

Workshop

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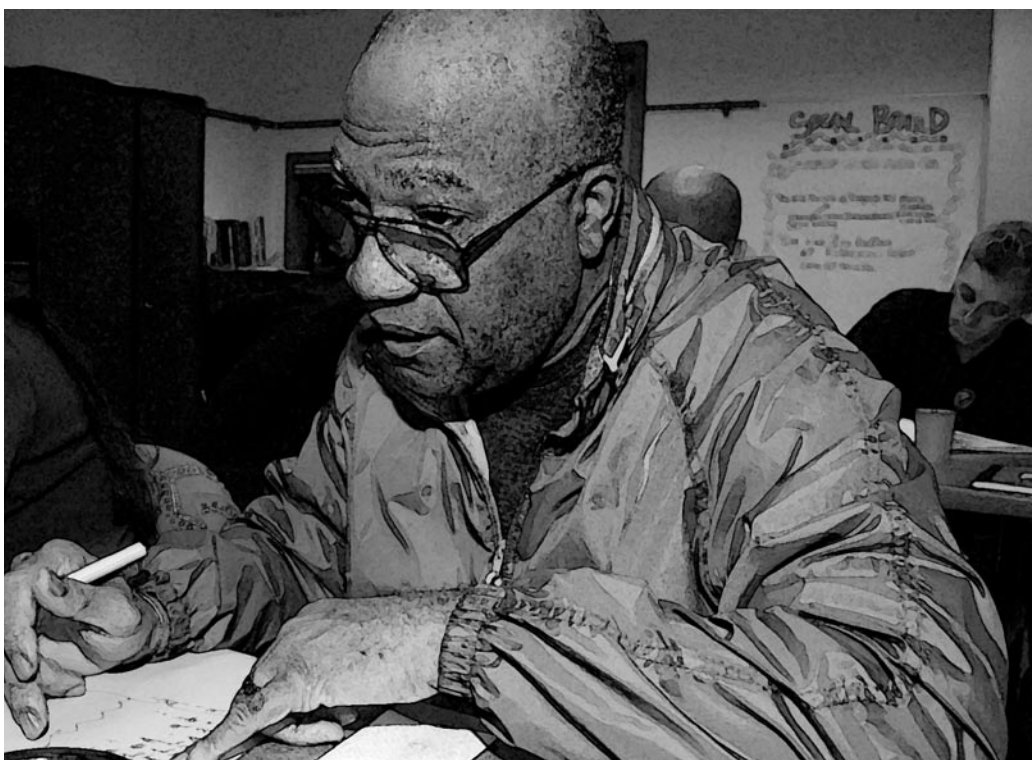
Workshop

V

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## Assessing for Learning Facilitator's Guide

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### WORKSHOP II: ASSESSING PROCESS SKILLS

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**A Professional Development Curriculum from the  
Institute for Inquiry®**

*The second in a set of five workshops for teacher professional development*

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You can download your own copy of this guide at [www.exploratorium.edu/ifi/assessing](http://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](http://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](http://www.exploratorium.edu/ifi/help). These plug-ins may require additional memory.

**You can download any of the  
ASSESSING FOR LEARNING workshop guides at  
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A screenshot of the Exploratorium Institute for Inquiry website. The header reads "Workshops professional development experiences for educators". Below this is a large image of hands holding a globe. To the right of the image is a text block: "For more than 30 years, the Institute for Inquiry has served as a professional development center for teachers, administrators, and professional developers interested in exploring the theory and practice of inquiry-based teaching and learning. Our workshops and custom collaborations illuminate the power of learning scientific content through inquiry and introduce strategies for providing inquiry experiences in the classroom." Below this is a section titled "Lead your own Workshops" with a sub-header "A series of facilitator's guides published on the Web for professional developers working with teachers." It lists three guides: "Fundamentals of Inquiry" (Five workshops designed to introduce teachers to inquiry teaching), "Assessing for Learning" (Available Fall 2006), and "Workshop Schedule" (See a current schedule of Institute for Inquiry offerings). Below the list is a "Workshop Brochure" link with the text "Download information about our workshop offerings." At the bottom of the page is a navigation bar with links: "ABOUT THE INSTITUTE | WORKSHOPS | LIBRARY". The Exploratorium logo is in the bottom right corner.

# Assessing Process Skills

## Welcome

Welcome to *Assessing Process Skills*, the second 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 at the Exploratorium 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

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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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# ABOUT THIS WORKSHOP

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

# The Workshop in Context

## **ASSESSING FOR LEARNING**

*Assessing Process Skills* is the second 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 10 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:



### **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).

Workshop



### **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: Effective Questioning**

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



### **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).



### **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 followed 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

*Assessing Process Skills* is the second 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 classrooms.

In this workshop, teachers learn how observing students engaged in science, and examining their written work, can provide evidence of the use and development of their science process skills.

Because almost everything a student does can give some evidence about his or her thinking, it's sometimes difficult to pick out aspects that are of particular significance. By developing a way of looking at students' work—what learners do, write, draw, and say—teachers can identify what is most relevant for their learning.

This workshop offers guidelines in observing student behaviors that indicate the use of science process skills at various developmental levels during the course of doing regular classroom activities. It provides participants with the opportunity to consider behavioral “indicators of development” as a tool for assessment and teaching, and to practice recognizing these indicators.

In addition to discovering evidence through observation, this workshop also helps participants consider other ways to gather evidence of process-skill development—by asking appropriately phrased questions, for example, and by setting tasks so that students must use their science process skills.

## Goals

- To provide a method of observation designed to help teachers gather evidence of student use of process skills at different developmental levels.
- To help teachers add to observational evidence by offering strategies for framing questions and designing tasks that provide information about process skills in students' oral and written accounts of their work.

## 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 pro-

vided in the “Formative Assessment Basics” section, beginning on page 10 of this guide.

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 students must take to achieve these goals, and finally, determine how to help the students take those next steps.

This workshop—*Assessing Process Skills*—offers strategies for gathering and using evidence of student development of science process skills. Subsequent

workshops focus on gathering and using evidence about students' conceptual development in science.

## How the Workshop Works

This workshop requires one facilitator (although you might choose to have two to divide up the steps and to help with materials), and takes about three and a half hours. The second in a five-part series, it assumes facilitators and participants have already experienced Workshop I: *Introduction to Formative Assessment*, and are planning to go on to the remaining workshops. For those who want to review or revisit content basics, however, that information is available in each workshop guide.

Typically, planning takes about six hours, not includ-

ing 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.

At the start of this workshop, participants discuss what evidence they would look for to determine if students were using certain science process skills. Next, they are introduced to a list of behavioral indi-

cators of development that describe what process skills look like in action—that is, as students practice them. (For more detailed information on the process skills of science, see page 19.) The participants then practice applying those indicators as they observe colleagues engaged in a “fair testing” science experiment, after which they discuss and compare their experiences and reflect on the process.

### Take-Home Messages

- By observing regular classroom activities, teachers can use specific behavioral indicators to gather evidence of a student's process skill development.
- By using carefully framed tasks, teachers can find evidence of process skill development in a student's oral and written work.
- By using behavioral indicators, teachers can determine next developmental steps for a student once evidence of current developmental levels have been gathered.

Observing students at work is not the only way to gather evidence of science process skills, and participants next discuss other approaches for gathering evidence, including written and oral presentations. The workshop then turns to a consideration of how to use the evidence of process skills to generate next steps that will help students continue to

develop those skills. The facilitator concludes the workshop by reviewing the steps taken during the Formative Assessment Cycle and summarizing ideas for implementing those steps.

## 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

### **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 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.

# 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.

## 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

### 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."

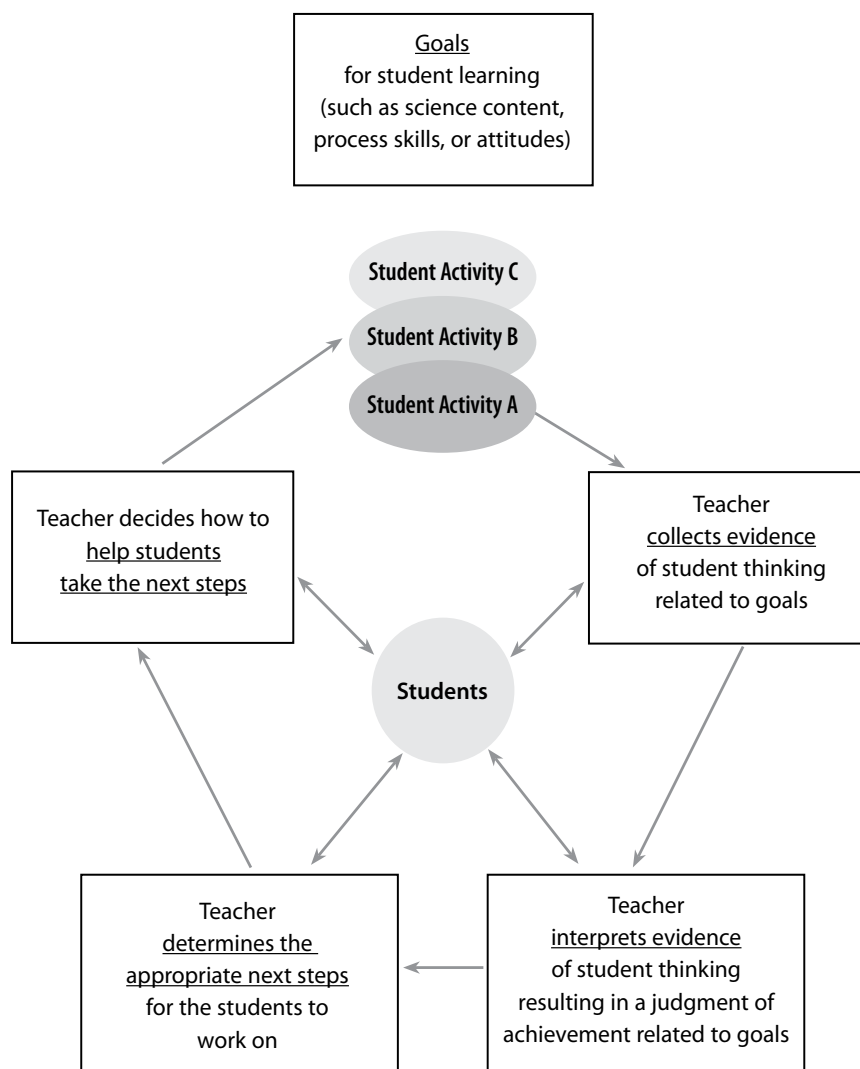
Wynne Harlen. *Enhancing Inquiry through Formative Assessment*. (San Francisco: Exploratorium, 2003) pp. 7–8.

(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-

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

referenced, allowing the teacher to match next steps with the needs of the individual student.

**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 17.

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](http://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](http://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.

# SCIENCE PROCESS SKILLS BASICS

- **An Introduction to Science Process Skills and Assessment**

# An Introduction to Science Process Skills and Assessment

## About the Process Skills of Science

This workshop offers participants practical ways to assess their students' use of the process skills of science. Developing process skills is crucial to building an understanding of the world and to learning science content: the ideas and concepts that explain how the natural and human-made worlds work. Process skills give learners ways to engage with science content.

Most curricula and standards documents distinguish skills from content knowledge, and envision using the skills across all the science content. Virtually all emphasize the importance of the science process skills addressed in this workshop, which include:

- observing (collecting evidence, measuring)
- raising questions (recognizing and defining investigable questions)
- hypothesizing (giving possible explanations)
- predicting (using ideas or evidence to predict an outcome)
- planning and conducting investigations (devising inquiries)
- interpreting (considering evidence, evaluating, drawing conclusions)
- communicating (presenting reports, using secondary sources)

Although these process skills may differ somewhat from those identified by various districts or projects,

we use this list because it seems most representative. Make substitutions, or subsume skills within these as appropriate to apply this list to the skills you are more familiar with. For instance, “inferring,” a process skill commonly listed in curricula, can be substituted for interpreting, or “measuring” can be subsumed within observation.

## Why It's Hard to Define Process Skills

Whatever set of process skills you use, it will probably be difficult to precisely define each one. This does not present a problem for applying formative assessment to the science process skills because the goal is to help students improve their skills in general, rather than as isolated entities. While curricula and standards documents don't all use the same lan-

guage, most describe the process skills in similar ways. However, differences in definitions and descriptions can occasionally lead to disagreement and confusion.

Says author Wynne Harlen in her book *The Teaching of Science in Primary Schools* (David Fulton Publishers Ltd, 1997, p. 26):

“Students at all grade levels and in every domain of science should have the opportunity to use scientific inquiry and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanation, constructing and analyzing alternative explanations, and communicating scientific arguments.”

National Research Council. *Classroom Assessment and the National Science Education Standards*. (Washington, DC: National Academy Press, 2000) p. 105.

“Process skills are described in various ways, all of which suffer from the problem of trying to draw boundaries round things which are not separable from each other...

“When we describe an example of ‘observing,’ there is some ‘hypothesizing’ going on as well, and even some degree of ‘investigating’... Almost any scientific activity begins with ‘observation’; it is part of identifying a problem or raising a question and is essential to collecting evidence...”

“In light of these points, it is reasonable to ask how useful it is to attempt to separate aspects of scientific activity. It may be best to regard it as a whole. However, the whole is so complex that, while the skills are not separable in practice, it is useful to describe certain aspects of scientific activity and to name them... These aspects of practice, which we call process skills, are not single skills but conglomerates of coherent skills. It is for convenience only that we refer to each as individual skills.”

Understanding this point can help people find common ground when disagreements arise.

### **Why Assess Process Skills?**

Determining a student's level of development in using scientific process skills is an important aim of science education for several reasons. These skills are important parts of the core thinking skills that are valued as outcomes of education. They are also essential in enabling children to develop understanding and the ability to identify and use relevant scientific evidence in solving problems and making decisions. Teachers need to help their students develop their process skills into scientific ones, just as they need to help students develop scientific ideas. Formative assessment is a tool that helps teachers help their students develop their process skills.

### **Using Developmental Indicators for Formative Assessment**

Formative assessment involves identifying a stu-

dent's current understanding related to a specific goal and identifying next steps in reaching that goal. This workshop introduces lists of developmental indicators of process skills. Teachers can use these lists to evaluate their students' current abilities related to the process skills, and identify next steps for each skill.

The indicators provided in this workshop map the development of process skills in terms of what children can do. Under each heading, benchmarks are arranged in a sequence that reflects typical progression. These sequences have been created from currently available information, including research into children's learning, the experiences of classroom teachers and subject specialists, and information obtained by survey and monitoring programs about the achievements of children at different ages and stages.

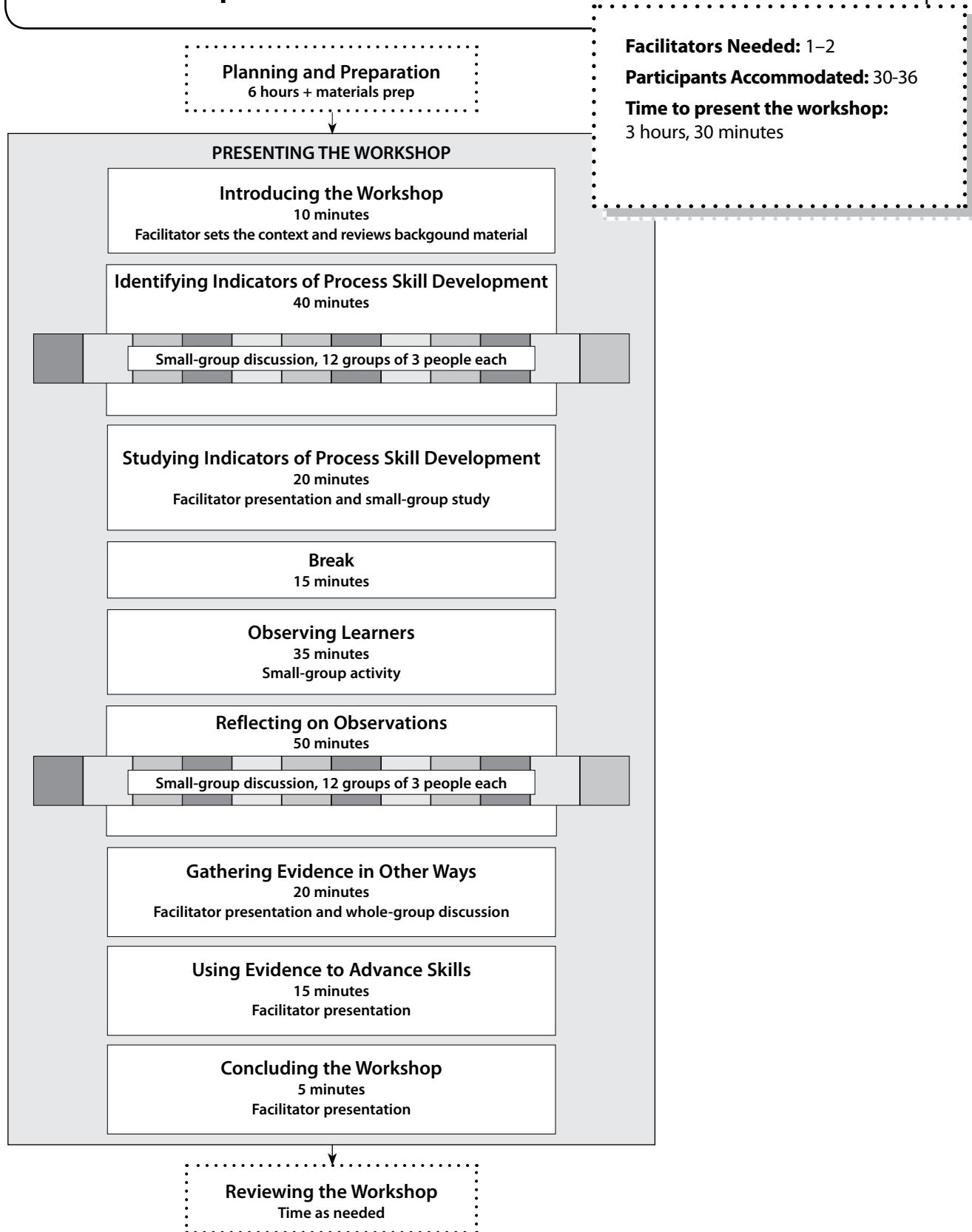
Still, there is no guarantee that this scheme will fit every child. Although the developmental indicators presented here are appropriate for ages 5–12, no attempt has been made to identify where children of a certain age or stage should have reached within this range. But this is not a requirement for formative assessment, which has as its goal to see where children are in making progress and where next steps ought to take them. By answering “yes” or “no” to the questions on the indicators lists on page M10, teachers can interpret evidence of understanding that can be found in what children say, what they do, what they make, write, and draw.

Finding where the positive answers to the questions turn to negative ones—or, more realistically, where it becomes difficult to say yes—locates a child's development on the list. Furthermore, and importantly, this process also indicates the next developmental step, serving as a pointer to where progress is to be made.

# PLANNING AND PREPARATION

- **Workshop at a Glance**
- **Essential Planning Steps**
- **Materials and Equipment**
- **Charts, Overheads, and Handouts**

# Workshop at a Glance



# Essential Planning Steps

## Overview

The *Assessing Process Skills* 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.

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, and handouts.

You'll also want to set aside time after the workshop to talk with your co-facilitator 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 content.** Review the Formative Assessment Basics section (see page 10). This is the foundation of the entire curriculum.

**3. Prepare materials.** Gather and organize all materials (see the complete list on pages 25–27).

- 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 52. They are identified with the letter M and numbered in order of use.

- Study the list of Additional Resources on page 17, deciding what you might want to copy for distribution at the end of the workshop.

**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.

## Planning Time Needed

- Typically, planning takes about 6 hours, not including time to gather and prepare materials and equipment

## An Important Note from the Institute for Inquiry

This workshop is the result of many years of development. While its format may seem adaptable, using it in ways other than those described here will not only change the workshop, 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.

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.

## 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.

**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.

- Some parts of the workshop are more challenging to facilitate than others. In particular, be sure to practice Steps 5 and 6 of Reflecting on Observations (page 41).

**7. 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 Step 2 of Introducing the Workshop (page 29), and practice presenting this information.

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

**8. Plan time and space carefully.** You'll need a space large enough for 30–36 participants to work together comfortably.

- 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 & Review Formative Assessment Strategies chart, 9:00–9:05; Distribute handout M3 and post chart M2, 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 below.

## 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.

**2. Watch your schedule.** Refer to the schedule you created (see Step 8, above) to keep the workshop on track.

## After the Workshop

You and your 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 48) will allow you to assess the results of your work and identify successes and challenges that can help guide subsequent workshops.

### Sample Schedule for Participants

|             |  |
|-------------|--|
| 9:00–9:10   | Introducing the Workshop                             |
| 9:10–9:50   | Identifying Indicators of Process Skills Development |
| 9:50–10:10  | Studying Indicators of Process Skills Development    |
| 10:10–10:25 | Break  |
| 10:25–11:00 | Observing Learners                                   |
| 11:00–11:50 | Reflecting on Observations                           |
| 11:50–12:10 | Gathering Evidence in Other Ways                     |
| 12:10–12:25 | Using Evidence to Advance Skills                     |
| 12:25–12:30 | Concluding the Workshop                              |



# Materials and Equipment

## Materials

These materials are used for the fair-test (towel-absorption) activity on page 38. Quantities are based on 36 participants working in groups of 6 per table; adjust as necessary.

### To set up at each table

| Item  | Number needed per group of 6       | Total Needed  |
|---|------------------------------------|---|
| <input type="checkbox"/> hand-lettered card that says "Which type of paper towel absorbs the most water?" | 1                                  | 6   |
| <input type="checkbox"/> 3–4 different brands of paper towels   | 1 sheet of each brand (3–4 sheets) | 24–30 sheets  |
| <input type="checkbox"/> set of measuring spoons  | 1                                  | 6   |
| <input type="checkbox"/> clear plastic cups   | 6                                  | 36  |
| <input type="checkbox"/> ruler  | 1                                  | 6   |
| <input type="checkbox"/> 1-quart or 1-liter pitcher filled with water                                     | 1                                  | 6   |
| <input type="checkbox"/> eyedropper   | 2                                  | 12  |
| <input type="checkbox"/> food coloring  |                                    | 4 total:<br>2 bottles each of<br>2 different colors |
| <input type="checkbox"/> paper and pencils for recording  |                                    | as needed   |
| <input type="checkbox"/> balance scale (optional)   |                                    | 1   |
| <input type="checkbox"/> 50–100ml graduated cylinder or measuring cup (optional)                          |                                    | 2   |

## Equipment

|  | Total Needed |
|--|--------------|
| <input type="checkbox"/> overhead projector (optional) | 1            |
| <input type="checkbox"/> marking pens for overheads    | 2            |

# Charts, Overheads, and Handouts

Masters begin on page 52, are identified by the letter *M* (for Master), and are numbered in order of use. Note that some masters will be used for both a handout and a chart or overhead.

| <b>Charts or Overheads</b><br><br>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 facsimiles onto chart paper or poster paper approximately the same size, or photocopy the masters onto overheads. If you use overheads, you'll need a marking pen to write on them. | Master Available on Page |
|---|--------------------------|
| <input type="checkbox"/> Formative Assessment Strategies (with blank boxes)<br>(for Introducing the Workshop; Identifying Indicators of Process Skill Development; Gathering Evidence in Other Ways; Using Evidence to Advance Skills; Concluding the Workshop)   | M1                       |
| <input type="checkbox"/> Take-Home Messages<br>(for Introducing the Workshop)   | M2                       |
| <input type="checkbox"/> Indicators for Early and Later Developmental Stages: "Predicting"<br>(for Identifying Indicators of Process Skill Development)   | M4                       |
| <input type="checkbox"/> Indicators of Development: "Predicting"<br>(for Identifying Indicators of Process Skill Development)   | M5                       |
| <input type="checkbox"/> Observing<br>(for Identifying Indicators of Process Skill Development)   | M7                       |
| <input type="checkbox"/> Planning and Conducting Investigations<br>(for Identifying Indicators of Process Skill Development)  | M8                       |
| <input type="checkbox"/> Indicators of Development: "Observing" & "Planning and Conducting Investigations"<br>(for Identifying Indicators of Process Skill Development and Studying Indicators of Process Skill Development)  | M9                       |
| <input type="checkbox"/> Fair-Testing Observations: Questions for Whole-Group Discussion<br>(for Reflecting on Observations)  | M14                      |
| <input type="checkbox"/> Three Important Points about Process Skill Development<br>(for Reflecting on Observations)   | M15                      |
| <input type="checkbox"/> Student Work Sample 1<br>(for Gathering Evidence in Other Ways)  | M16                      |
| <input type="checkbox"/> Student Work Sample 2<br>(for Gathering Evidence in Other Ways)  | M17                      |
| <input type="checkbox"/> Student Work Sample 3<br>(for Gathering Evidence in Other Ways)  | M18                      |
| <input type="checkbox"/> Helping Students Develop their Science Process Skills<br>(for Using Evidence to Advance Skills)  | M19                      |

| <b>Handouts</b><br><b>Photocopy these 8½" x 11" handouts as instructed below.</b>   | <b>Master Available<br/>on Page</b> |
|---|-------------------------------------|
| <input type="checkbox"/> Introduction to the Process Skills of Science<br>(Make one copy for each person (for Introducing the Workshop))                            | M3                                  |
| <input type="checkbox"/> Indicators of Development: Activity Sheet<br>Make one copy for each person (for Identifying Indicators of Process Skill Development)       | M6                                  |
| <input type="checkbox"/> Indicators for Assessing Process Skill Development<br>Make one copy for each person (for Studying Indicators of Process Skill Development) | M10a & M10b                         |
| <input type="checkbox"/> Fair-Testing Activity Sheet: Observer 1<br>Make two copies for each table. Total: 12 (for Observing Learners)                              | M11                                 |
| <input type="checkbox"/> Fair-Testing Activity Sheet: Observer 2<br>Make two copies for each table. Total: 12 (for Observing Learners)                              | M12                                 |
| <input type="checkbox"/> Fair-Testing Activity Sheet: Investigator<br>Make two copies for each table. Total: 12 (for Observing Learners)                            | M13                                 |
| <input type="checkbox"/> Helping Students Develop their Science Process Skills<br>Make one copy for each person (for Using Evidence to Advance Skills)              | M19                                 |
| <input type="checkbox"/> Formative Assessment Strategies (with filled-in boxes)<br>Make one copy for each person (for Using Evidence to Advance Skills)             | M20                                 |
| <input type="checkbox"/> Take-Home Messages<br>Make one copy for each person (for Concluding the Workshop)  | M2                                  |

# PRESENTING THE WORKSHOP

- **Introducing the Workshop**
- **Identifying Indicators of Process Skill Development**
- **Studying Indicators of Process Skill Development**
- **Observing Learners**
- **Reflecting on Observations**
- **Gathering Evidence in Other Ways**
- **Using Evidence to Advance Skills**
- **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.

Letting everyone know what they will be doing and why helps build trust and demonstrates your respect for the participants as learners. A respectful atmosphere is essential for fostering a free and open exchange of ideas.

Note that chart M1: "Formative Assessment Strategies" should remain posted for the entire workshop. Giving participants handouts of selected charts and overheads during the workshop makes it easier for participants to refer to the information displayed. This is especially important when the charts or overheads are long and complicated.

## 6 Steps • 10 Minutes

### 1. Set the context for the workshop Say:

► This is the second workshop in a series of five that deal with formative assessment. The purpose of this workshop is to further your understanding of formative assessment by addressing ways of gathering and evaluating evidence of how students use science process skills.

### 2. Post chart M1: "Formative Assessment Strategies."

Say:

► In the previous workshop, we talked about the Formative Assessment Cycle, which provides a framework for teachers to use assessment in promoting student learning. Now we'll be discussing how teachers can actually put formative assessment into practice, using the cycle as a framework.

### Materials Reminder

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

- Post chart M1: "Formative Assessment Strategies" (this chart stays posted through the entire workshop)
- Post chart M2: "Take-Home Messages"
- Distribute handout M3: "Introduction to the Process Skills of Science"

ASSESSING PROCESS SKILLS
CHART OR OVERHEAD & HANDOUT

### Take-Home Messages

- By observing regular classroom activities, teachers can use specific behavioral indicators to gather evidence of a student's process skill development.
- By using carefully framed tasks, teachers can find evidence of process skill development in a student's oral and written work.
- By using behavioral indicators, teachers can determine next developmental steps for a student once evidence of current developmental levels have been gathered.

INSTITUTE FOR INQUIRY:  
www.exploratorium.edu/ifi
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max M2

M1

In this workshop, we'll focus on formative assessment of process skills, paying particular attention to how teachers can gather evidence of how their students use the process skills of science. We'll also address how teachers can interpret this evidence and use it to make instructional decisions to help students improve their process skills. Assessing process skills is important, not only because they are part of the core thinking skills that are valued as outcomes of science education, but also because they are essential in enabling students to develop understanding of scientific ideas and concepts.

In subsequent workshops we'll focus on gathering and using evidence about students' ideas and conceptual understanding.

**3. Post chart M2: “Take-Home Messages.”** Tell participants:

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

**4. Distribute handout M3:**

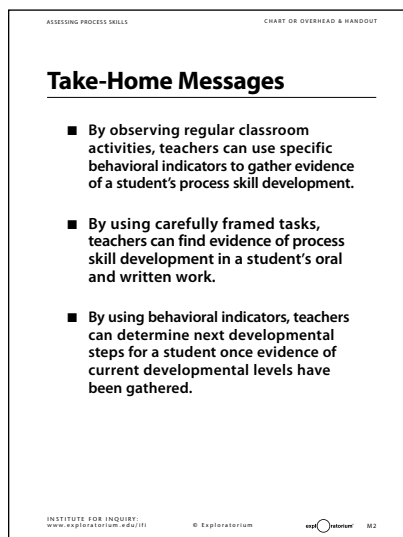
**“Introduction to the Process**

**Skills of Science.”** Tell participants

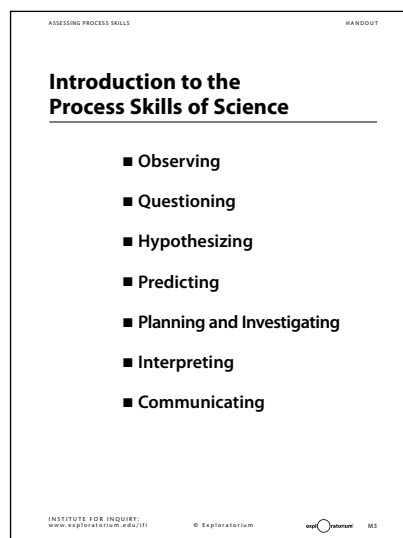
that these skills will be referred to throughout the workshop, and that you’ll go into depth about them later.

**5. Explain how the workshop relates to your district’s goals, standards, and other professional-development activities for science education.** Remind participants of their work in the previous workshop (*Introduction to Formative Assessment*), as appropriate.

**6. Tell participants that this workshop will take about three and a half hours, including a 15-minute break.**



**M2**



**M3**

# Identifying Indicators of Process Skill Development

## Overview

In this part of the workshop, participants consider what behaviors they would look for to see if students were demonstrating the use of certain science process skills during classroom investigations. Using the process skill of “predicting” as an example, facilitators model ways to recognize where students are along the developmental spectrum of that skill.

Participants then break into groups of two or three. Focusing on either “observing” or “planning and conducting investigations,” each group works to identify the kinds of student behaviors that would tell teachers where students were along the developmental spectrum of that process skill.

As participants consider this for both lower and upper elementary students, you can introduce the idea that behavioral indicators of development will be different at different

points, and that there is a progression in the development of each process skill.

In the classroom, evidence for formative assessment comes primarily from observing students during everyday activities. It’s important to be able to distinguish evidence that

is significant for assessment from evidence that is not. This section will help teachers develop the ability to identify evidence from classroom activities that is most useful for formative assessment.

## Materials Reminder

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

- Post chart M4: “Indicators for Early and Later Developmental Stages: ‘Predicting’”
- Post chart M5: “Indicators of Development: ‘Predicting’”
- Distribute handout M6: “Indicators of Development: Activity Sheet,” one copy to each group of three
- Post chart M7: “Observing”
- Post chart M8: “Planning and Conducting Investigations”
- Have marking pens ready for recording participant responses
- Post chart M9: “Indicators of Development: ‘Observing’ & ‘Planning and Conducting Investigations’”

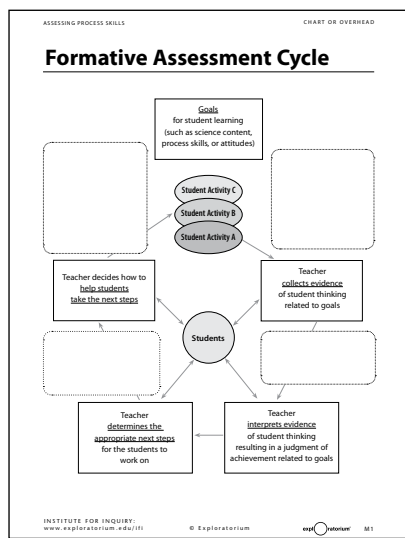
## 10 Steps • 40 Minutes

### Steps 1–3, 5 Minutes

### 1. Refer to chart M1: “Formative Assessment Cycle.” Tell participants:

► You may notice that this diagram of the Formative Assessment Cycle is a bit different from the one we used in the previous workshop. This one has empty boxes next to the four phases of the Cycle—at “collecting evidence,” “interpreting evidence,” “determining next steps,” and “helping students take next steps.”

As we work today, we’ll fill in the boxes with practical strategies for each phase of the Cycle.



M1

The major focus of this workshop will be on the “collecting evidence” phase, but later on, we’ll touch on the other phases of the Cycle as well.

## 2. Refer again to chart M1: “Formative Assessment Cycle.”

Write the word “observing” in the blank box at the upper right-hand corner of the chart or overhead.

Later in the workshop, you’ll be writing another phrase in this same box, so leave some room.

Explain to participants that they will begin by focusing on the “collecting evidence” part of the Cycle, using the strategy of observing student behavior during regular classroom activities. Say:

- To begin, we’ll be looking at strategies for collecting evidence about how students use their science process skills.

*There are many ways to get this information, but we’re going to begin by focusing on observation, because by watching students at work, you have the chance to see them actually putting into practice the skills you’re looking for. Do they really*

**NOTE:** In this part of the workshop, facilitators begin to write on chart M1: “Formative Assessment Cycle,” noting strategies associated with different aspects on the Cycle. If you’d prefer to keep the chart unmarked for use in future workshops, you can write the words and phrases on 3 x 5” index cards, taping them to the chart, then later remove the cards so you can re-use the chart. If you go this route, you’ll need 10–12 index cards and a roll of masking tape.

*observe? Do they really predict and plan and form hypotheses and conclusions? How effectively do they do so?*

*It’s useful to think about what science process skills actually look like when students practice them, so let’s look at a model for one of these skills. We’ll start with “prediction.”*

## 3. Model the identification of relevant observable behaviors by using the process skill of “predicting” as an example (5 minutes). Say:

- What would you look for to indicate a student was using the skill of prediction? Your first thought might be that it would probably be some evidence that they were thinking about what might happen, or what they might expect to find—some way of putting the skill into operational form.

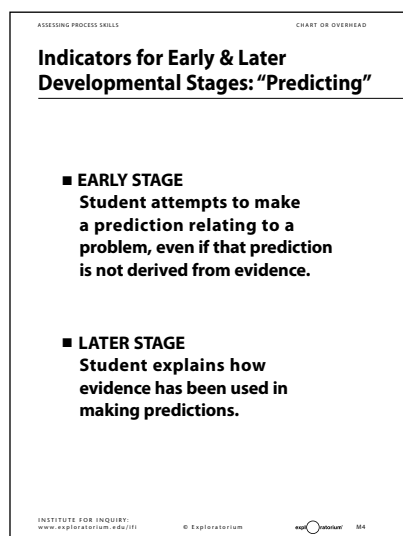
*Obviously, what constituted this evidence would depend on a number of factors. For instance, how would this skill be different for younger or older students? How would it develop as students gained experience?*

### Steps 4–6, 5 Minutes

**4. Post chart M4: “Indicators for Early and Later Developmental Stages: Predicting.”** Show the top of the sheet only (“Early Stage”), while keeping the bottom half (“Later Stage”) covered. Read:

#### ► EARLY STAGE

*Student attempts to make a prediction relating to a problem, even if that prediction is not derived from evidence.*



M4



Tell participants:

- For younger students, a prediction might look like a guess. But it should not be a “blind guess”; it should be based on some reasoning, even if the student may not be able to articulate that reasoning. For example, a younger student may say, “I think it will rain. I see clouds.” She may not be able to explain why she thinks it might rain if she sees clouds in the sky, but she still has some evidence for the prediction.

Uncover the “Later Stage” part of the chart. Read:

#### ► LATER STAGE

*Student explains how evidence has been used in making predictions.*

Tell participants:

- You might expect older students to be able to say, “I made this prediction because I’ve seen this pattern before, and that makes me think that what I predicted is really going to happen.”

*In other words, older children can justify a prediction in terms of a pattern in evidence or an idea that might explain it (for example, “I think it will rain because every time I see dark clouds, it rains”).*

#### 5. Post chart M5: “Indicators of Development: Predicting” and tell people:

- With some time and thought, you could probably work out some intermediate steps between the early and later stages of a process skill. If you did, you might come out with something like this.

- Go through levels 1 through 6 on the chart, and describe the identification of intermediate skill levels:

- Going from level 1 to level 6, you can see that there’s a progression from attempting to make a prediction—even if based on preconceived ideas—to making some use of evidence, using patterns, and so on.

*You can see the value of having this arranged in a developmental sequence. If you find that your students*

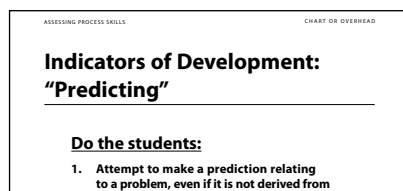
*are somewhere near level 3, then the next steps for them would be to consolidate their skills at level 3 (that is, to be sure they have a solid understanding of those skills), and then begin working on the behavior described at level 4.*

*Knowing the developmental sequence of a process skill is valuable in deciding next steps as well as in helping*

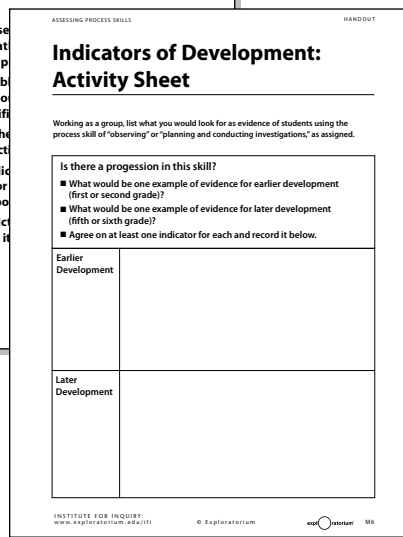
*understand the level at which a student is currently functioning.*

*It will be easier for you to use the idea of a developmental sequence if you come up with some examples of your own. You don’t have to do every level, but by doing a few, you’ll understand more fully what sort of thinking goes into identifying behaviors at different developmental levels.*

- #### 6. Have participants divide up into two groups of three at each table. Ask each trio to appoint someone to be a recorder / spokesperson. Distribute



M5



M6

handout M6: “Indicators of Development: Activity Sheet.” Tell people:

- This handout asks you to identify what you would look for as evidence of younger and older student behaviors using either the process skill of “observing” or of “planning and conducting investigations.” Try to come up with general descriptions of what to look for rather than specific examples.

**7. Split the whole group in half (15 minutes).** Assign half of the small groups to work on the process skill of “observing,” and the other half to work on “planning and conducting investigations.”

- Tell the groups working on “observing” that they should be focusing on *how* the students are observing (for example, observing differences), rather than on *what* they are observing.
- Tell the groups working on “planning and conducting investigations” that they should focus on *behaviors* that might be involved in planning and conducting an investigation, rather than on the *details* of a particular investigation.
- Point out that each group should consider behaviors they might expect to see for both younger students (grades 1–2) and older students (grades 4–5), and to try to find at least one behavior they can agree on for each age.

- Tell participants they have 15 minutes to work, and let them know when they have 5 minutes left.

### Steps 8–9, 10 Minutes

**8. Post charts M7: “Observing” and M8: “Planning & Conducting Investigations.”** Then have groups report out and record their responses. When time is up, explain that you will be recording responses on charts M7 and M8.

Ask the “Observing” group for examples of behavior for both younger and older students. Record the younger students’ behaviors on the top half of the chart and the older students’ on the bottom.

**9. Discuss participant responses as they are presented.** As you record what participants say, you can point out:

- At early stages of observation, students might
  - report few details,
  - identify differences rather than similarities, and
  - rely primarily on what they see.

At later stages, they might

- report in greater detail,
- identify similarities as well as differences,
- use multiple senses, and
- make observations relevant to what they are working on.

Next, record some responses from the “Planning and Conducting Investigations” group on the appropriate chart for both younger (top half) and older students (bottom half).

The image shows two overlapping charts. The top chart, labeled M7, is titled "Observing" and has a header "ASSESSING PROCESS SKILLS" and a footer "INSTITUTE FOR INQUIRY www.exploratorium.edu/ifi". The bottom chart, labeled M8, is titled "Planning & Conducting Investigations" and has a header "ASSESSING PROCESS SKILLS" and a footer "INSTITUTE FOR INQUIRY www.exploratorium.edu/ifi". Both charts have a large blank area for writing.

As statements accumulate, you may be able to make certain points in relation to the progression from early to later development. For example, you might say:

- Notice that at early stages of development, students tend to focus on doing immediate work without thinking about the next thing they'll need to do. Being able to think through several stages in an activity is a sign of a more advanced planning skill.

*Students may be able to figure out what variable they want to change, or what effects they need to compare, before they can identify how to measure that change or compare those effects. Recognizing that they may need to repeat a process for accuracy is a feature of even later development.*

**10. Summarize the discussion by providing examples (15 minutes).** Post chart M9: "Indicators of Development: 'Observing' & 'Planning and Conducting Investigations.'" Read some of the intermediate steps (Steps 2–5).

Tell people:

- These lists were developed by British educator Wynne Harlen based on her observation and research.

*If you had enough time to do the research involved, you might come up with similar lists. But even the brief exercise we just did can help you understand the nature of developmental indicators and consider using them in your practice. We'll be discussing this chart in greater depth in the next section.*

|  |                       |
|--|-----------------------|
| ASSESSING PROCESS SKILLS   | CHART OR OVERHEAD     |
| <b>Indicators of Development:<br/>"Observing" &amp;<br/>"Planning and Conducting Investigations"</b>   |                       |
| <b>Behavioral Indicators of Development:<br/>"Observing"</b>   |                       |
| <b>Do the students</b>   |                       |
| <ol style="list-style-type: none"> <li>1. Succeed in identifying obvious differences and similarities between objects and materials?</li> <li>2. Make use of several senses in exploring objects or materials?</li> <li>3. Identify differences of detail between objects or materials?</li> <li>4. Identify points of similarity between objects where differences are more obvious than similarities?</li> <li>5. Choose to use aids to the senses (such as a hand lens or microscope) for study of details as necessary?</li> <li>6. Distinguish from many observations those which are relevant to the problem at hand?</li> </ol> |                       |
| <b>Behavioral Indicators of Development:<br/>"Planning and Conducting Investigations"</b>  |                       |
| <b>Do the students</b>   |                       |
| <ol style="list-style-type: none"> <li>1. Start with a useful general approach, even if details are lacking or need further thought?</li> <li>2. Have some ideas of the variable that has to be changed or what different things are to be compared?</li> <li>3. Keep the same the things which should not change for a fair test?</li> <li>4. Have some idea beforehand of what to look for to obtain a result?</li> <li>5. Choose a realistic way of measuring or comparing things to obtain a result?</li> <li>6. Take steps to ensure that the results obtained are as accurate as they can reasonably be?</li> </ol>              |                       |
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**M9**

# Studying Indicators of Process Skill Development

## Overview

After identifying developmental levels in two science process skills, participants study handout M10a&b: "Indicators of Process Skill Development," which goes into more detail on the subject. In small groups, they examine and discuss the handout's list of indicators, which describes how students use these skills at different levels of development.

## 5 Steps • 20 Minutes

### Steps 1–2, 5 Minutes

#### 1. Set the context. Tell participants:

- We're going to take a few minutes now to look at the behavioral indicators of development for the process skills defined by Wynne Harlen's work, and practice applying them.

#### 2. Refer to chart M9: "Indicators of Development: 'Observing' and 'Planning and Conducting Investigations'"

Make the following points about the lists. Say:

- Notice that under each heading, the statements are arranged in a sequence that reflects typical progression, but may not fit every student. Within each skill, the indicators are listed according to the most likely sequence of development, but there is no grade level suggested, just a sequence expected in the 5- to 12-year-old age

range. When using formative assessment, it isn't necessary to tie the indicators to grade-level expectations.

All that's really needed is to see where students are in relation to further progress.

Looking across the process skills, you can see that differences relating to earlier and later development follow the same patterns. In most cases you can see a development:

- from simple skills to more elaborated skills;
- from the effective use of information in familiar situations to the effective use of information in unfamiliar situations;
- from unconscious to conscious actions.

#### 3. Have participants reconvene in their small discussion groups (10 minutes). Distribute handouts M10a and M10b: "Indicators for Assessing Process Skill Development." Tell participants

they'll be spending the next 10 minutes discussing process skill development. Say:

- Look at the lists that show the development of science process skills. Note that each skill is

## Materials Reminder

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

- Keep posted chart M9: "Indicators of Development: 'Observing' and 'Planning and Conducting Investigations'"
- Distribute handout M10a&b: "Indicators of Assessing Process Skills Development"

|  |                       |
|--|-----------------------|
| ASSESSING PROCESS SKILLS   | CHART OR OVERHEAD     |
| <b>Indicators of Development:</b><br>"Observing" &<br>"Planning and Conducting Investigations"             |                       |
| <b>Behavioral Indicators of Development:</b><br>"Observing"  |                       |
| Do the students  |                       |
| 1. Succeed in identifying obvious differences and similarities between objects and materials?              |                       |
| 2. Make use of several senses in exploring objects or materials?   |                       |
| 3. Identify differences of detail between objects or materials?  |                       |
| 4. Identify points of similarity between objects where differences are more obvious than similarities?     |                       |
| 5. Choose to use aids to the senses (such as a hand lens or microscope) for study of details as necessary? |                       |
| 6. Distinguish from many observations those which are relevant to the problem at hand?                     |                       |
| <b>Behavioral Indicators of Development:</b><br>"Planning and Conducting Investigations"                   |                       |
| Do the students  |                       |
| 1. Start with a useful general approach, even if details are lacking or need further thought?              |                       |
| 2. Have some ideas of the variable that has to be changed or what different things are to be compared?     |                       |
| 3. Keep the same the things which should not change for a fair test?                                       |                       |
| 4. Have some idea beforehand of what to look for to obtain a result?                                       |                       |
| 5. Choose a realistic way of measuring or comparing things to obtain a result?                             |                       |
| 6. Take steps to ensure that the results obtained are as accurate as they can reasonably be?               |                       |
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M9

divided into six levels that indicate a typical developmental progression.

These indicators help teachers watch for specific behaviors in student work, which gives the teacher some ideas of where students are in the developmental progression related to a particular skill.

The indicators also describe what a student's next step might be. For example, if a student demonstrates competence at level 4 of the Observing list, it's likely that he is also competent at levels 1, 2, and 3, and his next step would be level 5.

Remember, though, that every student develops in a different way, and you may not be able to precisely pin down a particular level. This is fine. You aren't trying to label students. Instead, you're trying to find out where the "edge" of their development is so you can help them take the next step.

For this activity, please spend about 10 minutes discussing process skill development in your small groups. In particular, pay attention to the indicators for "Observing" and "Planning and Conducting Investigations" because we'll be using them once again in the next part of the workshop.

### Steps 4–5, 5 Minutes

#### 4. Ask for questions and introduce the next part of the workshop (5 minutes). Tell participants:

► In the next part of the workshop, some of you are going to be watching others do an investigation. You'll use the indicators on the handout you just received to focus your observation. You'll have a chance to discuss the behavioral indicators of development in detail after the investigation. But before we start the activity, is there anything you want to ask about the indicators

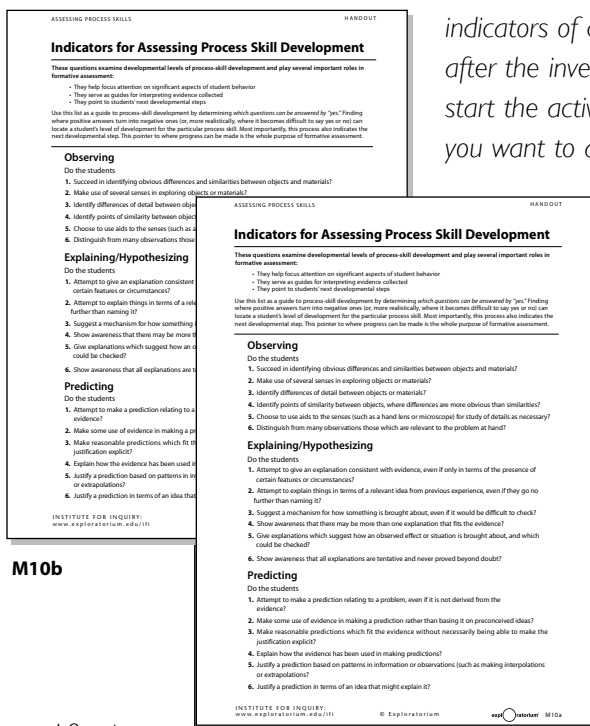
that you think you might need to clarify before you start?

Clarify any points of interpretation, but delay more detailed discussion until later.

**5. Announce a 15-minute break and prepare for the next part of the workshop.** After questions are answered, ask participants to

clear their tables and take a 15-minute break while you prepare for the next part of the workshop.

During the break, set out the materials needed for the paper-towel activity (the fair-testing activity) in the next part of the workshop. The complete materials list is on page 25.



M10b

M10a

# Observing Learners

## Overview

In this part of the workshop, participants practice observing indicators of development as their colleagues engage in a brief investigation relating to the absorption rate of paper towels.

Participants form groups of six, and those groups divide into Observers and Investigators. Observers watch the investigation, noting behavior on an indicators checklist or in the form of anecdotal notes.

Investigators later use the same tools to self-assess what they did in the investigation.

## 3 Steps • 35 Minutes

### Steps 1–2, 5 Minutes

**1. Tell participants to form working groups of six at their tables .** Distribute to

each group 2 copies of “Fair Testing Activity Sheet” handouts M11, M12, and M13. Instruct groups to designate two Observer 1s, two Observer 2s, and two Investigators, having each person take an Activity Sheet appropriate to their role. Introduce the activity, explaining:

► *This exercise will focus on using the indicators for the two process skills we considered in depth in the previous step, “Observing” and “Planning and Conducting Investigations.”*

## Materials Reminder

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

- Set out materials for the fair-testing (towel-absorption) activity, one set per table, including the Task Cards.
- Place at each table 2 each of handouts M11: “Fair-Testing Activity Sheet: Observer 1,” M12: “Fair-Testing Activity Sheet: Observer 2,” and M13: “Fair-Testing Activity Sheet: Investigator”

*If you're an Investigator, your task is to use the materials on the table to try and answer the question on the task card, "Which type of paper towel absorbs the most water?" Don't try to*

*simulate how a school-aged student might do the activity; rather, do it seriously yourself.*

*After doing the activity, Investigators will have*

**Fair-Testing Activity Sheet: Observer 1**

| Do Investigators: |    | Observing   |
|-------------------|----|---|
| YES               | NO |   |
|                   |    | 1. Succeed in identifying obvious differences and similarities between objects and materials?                   |
|                   |    | 2. Make use of several senses in exploring objects or materials?  |
|                   |    | 3. Identify differences of detail between objects or materials?   |
|                   |    | 4. Identify points of similarity between objects where differences are more obvious than similarities?          |
|                   |    | 5. Use their senses appropriately and extend their range of sight using a hand lens or microscope as necessary? |
|                   |    | 6. Distinguish from many observations those which are relevant to the problem in hand?                          |

**Fair-Testing Activity Sheet: Observer 2**

Your task is to observe the team of investigators carrying out the investigation, without interacting with investigator(s).

Observe the performance of investigators as a team, not as individuals, and start by recording observations of the first two process skills in the form below. If you have time, extend your observations to the other skills. After the investigation, discuss your experience and results with the other pair of observers.

| Do Investigators: |    | Planning/Conducting Investigations   |
|-------------------|----|--|
| YES               | NO |  |
|                   |    | 1. Start with a useful general approach, even if details are lacking or need further thought?          |
|                   |    | 2. Have some ideas of the variable that has to be changed or what different things are to be compared? |
|                   |    | 3. Keep the same the things which should not change for a fair test?                                   |
|                   |    | 4. Have some ideas beforehand of what to look for to obtain a result?                                  |
|                   |    | 5. Choose a realistic way of measuring or comparing things to obtain the results?                      |
|                   |    | 6. Take steps to ensure that the results obtained are as accurate as they can reasonably be?           |

**Fair-Testing Activity Sheet: Investigator**

| Do Investigators: |    | Observing   |
|-------------------|----|---|
| YES               | NO |   |
|                   |    | 1. Succeed in identifying obvious differences and similarities between objects and materials?                   |
|                   |    | 2. Make use of several senses in exploring objects or materials?  |
|                   |    | 3. Identify differences of detail between objects or materials?   |
|                   |    | 4. Identify points of similarity between objects where differences are more obvious than similarities?          |
|                   |    | 5. Use their senses appropriately and extend their range of sight using a hand lens or microscope as necessary? |
|                   |    | 6. Distinguish from many observations those which are relevant to the problem in hand?                          |

| Do Investigators: |    | Planning/Conducting Investigations   |
|-------------------|----|--|
| YES               | NO |  |
|                   |    | 1. Start with a useful general approach, even if details are lacking or need further thought?          |
|                   |    | 2. Have some ideas of the variable that has to be changed or what different things are to be compared? |
|                   |    | 3. Keep the same the things which should not change for a fair test?                                   |
|                   |    | 4. Have some ideas beforehand of what to look for to obtain a result?                                  |
|                   |    | 5. Choose a realistic way of measuring or comparing things to obtain the results?                      |
|                   |    | 6. Take steps to ensure that the results obtained are as accurate as they can reasonably be?           |

M13

*the opportunity to self-assess using the indicators. Then the Observers and Investigators will discuss and compare experiences. If you are an Observer, you should not intervene or talk to the Investigators while they are doing the activity.*

**2. Describe the different recording sheets and how to use them.** Tell participants:

- There are two different recording forms for Observers. Observer 1s will be working with a checklist form. Make tally or check marks on the line next to the appropriate process-skill indicator as you observe the Investigators.

Observer 2s will fill out a narrative-style recording sheet. As you notice the Investigators using process skills that indicate "Observing," or "Planning and Conducting Investigations," you should record anecdotal notes.

*And as I said before, if you're an Investigator, you'll be self-assessing when you're through with the activity.*

**3. Have participants begin the investigations and observations (30 minutes).** Tell them that they have 30 minutes to complete the task. Occasionally, remind participants how much time they have left.

After 25 minutes, give people a 5-minute warning. When the exercise is over, ask people to stop.



# Reflecting on Observations

## Overview

After the fair-test exercise, participants remain in their groups of six to reflect upon and compare findings and experiences and prepare reports to present to the whole group.

## 6 Steps • 50 Minutes

### Steps 1–3, 20 Minutes

**1. Explain the structure of the discussions.** Post chart M14: "Fair-Testing Observations: Questions for Whole-Group Discussion." Explain:

- I'd like each group to take about 20 minutes to compare and discuss experiences. The questions on the chart will guide you.

*For the first 10 minutes, Observer 1s and 2s should compare their experiences and findings, and Investigators should self-assess using the guidelines on handout M13, the investigators' activity sheet. For the next 10 minutes, the Observers and Investigators will compare findings and experiences. Observers should also talk about the usefulness of the recording forms they used. After 20 minutes, I'll ask you to report your findings to the whole group.*

**2. Tell the group to begin.** Tell Observer 1s and 2s to compare observations while Investigators self-assess.

**3. Tell groups to switch.** Alert people when 10 minutes have passed. Ask groups to switch so Observers and Investigators com-

pare findings and experiences.

**4. Call the whole group together for discussion and reporting-out (20 minutes).** Ask

various groups to report on the topics listed on the chart M14. Begin by taking responses from two or three groups about the first two points about the Observers' experiences. Say:

- How did the experiences of Observer 1s compare with those of Observer 2s? To what extent did the two observers in each pair agree with each other?

Take responses from two or three groups concerning the next two points about the Investigators' experiences. Say:

- To what extent were the indicators of process skill development useful for the investigators in self-evaluation? To what extent did the observers and the investigators agree?

Conclude by taking responses to the final two points about the use of the behavioral indicators of development, the recording forms, or anything else. Say:

- How could the procedures be adapted to be more efficient and/or more effective? Are there any other points you'd like to make about gathering information by observation?

## Materials Reminder

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

- Post chart M14: "Fair-Testing Observations: Questions for Whole-Group Discussion"
- Post chart M15: "Three Important Points about Process Skill Development"

### Fair-Testing Observations Questions for Whole-Group Discussions

1. How did the experiences of Observer 1s compare with those of Observer 2s?
2. Did the two Observers in each pair agree with each other?
3. Were the Indicators of Development useful for the Investigators' self-evaluation?
4. Did the Observers and the Investigators agree?
5. How could the procedures be adapted to be more efficient and/or more effective?
6. Other points about gathering information by observation?

M14

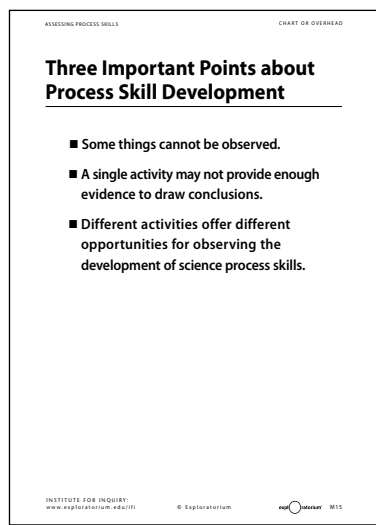


**5. Review the discussion. Address the questions on chart M14: “Fair-Testing Observations: Questions for Whole-Group Discussion.”** Then post chart M15: “Three Important Points about Process Skill Development.” After addressing all the points on chart M14, summarize the discussion by focusing on the more general issues, rather than the details of agreement or disagreement among groups about what actually happened.

Refer to chart M15 and introduce the following points (or reinforce them if they have already come up). Say:

► *Your observations can give you quite a bit of information, but you should also keep in mind these three important points:*

- **Some things cannot be observed.** *Reasons for a student's actions may not be apparent. In practice, teachers might consider supplementing observation with asking questions or having discussions with students.*
- **A single activity may not provide enough evidence to draw conclusions.** *Not all process skills may be used in an activity, and those that are used may be at different levels in other situations. In practice, observations of science process skills must be spread over several activities.*
- **Different activities offer different opportunities for observing the development of process skills.** *If you can't observe certain science process skills in use across several activities, it may be necessary to consider whether the activities are presenting a full range of opportunities for students to use and develop their skills.*



M15

**6. Conclude this portion of the workshop by summarizing the ideas presented (5 minutes).** (NOTE: Try to refer to specific things various participants said when reporting out.)

Point out that, in terms of observing the development of science process skills, behavioral indicators help teachers gather information in two ways:

1. By focusing attention on relevant aspects of what students do, and

2. By locating their current ability in the course of that skill's development.

While it's best for teachers to internalize the levels of development rather than needing to depend on a list, this takes time and practice.

- Remind participants that repeated observations are needed over a period of time, since not all activities involve the use of all the science process skills. It may take four or five weeks to establish where students are for all the skills. Suggest, for instance, that a teacher might focus on

one group of students for one activity, and pick up information about another group on another occasion. This is possible because process skills occur across every science topic. Alternatively, if an activity depends on one particular skill (for instance, when measurement is central to the activity), then the teacher might focus on this for all the students.

- End the discussion by telling participants that, while they have been focusing on observational evidence, there are other ways to gather evidence as well. The next part of the workshop introduces some of those strategies.

# Gathering Evidence in Other Ways

## Overview

Observing students at work is not the only way to gather evidence of the use and development of science process skills. In this part of the workshop, participants examine how students' writing about science can indicate their use of science skills as well.

## 3 Steps • 20 Minutes

### Steps 1–2, 10 Minutes

**1. Introduce the use of student writing as evidence of science process skill development.** Indicate chart M1: "Formative Assessment Strategies." Refer to the empty boxes and tell participants:

- We've just explored the strategy of "observing" using indicators for gathering evidence of process skill development. Now I'd like to introduce another strategy, and ask for your suggestions as well.

Add the words "writing prompts" to the blank box in the upper right-hand box. Continue:

- One frequently used strategy is to ask students to write about their experiences during an investigation. Here are some examples.

## 2. Post and read aloud student work samples (10 minutes).

Post chart

M16: "Student

Work Sample 1" and tell participants:

- This is the written reflection of a nine-year-old who is doing an investigation on how far away you can hear different coins dropping from different heights onto different surfaces. She is saying what she would do if she did it again, and has some good ideas for improvement. You can imagine that asking students to reflect on their investigations can give you information about their planning and investigating skills.

Read the chart aloud. Now post chart M17: "Student Work Sample 2," and explain:

- This was written by two ten-year-old children who were examining different fruits. This is their description of a lychee nut. Notice all the senses they use: sight, taste, smell. If you take another look at handout M10: "Indicators of Process Skill Development,"

## Materials Reminder

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

- Post charts M16, M17, and M18 (student work samples)
- Have available blank chart paper and marking pens to record participants' responses

**Student Work Sample 1**  
A Nine-Year-Old's Critical Reflection on Her Investigation

If I did this I think of a w and not just think of mo with differ heights. On two ideas, on you can here a tape record indicator.

**Student Work Sample 2**  
Observations Recorded by Two Ten-Year-Olds

When we examined a Lychee we found out that the skin or peel had tiny hairs on it. When we held it quite far away the whole fruit looked like a hard and over grown raspberry. When we peeled it was like an avo all either red or yellow red tasted like an avo low was really disgust the fruit is ripe when. Then when we took the we found that there was this was transparent. skin off we found the some sort of segment. Then we tasted the fly. After that we found the middle so we cut it brown after a few seconds and it smelt like a co ("Horse Chestnut")

**Student Work Sample 3**  
An Eleven-Year-Old's Prediction Based on Ideas about Spectacles and Eyesight

Our prediction is that people will be able to complete the test when they are much closer to the chart and the chart will be not so clear as the first test when they are further away from the chart. We also think that people with glasses will see better than other people because they have more focus in their glass lenses.

*you can relate this description to the item on the list that indicates the point at which students use several senses in their observations. You can imagine that the teacher might have asked the students to use their senses. Getting this level of description doesn't happen automatically.*

Read the chart aloud. Then post chart M18: "Student Work Sample 3." Tell participants:

- *This prediction about eye testing and how far you can see is from an eleven-year-old. It illustrates how you can get evidence of prediction from written work, and a good hypothesis, too.*

Read the chart aloud.

**3. Post blank chart paper, then ask participants if they can think of other ways to gather evidence.**

**(10 minutes).** Create a list of responses on the blank chart. If you are unclear on how any of the participants' suggestions would give teachers evidence of students' use of process skills, ask for an example of what process skills their strategy would encourage students to use.

Tell participants that the strategies they have just identified (the ones written on the chart) could be recorded on the Formative Assessment Strategies chart.

# Using Evidence to Advance

## Overview

In this part of the workshop, participants consider how gathering evidence can help identify ways to reinforce the science process skills students have, and identify new challenges for them to take on.

## 4 Steps • 15 Minutes

**1. Relate the Formative Assessment Cycle to the ideas explored so far (5 minutes).** Refer to chart M1: “Formative Assessment Strategies” and indicate how the various parts of the cycle have been illustrated in this workshop. Say:

► *Let’s review what we’ve done so far.*

*In the paper towel activity, we gathered information relating to goals by observing each other’s work and by using the indicators of process skill development to help focus on what to look for. That corresponds to the part of the Cycle where teachers “collect evidence relating to goals.”*

*For the next part of the cycle, we “interpreted the evidence” by using the developmental indicators to try to find the highest indicator demonstrated. This identifies a student’s current skill level.*

Write the words “developmental indicators: find highest level” (or annotate this to “dev. ind. find highest level”) in the lower right hand box on the chart.

► *Now that we have that information, we can go on to the third part of the Cycle, “determining appropriate next steps” Being able to identify their current developmental level gives you the opportunity to help students reinforce their abilities at that*

*level, and move up to the next level of skill.*

Write the words “dev. ind. reinforce current level,

move to next” in the lower left-hand box on the chart.

► *In this part of the workshop, we’re going to look at different strategies for this fourth part of the Cycle, helping students take the next steps.*

## Steps 2–3, 5 Minutes

**2. Present how to help learners improve skill levels.** Indicate the box titled “Teacher decides how to help students take next steps” on chart M1: “Formative Assessment Strategies” and say:

► *Let’s say that during a range of investigations, a teacher had been observing her students’ prediction skills and found that they were somewhere in the middle of the developmental range. What could the teacher do to help learners develop their ability to make predictions?*

*A first thought might be to provide opportunities for students to practice the skill.*

Write the words “opportunities for practice” in the upper left-hand box of the chart. Then say:

► *Or she might ask questions, for example, that require students to make predictions, such as “What do you think is going to happen?”*

Write the words “ask questions” in the upper left-

## Materials Reminder

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

- Post chart and distribute handout M19: “Helping Students Develop Their Science Process Skills.”
- Distribute handout M20: “Formative Assessment Strategies”

hand box of the chart. Continue:

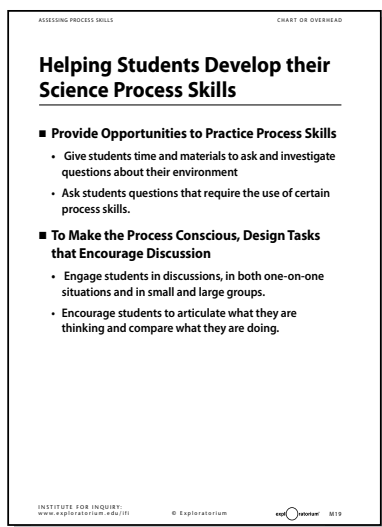
- Or she might organize students so they compare predictions and question each other about the evidence on which their predictions are based. Older students might be asked directly about how they arrived at their predictions and about the process of prediction in general, making them more conscious of what they are doing when they make a prediction.

We're running out of space on our chart, but you get the idea—that there is a great variety of strategies for teachers to help students improve their skill levels.

**3. Point out techniques for helping students develop process skills.** Display chart M19: “Helping Students Develop Their Science Process Skills” and distribute the corresponding handout. Say:

- These strategies can be used to help students develop any of their science process skills.

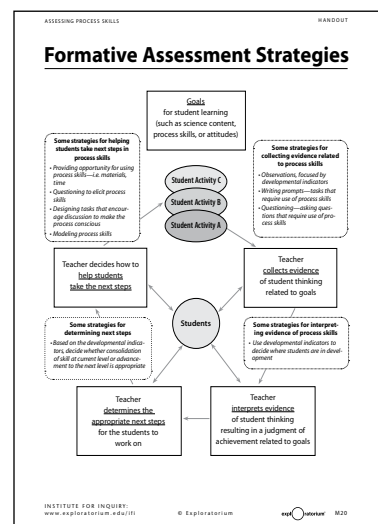
Read the chart aloud.



M19

**4. Distribute handout M20: “Formative Assessment Strategies,” which is a filled-in version of chart M1 (5 minutes).** Tell participants:

- This handout will give you some ideas about strategies that can be used to collect and evaluate evidence of development for each part of the Formative Assessment Cycle. You'll probably want to add other strategies as you discover them. You could start with some of the ideas we generated earlier.



M20

Refer to the chart of participant suggestions created during the Gathering Evidence in Other Ways section of the workshop, on page 43.

# Concluding the Workshop

## Overview

This section concludes the workshop, summarizing what participants did and the pedagogical ideas they considered.

## 3 Steps • 5 Minutes

**1. Refer to Chart M1: “Formative Assessment Strategies.”** Tell participants:

► *Today we identified and investigated some practical methods for assessing student learning for each of the four stages of the Formative Assessment Cycle.*

**2. Distribute handout M2: “Take-Home Messages,” and any additional resources you’ve prepared.**

Read the take-home messages out loud and tell people:

► *These are the take-home messages we looked at when we began. Hopefully, each message has been clarified by the work we’ve done here, and will help you recognize new strategies to bring to your practice.*

## Materials Reminder

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

- Distribute handout M2: “Take-Home Messages”

### Take-Home Messages

- By observing regular classroom activities, teachers can use specific behavioral indicators to gather evidence of a student’s process skill development.
- By using carefully framed tasks, teachers can find evidence of process skill development in a student’s oral and written work.
- By using behavioral indicators, teachers can determine next developmental steps for a student once evidence of current developmental levels have been gathered.

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M2

**3. Thank participants and bring the workshop to a close.** If appropriate, remind people that this is the second in a set of five workshops. Tell participants when and where the next workshop session will meet.

# 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 there was 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 impor-

tance 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](http://www.exploratorium.edu/ifi/workshops).

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

### Elements of Inquiry

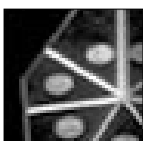
Three workshops that serve as building blocks for an immersion into inquiry by focusing on various hands-on approaches and process skills related to inquiry learning.



#### 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).

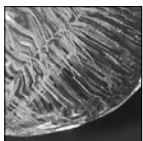
*Preview the workshop at [www.exploratorium.edu/ifi/comparing](http://www.exploratorium.edu/ifi/comparing)*



#### 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](http://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](http://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](http://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

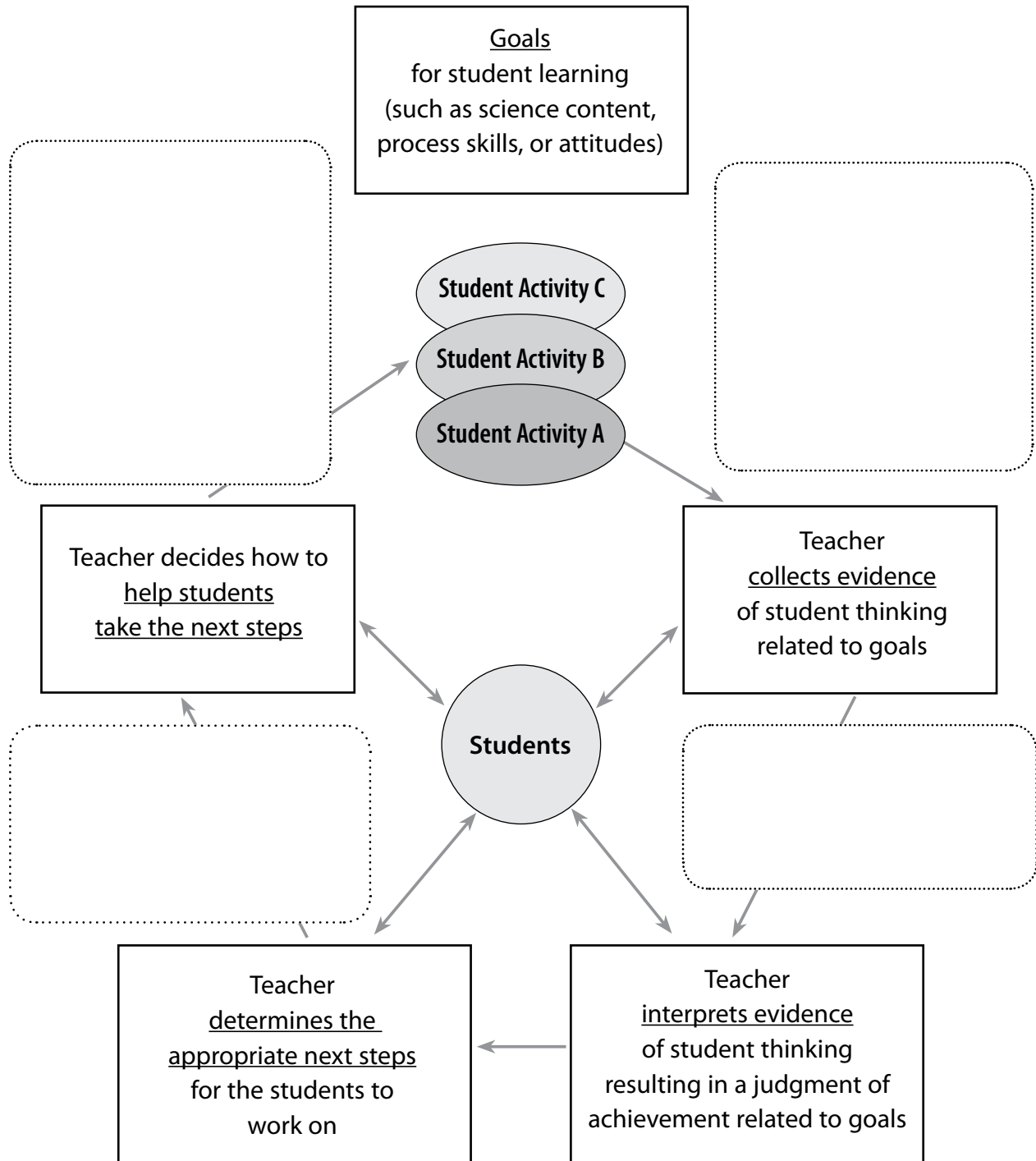
Participants examine how current classroom activities can be modified to incorporate elements of inquiry (about 3 hours).

*Preview the workshop at [www.exploratorium.edu/ifi/subtleshifts](http://www.exploratorium.edu/ifi/subtleshifts)*

# Reproducible Masters

|  |                             | Page    |
|--|-----------------------------|---------|
| • <b>Formative Assessment Strategies (with blank boxes)</b>                                    | chart or overhead           | M1      |
| • <b>Take-Home Messages</b>  | chart or overhead & handout | M2      |
| • <b>Introduction to the Process Skills of Science</b>   | handout                     | M3      |
| • <b>Indicators for Early and Later Developmental Stages: “Predicting”</b>                     | chart or overhead           | M4      |
| • <b>Indicators of Development: “Predicting”</b>   | chart or overhead           | M5      |
| • <b>Indicators of Development: Activity Sheet</b>   | handout                     | M6      |
| • <b>Observing</b>   | chart                       | M7      |
| • <b>Planning and Conducting Investigations</b>  | chart                       | M8      |
| • <b>Indicators of Development: “Observing” &amp; “Planning and Conducting Investigations”</b> | chart or overhead           | M9      |
| • <b>Indicators for Assessing Process Skill Development (2 pages)</b>                          | handout                     | M10 a&b |
| • <b>Fair-Testing Activity Sheet: Observer 1</b>   | handout                     | M11     |
| • <b>Fair-Testing Activity Sheet: Observer 2</b>   | handout                     | M12     |
| • <b>Fair-Testing Activity Sheet: Investigator</b>   | handout                     | M13     |
| • <b>Fair-Testing Observations: Questions for Whole-Group Discussion</b>                       | chart or overhead           | M14     |
| • <b>Three Important Points about Process Skill Development</b>                                | chart or overhead           | M15     |
| • <b>Student Work Sample 1</b>   | chart or overhead           | M16     |
| • <b>Student Work Sample 2</b>   | chart or overhead           | M17     |
| • <b>Student Work Sample 3</b>   | chart or overhead           | M18     |
| • <b>Helping Students Develop their Science Process Skills</b>                                 | chart or overhead & handout | M19     |
| • <b>Formative Assessment Strategies (with filled-in boxes)</b>                                | handout                     | M20     |

# Formative Assessment Cycle



# Take-Home Messages

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- By observing regular classroom activities, teachers can use specific behavioral indicators to gather evidence of a student's process skill development.
- By using carefully framed tasks, teachers can find evidence of process skill development in a student's oral and written work.
- By using behavioral indicators, teachers can determine next developmental steps for a student once evidence of current developmental levels have been gathered.

# Introduction to the Process Skills of Science

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- Observing
- Questioning
- Hypothesizing
- Predicting
- Planning and Investigating
- Interpreting
- Communicating

# Indicators for Early & Later Developmental Stages: “Predicting”

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## ■ EARLY STAGE

**Student attempts to make a prediction relating to a problem, even if that prediction is not derived from evidence.**

## ■ LATER STAGE

**Student explains how evidence has been used in making predictions.**



# Indicators of Development: “Predicting”

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## Do the students:

1. **Attempt to make a prediction relating to a problem, even if it is not derived from evidence?**
2. **Make some use of evidence in making a prediction, rather than basing that prediction on preconceived ideas?**
3. **Make reasonable predictions which fit the evidence without necessarily being able to make the justification explicit?**
4. **Explain how the evidence has been used in making predictions?**
5. **Justify a prediction based on patterns in information or observations (such as making interpolations or extrapolations)?**
6. **Justify a prediction in terms of an idea that might explain it?**

# Indicators of Development: Activity Sheet

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Working as a group, list what you would look for as evidence of students using the process skill of “observing” or “planning and conducting investigations,” as assigned.

**Is there a progression in this skill?**

- What would be one example of evidence for earlier development (first or second grade)?
- What would be one example of evidence for later development (fifth or sixth grade)?
- Agree on at least one indicator for each and record it below.

**Earlier  
Development**

**Later  
Development**

# Observing

---

# Planning & Conducting Investigations

---

# Indicators of Development:

## **“Observing” & “Planning and Conducting Investigations”**

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### **Behavioral Indicators of Development: “Observing”**

#### **Do the students**

1. Succeed in identifying obvious differences and similarities between objects and materials?
2. Make use of several senses in exploring objects or materials?
3. Identify differences of detail between objects or materials?
4. Identify points of similarity between objects where differences are more obvious than similarities?
5. Choose to use aids to the senses (such as a hand lens or microscope) for study of details as necessary?
6. Distinguish from many observations those which are relevant to the problem at hand?

### **Behavioral Indicators of Development: “Planning and Conducting Investigations”**

#### **Do the students**

1. Start with a useful general approach, even if details are lacking or need further thought?
2. Have some ideas of the variable that has to be changed or what different things are to be compared?
3. Keep the same the things which should not change for a fair test?
4. Have some idea beforehand of what to look for to obtain a result?
5. Choose a realistic way of measuring or comparing things to obtain a result?
6. Take steps to ensure that the results obtained are as accurate as they can reasonably be?

# Indicators for Assessing Process Skill Development

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These questions examine developmental levels of process-skill development and play several important roles in formative assessment:

- They help focus attention on significant aspects of student behavior
- They serve as guides for interpreting evidence collected
- They point to students' next developmental steps

Use this list as a guide to process-skill development by determining *which questions can be answered by "yes."* Finding where positive answers turn into negative ones (or, more realistically, where it becomes difficult to say yes or no) can locate a student's level of development for the particular process skill. Most importantly, this process also indicates the next developmental step. This pointer to where progress can be made is the whole purpose of formative assessment.

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## Observing

Do the students

1. Succeed in identifying obvious differences and similarities between objects and materials?
2. Make use of several senses in exploring objects or materials?
3. Identify differences of detail between objects or materials?
4. Identify points of similarity between objects, where differences are more obvious than similarities?
5. Choose to use aids to the senses (such as a hand lens or microscope) for study of details as necessary?
6. Distinguish from many observations those which are relevant to the problem at hand?

## Explaining/Hypothesizing

Do the students

1. Attempt to give an explanation consistent with evidence, even if only in terms of the presence of certain features or circumstances?
2. Attempt to explain things in terms of a relevant idea from previous experience, even if they go no further than naming it?
3. Suggest a mechanism for how something is brought about, even if it would be difficult to check?
4. Show awareness that there may be more than one explanation that fits the evidence?
5. Give explanations which suggest how an observed effect or situation is brought about, and which could be checked?
6. Show awareness that all explanations are tentative and never proved beyond doubt?

## Predicting

Do the students

1. Attempt to make a prediction relating to a problem, even if it is not derived from the evidence?
2. Make some use of evidence in making a prediction rather than basing it on preconceived ideas?
3. Make reasonable predictions which fit the evidence without necessarily being able to make the justification explicit?
4. Explain how the evidence has been used in making predictions?
5. Justify a prediction based on patterns in information or observations (such as making interpolations or extrapolations)?
6. Justify a prediction in terms of an idea that might explain it?

# Indicators for Assessing Process Skill Development

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## Raising Questions

Do the students

1. Readily ask a variety of questions, including those that can and cannot be investigated?
2. Participate effectively in discussing how their questions can be answered?
3. Recognize a difference between an investigable and a noninvestigable question?
4. Suggest how answers to questions of various kinds can be found?
5. Choose a realistic way of measuring or comparing things to obtain a result?
6. Help in turning their own questions into a form that can be tested?

## Planning and Conducting Investigations

Do the students

1. Start with a useful general approach even if details are lacking or need further thought?
2. Have some ideas of the variable that has to be changed or what different things are to be compared?
3. Keep the same the things which should not change for a fair test?
4. Have some idea beforehand of what to look for to obtain a result?
5. Choose a realistic way of measuring or comparing things to obtain a result?
6. Take steps to ensure that the results obtained are as accurate as they can reasonably be?

## Predicting

Do the students

1. Discuss what they find in relation to their initial questions?
2. Compare their findings with their earlier predictions?
3. Notice associations between changes in one variable and another?
4. Identify patterns or trends in their observations or measurements?
5. Check any patterns or trends against all the evidence?
6. Draw conclusions which summarize and are consistent with all the evidence?

## Communicating

Do the students

1. Talk freely about their activities and the ideas they have, with or without making a written record?
2. Listen to others' ideas and look at their results?
3. Report events in drawings, writings, models, paintings, and so on?
4. Use tables, graphs, and charts to record and report results when these are suggested?
5. Regularly and spontaneously use information from books (or other resources) to check or supplement their investigations?
6. Choose a form for recording or presenting results which is both considered and justified?

Adapted from *Teaching, Learning and Assessing Science 5–12* by Wynne Harlen. Sage, 2000, pages 147–152.

# Fair-Testing Activity Sheet: Observer 1

| Do investigators:<br>YES<br>NO |  | Observing   |
|--------------------------------|--|---|
|                                |  | 1. Succeed in identifying obvious differences and similarities between objects and materials?                   |
|                                |  | 2. Make use of several senses in exploring objects or materials?  |
|                                |  | 3. Identify differences of detail between objects or materials?   |
|                                |  | 4. Identify points of similarity between objects where differences are more obvious than similarities?          |
|                                |  | 5. Use their senses appropriately and extend their range of sight using a hand lens or microscope as necessary? |
|                                |  | 6. Distinguish from many observations those which are relevant to the problem in hand?                          |

| Do investigators:<br>YES<br>NO |  | Planning/Conducting Investigations   |
|--------------------------------|--|--|
|                                |  | 1. Start with a useful general approach, even if details are lacking or need further thought?          |
|                                |  | 2. Have some ideas of the variable that has to be changed or what different things are to be compared? |
|                                |  | 3. Keep the same the things which should not change for a fair test?                                   |
|                                |  | 4. Have some ideas beforehand of what to look for to obtain a result?                                  |
|                                |  | 5. Choose a realistic way of measuring or comparing things to obtain the results?                      |
|                                |  | 6. Take steps to ensure that the results obtained are as accurate as they can reasonably be?           |



# Fair-Testing Activity Sheet: Observer 2

Your task is to observe the team of investigators carrying out the investigation, without interacting with investigator(s).

Observe the performance of investigators as a team, not as individuals, and start by recording observations of **the first two process skills** in the form below. If you have time, extend your observations to the other skills.

After the investigation, discuss your experience and results with the other pair of observers.

|                                    |  |
|------------------------------------|--|
| Observing                          |  |
| Planning/Conducting Investigations |  |
| Communicating                      |  |
| Raising Questions                  |  |
| Predicting                         |  |
| Explaining (Hypothesizing)         |  |
| Interpreting                       |  |

# Fair-Testing Activity Sheet: Investigator

| Did investigators: |    | Observing   |
|--------------------|----|---|
| YES                | NO |   |
|                    |    | 1. Succeed in identifying obvious differences and similarities between objects and materials?                   |
|                    |    | 2. Make use of several senses in exploring objects or materials?  |
|                    |    | 3. Identify differences of detail between objects or materials?   |
|                    |    | 4. Identify points of similarity between objects where differences are more obvious than similarities?          |
|                    |    | 5. Use their senses appropriately and extend their range of sight using a hand lens or microscope as necessary? |
|                    |    | 6. Distinguish from many observations those which are relevant to the problem in hand?                          |

| Did investigators: |    | Planning/Conducting Investigations   |
|--------------------|----|--|
| YES                | NO |  |
|                    |    | 1. Start with a useful general approach, even if details are lacking or need further thought?          |
|                    |    | 2. Have some ideas of the variable that has to be changed or what different things are to be compared? |
|                    |    | 3. Keep the same the things which should not change for a fair test?                                   |
|                    |    | 4. Have some ideas beforehand of what to look for to obtain a result?                                  |
|                    |    | 5. Choose a realistic way of measuring or comparing things to obtain the results?                      |
|                    |    | 6. Take steps to ensure that the results obtained are as accurate as they can reasonably be?           |

# **Fair-Testing Observations**

## **Questions for Whole-Group Discussions**

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- 1. How did the experiences of Observer 1s compare with those of Observer 2s?**
- 2. Did the two Observers in each pair agree with each other?**
- 3. Were the Indicators of Development useful for the Investigators' self-evaluation?**
- 4. Did the Observers and the Investigators agree?**
- 5. How could the procedures be adapted to be more efficient and/or more effective?**
- 6. Other points about gathering information by observation?**

# Three Important Points about Process Skill Development

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- Some things cannot be observed.
- A single activity may not provide enough evidence to draw conclusions.
- Different activities offer different opportunities for observing the development of science process skills.

# Student Work Sample 1

## A Nine-Year-Old's Critical Reflection on Her Investigation

If I did this again, I would try to think of a way to test the sound and not just guess and try to think of more surfaces and try with different coins at different heights. On the sound I have got two ideas, one, see how far away you can hear it drop, and two, get a tape recorder with a sound level indicator.

# Student Work Sample 2

## Observations Recorded by Two Ten-Year-Olds

When we examined a Lychee we found out that the skin or peel had tiny hairs on it. When we held it quite far away the whole fruit looked like a hard and over grown raspberry. When we tasted the peel it was like an avocado. The peel was all either red or yellow as I just said the red tasted like an avocado but the yellow was really disgusting. This meant that the fruit is ripe when it is red not yellow. Then when we took the peel off totally we found that there was another skin but this was transparent. When we took that skin off we found that the juice was in some sort of segments like an orange. Then we tasted the flesh and it was lovely. After that we found a stone or seed in the middle so we cut it open and it went brown after a few seconds then we smelt it and it smelt like a conker\*.

(\*Horse Chestnut)

# Student Work Sample 3

## An Eleven-Year-Old's Prediction Based on Ideas about Spectacles and Eyesight

Our prediction is that people will be able to complete the test when they are much closer to the chart and the chart will be not so clear as the first test when they are further away from the chart. We also think that people with glasses will see better than other people because they have more focus in their glass lenses.

# Helping Students Develop their Science Process Skills

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## ■ Provide Opportunities to Practice Process Skills

- Give students time and materials to ask and investigate questions about their environment
- Ask students questions that require the use of certain process skills.

## ■ To Make the Process Conscious, Design Tasks that Encourage Discussion

- Engage students in discussions, in both one-on-one situations and in small and large groups.
- Encourage students to articulate what they are thinking and compare what they are doing.



# Formative Assessment Strategies

