursuit of scientific explanations often begins with a question about a natural phenomenon. Science is a way of developing answers, or improving explanations, for observations or events in the natural world. The scientific question can emerge from a child's curiosity about where the dinosaurs went or why the sky is blue. Or the question can extend scientists' inquiries into the process of extinction or the chemistry of ozone depletion.

Once the question is asked, a process of scientific inquiry begins, and there eventually may be an answer or a proposed explanation. Critical aspects of science include curiosity and the freedom to pursue that curiosity. Other attitudes and habits of mind that characterize scientific inquiry and the activities of scientists include intelligence, honesty, skepticism, tolerance for ambiguity, openness to new knowledge, and the willingness to share knowledge publicly.

Scientific inquiry includes systematic approaches to observing, collecting information, identifying significant variables, formulating and testing hypotheses, and taking precise, accurate, and reliable measurements. Understanding and designing experiments are also part of the inquiry process.

Scientific explanations are more than the results of collecting and organizing data. Scientists also engage in important processes such as constructing laws, elaborating models, and developing hypotheses based on data. These processes extend, clarify, and unite the observations and data and, very importantly, develop deeper and broader explanations. Examples include the taxonomy of organisms, the periodic table of the elements, and theories of common descent and natural selection.

One characteristic of science is that many explanations continually change. Two types of changes occur in scientific explanations: new explanations are developed, and old explanations are modified.

Just because someone asks a question about an object, organism, or event in nature does not necessarily mean that person is pursuing a scientific explanation. Among the conditions that must be met to make explanations scientific are the following:

- *Scientific explanations are based on empirical observations or experiments*. The appeal to authority as a valid explanation does not meet the requirements of science. Observations are based on sense experiences or on an extension of the senses through technology.
- *Scientific explanations are made public.* Scientists make presentations at scientific meetings or publish in professional journals, making knowledge public and available to other scientists.
- *Scientific explanations are tentative.* Explanations can and do change. There are no scientific truths in an absolute sense.
- *Scientific explanations are historical.* Past explanations are the basis for contemporary explanations, and those, in turn, are the basis for future explanations.

- *Scientific explanations are probabilistic*. The statistical view of nature is evident implicitly or explicitly when stating scientific predictions of phenomena or explaining the likelihood of events in actual situations.
- *Scientific explanations assume cause-effect relationships*. Much of science is directed toward determining causal relationships and developing explanations for interactions and linkages between objects, organisms, and events. Distinctions among causality, correlation, coincidence, and contingency separate science from pseudoscience.
- *Scientific explanations are limited*. Scientific explanations sometimes are limited by technology, for example, the resolving power of microscopes and telescopes. New technologies can result in new fields of inquiry or extend current areas of study. The interactions between technology and advances in molecular biology and the role of technology in planetary explorations serve as examples.

Science cannot answer all questions. Some questions are simply beyond the parameters of science. Many questions involving the meaning of life, ethics, and theology are examples of questions that science cannot answer. Refer to the *National Science Education Standards* for Science as Inquiry (pages 145-148 for grades 5-8 and pages 175-176 for grades 9-12), History and Nature of Science Standards (pages 170-171 for grades 5-8 and pages 200-204 for grades 9-12), and Unifying Concepts and Processes (pages 116-118). Chapter 3 of this document also contains a discussion of the nature of science.

Materials and Equipment
- 1 cube for each group of four students (black-line masters are provided).
- (Note: you may wish to complete the first portion of the activity as a demonstration for the class. If so, construct one large cube using a cardboard box. The sides should have the same numbers and markings as the black-line master.)
- 10 small probes such as tongue depressors or pencils.
- 10 small pocket mirrors.

Instructional Strategy

Engage:
Begin by asking the class to tell you what they know about how scientists do their work. How would they describe a scientific investigation? Get students thinking about the process of scientific inquiry and the nature of science. This is also an opportunity for you to assess their current understanding of science. Accept student answers and record key ideas on the overhead or chalkboard.

Explore:
(The first cube activity can be done as a demonstration if you construct a large cube and place it in the center of the room.) First, have the students form groups of three or four. Place the cubes in the center of the table where the students are working. The students should not touch, turn, lift, or open the cube. Tell the students they have to identify a question associated with the cube. Allow the students to state their questions. Likely questions include:

- What is in the cube?
- What is on the bottom of the cube?
- What number is on the bottom?

You should direct students to the general question*, what is on the bottom of the cube*? Tell the students that they will have to answer the question by proposing an explanation, and that they will have to convince you and other students that their answer is *based on evidence*. (Evidence refers to observations the group can make about the visible sides of the cube.) Allow the students time to explore the cube and to develop answers to their question. Some observations or statements of fact that the students may make include:

- The cube has six sides.
- The cube has five exposed sides.
- The numbers and dots are black.
- The exposed sides have numbers 1, 3, 4, 5, and 6.
- The opposite sides add up to seven.
- The even-numbered sides are shaded.
- The odd-numbered sides are white.

Ask the students to use their observations (the data) to propose an answer to the question: *What is on the bottom of the cube*? The student groups should be able to make a statement such as: *We conclude there is a 2 on the bottom*. Students should present their reasoning for this conclusion. For example, they might base their conclusion on the observation that the exposed sides are 1, 3, 4, 5, and 6, and because 2 is missing from the sequence, they conclude it is on the bottom. Use this opportunity to have the students develop the idea that combining two different but logically related observations creates a stronger explanation. For example, 2 is missing in the sequence (that is, 1, _, 3, 4, 5, 6) and that opposite sides add up to 7 (that is, 1—6; 3—4; _—5) and because 5 is on top, and 5 and 2 equal 7, 2 could be on the bottom.

If done as a demonstration, you might put the cube away without showing the bottom or allowing students to dismantle it. Explain that scientists often are uncertain about their proposed answers, and often have no way of knowing the absolute answer to a scientific question. Examples such as the exact ages of stars and the reasons for the extinction of prehistoric organisms will support the point.

Explain:

Begin the class period with an explanation of how the activity simulates scientific inquiry and provides a model for science. Structure the discussion so students make the connections between their experiences with the cube and the key points (understandings) you wish to develop.

- Key points from the *Standards* include the following:
- Science originates in questions about the world.

- Science uses observations to construct explanations (answers to the questions). The more observations you had that supported your proposed explanation, the stronger your explanation, even if you could not confirm the answer by examining the bottom of the cube.
- Scientists make their explanations public through presentations at professional meetings and journals.
- Scientists present their explanations and critique the explanations proposed by other scientists.

The activity does not explicitly describe "the scientific method." The students had to work to answer the question and probably did it in a less than systematic way. Identifiable elements of a method—such as observation, data, and hypotheses—were clear but not applied systematically. You can use the experiences to point out and clarify scientific uses of terms such as observation, hypotheses, and data.

For the remainder of the second class period you should introduce the "story" of an actual scientific discovery. Historic examples such as Charles Darwin would be ideal. You could also assign students to prepare brief reports that they present.

Elaborate:

The main purpose of the second cube is to extend the concepts and skills introduced in the earlier activities and to introduce the role of prediction, experiment, and the use of technology in scientific inquiry. The problem is the same as the first cube: *What is on the bottom of the cube?* Divide the class into groups of three and instruct them to make observations and propose an answer about the bottom of the cube. Student groups should record their factual statements about the second cube. Let students identify and organize their observations. If the students are becoming too frustrated, provide helpful suggestions. Essential data from the cube include the following (see black-line master):

- Names and numbers are in black.
- Exposed sides have either a male or female name.
- Opposing sides have a male name on one side and a female name on the other.
- Names on opposite sides begin with the same letters.
- The number in the upper-right corner of each side corresponds to the number of letters in the name on that side.
- The number in the lower-left corner of each side corresponds to the number of the first letter that the names on opposite sides have in common.
- The number of letters in the names on the five exposed sides progresses from three (Rob) to seven (Roberta).

Four names, all female, could be on the bottom of the cube: Fran, Frances, Francene, and Francine. Because there are no data to show the exact name, groups might have different hypotheses. Tell the student groups that scientists use patterns in data to make predictions and then design an experiment to assess the accuracy of their prediction. This process also produces new data.

Tell groups to use their observations (the data) to make a prediction of the number in the upper-right corner of the bottom. The predictions will most likely be 4, 7, or 8. Have the team decide which corner of the bottom they wish to inspect and why they wish to inspect it. The students might find it difficult to determine which corner they should inspect. Let them struggle with this and even make a mistake—this is part of science! Have one student obtain a utensil, such as a tweezers, probe, or tongue depressor, and a mirror. The student may lift the designated corner less than one inch and use the mirror to look under the corner. This simulates the use of technology in a scientific investigation. The groups should describe the data they gained by the "experiment." Note that the students used technology to expand their observations and understanding about the cube, even if they did not identify the corner that revealed the most productive evidence.

If students observe the corner with the most productive information, they will discover an 8 on the bottom. This observation will confirm or refute the students' working hypotheses. Francine or Francene are the two possible names on the bottom. The students propose their answer to the question and design another experiment to answer the question. Put the cube away without revealing the bottom. Have each of the student groups present brief reports on their investigation.

Evaluate:

The final cube is an evaluation. There are two parts to the evaluation. First, in groups of three, students must create a cube that will be used as the evaluation exercise for other groups. After a class period to develop a cube, the student groups should exchange cubes. The groups should address the same question: *What is on the bottom of the cube?* They should follow the same rules—for example, they cannot pick up the cube. The groups should prepare a written report on the cube developed by their peers. (You may have the students present oral reports using the same format.) The report should include the following:

- title,
- the question they pursued,
- observation—data,
- experiment—new data,
- proposed answer and supporting data,
- a diagram of the bottom of the cube, and
- suggested additional experiments.

Due to the multiple sources of data (information), this cube may be difficult for students. It may take more than one class period, and you may have to provide resources or help with some information.

Remember that this activity is an evaluation. You may give some helpful hints, especially for information, but since the evaluation is for inquiry and the nature of science you should limit the information you provide on those topics.

Student groups should complete and hand in their reports. If student groups cannot agree, you may wish to make provisions for individual or "minority reports." You may wish to have groups present oral reports (a scientific conference). You have two opportunities to evaluate students on this activity: you can evaluate their understanding of inquiry and the nature of science as they design a cube, and you can assess their abilities and understandings as they figure out the unknown cube.

PDF Activities

- **Cube #1**
- **Cube #2**
- **Cube #3**

References

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