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Assessing for Learning Facilitator's Guide

WORKSHOP III: EFFECTIVE QUESTIONING

A Professional Development Curriculum from the Institute for Inquiry®

The third in a set of five workshops for teacher professional development

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This material is based upon work supported by the National Science Foundation under Grant No. 9911834. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Major support for the Institute for Inquiry has been provided by the National Science Foundation, California Department of Education, The Noyce Foundation, Marin Community Foundation, Stephen D. Bechtel, Jr., and the S. D. Bechtel, Jr. Foundation.

Additional funding was made possible by Wells Fargo Foundation, The San Francisco Foundation, American Honda Foundation, Richard Lounsbery Foundation, The Grove Foundation, and Washington Mutual.

You can download your own copy of this guide at www.exploratorium.edu/ifi/assessing. A wealth of background material, for this and the other guides in the series, can be found at www.exploratorium.edu/ifi/library.

In order to access these materials, you will need Macromedia Flash Player 5 or higher and Adobe Acrobat Reader 4 or higher, available for free downloading at www.exploratorium.edu/ifi/help. These plug-ins may require additional memory.

You can download any of the ASSESSING FOR LEARNING workshop guides at www.exploratorium.edu/ifi/workshops.

Effective Questioning

Welcome

Welcome to *Effective Questioning*, the third workshop in the ASSESSING FOR LEARNING curriculum. The five workshops in this series introduce formative assessment and offer ways for teachers to begin applying elements of formative assessment in their own classrooms.

This five-part curriculum is designed to be presented in sequence and in its entirety. To help facilitators review key concepts that pertain to the entire curriculum, each workshop guide contains a section on Formative Assessment Basics.

Created by British educator and author Wynne Harlen in collaboration with the staff of the Exploratorium Institute for Inquiry in San Francisco, this curriculum has been offered to science educators and professional developers since 1996.

In 2000, the National Science Foundation asked that the Institute for Inquiry make these workshops available to even more educators. The result is a series of guides that provide step-by-step instructions and access to support materials online so that professional developers and teacher educators can present these workshops on their own.

LYNN RANKIN
Director
Institute for Inquiry

Contents

Acknowledgments

ASSESSING FOR LEARNING is based on original work by British educator and author Wynne Harlen in collaboration with the Exploratorium's Institute for Inquiry in San Francisco. Formerly Director of the Scottish Research Council, Dr. Harlen has spent the last thirty years involved in research on assessment and student learning in primary science education. Her books, including *The Teaching of Science in Primary Schools; Primary Science: Taking the Plunge;* and *Teaching, Learning, and Assessing Science 5–12,* are used by educators throughout the world. Since 1996 she has been the primary presenter of a five-day series of workshops on formative assessment at the Institute for Inquiry. The core ideas and activities from those workshops, as well as Dr. Harlen's original drafts of this document, form the basis for these guides.

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Special Thanks

We are very grateful to workshop reviewers David Hartney and Pat McGlashan of First Hand Learning, Inc., Buffalo, NY, and Karen Worth, Educational Development Center, Newton, MA, for their exceptional contributions in the testing and refinement of this curriculum.

Thanks also to Doris Ash for her numerous contributions, and to the many educators from across the country whose participation has aided in the development of these workshops.

The Institute for Inquiry would also like to thank Rob Semper, Executive Associate Director of the Exploratorium and Director of the Center for Learning and Teaching, and Bronwyn Bevan, Associate Director of the Center for the Learning and Teaching, for providing institutional support.

ABOUT THIS WORKSHOP

- **The Workshop in Context**
- **Workshop Overview**

The Workshop in Context

Assessing for Learning

Effective Questioning is the third of five workshops in the Assessing for Learning curriculum. The workshops in this curriculum are designed to be used sequentially so that participants work step-by-step toward a full understanding of formative assessment. All five workshops take as their starting point the Formative Assessment Basics, introduced on page 9 of this guide and available in each of the five facilitator guides in this series.

The Assessing for Learning curriculum consists of the following workshops:

I

Workshop I: Introduction to Formative Assessment

Participants discover the purpose of formative assessment and find out how it differs from summative assessment (about 2 hours).

II

Workshop II: Assessing Process Skills

Participants learn how to observe and interpret students' use of the process skills of science (about 3 hours).

Workshop III

Workshop III: Effective Questioning

Participants identify questions that are useful for eliciting students' ideas and for encouraging the use of science process skills (about 2 hours).

IV

Workshop IV: Assessing Science Ideas

Participants create indicators of development for specific scientific ideas and consider the nature of feedback that helps student learning (about 2 hours).

V

Workshop V: Student Self-Assessment

Participants investigate the value of students assessing their own and their peers' work and explore ways to communicate goals and criteria to students (about 2 hours).

How to Use the Curriculum

This curriculum is designed to be presented in sequence and in its entirety. If you decide to present less than the full curriculum, it's important to communicate this to participants, so they aren't left with the impression that they have been introduced to all the main ideas related to formative assessment. For example:

- Doing only Workshop I would be a good introduction to formative assessment, but would not offer teachers any practical strategies to implement in the classroom.
- Doing Workshops II, III, IV, or V alone would offer classroom strategies, but without the overview of formative assessment to put those strategies in context.
- Doing Workshop I following by one of the other workshops would provide an overview of formative assessment and a single strategy to implement it, but would give an incomplete picture of formative assessment practice.

Workshop Overview

A Quick Summary

Effective Questioning is the third in a set of five guides in the ASSESSING FOR LEARNING curriculum. The guides are designed to help facilitators plan and present professional development workshops for educators interested in developing an understanding of formative assessment and how to begin to apply it in their classroom.

The first workshop in this series introduced the Formative Assessment Cycle, which provides the conceptual foundation for the curriculum.

In Workshop II, *Assessing Process Skills*, participants explored how to use observation to gather evidence of the use and development of process skills. However, observation is not always useful for finding out students' scientific ideas, which are not necessarily demonstrated by their actions. In this workshop, *Effective Questioning*, we explore another way teachers can gain access to the ideas that students have: by asking carefully thought-out questions.

In the classroom, teachers create opportunities for students to express their ideas by asking questions or setting assignments. An assignment, in fact, is very much like a question. Both are requests, or invitations, for students to express their ideas. It's important to find out what students are thinking. With that information, you can encourage students to test those ideas and develop them toward ones that are consistent with evidence and a scientific view of how things work.

When carefully done, questioning is a powerful and effective tool for carrying out formative assessment in the classroom. But how do you ask questions that get you the information you want? In fact, some questions are more effective than others for discovering what students are thinking about a particular topic. This workshop is designed to focus on the importance of the thoughtful and respectful formulation of questions as a way of gathering evidence of students' ideas.

Goals

- **To help teachers understand the importance of effective questioning in revealing students' ideas.**
- **To help teachers understand the importance of effective questioning in creating a classroom climate that honors students' thoughts and feelings.**
- **To help teachers understand that some types of questions are more useful than others for eliciting students' ideas.**

The Goals of the Workshop

One of the overall aims of the ASSESSING FOR LEARNING curriculum is to help teachers understand formative assessment as a recurring cycle of events. Information about the Formative Assessment Cycle is provided in the Formative Assessment Basics section of this guide, which begins on page 9.

The Formative Assessment Cycle, presented in detail in Workshop I of this series (*Introduction to Formative Assessment*), begins with the collection of evidence relating to the science goals of student work. By interpreting that evidence, a teacher can determine

students' current levels of understanding or abilities relating to science goals, decide what next developmental steps to take to achieve those goals, and finally, determine how to help students take those next steps.

This workshop—*Effective Questioning*—focuses on ways teachers can identify questions that are useful for eliciting students' ideas, and offers strategies for using questioning effectively in the classroom.

How the Workshop Works

Participants begin the workshop by doing two simple hands-on activities. After each one, they write a sample question they might ask to help students express their explanations in the classroom. These questions are discussed, sorted, and analyzed, giving participants the opportunity to explore how different kinds of questions can elicit different kinds of information from students. The facilitator then introduces a list of questions that could encourage students to use various process skills. Then, participants discuss ways to create a classroom climate that encourages students to express their ideas, and the facilitator then summarizes the session to reinforce the take-home messages.

Typically, planning takes about four hours, not including the time necessary to prepare materials. In this guide, we list materials for 36 participants. For fewer participants, quantities of materials and other workshop logistics can be adjusted as needed.

We recommend 12 to 36 participants for our workshops. Having fewer than 12 does not allow for the lively group interaction that is such an important component of the workshop. Having more than 36 makes whole-group discussions unwieldy and can necessitate an additional facilitator.

Take-Home Messages

- **The way in which questions are expressed determines what happens as a result—whether they elicit a student's understanding, lead to action and use of process skills, or are answered by recall of facts.**
- **Questions that invite students to express their own ideas are open-ended and person-centered.**
- **Thoughtful questions require time for thoughtful answers.**
- **Teacher reactions to student answers, and the general ethos of the classroom, can encourage students to openly express their ideas.**

About the Take-Home Messages

The take-home messages are brief statements that convey the central pedagogical ideas encountered during the workshop. By introducing the messages early on, facilitators set the context for what is to follow, and inform participants of the purpose and content of the workshop. This transparency of purpose is an important initial step in establishing an atmosphere of trust between facilitators and learners. Such trust is critical in creating a climate in which learners feel comfortable expressing opinions and considering new ideas.

Understanding of the messages deepens as the workshop progresses, and as participants become intellectually engaged in building new ideas based on their firsthand experiences and their conversations with each other. The take-home messages are revisited at the end of the workshop as a way to summarize and reinforce the understandings participants have constructed.

FORMATIVE ASSESSMENT BASICS

- **The Inquiry Connection**
- **The Formative Assessment Cycle**
- **Additional Resources**

The Inquiry Connection

Formative Assessment and Learning Science through Inquiry

From their earliest years, children develop ideas about the world that make sense to them, but don't necessarily correspond to the scientific view. How do we help children develop their ideas into more scientific ones?

Experience and research show that merely teaching "correct" scientific ideas does not necessarily change students' understanding. Change is more likely to happen when students test their scientific ideas for themselves. Teaching through inquiry helps students test their existing ideas about scientific phenomena, consider alternative ideas, and gradually develop an understanding that is more consistent with evidence and with the scientific view of how things work. But students often need help with this process. Formative assessment gives teachers the means to help students express their ideas and rigorously test them.

In general, when students engage in science inquiry, they go through the following phases:

• They begin by observing and exploring materials, and they raise questions about their observations.

• They choose a question to investigate, and then plan and do an investigation to try to answer their question.

• During the course of the investigation, they come up with ideas to explain what they're seeing, and find ways to test those ideas.

• Finally, they interpret the results of their investigations and communicate those results to others.

In order to help students have productive inquiry experiences in which they express and test ideas that can lead to new scientific understanding, teachers need to check in and offer guidance in every phase of the process. To do their investigations, students must be able to ask questions that can be investigated. And in order for students to draw conclusions based on evidence, they need to be able to plan systematic investigations to gather that evidence. The teacher's role in this process is to find out how the student is doing in each phase, and help them make progress.

To know how students are doing, teachers need a way to "get into students' heads" and understand how they're thinking. Each of the above phases of inquiry is an entry point for the teacher to carry out assessment that will provide information on how students understand science concepts, and on how effectively they are using the process skills of science (such as observing, questioning, planning, interpreting and communicating). The teacher can then use this information to determine what next steps students need to take in order to increase their understanding of science concepts and improve their ability to use the process skills of science. The teacher can then guide students in ways that will help them take next steps in learning.

Ideas about Formative Assessment

"Ideas about assessments have undergone important changes in recent years. In the new view, assessment and learning are two sides of the same coin. . . . When students engage in assessments, they should learn from those assessments."

National Research Council, *National Science Education Standards.* (Washington, DC: National Academy Press, 1996), pp. 5–6.

But of course it is the students who do the learning—and the more they are aware of the learning goals of their activities, the more they are able to recognize for themselves how to make progress. Part of the teacher's role, then, is to share goals with students, provide them with skills and opportunities for assessing their own progress, and help in deciding their next steps. All these aspects of teaching—gathering information about students' learning, interpreting it in terms of their progress, using it to decide next steps, feeding back to students how to move forward, and helping students understand the goals of their work and assess their own progress—are encompassed in the concept of formative assessment, and form the basis for the ASSESSING FOR LEARNING curriculum.

While formative assessment is essential when teaching science through inquiry, this powerful teaching strategy can also be applied effectively to all science teaching approaches (as well as any other curricular topic). Because formative assessment involves periodically checking students' current understanding during—rather than after—instruction, it provides useful information which allows teachers to tailor their teaching to a single student's, or a whole class's, specific needs. Using assessment to inform teaching is important in any instructional approach. However, it is critical to inquiry, in which students are raising questions and designing investigations to test their own ideas. Teachers must assess progress at every step of the investigation in order to ensure that their investigations are sound enough for students to draw useful conclusions that help them more fully develop their scientific ideas.

Assessment and Inquiry

"Assessments have become more sophisticated and varied as they have focused on higher-order skills. Rather than simply checking whether students have memorized certain items of information, new assessments probe for students' understanding, reasoning, and use of that knowledge—the skills that are developed through inquiry."

National Research Council, *National Science Education Standards.* (Washington, DC: National Academy Press, 1996, p. 6.

The Formative Assessment Cycle

Overview

Assessment is part of every teacher's job. The type of assessment teachers are most familiar with—in which they examine students' work in order to determine grades, write evaluations, compare levels of achievement, and make decisions about promotion—is called *summative assessment*.

In doing *formative assessment*, teachers also examine and evaluate students' thinking—but in this case, they do so in order to make pedagogical decisions for the purpose of helping students get closer to learning goals. Teachers use the information they gather about student work to determine what students need to do next that will help them progress toward the goals of the lesson.

The value of this kind of assessment is attested to not only by individual teachers who have used it effectively in their classrooms, but also by a significant body of research, as the sidebar at right, "Research on Formative Assessment," indicates.

Research on Formative Assessment

"In a review of research on assessment and classroom learning, Black and Wiliam [Black, P. J., and D. Wiliam. 1998. 'Assessment and Classroom Learning.' *Assessment in Education*. 5 (1) 7–74, 1998.] identified and analyzed 250 studies comparing classrooms where formative assessment was and was not practiced. This revealed striking evidence that, on almost every kind of academic measure, students whose teachers systematically applied formative assessment techniques outperformed similar students who did not receive such treatment. These differences were significant, both statistically and educationally.

"There was also evidence that the gain was greatest for lower-achieving students. This exhaustive study leaves the reader convinced that the improvement of formative assessment practices in United States classrooms might be the closest thing to the elusive 'magic bullet' that education reformers might find."

Wynne Harlen. *Enhancing Inquiry through Formative Assessment*. (San Francisco: Exploratorium, 2003) pp. 7–8.

The Formative Assessment Cycle

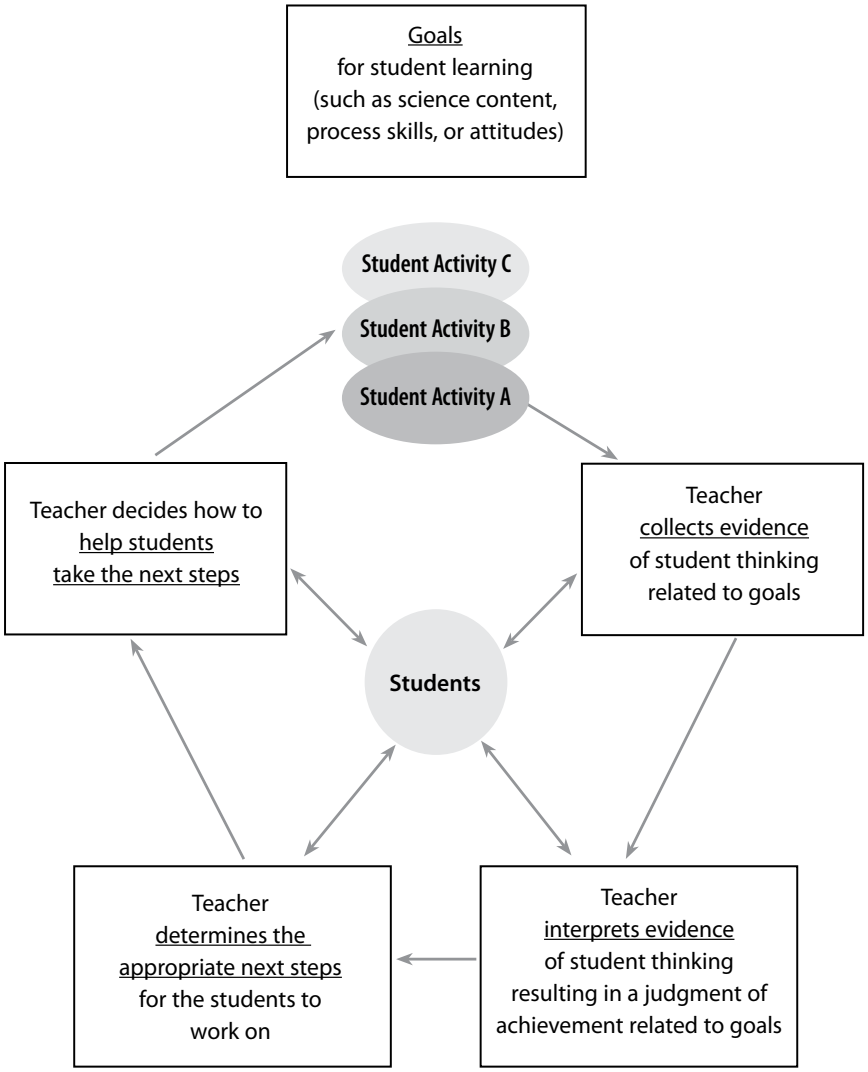
It's useful to think of what teachers (and students) do in formative assessment as a cycle of events, as shown in the diagram on the next page and on M1. If you follow the diagram clockwise, you'll be able to see how the process can bring students ever closer to the learning goals.

Before instruction begins, the teacher decides what the learning goals will be. These goals, shown at the top of the diagram, can be scientific attitudes, conceptual ideas about science content, or science process skills, since all are important in science instruction.

The teacher also chooses an initial learning activity (represented in the diagram as Activity A) meant to begin the process of helping students achieve the learning goals. Although the teacher can have plans for subsequent activities students might do to reach these goals, it's important to remain flexible. Information gathered and interpreted in the course of formative assessment may suggest ways of modifying plans so they more effectively address goals.

Teacher Collects Evidence Relating to Goals. During the initial activity (Activity A), the teacher collects evidence of students' thinking in relation to the goals. The teacher can gather evidence in many ways, such as by watching students as they work,

Formative Assessment Cycle



questioning them, or by asking them to communicate their understanding through writing or drawing.

Gathering evidence should be an integral part of any lesson. Lessons may already include opportunities to elicit the use of certain process skills or the application of specific scientific ideas, or the teacher may need to plan something especially for this purpose. Planning may involve deciding, for instance, what questions to ask in order to encourage the kinds of thinking and learning intended in a particular activity.

Lesson preparation that includes plans for eliciting student thinking in relation to the learning goals has a double benefit. First, it ensures that students use and develop process skills and scientific ideas; and

"One teacher, in planning a lesson on simple circuits, decided to have the students draw on the whiteboard all the circuits they tried to construct, both those that did and those that didn't work. This form of communication gave her an immediate picture of the way the students' ideas were developing and enabled her to work with those who were unsure and needed help understanding what is essential in a complete circuit."

Wynne Harlen. *Enhancing Inquiry through Formative Assessment.* (San Francisco: Exploratorium, 2003) p. 22.

second, it gives teachers opportunities to assess the development of those skills and ideas. In this way, teaching and assessment are closely intertwined.

Teacher Interprets Evidence. Once evidence of student work has been gathered, the teacher needs to interpret that evidence to find out how students are progressing toward their learning goals. In order to do this, the teacher considers more than just the extent to which the student has reached the learning goal, but also the student's experience, past achievements, recent progress, and the effort the student has made. The teacher's interpretation is then student-referenced, allowing the teacher to match next steps with the needs of the individual student.

A classroom teacher asked her students to draw a picture of a crayfish, label the parts, and describe the function of each. She wanted to see how her students used their process skills of close observation, and to elicit their understanding of structure and function. One student's drawing labeled only the legs, but distinguished between those used for movement and those used for feeding. Despite the fact that the student's work was incomplete, the teacher saw it as an indication that he had observed very closely and understood issues of structure and function. For the teacher, this was a sign of improvement, since the student had not been able to focus well in previous observations.

—Institute for Inquiry

Teacher Determines Appropriate Next Steps. The process of interpreting evidence leads the teacher to arrive at a judgment about where students are in relation to the learning goals. In the diagram, the phrase "judgment of achievement" in the lower right-hand box refers to what the teacher thinks a student knows in relation to goals, and not how well the student is doing.

Once this judgment has been made, the teacher determines the developmental steps students need to take next in order to increase their understanding of scientific ideas, improve their science process skills, or enhance their scientific attitudes.

In a third-grade classroom, students were investigating the effects of water on plant growth: they had given different amounts of water to similar plants in various places around the room. The teacher decided that the next step was to have her students think about how to choose which condition to keep the same (such as the location of the plants) in order to make their experiment a "fair test."

—Institute for Inquiry

Teachers are accustomed to drawing on their experience to decide what would help students who show varying degrees of mastery. But there are also a number of sources that can help teachers consider the developmental progression of certain scientific ideas and process skills. For more information, see the Additional Resources on page 16.

It is this iterative process that distinguishes formative assessment from other kinds of assessment. Here, information about student achievement is gathered and interpreted and used to help make the next instructional decision.

In order to help her students plan for a "fair test," a third-grade teacher asked her students how they could tell if differences in plant growth were due to differences in the amount of water each plant received, or to where the plant was located. The students responded by deciding that it would be important to keep all the plants in the same place. That way, they reasoned, they could test for the effect of watering without being confused by the effects of light or heat from different locations.

—Institute for Inquiry

For instance, if a teacher is trying to help further develop students' conceptual ideas, useful strategies include helping students test their existing scientific ideas, providing access to more scientific ideas than they currently have, and enhancing communication and reflection. Teachers can help students design experiments and investigations to test their ideas. They can give students reference materials, or introduce them to alternative, more scientific ideas and support them in thinking about those ideas. And they can set up situations in which students work together to create explanations of scientific phenomena they encounter in experiments and investigations.

About the Student's Role in the Formative Assessment Cycle

Students are at the center of the Formative Assessment Cycle because they play a central role in formative assessment. Every action a teacher takes during the cycle involves interactions with students.

In addition to teachers evaluating and supporting student progress toward learning goals, students can also take action on their own behalf. When students know about the goals of instruction, they can give the teacher evidence about their own understanding in relation to those goals. The more students can take on the role of self-assessment, the more they can move toward being able to decide their own next steps.

Student Self-Assessment

"Student participation is a key component of successful assessment strategies at every step. If students are to participate effectively in the process, they need to be clear about the target and the criteria for good work, to assess their own efforts in light of the criteria, and to share responsibility in taking action in light of the feedback."

National Research Council. *Classroom Assessment and the National Science Education Standards*. (Washington, DC.: National Academy Press, 2000) p. 1.

Additional Resources

These resources can provide valuable information about formative assessment to facilitators and participants alike.

- ❑ Black, Paul, and Dylan Wiliam. "Inside the Black Box: Raising Standards through Classroom Assessment." Online article available at www.pdkintl.org/kappan/kbla9810.htm.
- ❑ Black, Paul, Christine Harrison, Clare Lee, Bethan Marshal, and Dylan Wiliam. *Working Inside the Black Box: Assessment for Learning in the Classroom.* London: King's College Department of Education & Professional Studies, 2002. Particularly useful for Workshops III, IV, and V.
- ❑ Harlen, Wynne. "Encouraging and Handling Children's Questions." Chapter 13 in *The Teaching of Science in Primary Schools.* London: David Fulton Ltd., 2000. Particularly useful for Workshop III.
- ❑ Harlen, Wynne. *Enhancing Inquiry through Formative Assessment.* San Francisco: Exploratorium, 2003. This monograph sets out research evidence and theoretical points to make the case for using formative assessment in inquiry science teaching. Available online at www.exploratorium.edu/ifi/resources/harlen_monograph.pdf.
- ❑ Harlen, Wynne. *Teaching, Learning & Assessing Science 5–12.* London: Sage Publications, 2006. This book presents a theoretical rationale for why science should be taught in constructivist ways. Chapters 7–12 offer an explanation of the role formative assessment plays in that type of teaching.

In addition to the resources above, the publications listed below can offer support for teachers interested in further information on science education standards and the developmental progression of science ideas and process skills at different grade levels.

- American Association for the Advancement of Science. *Atlas of Scientific Literacy.* Washington, DC: American Association for the Advancement of Science and the National Science Teachers Association, 2001.
- American Association for the Advancement of Science. *Benchmarks for Science Literacy.* New York: Oxford University Press, 1993.
- National Assessment of Educational Progress (NAEP). "The NAEP Science Achievement Levels." National Center for Education Statistics (NCES), 2002. http://nces.ed.gov/nationsreportcard/science/achieveall.asp.
- National Research Council. *National Science Education Standards.* Washington, DC: National Academy Press, 1996.

PLANNING AND PREPARATION

- **Workshop at a Glance**
- **Essential Planning Steps**
- **Charts, Handouts, and Facilitator Tools**
- **Materials and Equipment**
- **Setting Up the Hinged Mirrors and Floating Eggs Activities**

Workshop at a Glance

Facilitators needed: 1–2

Participants accommodated: 30–36

Time to present the workshop: about 2 hours

Planning and Preparation
4 hours + materials prep

PRESENTING THE WORKSHOP

Introducing the Workshop
5 minutes
Facilitator sets the context

Writing Questions to Reveal Students' Ideas
30 minutes
Individual activity

Analyzing Questions
35 minutes
Whole-group discussion

Identifying Open and Closed Questions
10 minutes
Whole-group discussion

Questioning to Reveal the Use of Process Skills
10 minutes
Whole-group discussion

Examining Questioning in Practice
15 minutes
Whole-group video viewing and discussion

Concluding the Workshop
10 minutes
Facilitator summarizes the workshop

Reviewing the Workshop
time as needed

Essential Planning Steps

Planning Time Needed

4 hours, not including time to gather and prepare materials and equipment

Overview

The *Effective Questioning* workshop requires a good deal of planning and preparation. Below you'll find step-by-step instructions, divided into three categories: Before the Workshop, On the Day of the Workshop, and After the Workshop.

The workshop requires one facilitator, although you might choose to have two and divide up the steps. If two facilitators will be presenting the workshop, it's important to go over these steps together, arriving at a shared understanding of workshop goals. There's a lot to do, including reading through this entire guide, preparing to lead discussions, trying the workshop yourselves as if you were participants, arranging for an appropriate space, and preparing materials, charts, handouts, equipment, and facilitator's tools.

You'll also want to set aside time after the workshop to talk with your co-facilitator (if there is one) about what went well and what could be improved for subsequent workshops.

Before the Workshop

1. Read this guide all the way through. It is essential for you to read through this guide before doing any of the other planning steps. You may want to flag sections that don't make immediate sense to you, coming back to them as the goals of the workshop become clearer.

2. Become familiar with the formative assessment basics. Review the Formative Assessment Basics section (see page 9). This is the foundation of the entire curriculum.

3. Prepare materials. Gather and organize all materials (see the complete list on page 23).

• Prepare the handouts, charts, and overheads, and organize them in the order in which you will use them during the workshop. Masters start on page 43. They are identified with the letter *M* and numbered in order of use.

• Study the list of Additional Resources on page 16, deciding what you might want to copy for distribution at the end of the workshop.

An Important Note from the Institute for Inquiry

This workshop is the result of many years of development with educators across the country. While its format may seem adaptable, using it in ways other than those described here will not only change the participants' experience, but the outcome as well. We recommend becoming familiar with the planning and presentation of the workshop and experiencing its intended results before considering any adaptation.

• Participants do two simple activities at the beginning of the workshop: a Hinged Mirrors activity and a Floating Eggs activity. For the Hinged Mirrors activity, you'll need to duct-tape together two small mirrors at one edge. For the Floating Eggs activity, you'll need to make hard-boiled eggs before the day of the workshop. (Raw eggs will work, but can be messy.) You'll also need to make a salt-water solution

in which the eggs will float. If you mix the solution the day before the workshop, the salt will settle and your solution will be clear, which will allow you to better see what's happening. See the Materials list on page 23 for exact quantities needed, and see M3: "Hinged Mirrors and Floating Eggs Activity Instruction Sheet" for activity instructions.

• Before the workshop begins, you'll need to set up each table for the two activities. Put two Hinged Mirrors setups on three tables, and two Floating Eggs setups on the other three tables. When participants are done with one activity, you'll need to switch the activity setups so participants at each table get to do both (see page 24).

A Note About Scripts

Many of the steps in this guide contain scripted information, set in italic type and marked with gray arrows. The scripts are intended to illustrate one way of presenting information and instructions to workshop participants. While the content of the scripts is crucial, the exact wording is not. After thoroughly familiarizing yourself with the scripts and noting the important points, you may decide to convey the information in your own words rather than reading the scripts to participants word for word.

4. Do the workshop as learners. Meet with your co-facilitator, if there is one, and go through the workshop as if you were participants.

Do all the same tasks workshop participants will be asked to do. This will help you better understand the kinds of responses they will give, the kinds of problems that could come up, and the kinds of questions people may ask.

5. Go over the workshop as facilitators. Go through the workshop again, this time as facilitators. If there will be more than one facilitator, decide which sections and tasks each facilitator will be responsible for.

6. Familiarize yourself with each step. Be sure you understand the purpose of each section and each discussion. Keep the take-home messages (M2) in mind as your overall guide. These messages express the pedagogical ideas participants should take away from the workshop.

• Note that two workshop sections—Writing Questions to Reveal Students' Ideas (page 28) and Analyzing Questions (page 30)—are particularly demanding and require that facilitators have a firm understanding of the different kinds of questions introduced in the workshop.

• The Writing Questions to Reveal Students' Ideas section of the workshop asks facilitators to quickly sort through participants' questions, identifying examples of the four kinds of questions introduced in the section. Be sure you are familiar with the characteristics of these questions so you can work quickly and accurately. Have ready a copy of facilitator tool M4: "Sorting Questions—Facilitator's Worksheet" for the activity. To practice sorting questions, you may want to cut up handout M7a&b: "Hinged Mirrors & Floating Eggs Sample Questions" and see if you can put the sentence strips back in order.

7. Be aware of "wait time." The Examining Questioning in Practice section of the workshop (page 36) introduces the idea of "wait time," an 8-second pause that gives students a chance to gather their thoughts so they can comfortably answer a question.

• As you go over the workshop in advance, try to come up with ways to remind yourself to pause for 8 seconds to allow participants to come up with answers in the same way.

• During the workshop, ask questions in carefully thought-out words, and don't rephrase them if there is a period of silence while participants are thinking.

8. Be prepared to set the context. Setting the context for the workshop is crucial. The facilitator who introduces the workshop should study the script in Steps 1 and 2 of Introducing the Workshop (page 26), and practice presenting this information.

• The facilitator should also be prepared to relate this workshop to district goals, standards, and other professional development activities.

9. Plan time and space carefully. You'll need a space large enough for 30–36 participants to work together comfortably. You'll also need a place to post charts so all can see, and/or a blank wall for projecting overheads.

• Create a detailed schedule for facilitators to refer to during the workshop. Note the beginning and ending times for each step (e.g., Set context & distribute handouts, 9:00–9:05; Introduce activities, 9:05–9:10).

• Prepare a simplified version of the schedule for participants, which you can post at the beginning of the workshop. A sample schedule is shown in the next column.

On the Day of the Workshop

1. Prepare the room. Set up your equipment and put handouts, charts and overheads where you'll have access to them when you need them.

Sample Schedule for Participants

9:00–9:05	Introducing the Workshop
9:05–9:35	Writing Questions to Reveal Students' Ideas
9:35–10:10	Analyzing Questions
10:10–10:20	Identifying Open and Closed Questions
10:20–10:30	Questioning to Reveal the Use of Process Skills
10:30–10:45	Questioning in Practice
10:45–10:55	Concluding the Workshop

2. Put two Floating Eggs setups on half the tables, and two Hinged Mirrors setups on the other half of the tables. See page 24 for details.

3. Watch your schedule. Refer to the schedule you created (see Step 9) to keep the workshop on track.

After the Workshop

You and you co-facilitator (if there is one) should take some time to reflect on your experiences. Issues of logistics, communication, outcomes, and expectations can be addressed at this point. The Facilitation Review (page 39) will allow you to assess the results of your work and identify successes and challenges that can help guide subsequent workshops.

Charts, Handouts, and Facilitator Tools

Masters begin on page 43. They are identified by the letter *M* (for Master) and are numbered in order of use. Note that some masters will be used as both handouts and charts or overheads.

Charts or Overheads **You can prepare these as either large charts or overheads. If you have access to a copy machine that can enlarge to poster size, enlarge these masters 400% to create charts that are 34" x 44". Otherwise, hand-copy the masters onto chart paper or poster paper approximately the same size. Alternatively, you can photocopy the masters onto overhead transparencies. You'll need one of each.**	**Master Available on Page**
❑ Formative Assessment Cycle (for Introducing the Workshop)	M1
❑ Take-Home Messages (for Introducing the Workshop; reuse in Concluding the Workshop)	M2
❑ Different Kinds of Questions (for Analyzing Types of Questions)	M5
❑ Questions for Encouraging Process Skills (for Questioning to Reveal the Use of Process Skills)	M6
❑ Creating an Atmosphere for Sharing Ideas (for Examining Questioning in Practice)	M7

Handouts **Photocopy one for each participant.**	**Master Available on Page**
❑ Formative Assessment Cycle (for Introducing the Workshop)	M1
❑ Take-Home Messages (for Introducing the Workshop and Concluding the Workshop)	M2
❑ Hinged Mirrors and Floating Eggs Activity Instruction Sheet (for Writing Questions to Reveal Students' Ideas)	M3
❑ Different Kinds of Questions (for Analyzing Types of Questions)	M5
❑ Questions for Encouraging Process Skills (for Questioning to Reveal the Use of Process Skills)	M6
❑ Hinged Mirrors and Floating Eggs Sample Questions (for Concluding the Workshop)	M8a&b

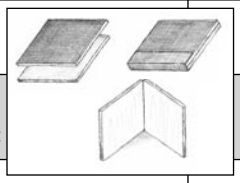
Facilitator Tools	**Master Available on Page**
❑ Sorting Questions—Facilitator's Worksheet (for Writing Questions to Reveal Student Ideas)	M4

Materials and Equipment

Materials

Quantities are based on 36 participants for 6 table groups of 6 people each. Adjust as necessary. Three table groups will be doing the Floating Eggs activity, while the other 3 table groups will be doing the Hinged Mirrors activity. Use this chart to help keep track of what you need. Materials are simple and commonly available. All are used for the Hinged Mirrors and Floating Eggs activity in Writing Questions to Reveal Students' Ideas, on page 28. For details on these activities, see page 24.

For the Floating Eggs activity	Per Table	Total
❑ hard boiled eggs (raw will work, but can be messy)	4	12
❑ plastic spoons	4	12
❑ clear plastic container big enough to float an egg (such as a large plastic bowl, deli container, or food-storage container)	4	12
❑ enough water to float eggs in containers	as needed	
❑ salt		2 pounds
❑ paper towels (for cleanup)	1	3
For the Hinged Mirrors activity		
❑ 2 small mirrors (approximately 4" x 4") duct-taped together at one edge, their reflective sides facing each other:	2	6
❑ protractor (optional)	2	6
❑ several pennies or other small objects	2	6
For participants' questions		
❑ 3" x 5" index cards	2 per person	72
❑ pencils	1 per person	36



Equipment

For entire workshop	Per Table	Total
❑ overhead projector (optional)		1
❑ marking pen for overheads (if used)		2
❑ sink, or other source of water for the Floating Eggs activity		1

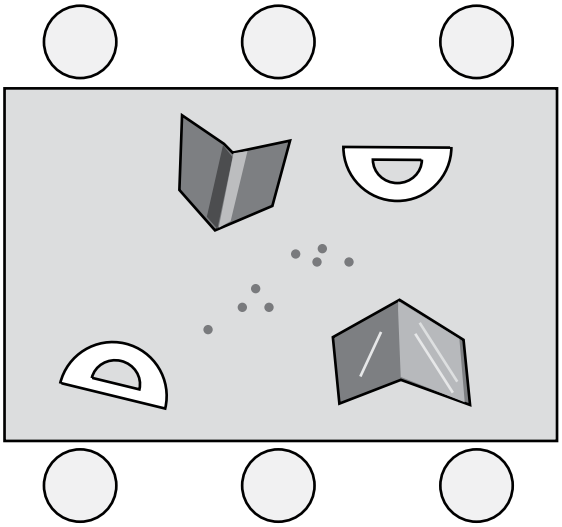
Setting Up the Hinged Mirrors and Floating Eggs Activities

For 36 participants, you'll need six tables of six people each. Set up three tables for the Hinged Mirrors activity, and three for the Floating Eggs activity, as shown below. Put two setups for each activity on a table. A complete list of materials is on page 23.

Place 2 setups for the Hinged Mirrors Activity on Tables 1, 2, and 3

• Make 6 hinged mirrors as shown on page 23.

• On three tables, place 2 hinged mirrors, 2 protractors (if used), and several pennies or other small objects.



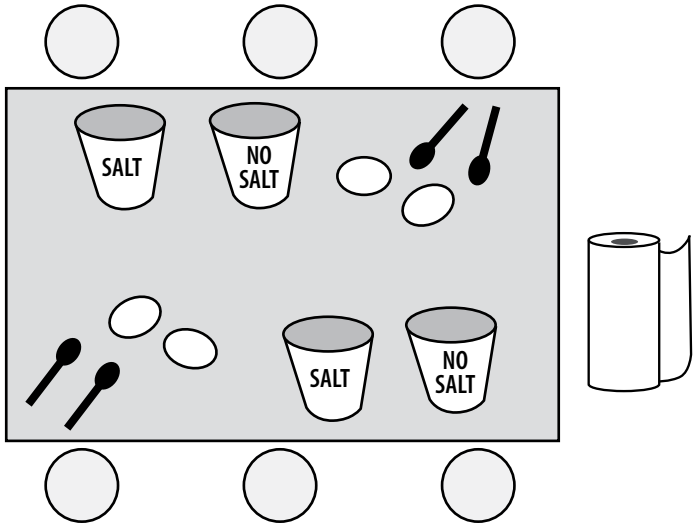
Place 2 setups for the Floating Eggs Activity on Tables 4, 5, and 6

• On three tables, place 4 spoons, 4 hard-boiled eggs, and 4 clear plastic containers, 2 filled with fresh water and 2 filled with salt water (you can label them if you want).

• Remember to mix the salt water in advance so the water sits long enough to clear up.

• Be sure that the eggs float in the salt water (you may need to use quite a bit of salt, depending upon the size of your containers).

• Have a roll of paper towels nearby for clean-up.



PRESENTING THE WORKSHOP

- **Introducing the Workshop**
- **Writing Questions to Reveal Students' Ideas**
- **Analyzing Questions**
- **Identifying Open and Closed Questions**
- **Questioning to Reveal the Use of Process Skills**
- **Examining Questioning in Practice**
- **Concluding the Workshop**

Introducing the Workshop

Overview

In this opening section, facilitators talk about the workshop's purpose, touch on how the Formative Assessment Cycle can serve as a framework for putting formative assessment into practice, and introduce the take-home messages, the central pedagogical ideas of the workshop.

This is also a time to explain how participants will be working together. Letting everyone know what they will be doing is an important step in building trust and demonstrating respect for the participants as learners. A respectful atmosphere is essential to fostering a free and open exchange of ideas.

Note that this part of the workshop refers back to the Formative Assessment Cycle introduced in the first workshop, *Introduction to Formative Assessment*. For more information on this cycle, which forms the foundation for this series, see the Formative Assessment Basics section in this guide, which begins on page 9.

Materials Reminder

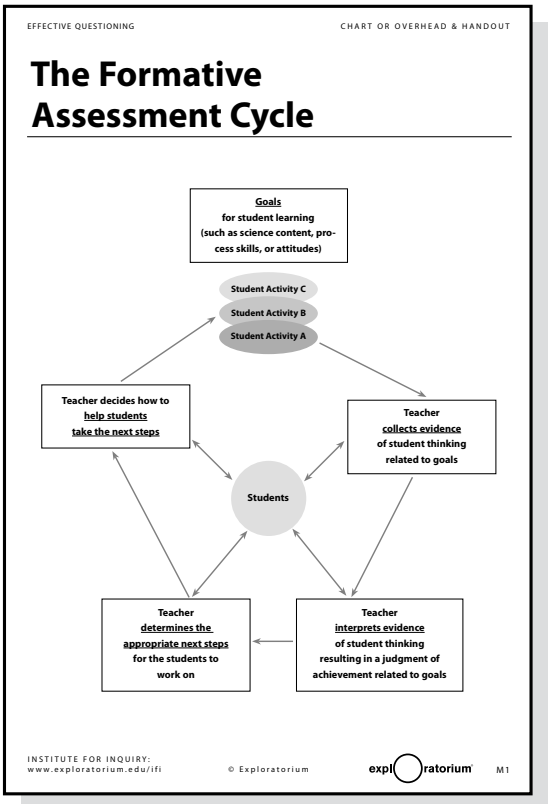
During this part of the workshop, facilitators will need to:

- **Post chart M1: "The Formative Assessment Cycle" and distribute corresponding handout**
- **Post chart M2: "Take-Home Messages" and distribute corresponding handout**

This is the third of five workshops in the ASSESSING FOR LEARNING series. It's designed to further your understanding of formative assessment by exploring how asking questions can help teachers gather evidence about students' scientific ideas.

Finding out students' scientific ideas is an important first step to helping students develop ideas that are more aligned with correct scientific thinking.

Once you know their ideas, you can encourage students to test those ideas using their science process skills. For example, if you find that students studying magnets think that magnets stick to anything metal, you could encourage them to check their ideas by testing magnets with different kinds of metal. If they had thought differently about how magnets work, there might be a different, more appropriate next step for them. So it's important to find out students' existing ideas, which is the focus of this workshop.



M1

5 Steps ◆ 5 Minutes

1. Set the context by describing the workshop. Introduce yourselves and welcome participants. Then, in your own words, relate the following information:

The next workshop focuses on deciding appropriate next steps for developing students' ideas.

2. Post chart M1: "The Formative Assessment Cycle" and distribute the corresponding handout. Begin by calling attention to the "collecting evidence" part of the cycle, and then relate the following information in your own words:

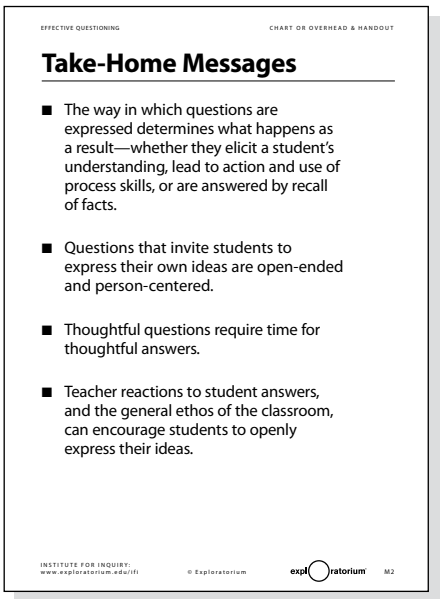
► *The first workshop in this series introduced the Formative Assessment Cycle. In the second workshop, we considered how observation could help teachers collect evidence of students' use of process skills.*

However, observation is not very useful for finding out students' scientific ideas, which don't necessarily show up in what they do. Questioning is one of the most common and useful ways to help teachers gain access to students' ideas.

It turns out, though, that different kinds of questions elicit different kinds of answers, so it isn't always easy to ask the questions that get you the information you want. In this workshop, which runs about two hours, we'll concentrate on the best ways to ask questions to collect evidence about students' ideas, and we'll look at some other useful ways of using questions in formative assessment.

3. Post chart M2: "Take-Home Messages" and distribute the corresponding handout. Tell participants:

► *Throughout the workshop, you'll be working to develop your own understanding of the pedagogical ideas these messages express.*


EFFECTIVE QUESTIONING CHART OR OVERHEAD & HANDOUT

Take-Home Messages

- The way in which questions are expressed determines what happens as a result—whether they elicit a student's understanding, lead to action and use of process skills, or are answered by recall of facts.
- Questions that invite students to express their own ideas are open-ended and person-centered.
- Thoughtful questions require time for thoughtful answers.
- Teacher reactions to student answers, and the general ethos of the classroom, can encourage students to openly express their ideas.

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M2

4. Explain how the workshop relates to your district's goals, standards, and other professional development activities for science education.

5. Tell participants that the workshop will take about two hours. Also let them know if there will be a break.

Writing Questions to Reveal Students' Ideas

Overview

In this section, participants do two simple activities. Then they each write a question that a teacher in a classroom might ask to find out how students would explain the phenomena they just saw.

Participants are seated six to a table, at six tables. Half the participants do the Floating Eggs activity while the other half do the Hinged Mirrors activity. After ten minutes the facilitator switches the materials at the tables so that participants get a chance to do both activities.

At the end of this section, the facilitators quickly sort participants' questions into categories. Facilitator tool M4: "Sorting Questions" will help you do this. Category labels are included on this sheet, but you don't want to reveal these to participants until later.

Materials Reminder

During this part of the workshop, facilitators will need to:

- **Make sure materials for the Hinged Mirrors and Floating Eggs activities are set out, as shown on page 24**
- **Distribute handout M3: "Hinged Mirrors and Floating Eggs Activity Instruction Sheet"**
- **Distribute to each participant two blank 3" x 5" cards and a pencil**
- **Have available for facilitator(s) M4: "Sorting Questions—Facilitator Worksheet"**

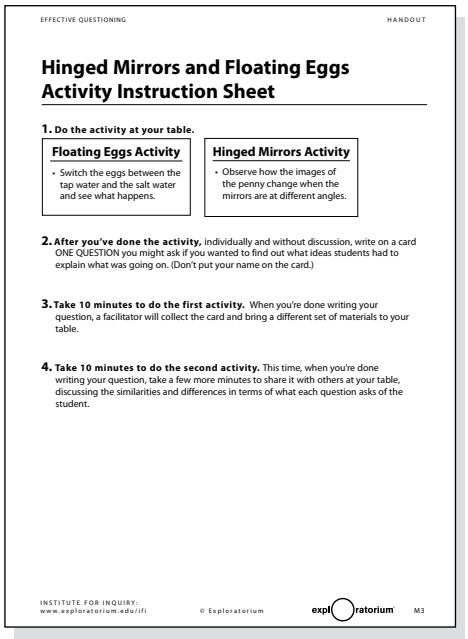
7 Steps ◆ 30 Minutes

1. Seat participants six to a table, at six tables (or as close as possible to such an arrangement). Three tables should have materials for the Hinged Mirrors activity, and three should have materials for the Floating Eggs activity. See page 24 for details.

2. Introduce this part of the workshop (5 minutes). Then distribute to each participant two 3" x 5" cards, a pencil, and handout M3: "Hinged Mirrors and Floating Eggs Activity Instruction Sheet." Tell participants:

▶ *In this part of the workshop, we'll be doing two simple activities, beginning with the one on your table right now.*

Then you'll imagine that you're in a classroom, and your students have just done the same activity. Using one of the 3" x 5" cards I just gave you, you'll write one question you would ask students that would help you find out the ideas they have to explain what they observed.



EFFECTIVE QUESTIONING HANDOUT

Hinged Mirrors and Floating Eggs Activity Instruction Sheet

1. Do the activity at your table.

Floating Eggs Activity
- Switch the eggs between the tap water and the salt water and see what happens.

Hinged Mirrors Activity
- Observe how the images of the penny change when the mirrors are at different angles.

2. After you've done the activity, individually and without discussion, write on a card ONE QUESTION you might ask if you wanted to find out what ideas students had to explain what was going on. (Don't put your name on the card.)

3. Take 10 minutes to do the first activity. When you're done writing your question, a facilitator will collect the card and bring a different set of materials to your table.

4. Take 10 minutes to do the second activity. This time, when you're done writing your question, take a few more minutes to share it with others at your table, discussing the similarities and differences in terms of what each question asks of the student.

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M3

3. Ask participants to refer to handout M3: "Hinged MIrrors and Floating Eggs Activity Instruction Sheet" to do the activity at their table (10 minutes). Tell people:

▶ *After you do the activity at your table, we'll trade materials, so everyone will get to do both activities. Later on, we'll use the questions we write as examples when we consider the types of questions that work best in helping students reveal the*

ideas they have when they explain the things they observe.

When you write your question, please put the exact words you would use on the card. Do this individually, and without discussion. Don't put your name on the card. You'll have about 10 minutes to work.

4. After 10 minutes, collect the cards. Be sure to warn people to finish their work a few minutes in advance.

5. Switch the activity materials (10 minutes). After collecting all the cards, switch the Floating Eggs materials to the Hinged Mirrors tables, and the Hinged Mirrors materials to the Floating Eggs tables. Tell participants:

▶ *Do the second activity, and write a new question on your second 3" x 5" card. Again, try to write a question that you think would help you learn what ideas a student has to explain why the materials work the way they do. I'll tell you when 10 minutes is up.*

6. Sort the questions you collected. While participants are writing their second questions, start sorting the questions you collected into groups. Try to find an example of at least one question for each of the four categories in the box below. (NOTE: Hold on to the sorted questions for now. You'll use the examples in the next part of the workshop.)

7. Have participants discuss their new questions (5 minutes). Say:

▶ *After everyone at your table is done, I'd like you to take about five minutes to share and discuss the differences and similarities of the questions you've written with the other people at your table. Hang on to your questions, though. You'll be needing them a little later.*

Subject-Centered Questions *questions that have only one right answer because they ask for explanations of the phenomena involved in the activity* such as, "Why does the penny's image change when you move the mirrors?" and "Does the size of the egg make a difference whether or not it will float?"	**Process-Centered Questions** *questions that ask students to "do" something (such as observe, plan, measure, and so on), requiring them to use one of their process skills, but without asking for explanations of the phenomena involved* such as, "How does the angle between the mirrors relate to the number of images of the coin?" and "What do you notice about the eggs?"
Person-Centered Questions *questions that have no "right" or "wrong" answers because they ask a student what he or she thinks are possible explanations of the phenomena involved in the activity* such as, "What do you think caused different numbers of pennies to appear when you moved the mirror?" and "Why do you think the eggs floated in the salt water?"	**"Other" Types of Questions** *questions that don't quite fit into any of the other three groups* such as, "How do you think mirror images form?" and "What do you know about the properties of salt and fresh water?"

Analyzing Questions

Materials Reminder

During this part of the workshop, facilitators will need to:

- **Post chart M5: "DifferentKinds of Questions" and distribute the corresponding handout**

Overview

In this part of the workshop, the facilitator introduces participants to four categories of questions and helps people understand the similarities and differences between them. Once participants can identify these different types of questions, they discuss their own examples in their groups.

Take about five minutes each for Steps 1–5. Steps 6 and 7 will take about 10 minutes.

7 Steps ◆ 35 Minutes

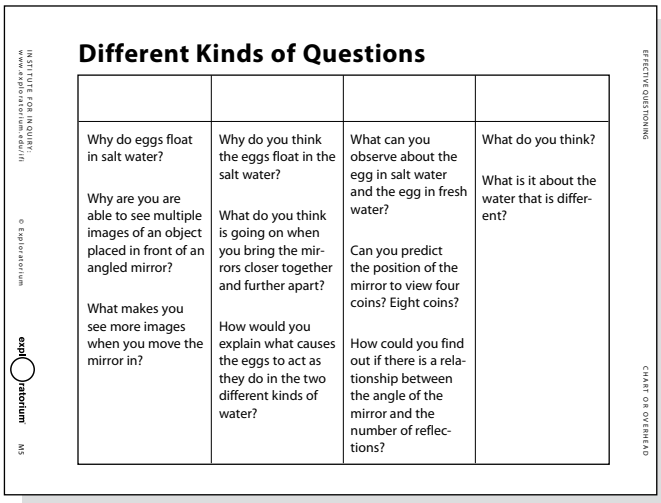
1. Introduce the different types of questions. Post chart M5: "Different Kinds of Questions" and distribute the corresponding handout. This is a chart showing sets of questions in four different columns.

Tell participants that different kinds of questions can elicit different kinds of answers, and that this chart offers one way to think about the kinds of questions they can ask in the classroom.

2. Read and discuss the questions in the first column. Without revealing the kinds of questions in each column, read out loud the three questions in the first column, which show examples of Subject-Centered questions. Ask:

▶ *What do you think these questions have in common?*

Take a few responses.



M5

The main feature these questions have in common is that they ask for a single right answer about a particular science subject or phenomenon. If participants don't come up with this idea on their own, you can ask probing questions such as:

▶ *What is being asked of the students here?*

Once you've taken a few responses, explain:

▶ *These kinds of questions ask for an answer about a particular science subject—in this case, angled mirrors or floating and sinking eggs. These are "Subject-Centered questions." They ask for answers that can be right or wrong.*

Write the words "Subject-Centered" above the first column on the chart. Then add, out loud, one of the Subject-Centered questions from the cards you sorted earlier.

3. Read and discuss the questions in the second column. Ask what participants think these questions have in common, and take a few responses.

The main feature these questions have in common is that they ask for students' own ideas, and any response that describes their ideas is considered a "right" answer because it is

what they think. If participants don't come up with this on their own, you can ask a question such as:

- *What is being asked of the student here?*

Once you've taken a few responses, explain:

- *These kinds of questions ask for what students think about a particular science subject. They can be called "person-centered," and have no "wrong" answers because they ask for students to explain what they think.*

Write the words "Person-Centered" above the second column on the overhead. Then add aloud one of the Person-Centered questions you identified from the group.

4. Read and discuss the questions in the third column. Ask again what participants think these questions have in common, and take a few responses.

The main feature these questions have in common is that they ask students to do something that requires them to use one of their process skills. If participants don't come up with this on their own, you can ask such questions as:

- *What is being asked of the students? Are they being asked for an idea that explains why something they noticed is happening, or are they being asked something else?*

Once you've taken a few responses, explain:

- *These kinds of questions don't really ask for students' ideas directly, but allow you to collect evidence of their skills and can be useful in helping students test their ideas.*

Write the words "Process-Centered" above the third column on the overhead, than add aloud one of the Process-Centered questions you sorted from the group.

5. Introduce and discuss the questions in the fourth column. Once the three main categories have been discussed, introduce a fourth category, "Other," explaining that not all questions will fit neatly into the other three categories.

Read the examples from the "Other" category on the sheet. Add an example, if you found one, from the questions on the cards you sorted earlier. Then write "Other" above the last column on the chart.

6. Have participants sort and discuss the questions they wrote in their table groups. Ask participants to work with their table group, taking 10 minutes to discuss the questions they wrote on their 3 x 5 cards and trying to sort them into the 4 categories.

As they work, circulate among the groups and offer assistance if needed. It may be useful to remind groups that asking students what they think makes it a Person-Centered question; asking students to predict or observe, or employ some other process skill, makes it a Process-Centered question. Subject-Centered questions are usually constructed to solicit one right answer.

7. Conclude this part of the session. Reinforce the ideas behind the different kinds of questions by explaining:

- *Of all the kinds of questions teachers can ask, the Person-Centered ones are the most useful for finding out students' ideas. They ask students to explain what they think, rather than asking for correct answers or asking students to use their process skills. Person-Centered questions invite students to voice their ideas in a way that does not put pressure on them to be "right."*

Identifying Open and Closed Questions

Materials Reminder

- **No new materials are needed**

Overview

Person-Centered questions can be "open" or "closed," and the open ones are more effective at eliciting students' ideas. In this part of the workshop, the facilitator gives examples of both kinds of questions, and participants are asked to come up with examples of their own.

4 Steps ◆ 10 Minutes

1. Introduce the idea of "open" and "closed" questions. Tell participants:

► *Now that we've identified Person-Centered questions as being the most effective kind for eliciting student ideas, we'll look a bit more closely at them, and make one further distinction that can be very useful in the classroom.*

Listen to these two questions about the floating eggs:

First, "What do you think makes the egg float in the salt water, but not in the fresh water?"

Second, "Do you think the salt water is more dense than the fresh water, and that's what makes the egg float?"

The first question is an "open" one and the second one is "closed." Open questions invite students to think, and to express their ideas in an extended way, while closed questions require very limited types of answers and often have the expected answer "built in."

2. Ask for examples of open and closed questions (5 minutes). Ask participants if they have examples of open or closed questions on their 3" x 5" cards, or if they can come up with examples. Try to get at least one example of each.

As participants give their responses, repeat each one out loud. If participants don't come up with examples, be ready with ones of your own. For instance, one example of an open question for the mirrors activity is: "Why do you think different numbers of images appear as the mirror is moved?" An example of a closed question is "Do you think you see more images when the mirrors are close together because the light from the coin has to bounce back and forth many times to get to your eye?"

3. Summarize the difference between open and closed questions. After you take some responses, summarize the difference between open and closed Person-Centered questions. Say:

► *Open questions invite open responses. Closed questions ask for agreement or disagreement, or to choose between alternatives, typically in one-word answers.*

If you think one of the responses is open when the participant thought it was closed (or the other way around), say:

► *It seems to me that your question is open because it could invite a variety of responses,*

or

► *It seems to me that your question is closed because it asks for agreement or disagreement. Were you thinking of it in a different way?*

Usually, the participant will either agree with you in retrospect or clarify why he or she thinks it is a good example of an open or closed question.

4. Conclude by describing the most useful type of question. Explain:

► *A question that is both open and Person-Centered is most useful in the classroom because it gives the student the opportunity to articulate his or her ideas, and not just agree or disagree with a stated idea.*

Questioning to Reveal the Use of Process Skills

Materials Reminder

During this part of the workshop, facilitators will need to:

- **Post chart M6: "Questions for Encouraging Process Skills" and distribute the corresponding handout**

Overview

As the previous two sections revealed, different types of questions elicit different types of responses. Process-Centered questions allow teachers to gather evidence of students' process skills by encouraging students to use those skills.

While this workshop concentrates on gathering evidence of students' ideas, this section touches on using questions to gather evidence of process skill development, and provides some sample questions targeting specific skills.

2 Steps ◆ 10 Minutes

1. Discuss how questions can be used to focus on process skills (5 minutes). Tell participants:

▶ *Questions that require students to use process skills when responding are important, but as you've seen, they should not be confused with questions that are useful for accessing students' ideas.*

Earlier in this workshop, we collected some Process-Centered questions about the Floating Eggs activity, such as "What do you observe about the egg in the salt water and the egg in the fresh water?"

This question asks students to exercise the process skill of observation, and at the same time, gives the teacher the opportunity to gather evidence of the students' observation skills.

2. Present examples of questions focused on process skills (5 minutes). Post chart M6: "Questions for Encouraging Process Skills" and distribute the corresponding handout. Explain:

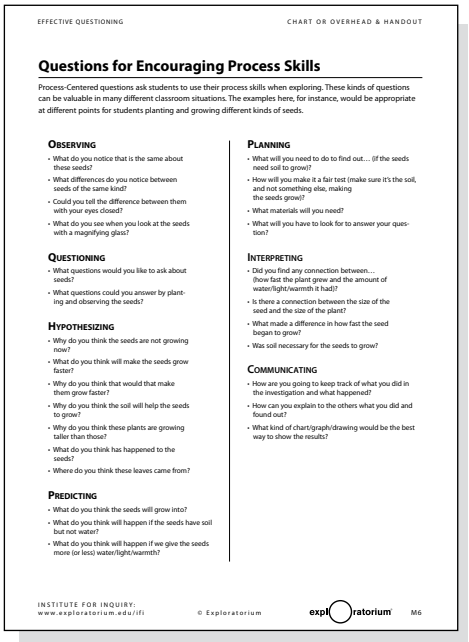
▶ *These are examples of questions that would encourage the use of all the process skills for students doing an activity involving sprouting seeds and growing plants. Look at how different kinds of questions can help the teacher gather information about different process skills. I'll read some of the examples.*

• Questions such as, "What do you notice that is the same about these seeds?" could help you gather information about the students' ability to observe closely.

• If you wanted to find out about students' ability to ask investigable questions, you'd ask a different kind of question, such as, "What questions could you answer by planting and observing the seeds?"

• If you wanted to find out about students' ability to predict, you could ask questions such as, "What do you think will happen if the seeds have soil but not water?"

• And if you wanted to find out



EFFECTIVE QUESTIONING CHART OR OVERHEAD & HANDOUT

Questions for Encouraging Process Skills

Process-Centered questions ask students to use their process skills when exploring. These kinds of questions can be valuable in many different classroom situations. The examples here, for instance, would be appropriate at different points for students planting and growing different kinds of seeds.

OBSERVING
- What do you notice that is the same about these seeds?
- What differences do you notice between seeds of the same kind?
- Could you tell the difference between them with your eyes closed?
- What do you see when you look at the seeds with a magnifying glass?

QUESTIONING
- What questions would you like to ask about seeds?
- What questions could you answer by planting and observing the seeds?

HYPOTHESIZING
- Why do you think the seeds are not growing now?
- What do you think will make the seeds grow faster?
- Why do you think that would that make them grow faster?
- Why do you think the soil will help the seeds to grow?
- Why do you think these plants are growing taller than those?
- What do you think has happened to the seeds?
- Where do you think these leaves came from?

PREDICTING
- What do you think the seeds will grow into?
- What do you think will happen if the seeds have soil but not water?
- What do you think will happen if we give the seeds more (or less) water/light/warmth?

PLANNING
- What will you need to do to find out… (if the seeds need soil to grow)?
- How will you make it a fair test (make sure it's the soil, and not something else, making the seeds grow)?
- What materials will you need?
- What will you have to look for to answer your question?

INTERPRETING
- Did you find any connection between… (how fast the plant grew and the amount of water/light/warmth it had)?
- Is there a connection between the size of the seed and the size of the plant?
- What made a difference in how fast the seed began to grow?
- Was soil necessary for the seeds to grow?

COMMUNICATING
- How are you going to keep track of what you did in the investigation and what happened?
- How can you explain to the others what you did and found out?
- What kind of chart/graph/drawing would be the best way to show the results?

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M6

about students' ability to plan, you might ask questions like, "What would you need to do to find out if seeds need soil to grow?"

You can use these examples at a later date as a resource to help you formulate process-centered questions for any topic. Notice that the questions for encouraging hypotheses are similar to the Person-Centered questions we used to find out students' ideas. This is because asking for a hypothesis—a possible explanation—is the same as asking for someone's ideas. But right now, let's get back to the main focus of this workshop, which is using questions to gather evidence of students' ideas.

Examining Questioning in Practice

Materials Reminder

During this part of the workshop, facilitators will need to:

- **Post chart M7: "Creating an Atmosphere for Sharing Ideas"**

Overview

By this point, participants have examined how asking different kinds of questions can give them different kinds of evidence about students' thinking and learning. In this part of the workshop, participants are offered some strategies for creating a supportive atmosphere in the classroom, so students feel safe in voicing their ideas.

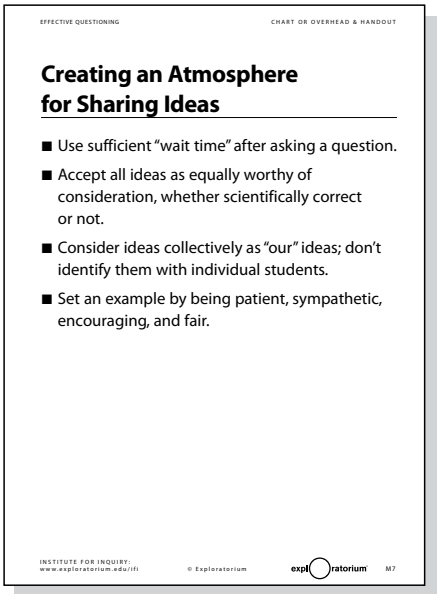
4 Steps ◆ 15 Minutes

1. Talk about "wait time." Remind participants that asking questions is only half the process of obtaining evidence of scientific thinking in the classroom. Students must also feel free to comfortably answer questions.

Introduce the idea of the teacher giving sufficient "wait time"—that is, allowing learners enough time to think before answering. Point out that you have been modeling wait time throughout this session, waiting at least 8 seconds after asking questions before taking any answers. Explain:

▶ *If you want thoughtful answers, you must give adequate time for students to think.*

2. Post chart M7: "Creating an Atmosphere for Sharing Ideas," and introduce the idea that questioning is most effective in a supportive classroom atmosphere. Point out that there are a number of ways in which teachers can create a classroom atmosphere that supports students to share their ideas. Use "wait time" as an example. Also, point out that, in order for students to freely express their ideas, teachers need to accept all ideas as equally worthy of consideration, whether they are scientifically correct or not. Another way to create a safe and supportive atmos-phere is to consider ideas collectively as "ours" and not identify them with an individual student.


EFFECTIVE QUESTIONING CHART OR OVERHEAD & HANDOUT

Creating an Atmosphere for Sharing Ideas

- Use sufficient "wait time" after asking a question.
- Accept all ideas as equally worthy of consideration, whether scientifically correct or not.
- Consider ideas collectively as "our" ideas; don't identify them with individual students.
- Set an example by being patient, sympathetic, encouraging, and fair.

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M7

3. Discuss ways to create a supportive classroom atmosphere. Say:

▶ *Let's take 15 minutes to discuss other ways to create an atmosphere where students feel free to express their ideas.*

Take responses for 15 minutes. Teachers usually have many ideas for creating safe, supportive classroom climates.

4. Conclude the discussion. Explain:

▶ *These points are important to a classroom ethos in which students feel able to express their ideas, whether the ideas are "correct" or not. A safe and supportive atmosphere is a basic requirement to gain access to students' ideas, so teachers can decide where they are and how to help them take next steps, which will be discussed in the next workshop in this series.*

Concluding the Workshop

Overview

This final section offers an opportunity to summarize the workshop and review the take-home messages.

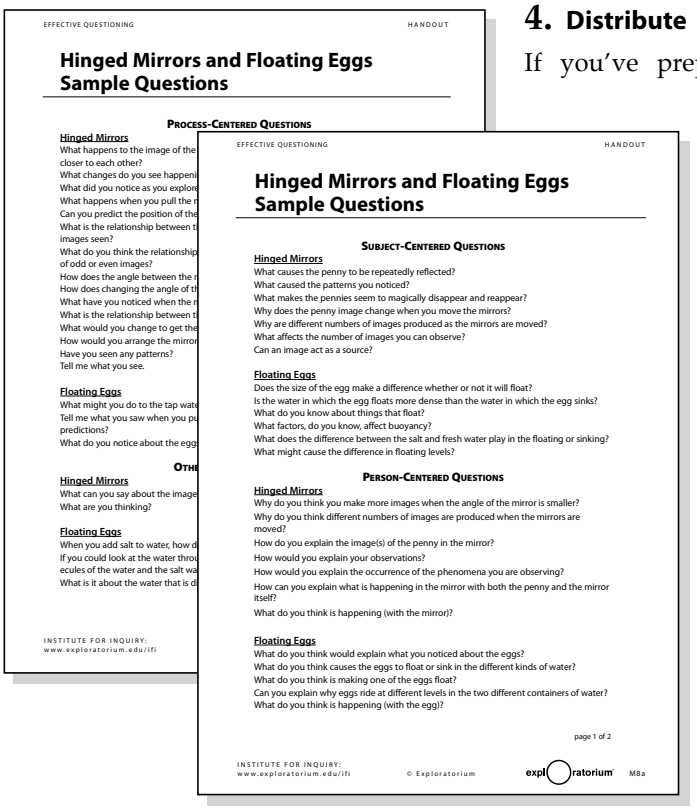
5 Steps • 10 Minutes

1. Spend a few minutes summarizing the main features of the workshop. Tell participants:

► *Today we explored ways to use questioning most effectively in the classroom. We identified different types of questions and how they might be used, and examined some of the information each type of question might elicit from students—in particular, for gathering evidence of students' scientific thinking, as well as for support in practicing science process skills. We also went over some recommendations for helping to make the classroom a supportive place, so students can feel confident enough to speak openly about their ideas.*

2. Distribute handout M8a&b: "Hinged Mirrors and Floating Eggs Sample Questions." Tell participants:

► *On this handout is a list of some of the questions people have asked in response to the Hinged Mirrors and Floating Eggs activities. You can use it as a resource to remind you of examples of Person-Centered, Subject-Centered, and Process-Centered questions.*



EFFECTIVE QUESTIONING HANDOUT

Hinged Mirrors and Floating Eggs Sample Questions

PROCESS-CENTERED QUESTIONS

Hinged Mirrors
What happens to the image of the
closer to each other?
What changes do you see happeni
What did you notice as you explor
What happens when you pull the
Can you predict the position of the
What is the relationship between t
images seen?
What do you think the relationship
of odd or even images?
How does the angle between the
How does changing the angle of t
What have you noticed when the
What is the relationship between t
What would you change to get the
How would you arrange the mirro
Have you seen any patterns?
Tell me what you see.

Floating Eggs
What might you do to the tap wat
Tell me what you saw when you pu
predictions?
What do you notice about the egg

OTHE

Hinged Mirrors
What can you say about the image
What are you thinking?

Floating Eggs
When you add salt to water, how d
If you could look at the water throu
ecules of the water and the salt wa
What is it about the water that is d

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EFFECTIVE QUESTIONING HANDOUT

Hinged Mirrors and Floating Eggs Sample Questions

SUBJECT-CENTERED QUESTIONS

Hinged Mirrors
What causes the penny to be repeatedly reflected?
What caused the patterns you noticed?
What makes the pennies seem to magically disappear and reappear?
Why does the penny image change when you move the mirrors?
Why are different numbers of images produced as the mirrors are moved?
What affects the number of images you can observe?
Can an image act as a source?

Floating Eggs
Does the size of the egg make a difference whether or not it will float?
Is the water in which the egg floats more dense than the water in which the egg sinks?
What do you know about things that float?
What factors, do you know, affect buoyancy?
What does the difference between the salt and fresh water play in the floating or sinking?
What might cause the difference in floating levels?

PERSON-CENTERED QUESTIONS

Hinged Mirrors
Why do you think you make more images when the angle of the mirror is smaller?
Why do you think different numbers of images are produced when the mirrors are moved?
How do you explain the image(s) of the penny in the mirror?
How would you explain your observations?
How would you explain the occurrence of the phenomena you are observing?
How can you explain what is happening in the mirror with both the penny and the mirror itself?
What do you think is happening (with the mirror)?

Floating Eggs
What do you think would explain what you noticed about the eggs?
What do you think causes the eggs to float or sink in the different kinds of water?
What do you think is making one of the eggs float?
Can you explain why eggs ride at different levels in the two different containers of water?
What do you think is happening (with the egg)?

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M8a&b

3. Review the take-home messages. Conclude the workshop by reviewing chart M2: "Take-Home Messages," briefly going over each one.

4. Distribute additional resources. If you've prepared any additional resources for participants, take this opportunity to pass them out.

5. Thank participants and bring the workshop to a close. Remind people that this is the third in a set of five workshops. As appropriate, tell participants when and where the next workshop will take place.

Materials Reminder

During this part of the workshop, facilitators will need to:

- **Post chart M2: "Take-Home Messages"**
- **Distribute handout M8a&b: "Hinged Mirrors and Floating Eggs Sample Questions"**
- **Distribute any additional materials you have prepared**

REVIEWING THE WORKSHOP

- **Facilitation Review**

Facilitation Review

Overview

It's a good idea to set aside some time after the workshop to get together with your co-facilitator (if you had one) and reflect on what worked and what didn't work. You can think and talk about your own facilitation and the workshop design, and consider what adjustments you can make for subsequent workshops. You'll also want to consider how the group's understanding of formative assessment developed during the workshop.

If you were the sole facilitator, take some time to consider the questions below and jot down notes for use when you present the workshop again.

4 Steps ◆ Time as needed

1. Acknowledge what you did well, and reflect on the goals. Start by taking a few minutes to talk about what went well during the workshop. Share any insights you gained about good facilitation strategies. Identify some things you did that helped groups get over difficult spots. Also, ask yourselves what you might do differently next time to improve the workshop.

2. Go through the workshop from beginning to end. Discuss not only how you facilitated different parts of the workshop, but also what participants did, and what they learned in each part of the workshop:

- Were all participants fully engaged in all parts of the workshop? Were there some steps that seemed particularly difficult for any of them? What could you do to encourage more active participation or help participants through difficult spots?
- Did participants develop their own understanding of the take-home messages? If so, how did they demonstrate their understanding? If not, what could you do differently to help them arrive at an understanding?
- Were participants inspired to consider applying some of their new ideas in their own classrooms?

3. Review the logistics of the workshop.

- Did you remain on schedule?
- Did you ever feel rushed to complete a step or did you finish early?
- What adjustments could you make that would be helpful?
- How did the distribution and cleanup of materials go?
- Is there anything you could do next time to make the workshop run more smoothly?

4. Consider how you worked together with your co-facilitator.

- Were you able to transition smoothly from one part of the workshop to the next?
- Were you able to transition smoothly between the roles of primary and secondary facilitator?
- Did you communicate effectively with each other during the workshop?
- What could you do to improve transitions and communication?

MORE FROM THE INSTITUTE FOR INQUIRY

- **About the Exploratorium Institute for Inquiry**
- **More Workshops on the Web**

About the Exploratorium Institute for Inquiry

The Exploratorium is San Francisco's innovative museum of science, art, and human perception. Here, hundreds of interactive exhibits engage visitors in seeking answers to the questions that emerge as they play and experiment with all kinds of intriguing phenomena.

The process of discovery and exploration is at the foundation of the Exploratorium Institute for Inquiry (IFI), a group of scientists and educators dedicated to developing and promoting inquiry-based science learning.

For more than thirty years, we have been educating teachers, administrators, and professional developers about the theory and practice of inquiry-based learning. Our workshops emphasize both the importance of engaging learners in firsthand experience with materials and phenomena, and the necessity for learners to play an active role in building new knowledge. Our work is shaped and refined by our own knowledge and experience, and by the invaluable input of teachers and professional developers working in the field.

For more information contact

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Since 1969, the Exploratorium has been bringing hands-on learning to visitors from around the world. Filled with hundreds of interactive exhibits, the museum offers programs for the public as well as for science and education professionals.

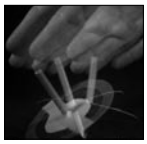
More Workshops on the Web

In addition to the ASSESSING FOR LEARNING curriculum, the Exploratorium also offers a series of five FUNDAMENTALS OF INQUIRY workshops. You can find more information at www.exploratorium.edu/ifi/workshops.

The FUNDAMENTALS OF INQUIRY curriculum is organized into these three areas:

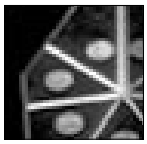
Elements of Inquiry

Three workshops that serve as building blocks for an immersion into inquiry by focusing on various hands-on approaches and process skills related to inquiry learning.



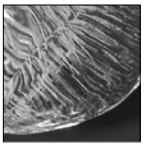
Workshop I: Comparing Approaches to Hands-On Science

Participants discover that different approaches to hands-on teaching support different goals for learning (about 3.5 hours).
Preview the workshop at www.exploratorium.edu/ifi/comparing



Workshop II: Process Skills

Participants identify the tools needed to carry out inquiry—the process skills—and examine the role of these skills in learning (about 3.5 hours).
Preview the workshop at www.exploratorium.edu/ifi/skills



Workshop III: Raising Questions

Participants examine the kinds of questions learners ask about phenomena and find out how to turn "noninvestigable" questions into "investigable" ones (about 3.5 hours).
Preview the workshop at www.exploratorium.edu/ifi/questions

Immersion in Inquiry

In this workshop, participants plan and conduct an investigation that illustrates how deep conceptual content—in this case, about stream flow and erosion—can be learned through a carefully orchestrated science inquiry process. At the same time, the activity illuminates the process of inquiry itself.

Workshop IV: Stream Table Inquiry

Participants experience inquiry firsthand, learning scientific process and content through an extended investigation (about 6 hours).
Preview the workshop at www.exploratorium.edu/ifi/streamtable

Connections to the Classroom

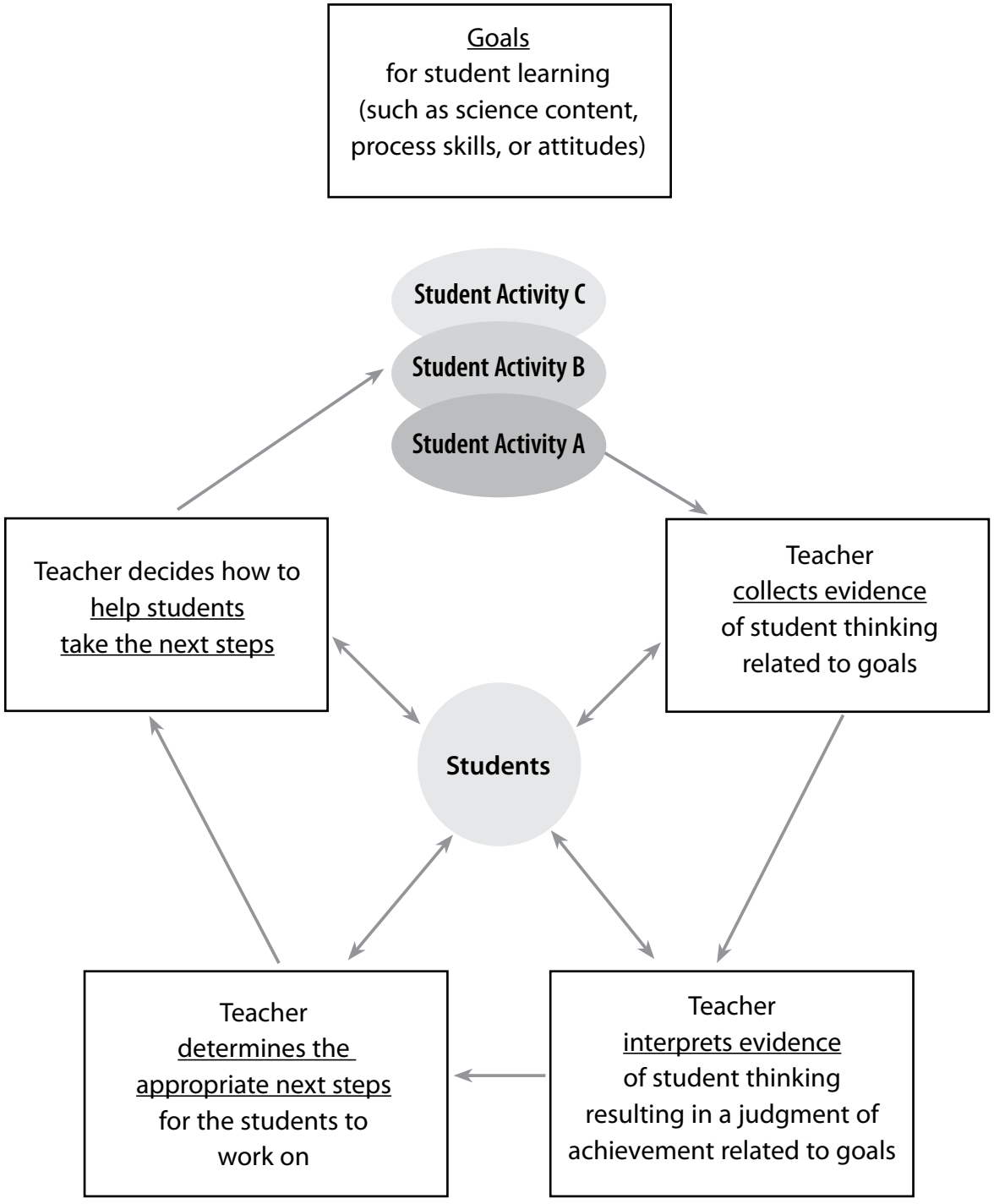
This last workshop focuses on helping participants make connections between what they have experienced in the previous workshops and what they can do in their classrooms to incorporate more science inquiry.

Workshop V: Subtle Shifts: Adapting Activities for Inquiry

Participants examine how current classroom activities can be modified to incorporate elements of inquiry (about 3 hours).
Preview the workshop at www.exploratorium.edu/ifi/subtleshifts

REPRODUCIBLE MASTERS

Formative Assessment Cycle



Take-Home Messages

- The way in which questions are expressed determines what happens as a result—whether they elicit a student's understanding, lead to action and use of process skills, or are answered by recall of facts.

- Questions that invite students to express their own ideas are open-ended and person-centered.

- Thoughtful questions require time for thoughtful answers.

- Teacher reactions to student answers, and the general ethos of the classroom, can encourage students to openly express their ideas.

Hinged Mirrors and Floating Eggs Activity Instruction Sheet

1. Do the activity at your table.

Floating Eggs Activity

- Switch the eggs between the tap water and the salt water and see what happens.

Hinged Mirrors Activity

- Observe how the images of the penny change when the mirrors are at different angles.

2. After you've done the activity, individually and without discussion, write on a card ONE QUESTION you might ask if you wanted to find out what ideas students had to explain what was going on. (Don't put your name on the card.)

3. Take 10 minutes to do the first activity. When you're done writing your question, a facilitator will collect the card and bring a different set of materials to your table.

4. Take 10 minutes to do the second activity. This time, when you're done writing your question, take a few more minutes to share it with others at your table, discussing the similarities and differences in terms of what each question asks of the student.

Sorting Questions—Facilitator's Worksheet

Subject-Centered

Example: "Why does the penny image change when you move the mirror?"

Person-Centered

Example: "Why do you think the egg floated in one container, but not the other?"

Process-Centered

Example: "Can you predict the position of the mirror to view four coins? Eight coins? "

Other

Example: "What is it about the water that is different?"

Different Kinds of Questions

Why do eggs float in salt water? Why are you able to see multiple images of an object placed in front of an angled mirror? What makes you see more images when you move the mirror in?	Why do you think the eggs float in the salt water? What do you think is going on when you bring the mirrors closer together and further apart? How would you explain what causes the eggs to act as they do in the two different kinds of water?	What can you observe about the egg in salt water and the egg in fresh water? Can you predict the position of the mirror to view four coins? Eight coins? How could you find out if there is a relationship between the angle of the mirror and the number of reflections?	What do you think? What is it about the water that is different?

Questions for Encouraging Process Skills

Process-Centered questions ask students to use their process skills when exploring. These kinds of questions can be valuable in many different classroom situations. The examples here, for instance, would be appropriate at different points for students planting and growing different kinds of seeds.

Observing

- What do you notice that is the same about these seeds?
- What differences do you notice between seeds of the same kind?
- Could you tell the difference between them with your eyes closed?
- What do you see when you look at the seeds with a magnifying glass?

Questioning

- What questions would you like to ask about seeds?
- What questions could you answer by planting and observing the seeds?

Hypothesizing

- Why do you think the seeds are not growing now?
- What do you think will make the seeds grow faster?
- Why do you think that would that make them grow faster?
- Why do you think the soil will help the seeds to grow?
- Why do you think these plants are growing taller than those?
- What do you think has happened to the seeds?
- Where do you think these leaves came from?

Predicting

- What do you think the seeds will grow into?
- What do you think will happen if the seeds have soil but not water?
- What do you think will happen if we give the seeds more (or less) water/light/warmth?

Planning

- What will you need to do to find out… (if the seeds need soil to grow)?
- How will you make it a fair test (make sure it's the soil, and not something else, making the seeds grow)?
- What materials will you need?
- What will you have to look for to answer your question?

Interpreting

- Did you find any connection between… (how fast the plant grew and the amount of water/light/warmth it had)?
- Is there a connection between the size of the seed and the size of the plant?
- What made a difference in how fast the seed began to grow?
- Was soil necessary for the seeds to grow?

Communicating

- How are you going to keep track of what you did in the investigation and what happened?
- How can you explain to the others what you did and found out?
- What kind of chart/graph/drawing would be the best way to show the results?

Creating an Atmosphere for Sharing Ideas

- Use sufficient "wait time" after asking a question.
- Accept all ideas as equally worthy of consideration, whether scientifically correct or not.
- Consider ideas collectively as "our" ideas; don't identify them with individual students.
- Set an example by being patient, sympathetic, encouraging, and fair.

Hinged Mirrors and Floating Eggs Sample Questions

Subject-Centered Questions

Hinged Mirrors

What causes the penny to be repeatedly reflected?
What caused the patterns you noticed?
What makes the pennies seem to magically disappear and reappear?
Why does the penny image change when you move the mirrors?
Why are different numbers of images produced as the mirrors are moved?
What affects the number of images you can observe?
Can an image act as a source?

Floating Eggs

Does the size of the egg affect whether or not it will float?
Is the water in which the egg floats more dense than the water in which the egg sinks?
What do you know about things that float?
What factors do you know about that affect buoyancy?
What is the difference between salt and fresh water in the egg floating or sinking?
What might cause the difference in floating levels?

Person-Centered Questions

Hinged Mirrors

Why do you think you make more images when the angle of the mirror is smaller?

Why do you think different numbers of images are produced when the mirrors are moved?

How do you explain the image(s) of the penny in the mirror?

How would you explain your observations?

How would you explain the occurrence of the phenomena you are observing?

How can you explain what is happening in the mirror with both the penny and the mirror itself?

What do you think is happening (with the mirror)?

Floating Eggs

What do you think would explain what you noticed about the eggs?
What do you think causes the eggs to float or sink in the different kinds of water?
What do you think is making one of the eggs float?
Can you explain why eggs ride at different levels in the two different containers of water?
What do you think is happening (with the egg)?

Hinged Mirrors and Floating Eggs Sample Questions

Process-Centered Questions

Hinged Mirrors

What happens to the image of the penny when you move the two sides of the mirror closer to each other?
What changes do you see happening when you move the mirror?
What did you notice as you explored the penny and mirrors?
What happens when you pull the mirrors closer together?
Can you predict the position of the mirror necessary to view four coins? Eight coins?
What is the relationship between the position of the mirror and the number of penny images seen?
What do you think the relationship is between the measures of the angle and the number of odd or even images?
How does the angle between the mirrors relate to the number of images of the coin?
How does changing the angle of the mirror change the number of pennies?
What have you noticed when the mirror is open wide vs. opened narrow and why?
What is the relationship between the position of the viewer and the penny/mirror system?
What would you change to get the "most" reflections of the penny in your mirrors?
How would you arrange the mirrors to see two pennies?
Have you seen any patterns?
Tell me what you see.

Floating Eggs

What might you do to the tap water to get the "sinker" to float?
Tell me what you saw when you put the eggs in the two tubs. Did the results match your predictions?
What do you notice about the eggs?

Other Kinds of Questions

Hinged Mirrors

What can you say about the image in the mirror?
What are you thinking?

Floating Eggs

When you add salt to water, how does it change the properties of water?
If you could look at the water through a powerful microscope, what do you think the molecules of the water and the salt water would look like?
What is it about the water that is different?