WORKSHOP I: COMPARING APPROACHES TO HANDS-ON SCIENCE

A Professional Development Curriculum from the Institute for Inquiry®

*The first in a set of five workshops for teacher professional development.*
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⚠️ Caution: The experiments in this guide were designed with safety and success in mind. But even the simplest activity or the most common materials can be harmful when mishandled or misused. Use common sense whenever you're exploring or experimenting.

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

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

You can download any of the Fundamentals of Inquiry workshop guides at www.exploratorium.edu/ifi/workshops/fundamentals.
Welcome

For more than thirty years, the Exploratorium Institute for Inquiry has been educating teachers, administrators, and professional developers about the theory and practice of inquiry-based teaching and learning. We have witnessed firsthand the power of science coming alive and having real meaning for students and teachers when they focus on the questions of science, rather than just the answers.

In 2000 we received a major grant from the National Science Foundation to make what we have learned available to even more educators. The result is a series of guides that provide step-by-step instructions and access to complete materials online so professional developers and teacher educators can present these workshops on their own.

Comparing Approaches to Hands-On Science is the first of five workshops designed to introduce teachers to the benefits of inquiry-based teaching. In this workshop, participants experience three very different ways of doing hands-on science, then analyze and compare the approaches, and consider the purposes for which each might best be used in the classroom.

We hope you find this workshop useful in establishing a vibrant setting for teachers to learn and extend their practice. And we hope that, like us, you will be inspired by seeing teachers become enthused about science, eager to bring the very best ideas and approaches to their students.

—LYNN RANKIN
Director
Institute for Inquiry
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ABOUT THIS WORKSHOP

- Workshop Overview
- The Workshop in Context
A Quick Summary

This is the first of five guides in the Fundamentals of Inquiry curriculum. The guides are designed to help facilitators plan and present professional development workshops for educators interested in developing an understanding of inquiry-based science instruction. Comparing Approaches to Hands-On Science offers teachers an opportunity to experience and assess three different types of science-teaching approaches, and to examine how each might best be used in the classroom.

Unlike many professional development workshops, Comparing Approaches does not provide teachers with activities to take back to the classroom. Instead, it focuses on giving teachers an opportunity they rarely get: to think about how they teach.

Comparing Approaches can be used as part of the Fundamentals of Inquiry curriculum, or it can be presented on its own. While none of the hands-on approaches in this workshop fully represent inquiry, Comparing Approaches does prepare teachers for the closer examination of inquiry that takes place in subsequent curriculum workshops. For information about the complete series, see page 8.

The Goals of the Workshop

Many people see “hands-on science” as a single approach to teaching rather than as a wide range of approaches that can vary considerably from each other. Effective science teaching requires that educators understand differences among approaches and develop the ability to draw upon one or another in appropriate situations.

To address this issue, the Institute for Inquiry has created this professional development workshop to help teachers become more thoughtful about the pedagogy and instructional value of different approaches to teaching science, and to enable teachers to make informed choices in matching these approaches to the learning goals they have for their students.

Goals

- To help teachers become more thoughtful about the pedagogy and instructional value of different approaches to teaching science.
- To enable teachers to make informed choices in matching different teaching approaches to particular learning goals they have for their students.

How the Workshop Works

This workshop takes about three-and-a-half hours and is designed to be led by three facilitators. Typically, planning takes about six hours, not including the time necessary to prepare materials. In this guide, we list materials for 36 participants. For fewer participants, quantities of materials and other workshop logistics can be adjusted as needed.

We recommend 12 to 36 participants for our workshops. Having fewer than 12 does not allow for the lively group interaction that is such an important component of the workshop. Having more than 36 makes whole group discussions unwieldy and can necessitate an additional facilitator.
The workshop begins with work at three different stations, where teachers create spinning tops and learn science in three very different ways. The approaches sampled at these stations represent a variety of methods for teaching hands-on science.

Work at the stations serves as a foundation for small-group “Making Meaning” discussions, which are the primary focus of the workshop. In these discussions, teachers identify the characteristics of the different approaches, compare them, and discuss applying them in the classroom. By reflecting on their own thinking and learning, and by sharing their thoughts with others, participants begin to develop a deeper understanding of the experiences they have had and make connections to teaching and learning science. These discussions lead to an understanding of what we call “take-home messages,” the pedagogical ideas upon which the workshop is built.

By carefully analyzing and comparing different approaches to hands-on science, teachers can recognize and make useful pedagogical distinctions among the three different approaches. These distinctions will help them make more discriminating choices in their classrooms as they consider a broader range of learning goals and how best to meet those goals in order to better support students’ learning.

Looking closely at different approaches can also help teachers realize that there are valuable learning opportunities for their students in approaches they may not have tried. In particular, they may see that some of the learning experiences they would like for their students are only available in approaches in which students have the opportunity to take more responsibility for their own learning; for example, by asking their own questions and planning their own investigations.

**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 facilitator and learner. This trust is critical in creating a climate in which learners feel comfortable expressing opinions and considering new ideas.

Understanding of the take-home 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. By returning to the take-home messages at the end of the workshop, these ideas summarize and reinforce the understandings that participants have constructed.
The Workshop in Context

**FUNDAMENTALS OF INQUIRY**

*Comparing Approaches* is the first of five workshops in the FUNDAMENTALS OF INQUIRY curriculum, designed to introduce teachers to the benefits of inquiry-based teaching. Though most of the workshops can be used individually, the series is best presented as a comprehensive whole. Below are brief descriptions of the five workshops.

The FUNDAMENTALS OF INQUIRY curriculum is organized into three areas:

**Elements of Inquiry**

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

- **Workshop I: Comparing Approaches to Hands-On Science**
  Participants discover that different approaches to hands-on teaching support different goals for learning (about 3.5 hours).
  Preview the workshop at www.exploratorium.edu/ifi/comparing

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

- **Workshop III: Raising Questions**
  Participants examine the kinds of questions learners ask about phenomena and find out how to turn “noninvestigable” questions into “investigable” ones (about 3.5 hours).
  Preview the workshop at www.exploratorium.edu/ifi/questions

**Immersion in Inquiry**

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

- **Workshop IV: Stream Table Inquiry**
  Participants experience inquiry firsthand, learning scientific process and content through an extended investigation (about 6 hours).
  Preview the workshop at www.exploratorium.edu/ifi/streamtable

**Connections to the Classroom**

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

- **Workshop V: Subtle Shifts: Adapting Activities for Inquiry**
  Participants examine how current classroom activities can be modified to incorporate elements of inquiry (about 3 hours).
  Preview the workshop at www.exploratorium.edu/ifi/subtleshifts
PLANNING AND PREPARATION

• Workshop at a Glance
• Essential Planning Steps
• Sample Room Setup
• Materials
• Charts and Handouts
• Background Science for Workshop Activities
This diagram shows how participants move through the workshop. Note that while participants move from station to station, facilitators do not. Each station has a facilitator who stays in place throughout the workshop. Note also that when participants arrive at Station A, the facilitator there has them count off by three’s, in order to assign them to one of the three Making Meaning discussion groups that they will join later in the workshop. Those groups—identified here by different shades of gray—come together again to form the three Making Meaning discussion groups. Note that all times are approximate.

**Workshop at a Glance**

**Workshop Time:** Approximately 3½ hours  
**Facilitators Needed:** 3  
**Participants Accommodated:** 36  

**Introducing the Workshop**  
One facilitator introduces the workshop to all 36 participants at once. Facilitators divide the group in half. One half (18 people) go to Station C. The remaining group is divided in half again. One group (9) goes to Station A; the other (9), to Station B.

**Experiencing Three Approaches to Hands-On Science**  
- After 25 minutes, groups at Stations A and B switch, while the group at Station C remains.
- After another 25 minutes (and a 15-minute break), groups that did Stations A and B go to Station C. The group that began at Station C divides in half: One half goes to Station A; the other half goes to Station B.
- After a last 25 minutes, the groups at Stations A and B switch, while the group at Station C remains.

**Making Meaning Discussion Groups**  
When work at all stations is complete, participants go to one of the three discussion groups assigned at Station A (shown here in three shades of gray).
Essential Planning Steps

Overview


It’s important that you and your co-facilitators go over these steps together, arriving at a shared understanding of workshop goals and of how the workshop works. There are a number of things to do, including reading through this entire guide, preparing yourselves to lead discussions, trying the workshop yourselves, ordering materials, finding an appropriate space, and preparing charts and handouts.

You’ll also want to set aside time after the workshop to talk with your co-facilitators 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 you do any of the planning steps that follow. 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. View a brief online preview of the workshop. This preview, which introduces the workshop with sound and images, can be viewed by facilitators and participants. It’s available on the Web at www.exploratorium.edu/ifi/comparing.

3. Prepare materials. Gather and organize all materials (see the complete list on page 16). Materials are all common and easily available.

   • Duplicate and prepare all the charts and handouts (see page 17).
   • Determine guidelines for the Making Meaning small-group discussions (page 32), and write the guidelines on the blank “Discussion Guidelines” chart (M9).
   • To simplify setup on the day of the workshop, organize charts and handouts according to when and where they will be used, and put materials in three separate boxes marked Station A, Station B, and Station C.

4. Do the workshop as learners. Once materials are available, meet together and go through the workshop as if you were participants, so you can get a feel for how teachers will experience it.
• Make and experiment with tops at each station. (Note that each facilitator should keep the top made when going over instructions at Station A to display to participants during the workshop.)

• The Making Meaning discussion is the heart of the activity. Go through it step by step, responding to the prompts and discussing the questions with each other. Use your experiences to anticipate what issues might arise when working with participants.

5. **Do the workshop as facilitators.** Go through the workshop again, this time as facilitators. Decide on what tasks each of the three facilitators should do. There should be:

   • One facilitator who introduces the activity
   • One facilitator at each of the three stations (note that facilitators remain at the their stations as participants rotate through)
   • One facilitator to lead each of the three discussion groups
   • One facilitator who brings the workshop to a close

Note that facilitation at Stations A and B is relatively light-handed. The instructions are straightforward and the tasks are fairly simple. Facilitation at Station C, however, is somewhat more demanding because participants will be following their own questions and interests, which might lead in unanticipated directions.

• There are brief report-outs at the conclusion of work at each station, when participants talk about their experiences and discoveries. The prompts and facilitation hints provided are all you need to facilitate the report-outs effectively.

6. **Familiarize yourself with each step.** Facilitators for each station should read through the steps carefully and study the prompts and facilitation hints, highlighting any points they decide are particularly important or useful.

• Most steps in the workshop are instructional, and some contain scripts. The scripted information (*set in italics* and marked with gray arrows) is particularly important to convey in a way that is as close as possible to what is written. It will probably work best for you, however, to say it in your own words, rather than reading it aloud.

    A Note about Scripts
    The scripts in this guide 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.

• As you go through the workshop the second time, be sure you understand how the Making Meaning discussion is structured and what understandings it is intended to generate. We have provided extensive facilitation guidance for leading this discussion. Note that the M1: “Take-Home Messages” express the pedagogical ideas participants should take away from this workshop.

7. **Be prepared to set the context.** Setting the context for the workshop is crucial. The facilitator who introduces the workshop should study the information in Step 1 of Introducing the Workshop (page 22) and practice setting the context in his or her own words.

• In setting the context, the facilitator should relate the workshop to district goals, standards,
and other professional development activities. Information on how this workshop relates to inquiry and to the National Science Education Standards can be found on page 47 of this guide.

8. Plan time and space carefully.

- Create a detailed schedule for facilitators to refer to during the workshop. Note the beginning and ending times for each step (e.g., Introduce the Workshop, 9:00–9:10; Stations A & B, first rotation, 9:10–9:35; second rotation, 9:35–10:00; etc.). Be sure to include times for breaks.

- Prepare a simplified version of the schedule for participants, which you can post at the beginning of the workshop. A sample schedule is shown at right.

- In order for participants to get the most out of the Making Meaning discussion (the primary focus of the workshop), it is important to allow at least the amount of time indicated for each of the steps.

- It is also important that you arrange for discussion groups of no more than 12 people each, so everyone has ample opportunity to engage in the dialogue. Groups that are too small, however, tend to inhibit lively interaction and exchange of ideas, so each should have at least 6 participants.

- Remember that times given in this workshop are approximate. As you prepare to lead the workshop, going over each step in advance, you may find that you need more time than is suggested. Build this extra time into your schedule.

- Decide where the workshop will take place. You’ll need one large space for the whole group to meet at the beginning and end of the workshop.

You’ll also need three separate spaces for the three different stations, as well as areas where the three Making Meaning discussion group will meet. See the Sample Room Setup on page 15 for additional information.

<table>
<thead>
<tr>
<th>Sample Schedule for Comparing Approaches Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00–9:10</td>
</tr>
<tr>
<td>9:10–10:00</td>
</tr>
<tr>
<td>10:00–10:15</td>
</tr>
<tr>
<td>10:15–11:05</td>
</tr>
<tr>
<td>11:05–12:10</td>
</tr>
<tr>
<td>12:10–12:20</td>
</tr>
</tbody>
</table>

9. Assess needs for additional information. Be sure to read “How Comparing Approaches Relates to the NSES and to Inquiry” on page 47. It offers background information about the Institute for Inquiry’s approach to inquiry learning, as well as information on how this workshop supports the Standards. You may want to copy this section for participants.

- The additional resources on the next page may also be of interest to you or participants. Before presenting this workshop, read through them and decide which, if any, to copy for distribution.
PLANNING & PREPARATION

On the Day of the Workshop

1. **Prepare the room.** Set out all the materials for the stations, post charts in appropriate places, and put handouts where you can access them when needed.
   - Use the Materials Reminder box at the beginning of each section as a guide to help you set up the stations.

2. **Make sure sample tops are available at each station.** These are the same tops facilitators made while planning the workshop.

3. **Watch your schedule.** Refer to the schedule you created before the workshop to keep things on track. (See #8 on page 13.)

After the Workshop

You and your co-facilitator 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 43) will allow you to assess the results of your work and identify the successes and challenges that can help guide subsequent workshops.

Additional Resources


Sample Room Setup

This diagram shows a sample setup for 36 people. Note that the largest space you’ll need will have to accommodate the entire group of 36 as you introduce and close the workshop. After work at each station, station spaces can be used for the Making Meaning discussion groups.

Essential features:

- Three separate rooms or enough separation between stations to prevent distraction from conversations at nearby stations
- A place to mount charts and posters at each station
- Tables for 9 people to work at Stations A and B (expandable to 13 chairs for discussions)
- Materials Table at Station C
- Tables with space for 18 people to work at Station C
# Materials

Quantities are based on 36 participants.

<table>
<thead>
<tr>
<th>Item</th>
<th>Station A</th>
<th>Station B</th>
<th>Station C</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>scissors</td>
<td>6 pairs</td>
<td>6</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>drawing compasses</td>
<td>6</td>
<td>6</td>
<td>9</td>
<td>21</td>
</tr>
<tr>
<td>pennies ($2 worth)</td>
<td>200</td>
<td>400</td>
<td>500</td>
<td>1,100</td>
</tr>
<tr>
<td>pennies ($4 worth)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pennies ($5 worth)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pennies ($11 worth)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>¾&quot; masking tape</td>
<td>4 rolls</td>
<td>4 rolls</td>
<td>8 rolls</td>
<td>16 rolls</td>
</tr>
<tr>
<td>stopwatches (or other timers with second hands)</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>1&quot; rubber bands</td>
<td>60</td>
<td>50</td>
<td>50</td>
<td>2 pkgs.</td>
</tr>
<tr>
<td>pencils, small scoring (as used in golf)</td>
<td>30</td>
<td>20</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>pencils, standard</td>
<td>18</td>
<td>12</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>¾&quot; dowels in various lengths, from 6&quot; to 12&quot;</td>
<td>25</td>
<td>40</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>bamboo skewers 10&quot; to 12&quot; long</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5&quot; posterboard squares</td>
<td>30</td>
<td>30</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>9&quot; x 12&quot; posterboard rectangles</td>
<td>30</td>
<td>60</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>modeling clay ½ lb.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>modeling clay 1 lb.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>modeling clay 1¼ lb.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pencil sharpeners</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3 (or 1 centrally)</td>
</tr>
<tr>
<td>metal paper clips, No. 1</td>
<td>50</td>
<td>1 box</td>
<td>2 boxes</td>
<td></td>
</tr>
<tr>
<td>12&quot; rulers</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>emery boards</td>
<td>3</td>
<td>4</td>
<td>1 package</td>
<td></td>
</tr>
<tr>
<td>1&quot; and 2&quot; metal washers</td>
<td></td>
<td></td>
<td></td>
<td>30 each</td>
</tr>
<tr>
<td>5&quot; paper plates, heavy</td>
<td></td>
<td></td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>9&quot; or 10&quot; paper plates, heavy</td>
<td>15</td>
<td>30</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>cardboard pieces, approx. 20&quot; on a side</td>
<td>6</td>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>coffee stirrers</td>
<td></td>
<td></td>
<td></td>
<td>1 package</td>
</tr>
<tr>
<td>5&quot; plastic plates</td>
<td>20</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9&quot; or 10&quot; plastic plates</td>
<td>20</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>homemade tops (created by facilitators while planning the workshop)</td>
<td>1 (see M2)</td>
<td>1 (see M5)</td>
<td>1 (see M5)</td>
<td>3</td>
</tr>
</tbody>
</table>
Charts and Handouts

Masters for all charts begin on page 48. They are identified by the letter M (for Master) and numbered in order of use.

### Charts

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.

<table>
<thead>
<tr>
<th></th>
<th>For Intro.</th>
<th>For Station A</th>
<th>For Station B</th>
<th>For Station C</th>
<th>For Making Meaning Discussions</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Take-Home Messages”</td>
<td>M1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Make one chart for Introducing the Workshop; reuse in Concluding the Workshop.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Spinning Top: Station A”</td>
<td>M2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Make one chart for Station A.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Station B Instructions”</td>
<td>M4</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Make one chart for Station B.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Spinning Top: Stations B &amp; C”</td>
<td>M5</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Make two charts, one for Station B and one for Station C.</td>
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<tr>
<td>“Station C Instructions”</td>
<td>M6</td>
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<td>Make one chart for Station C.</td>
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<tr>
<td>“Final Discussion Points”</td>
<td>M7</td>
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<tr>
<td>Make three charts, one for each discussion group (Making Meaning Step 1).</td>
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<tr>
<td>“Discussion Guidelines”</td>
<td>M8</td>
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<tr>
<td>Make 3 charts, one for each discussion group (Making Meaning Step 3).</td>
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<tr>
<td>“Identifying Characteristics of the Different Approaches”</td>
<td>M9</td>
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<tr>
<td>Enlarge this chart by 730% to make it 62” x 80”, or draw a facsimile of the chart onto poster paper. Make 3 charts, one for each discussion group (Making Meaning Step 4).</td>
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<td>“Learner Control”</td>
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<tr>
<td>Make 3 charts, one for each discussion group (Making Meaning Step 5).</td>
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<td>“How Would You Use the Approaches?”</td>
<td>M12</td>
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<tr>
<td>Enlarge this chart by 365% to make it 31” x 40”, or draw a facsimile of the chart onto poster paper. Make 3 charts, one for each discussion group (Making Meaning Step 6).</td>
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## Handouts

Photocopy these handouts, making one for each participant.

<table>
<thead>
<tr>
<th>Handout</th>
<th>Page</th>
<th>Quantities</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Take-Home Messages”</td>
<td>M1</td>
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</tr>
<tr>
<td>“Station A Activity Sheet”</td>
<td>M3</td>
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<tr>
<td>“Identifying Characteristics of the Different Approaches”</td>
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<td>“Learner Control”</td>
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<tr>
<td>“Categories for Comparing Different Approaches”</td>
<td>M11</td>
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</tr>
<tr>
<td>“How Would You Use the Approaches?”</td>
<td>M12</td>
<td>36</td>
</tr>
</tbody>
</table>
Background Science for Workshop Activities

Key Concepts in the Science of Tops

The sample hands-on approaches in this workshop are only partial lessons, and participants do not have enough time at each station to develop a deep understanding of the science concepts introduced. However, at each station participants do learn some simple science involving how particular variables affect spinning tops. The following are some of the main ideas that participants encounter.

Key Concepts at All the Stations

Throughout the workshop, participants are concerned with the stability of tops—what makes a top stay upright and continue to spin. A top is stable when its mass is centered over the tip of the spindle. At the three stations, people encounter several ideas about what affects stability.

By spinning a top, you give it energy (rotational kinetic energy). The top loses energy primarily through friction between the spindle tip and the surface on which it spins. As the top loses energy it slows down and becomes less stable, eventually falling over.

Symmetry is another important concept here. To be stable, tops must be balanced. Since symmetrical tops have their mass evenly distributed about the spindle, they are in balance. Therefore, symmetrical tops are much more stable than asymmetrical ones.

Key Concepts at Station A

The focus of this station is that the amount and distribution of mass (or weight) about the spindle affects the stability of the top. (People can use the term weight if they choose, since weight is proportional to mass.) For tops with consistent initial spins (i.e., starting with the same rate of rotation), putting the mass farther from the spindle and adding more mass increases stability. Mass that is farther from the spindle is moving faster than mass close to the spindle and therefore has more energy to start with. Adding more mass also increases starting energy. The more initial energy a spinning top has, the longer it will spin.

The greater the distance between the center of body mass and the tip of the spindle, the less stable the top.
Key Concepts at Station B

At Station B, participants will see that the distribution of mass (or weight) vertically along the spindle affects a top’s stability. The higher the mass, the less stable the top. As the illustration on page 19 shows, when it begins to tip, a top with its center of mass far away from the tip of the spindle goes farther “out of balance” than a top with its center of mass set close to the tip of the spindle.

Key Concepts at Station C

Station C does not focus explicitly on a particular concept. However, many concepts begin to emerge as participants create and explore tops with the available materials. These concepts are primarily about factors that affect stability. For instance, a top is more stable

• the faster it spins
• the more mass (or weight) it has
• the farther its mass is from the spindle
• the lower its mass is on the spindle
• the more symmetrical it is
• the less friction it experiences
PRESENTING THE WORKSHOP

• Introducing the Workshop
• Experiencing Three Approaches to Hands-On Science (Stations A, B, and C)
• Making Meaning: Small-Group Discussions
• Concluding the Workshop
Introducing the Workshop

Overview

To begin, one facilitator establishes the tone by stating the purpose of the workshop and explaining how participants will work together. Letting everyone know what they will be doing and how they will be doing it is important in order to build trust and demonstrate your respect for the participants as learners. A respectful atmosphere is essential for fostering a free and open exchange of ideas.

5 Steps • 10 Minutes

1. Ask participants to introduce themselves. Begin the workshop by introducing the facilitators and asking the participants to introduce themselves.

2. Set the context for the workshop. Relate the following information to participants in your own words:

   - In this workshop, you’ll experience three different approaches to teaching hands-on science and then consider how you might use each one most effectively in your classrooms.

   This workshop has two major parts: hands-on science activities, followed by small-group discussions.

   We’ll start by building spinning tops at three stations that represent the three different hands-on approaches. These approaches are only a sampling of the many ways there are to do hands-on science. Each is only a brief representation of a particular approach, and does not include everything you might do in a classroom.

   - At Station A, you’ll follow very specific directions from an activity sheet.
   - At Station B, you’ll have a challenge to meet using a variety of materials in any way you choose.
   - At Station C, you’ll use a variety of materials to find out about the structure and behavior of tops in any way you choose.

But the purpose of doing these activities is not to take them back to do with students. Instead, you’ll use your experiences here as the basis for thinking and talking about pedagogy and the instructional choices you make in the classroom.

After working at the stations, you’ll move on to the heart of the activity: small-group discussions where you’ll have a chance to reflect on the pedagogical implications of your experiences. The real purpose of this workshop is to give you the opportunity to think about the pedagogy of different hands-on approaches and about the instructional choices you make in the classroom. You’ll:

   - Identify characteristics that distinguish each approach
   - Compare characteristics across approaches

Materials and Space Reminder

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

- Begin by gathering everyone at one location
- Post chart M1: “Take-Home Messages”
- (Optional) Post workshop schedule for participants (see page 13)
• Discuss ways that each approach fits with different types of learning goals.
Keep these questions in mind as you work at each station:
• How much control do learners have over what happens in each approach?
• How is science content addressed in each approach?

3. Refer to chart M1: “Take-Home Messages,” and read the messages aloud. Tell participants:

Through direct experience and discussion, you’ll be working to develop your own understanding of the pedagogical ideas these take-home messages express.

4. Tell participants why you chose to present this workshop, describing how the workshop relates to the specific goals, standards, and other professional development activities of your district. You may also want to talk about how the workshop relates to state and national standards. For more on how Comparing Approaches connects to the National Science Education Standards, see page 45.

5. Address the timing of the workshop and divide participants for work at the stations. Tell people:

Now we’re going to divide into three working groups. Each group will rotate through three hands-on stations.

You’ll be divided twice during the workshop: once now, and again when you get to Station A, where you’ll “count off” by threes to be in one of three discussion groups at the end of the workshop.

Tell participants that the entire workshop will take about three-and-a-half hours, including 15 minutes for a break. If you’ve posted a schedule for participants, refer to it here.

• Divide the group in half. Have one half go to Station C. Divide the remaining half in half again. Ask one group to go to Station A and the other to go to Station B.
• Refer to the information in the box below (“How Groups Rotate”), and to the diagram on page 24.
EXPERIENCING THREE APPROACHES TO HANDS-ON SCIENCE

Station A: Following Directions to Make a Top

Overview

Station A illustrates a tightly guided approach. Participants go through a carefully orchestrated series of steps to arrive at specific concepts—in this case, that the amount and distribution of mass (or weight) make a difference in the stability of a top, which affects the duration of spin. There is very little facilitation necessary here.

Instructions are straightforward and the tasks are simple. The prompts (Step 5) are designed to ensure that participants arrive at the content goals of the activity. It is important to use the prompts for the report-outs as given because they elicit responses that participants will be able to refer to during the Making Meaning discussion.

Participants work in pairs to create tops according to directions on handout M3: “Station A Activity Sheet.”

7 Steps • 25 Minutes

1. Have groups count off.
   Have each new group that comes to the station count off by threes. Tell participants that their numbers determine which Making Meaning discussion group they’ll be in after the stations and tell them where each group will meet. Suggest that participants write down their group numbers so they don’t forget. Explain that this arrangement ensures that discussion groups will include people who experienced the stations in different orders with different colleagues. Note: Counting off only happens at Station A, so be sure to do this with each group.

2. Explain the task at this station. Tell participants they’ll be working in pairs to make and experiment with a simple top as shown in chart M2: “Spinning Top: Station A.” Also, show them the sample top you’ve made.  
   • Distribute handout M3: “Station A Activity Sheet.”
   • Have on hand one of the sample tops you made.

Materials Reminder

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

- Arrange all materials (page 16) on the table
- Post chart M2: “Spinning Top: Station A”
- Distribute handout M3: “Station A Activity Sheet”
then about 10 minutes for reporting out and cleanup. Tell them that you’ll circulate as they work and answer any questions.

3. **Have participants choose partners and make their tops.**

4. **Keep the group aware of the time.** Occasionally remind people how much time is left. Give a few minutes’ warning before ending the activity, and ask participants to complete the step they’re working on. (Don’t expect everyone to get to the last step.)

5. **Have pairs report their results.** Ask each group for a quick report, using the following prompts:
   - **When you moved the pennies away from the spindle, did the top spin for more or less time?**
   - **If you added extra pennies, did the top spin for more or less time?**

6. **Summarize the conclusions.** Reinforce the main ideas that the participants reported:
   - Moving the mass (or weight) outward makes the top more stable.
   - Adding more mass makes the top more stable.

You might want to note that these results could be built upon to learn more complex scientific concepts at another time.

7. **Have the group disassemble tops, clean up, and move on.** If participants have completed work at all three stations, have them go to their assigned discussion groups. If not, direct them to the next appropriate station.

---

**Facilitation Hints for Station A**

- **Keep Things Moving**
  Make sure all participants experience steps 6 and 7 on the “Station A Activity Sheet.”

- **Explore Differences**
  If there are significant differences in the three trials in step 6 or step 7 on the “Station A Activity Sheet,” ask participants if they can explain those differences (one way to get at controlling variables).

- **Control Variables**
  You may hear participants commenting on such matters as consistency of spin, differences in the surfaces on which the top spins, how well the body is attached to the spindle, and so on. If so, focus their attention on the importance of controlling variables by asking them to explain how they can be sure that their findings were fair and accurate.

- **Expect Different Reactions**
  You can expect that some people might find the activity sheet constraining and get bored. Others may be so eager to complete the activity that they don’t read the directions carefully. Still others will appreciate the specificity and clarity of the activity sheet and will work quickly through all the tasks.
Overview

Station B is designed to illustrate an approach that challenges learners to solve a problem in a way that highlights one particular science concept—in this case, that the higher the center of mass (or weight), the less stable the top.

Learners are likely to encounter a number of additional concepts as they solve the problem: the more mass, the more stable the top; the bigger the top body, the more stable the top; and symmetrical tops are more stable than asymmetrical ones. These concepts provide grounding for learning more formal science content at a later time.

The challenge is to make a top that can spin for 10 seconds or longer. The only requirement is that the length of the spindle below the body of the top must remain at 1 1/2 inches.

Other than meeting that requirement, participants may make all kinds of modifications with the available materials to increase spin duration. It’s a tough challenge, but not an impossible one.

For those who meet the first challenge, there are two further challenges to try. (See M4: “Station B Instructions.”)

The role of the facilitator at this station is to encourage participants to experiment with various factors that affect the spinning of their tops and notice which factors make a difference. The prompts (Step 4) are designed to ensure that participants arrive at the content goals of the activity. It is important to use the prompts as given because they elicit responses that participants will be able to refer to during the Making Meaning discussion.

7 Steps • 25 Minutes

1. Explain the task at this station. Tell participants that they’ll be working in pairs to try to meet the top-making challenge described on the chart you’ve posted.

Point out that for those who complete the initial challenge, there are two more challenges of increasing difficulty they can try.
• Tell participants they may use the available materials in any way they want as they try to meet the challenges.

• Ask people to keep track of the various factors that influence how long their tops spin.

• Tell people they’ll have about 15 minutes to complete the task, then 10 minutes for reporting out and cleanup. Explain that you’ll circulate as they work and answer any questions.

2. Have participants choose partners and make their tops. For the first group at the station, show your sample top, and explain that this basic design may give them an idea about how to get started in making their own tops.

3. Keep the group aware of the time. Occasionally remind people how much time is left. Give a few minutes’ warning before ending work on the challenges.

4. Have participants report what they learned. Begin with this prompt (take only a few responses):

► What factors made a difference in how long your top spun?

Most people will agree that it was harder.

Ask about other things participants noticed. Encourage brief responses so that as many people as possible have a chance to speak.

What helped increase spin duration and what didn’t help?

Here are some questions you can ask to bring out important conceptual points:

► Did how fast you started your top spinning affect its stability?

Did anyone try making a top with a wider body? What were the results?

Did anyone add more mass (or weight)? What were the results?

Did anyone try moving the mass farther from the spindle? What were the results?

5. Have participants form generalizations. As the discussion nears its end, ask:

► What conclusions can you draw about why tops spin for longer or shorter times?

6. Summarize the conclusions. Reinforce the participants’ main ideas. Then tell them:

► The concepts you learned here could serve as a foundation for learning more complex scientific concepts.

7. Have the group disassemble tops, clean up, and move on. If participants have completed work at all three stations, have them go to their assigned discussion groups. If not, direct them to the next appropriate station.
Facilitation Hints for Station B

For Steps 1–3

- **Offer Help Securing Spindle**
  At this station, securing the spindle to the top body can be particularly problematic. For those who have trouble, point out how to use bent paper clips and tape as shown in chart M5: “Spinning Top: Stations B & C.”

- **Help People If They Get Stuck**
  For people who are having a hard time getting started, or who get stuck, you might ask a simple question such as:
  ▶ What do you think you can change to make the top spin longer?

- **Offer Encouragement**
  As necessary, assure participants that the challenges are not impossible. Encourage those who become frustrated to keep experimenting with various modifications.

- **Reassure First-Timers**
  Be aware that this station might be more difficult for those who have yet to work with tops at any other station, and they may need some extra reassurance.

- **Respond to Negative Modifications**
  If someone has made a modification that decreased spin time, you might ask:
  ▶ What did you do that made it worse? If you did just the opposite, do you think it would work better?

- **Try Controlling Variables**
  Sometimes people change more than one factor at a time, making it difficult to determine which factor affected the spin time. You can help by asking which factor they think is making the difference. Note also any factors that have not been mentioned (e.g., how fast or consistently the top is spun). In that case, you might ask:
  ▶ Did you notice that you changed __________ as well?

- **Don’t Expect All to Meet Each Challenge**
  You can expect that a few of the pairs may not meet the first challenge and only a very few go on to the second and third challenges.

- **Encourage Tracking of Spin Factors**
  From time to time, remind participants to keep track of the various factors that influence how long their tops spin.

- **Expect Frustration Near Time Limit**
  As the time limit approaches, participants’ frustration levels may increase, just as they do with students in a classroom.

For Steps 4–7

- **Be Aware of Typical Responses**
  Participants typically identify the following factors as they keep tops spinning:
  - Putting more mass (or weight) on the body makes the top spin longer.
  - Putting the mass farther from the spindle makes the top spin longer.
  - The faster you spin the top, the longer it stays up.
  - Symmetrical tops spin longer.
  - Firmly attaching the body to the spindle keeps it from wobbling and helps it spin longer.

- **Recognize First Steps Toward Understanding**
  Though participants’ responses are not usually stated with scientific precision, they may be perfectly acceptable in expressing a beginning understanding of scientific concepts.
Overview

Station C is designed to illustrate an approach in which learners investigate phenomena that spark their personal interest.

Here, participants create tops of their own design. As they explore and share information with each other, learners encounter a number of scientific concepts. These concepts include the ideas that a top is more stable if it is spinning faster, has more mass (or weight), has its mass farther from the spindle, is more symmetrical, experiences less friction, or has its mass lower on the spindle. The concepts provide grounding for learning more formal science content at a later time.

The role of the facilitator at this station is to actively promote experimentation, observation, and questioning by making suggestions and asking questions.

The prompts in this section (Step 4) are designed to ensure that participants arrive at the content goals of the activity. It is important to use the prompts as given because they are meant to elicit responses that participants will be able to refer to during the Making Meaning discussion.

Materials Reminder

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

- Arrange all materials (page 16) on the materials table
- Post chart M5: “Spinning Top: Stations B & C”
- Post chart M6: “Station C Instructions”
- Have on hand one of the sample tops you made

7 Steps + 50 Minutes

1. Explain the task at this station. Tell participants:
   - Use the materials from the table to find out whatever you can about spinning tops. Work in pairs for about 35 minutes, then we’ll share findings and clean up for about 15 minutes.

For the first group at the station, display your sample top. Explain:
   - The idea is not simply to create a basic top like this one—although you may want to begin that way—but to use a variety of materials in exploring the structure and behavior of tops.

2. Ask participants to choose partners. Then have participants work in pairs to make their tops.
3. **Keep participants aware of the time.** Occasionally remind participants how much time they have left.

Give a 5-minute warning before ending the explorations so people can bring their work to a close.

4. **Have participants report their results.** Encourage brief responses so that as many people as possible have a chance to speak. Begin with a general prompt such as this:

► Please share with the group something about what affected how your tops spun.

To bring out important conceptual points, ask the following:

► Did the speed at which you started spinning your top affect its stability?

Did anyone try any of the following, and what were the results:

• adding more mass (or weight)?
• moving the mass farther from the spindle?
• making a top with a wider body?
• making a top that was asymmetrical or unbalanced?
• making alterations to the tip of the spindle or to the surface on which the top spun?
• moving the mass higher or lower on the spindle?

5. **Have participants form generalizations.** As the discussion nears its end, ask the group:

► What conclusions can you draw about why tops spin for longer or shorter times?

6. **Summarize the conclusions.** Reinforce the participants’ main ideas. Then tell them:

► The concepts you learned here could serve as a foundation for learning more complex scientific concepts.

7. **Have the group disassemble tops, clean up, and move on.** If participants have completed work at all three stations, have them go to their assigned discussion groups. If not, direct them to the next appropriate station.

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**Facilitation Hints for Station C**

**For Steps 1–3**

- **Encourage Exploration**
  
  Keep all suggestions open-ended to maximize opportunities for exploration and discovery. Suggestions you might make (e.g., “Can you create the biggest top? The most complex top?”) may lead to a challenge that actually narrows the focus and shuts down options rather than encouraging participants to go off on their own. You want them to experience ownership of their efforts.

- **Offer Construction Tips**
  Some people may have trouble stabilizing tops or securing a spindle to the top body. If they need help, show them how to use a paper clip and tape (as shown in chart M5: “Spinning Top: Stations B & C”) or suggest that they press a small amount of clay onto the top where the spindle and body connect.

- **Encourage Questions**
  Encourage participants to pay attention to the questions they ask
Facilitation Hints for Station C (continued)

themselves. This helps them see that they are actually asking questions as they explore and makes it more likely that the subject of raising questions will come up in the Making Meaning discussions.

- **Discourage Distractions**

Try to discourage experimentation with different colors, decorations, and so on, because such work moves participants away from science content.

- **Offer Spinning Tips**

If the tops aren’t working well, you might ask participants if they think the top will work better if the spindle passes through the center of mass (or center of gravity) of the body and the mass is evenly distributed. You might also ask if a sharply pointed spindle is better than a blunt one and whether a higher or lower center of mass works better.

- **Keep People Motivated**

If you notice participants’ interest flagging, suggest a new material or a new direction, or encourage them to walk around and see what others are doing.

- **Reassure First-Timers**

Be aware that this station might be difficult for those who have not yet worked at other stations, and they may need some extra reassurance. In the second rotation, however, participants who have had some experience with tops may have a clearer idea of the exploration they want to carry out than those who begin here. On the other hand, people who have already done Stations A and B may be a little weary of tops and find themselves stuck for exploration ideas. They may even quit before the time is up.

For Step 4

- **Be Aware of Typical Responses**

Participants typically identify the following factors that affect duration of spin:

- Tops that spin faster are more stable.
- The more mass (or weight) there is on the body, and the farther that mass is from the spindle, the more stable the top is.
- Symmetrical tops are more stable than asymmetrical tops.
- The less friction there is between the tip of the top and the surface it’s spinning on, the longer the top will spin.
- When the body is lower, or closer to the tip of the spindle, the top is more stable.

- **Recognize First Steps Toward Understanding**

Even if participants’ responses are not stated with scientific precision, they may be perfectly acceptable in expressing a beginning understanding of scientific concepts.

- **Distinguish Inquiry from Open-Ended Exploration**

If people confuse this station’s open-ended exploration with inquiry, explain that while they may have certain characteristics in common (such as opportunities for learners to ask questions and devise their own ways to find answers), this activity does not represent all there is to inquiry. Inquiry also includes testing, analyzing, drawing conclusions, and developing theories that fit with existing understanding and knowledge.

- **Recognize the Value of Open-Ended Exploration**

Note that what participants discover at this station about open-ended exploration will be useful in the Making Meaning discussion that follows. They will see that this approach provides learners with:

- more ownership of their work
- more choices about how they do that work
- more opportunities for asking their own questions
- more chances to ask a greater number and variety of questions
Overview

The Making Meaning discussions are really the heart of this workshop. Participants reflect upon, analyze, and discuss what they did and how they learned at each station. The purpose is to “make meaning”—to begin developing a deeper understanding of their experiences, and to connect them to the teaching and learning of science.

Although teachers are typically eager to talk about their opinions of each approach, you will want to move the discussion beyond personal preferences and beliefs about the right way to teach to a more objective consideration of the qualities and benefits of each approach.

It’s important for the facilitator to shape the discussion as necessary, but also to recognize that the group should have ownership of the conversation. You’ll need to make continual judgments about when it’s useful to explore an idea further and when to move things along.

The suggested structure and process for these discussions serve as a scaffold to help participants move to a deeper understanding of the characteristics and benefits of each approach. That structure has three major points, summarized in chart M7: “Final Discussion Points.”

After the Making Meaning discussions, the entire group reconvenes and a facilitator summarizes the workshop by revisiting the take-home messages. This portion of the workshop is described in Concluding the Workshop, on page 40.
Making Meaning
Discussions at a Glance

**Total time: 65 minutes**

1. **Explain the purpose and structure of the discussion (5 minutes).** Prepares participants for shifting from experimentation to reflection.

   - Now we're moving into the heart of the workshop, the Making Meaning discussion.

   In this discussion, you'll have the chance to analyze and discuss the approaches you experienced at the stations. This analysis will help you build an understanding of the pedagogy of each of the approaches. Then you'll be able to make more purposeful decisions about how and when to use the different approaches in your classroom.

   The discussion will take about an hour and will include:
   - A brief period of personal reflection
   - Setting discussion guidelines
   - Discussing the characteristics of each approach
   - Coming to an understanding of when to use a particular approach in the classroom.

   Refer to chart M7: “Final Discussion Points” and explain:
   - This discussion will be structured around the points summarized in the “Final Discussion Points” chart.

2. **Elicit personal reflections (7 minutes).** Gives participants the chance to organize thoughts in writing before discussion begins.

   - Distribute copies of handout M8: “Identifying Characteristics of the Different Approaches.”

   - Encourages participants to articulate how and why they would use particular approaches.

7 Steps • 65 Minutes
• Briefly remind participants what they did at Stations A, B, and C so they remember which station is which (i.e., the guided approach at Station A, the challenge approach at Station B, and the open exploration at Station C.)

• Ask participants to take about five minutes to write down the characteristics of the approaches they’ve experienced. If there’s any confusion about what you mean by “characteristics,” give them a few examples, such as “opportunities for raising questions,” “opportunities for team building,” “opportunities for learning specific content,” and so on.

3. Establish guidelines for the discussion (3 minutes).
When participants are finished writing, take a few minutes to set guidelines for the upcoming discussion. Setting discussion guidelines helps to create a climate in which active, collaborative, and focused reflection can take place in an atmosphere of trust, where people can disagree with each other in reasonable ways.

• Post the blank chart M9: “Discussion Guidelines,” and work with participants to fill it in. A sample of what you might write is shown below.

4. Discuss the identifying characteristics (20 minutes).
This step gives participants the opportunity to analyze and characterize the approaches in detail. The characteristics they identify will provide the foundation for comparing the approaches, which takes place in the following step.

• Post the blank chart M8: “Identifying Characteristics of Different Approaches” on which to record participants’ responses. (See sample responses below.)
Tell participants:

► Call out characteristics for each approach, and I’ll write them on the chart.

We’re brainstorming here, so just call out short phrases and hold any comments until after we’ve completed the lists.

Let’s do one approach at a time, starting with Station A.

After we have six to eight characteristics for one approach, we’ll move on to the next one.

After lists are completed, open things up for discussion. As people discuss the lists, more characteristics will surface and can be added to the chart.

Ask participants for reactions to, or comments about, the placement of characteristics or about other topics that come up during the discussion. You might try asking a question like this:

► Do you agree with all the characteristics we’ve identified? Why or why not?

5. Compare the approaches, focusing on levels of learner control (20 minutes). This part of the discussion brings the differences among the approaches into sharp relief and generates a discussion that includes a wide variety of perspectives. Participants begin by sharing their ideas with each other in pairs, as a way to “prime” their thinking for the group discussion. Explain:

► In order to understand the differences among these approaches, we can compare them using different pedagogical categories. For example, we can ask, “How much control do learners have in each approach?” We can also look at how science content is handled in each approach, the ways in which each approach fosters scientific attitudes, and the ways each promotes the use of science process skills.

We’re going to begin with the category “learner control.” How much control do learners have over what they do in each approach? Note that learner control isn’t an all-or-nothing matter. Learners may have control over some aspects of a lesson and the teacher over others.

Select a partner to discuss this with. I’ll be passing out a “Learner Control” handout, on which you can record your ideas.

Distribute handout M10: “Learner Control” and tell people they have 5 minutes for their one-on-one discussions.

- While participants are involved in their discussions, post the M10: “Learner Control” chart.
- After 5 minutes, ask for everyone’s attention and go over the categories on the “Learner Control” chart (see below). Ask:

► Who has control of the question or problem being addressed at Station A? Station B? Station C?

<table>
<thead>
<tr>
<th>Learner Control</th>
</tr>
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<tbody>
<tr>
<td>Who has control…</td>
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</table>

M10, with examples of typical responses
Who has control over the procedure or aspects of the procedure (for example, what materials to use, the way in which data are recorded)?

Who has control over the outcome? (Is it an open-ended problem with many possible solutions, or is there only one right answer?)

Record participants’ responses on the “Learner Control” chart. Do this for about 5 minutes, and then move on to a more in-depth discussion of learner control. Ask:

► What are the implications for learners having more or less control over various aspects of their learning?

How does having more or less control over what they do affect students’ learning?

Follow up by focusing on the level of teacher control. Ask:

► As learners become more self-directed, how does the teacher’s role change?

It’s important for participants to realize that less control by the teacher does not mean giving up responsibility for guiding learning. As the teacher turns over more control to the learner, the teacher’s role changes but doesn’t diminish. The teacher continues to play a very active role, determining what kinds of experiences to provide, the topic of study, the prompts to get learners started, what materials will be used, and so on. Most importantly, the teacher still provides facilitation to students during the activity.

• Distribute handout M11: “Categories for Comparing the Different Approaches” and ask:

► What does each approach contribute toward learning science content? What are the advantages and disadvantages in the way each approach addresses content?

Repeat for other categories on the “Categories for Comparing Different Approaches” chart, if time allows.

• At the end of the discussion, say:

► Although we didn’t get to all the categories today, you can take this list with you. You can use it to compare different approaches you might want to use in your classrooms. It will help you see which approaches support particular goals you have for your students.

6. Discuss using the approaches (10 minutes).

This step helps teachers articulate the pedagogical rationale for why they would use each approach in their classrooms and understand that they can choose different approaches to accomplish different goals.

• Post chart M12: “How Would You Use the Approaches?” and distribute the same handout.

Begin with a brief pair-share to help bring to the surface ideas about classroom application. Start the conversation by telling participants:

► Now we’re going to spend some time talking about putting these approaches to use in your classrooms. The subject of how and why you’d use these approaches has come up previously, but now we’re going to bring it into sharper focus by discussing your reasons for using particular choices in particular ways.
We’re going to begin, once again, by having you spend just 2 minutes sharing with a partner your ideas about how and why you’d use these approaches with students. Jot down your ideas on the handout. Then we’ll have a group discussion about the same topic.

You may find that you disagree with each other about the way you’d use the different approaches. That’s not a problem. There’s no one correct way to use these approaches. The purpose of the discussion is to examine how to use them from a variety of viewpoints.

Ask participants to pair up once again. Give them 2 minutes to share some ideas about how and why they would use the approaches with students.

After 2 minutes, get the attention of the group and ask:

► Will someone share how you would use one of these approaches in your classroom?

Encourage the person who shares to be explicit about the purpose for using the approach:

► Can you tell us what your learning goals would be for using the approach in that way?

After the first person has responded, ask the group:

► Would anyone use a different approach to accomplish the same learning goal? Explain what you’d do and why.

Would anyone use the same approach to accomplish a different learning goal? Explain what you’d do and why.

Move on by asking:

► Will someone else share how you’d use a different approach in your classroom?

Discuss as above. If there’s time, you can ask:

► What other factors might you consider when deciding how to use these approaches?

Some typical responses to that prompt include:

- Where it fits into the curriculum
- Previous hands-on science experiences of teacher and students
- Previous familiarity and comfort level of teacher and students with the different approaches

Complete the discussion by explaining:

► We’ve touched upon the idea that the three approaches you experienced today may be used in classrooms in a variety of different ways, and even in different combinations, for a variety of different purposes.

We’ve also seen that certain approaches may be
better suited to particular kinds of learning goals than others.

So you can choose which approaches to use with students based on which ones match best with what you are trying to accomplish.

7. Have participants reassemble as a whole group for the final phase of the workshop.

Facilitation Hints for Making Meaning Discussions

For Step 4
- **Allow Different Opinions to Emerge**
Differences of opinion emerge during the discussion, and participants begin to realize, “We don’t all think alike.” For example, one person may say that the structure at Station A is “constraining and limiting,” while another may note that the structure was “very helpful for learning about a specific topic.” These differences of opinion may be particularly striking when talking about Station C, because the open-ended nature of the approach evokes strong reactions. It’s useful for the differences to come out because they become the basis for helping people build a more well-rounded view of science teaching.

- **Avoid Favorites**
As noted earlier, people often talk about their personal preference or comfort level with one approach or another. Choosing a “favorite” approach can sometimes prevent teachers from recognizing that the other approaches have benefits for all learners, whether they’re “comfortable” with them or not. To facilitate a more objective consideration of each approach, ask them what characteristics of the approach made them feel that way about it. Then ask other participants if they feel similarly or differently.

For Step 5
- **Be Aware of Typical Responses**
Below are some typical responses from participants as they examine how each approach addresses science content:
  - At Station A, there’s a direct path toward a specific science concept.
  - At Station B, a specific science content goal is embedded within the challenge; additional content may be encountered as learners attempt to meet the challenge.
  - At Station C, learners don’t focus explicitly on science content. Many concepts begin to emerge as learners explore materials and phenomena, but teachers cannot specify what concepts learners will encounter. Through exploration, and by sharing information, learners begin to build an understanding of science content.

- **Summarize Learner Control**
After filling out the M10: “Learner Control” chart, you might want to summarize the analysis of the different approaches.
  - At Station A, learners follow directions on an activity sheet. What they do and how they do it is determined ahead of time by someone else. There is no learner choice involved.
  - At Station B, learners engage in a science challenge. In this case, someone else sets the challenge, but the learners are free to use the materials however they choose in order to meet the challenge.
  - At Station C, however, learners engage in open-ended explorations, and they determine for themselves what they do and how they do it.

- **Consider Where Activities Fall along a Continuum**
By examining the level of learner control, teachers begin to think about the kinds of activities they do and where those activities
might fall along a continuum of learner control—from little or no learner control to a great deal of learner control. This thinking sets the stage for the third part of the discussion, in which participants apply the approaches to practice.

**For Step 6**

**Explore Ways of Applying and Combining Approaches**
Participants sometimes ask about using the approaches in a specific order. In fact, they can be used in a number of different ways, and strategies for applying and combining approaches will vary from teacher to teacher. For instance, one person might think it best to begin with an open exploration (as in Station C) so students can become familiar with a variety of phenomena and materials, then move to a challenge (as in Station B) in order to focus the group on one critical concept. Another may propose using a guided activity (Station A) to lay the groundwork for an open exploration (Station C), and finally assess learning with a challenge (Station B). You might zero in on the rationale for using a particular sequence by asking about the characteristics that would make one approach a better way to begin or end learning than another, or if people think order really matters.

**Encourage Articulation of Rationale**
Participants sometimes come to the workshop with firm convictions about the “right way” to teach science. Whatever suggestions participants make, it’s important for them to explain how the characteristics of an approach match the learning goals they have in mind for their students. Some participants, for instance, might talk about how a focused approach to learning a specific concept is essential for laying a foundation for further understanding of more complex concepts. They may feel they learned more content in Station A. Others might counter that they learned more in Station C because there is more information to build upon, and having exposure to a broad range of concepts lays the foundation for learning specific concepts more deeply. Getting people to articulate the rationale for their thinking can lead to discussions that stimulate new ideas about learning science. No matter which approach participants favor, examining a wide variety of perspectives can enrich everyone’s thinking.
Concluding the Workshop

Overview
The purpose of this step is to summarize what participants did in the workshop and the pedagogical ideas they considered during the Making Meaning discussions.

4 Steps • 10 Minutes

1. Assemble the three small discussion groups so all participants conclude the workshop together. Tell them:
   - You just went through a workshop in which you made tops at three different stations. These were brief samples of different types of approaches meant to stimulate your thinking about teaching science.
   - Although we addressed three particular approaches in this workshop, the kind of analysis you did in the Making Meaning discussions can apply to the wide variety of methods for teaching hands-on science that you can choose from.
   - The most important thing to take with you from this workshop is not a collection of classroom activities for making tops, but new pedagogical ideas and a way of thinking about the choices you make when you teach science.

2. Remind participants that the workshop is for professional development only. Say:
   - The workshop you’ve just experienced was created especially for professional development, to help you think about the different

3. Distribute the handout M1: “Take-Home Messages” and refer to the corresponding chart. Say:
   - Let’s take a look at the take-home messages introduced at the beginning of the workshop again. All the activities we’ve done and the discussions we’ve had were aimed at giving you a greater understanding of these pedagogical ideas.

Read the take-home messages aloud. Then tell participants:
   - As you return to your classrooms, remember that, as a teacher, you have many teaching tools at your disposal and it is important to choose the right one for each purpose.

   As the book How People Learn, from the National Research Council puts it, “Asking which teaching technique is best is analogous to asking which tool is best—a hammer, a screwdriver, a knife, or pliers. In teaching, as in
carpentry, the selection of tools depends on the task at hand and the materials one is working with.\textsuperscript{1}

4. **Pass out copies of any additional resources you’ve prepared.** Encourage participants to continue the conversation with each other about hands-on science teaching.

5. **As appropriate, let participants know about upcoming workshops.** If you are planning to do the next workshop in the **Fundamentals of Inquiry** curriculum, say:

   > In the next workshop, Process Skills, you’ll have the opportunity to identify the tools needed to carry out inquiry.

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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-facilitators 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 different approaches to hands-on science developed during the workshop, and where you would like this group to go next in exploring the teaching of science.

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 enthusiastic about applying some of their new ideas in their own classrooms? Is there anything you could do to help engender more enthusiasm for trying out some of those new ideas?

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-facilitators.
   • Were you able to transition smoothly from one part of the workshop to the next?
   • 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
- How *Comparing Approaches* Relates to the NSES and to 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 Institute for Inquiry (IFI), a group of Exploratorium scientists and educators dedicated to developing and promoting inquiry-based science learning.

For more than thirty years, we have been educating teachers, administrators, and professional developers about the theory and practice of inquiry-based learning. Our workshops emphasize both the importance of engaging learners in first-hand 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.

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Fax: (415) 561-0307
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Web site: www.exploratorium.edu/ifi

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 five-part Fundamentals of Inquiry curriculum, Institute for Inquiry staff have also developed this five-part curriculum. Created with noted British researcher and educator Wynne Harlen, Assessing for Learning covers topics in both formative and summative assessment for teachers and professional developers. It’s available online at www.exploratorium.edu/ifi.

Assessing for Learning

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 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)
At the Institute for Inquiry, our work in science education is anchored in the belief that human beings are natural inquirers and that inquiry is at the heart of all learning. From an early age, as we discover objects and situations that are puzzling or intriguing—things that provoke our curiosity—we begin asking questions and looking for ways to find answers.

The Institute for Inquiry views inquiry as a way of learning that involves exploring the natural or material world, and that leads to asking questions, making observations, developing explanations, rigorously testing those explanations, and discussing and debating results with others.

Because inquiry can be such a powerful tool for learning science and for keeping wonder and curiosity alive in the classroom, our primary focus is creating opportunities for teachers to experience the power of learning science through inquiry.

**Comparing Approaches and the National Science Education Standards (NSES)**

In preparation for publishing the National Science Education Standards, the National Research Council offered “National Science Education Standards: A Sampler.” This 1992 document recognized that current science education reform efforts valued inquiry as central to learning science, stating that “school science education must reflect science as it is practiced.”

It cited as one primary goal preparing “students who understand . . . the modes of reasoning of scientific inquiry and can use them.”

But we also recognize that effective science education relies on many different ways of teaching science. As the National Science Education Standards states:

> Although the Standards emphasize inquiry, this should not be interpreted as recommending a single approach to science teaching. Teachers should use different strategies to develop the knowledge, understandings, and abilities described in the content standards. . . . Attaining the understandings and abilities described . . . cannot be achieved by any single teaching strategy or learning experience.

*Comparing Approaches to Hands-On Science* addresses this issue. It was designed in recognition that effective science education relies on many different ways of teaching science. In order to offer their students the best opportunities for learning science concepts and processes and developing scientific attitudes, teachers must be conversant with a broad range of approaches that they can draw upon in the classroom. These approaches encompass a variety of features that vary in the amount of structure teachers build into activities, the extent to which learners initiate and design investigations, and the amount of guidance and coaching teachers provide. This

2. Ibid., p. 7.
Comparing Approaches to Hands-On Science gives teachers the opportunity to experience, analyze, and compare different hands-on approaches to teaching science. The workshop helps teachers become more thoughtful about the pedagogy and instructional value of different approaches. It enables them to make informed choices as they match different approaches to particular learning goals they have for their students. This workshop also encourages teachers to consider using a broad range of approaches to teaching science, and this supports their students in attaining the understandings and abilities described in Chapter 6 ("Science Content Standards") of the National Science Education Standards.

Comparing Approaches to Hands-On Science

An important attribute of inquiry-based teaching is that it cultivates students’ abilities to take more responsibility for their own learning. The learner must become more adept at making decisions about what questions to raise, which to follow in depth, what materials and science tools to use for various tasks, and how to organize data.

Developing students’ abilities to become proficient inquirers happens gradually. At any point, teachers must decide on the optimal balance between the amount of learner self-direction versus the amount of direction from the teacher or instructional material.

While each of the three approaches presented in this workshop offers an effective way of teaching science, each also provides different degrees of learner self-direction and teacher direction. In this way, they represent how a variety of approaches can, when used thoughtfully, provide the necessary scaffolding to help students become more independent learners.

The kind of pedagogical thinking and analysis that teachers do in Comparing Approaches is crucial in order for them to become more reflective and discriminating about the choices they make and to recognize the benefits of inquiry-based science education, as well as the usefulness of other approaches.

## REPRODUCIBLE MASTERS

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</table>
Take-Home Messages

■ All approaches to hands-on science are not alike—each approach has distinguishable characteristics.

■ Different approaches to hands-on science support different objectives for learning.

■ Effective science teaching requires using a variety of approaches and matching the appropriate approach with specific content, process, and attitudinal learning goals.
Spinning Top: Station A

Rubber band on top

Body of the top

Spindle

Rubber band on bottom
Station A Activity Sheet

1. Using a compass and posterboard, draw a 4-inch circle. Cut it out.

2. Insert a small scoring pencil through the center of the circle so that the pointed end extends about \( \frac{3}{4} \) inch through the circle.

3. Push a twisted rubber band up tight against each side of the circle to stabilize the pencil so it is perpendicular to the circle.

4. Practice spinning the top a few times to make sure the pencil stays firmly attached and perpendicular to the circle.

5. Using masking tape, attach four evenly spaced pennies on the top surface of the top with each penny touching the pencil.

6. Take a few practice spins, and then time three spins. Record the times. (Note: A spin is considered ended when the top stops moving.)

   pennies in: Spin 1   Spin 2   Spin 3

7. Now, move the four pennies to the outside edge of the top surface and attach them evenly. Retest your top.

   pennies out: Spin 1   Spin 2   Spin 3

A. What were your best times:

   pennies in       pennies out

B. What did you notice?

________________________________________________________________
________________________________________________________________

C. Based on your results, if you move the weight farther out from the axis of a top, do you expect it to spin:

shorter   longer   the same

8. (If you finish early) Now add four more evenly spaced pennies. Retest your top.

   8 pennies out: Spin 1   Spin 2   Spin 3

How does this affect your times?
Station B Instructions

Challenge
Make a top with the spindle extending 1 1/2 inches (4 cm) below the body of the top that can spin for 10 seconds. Work with a partner. Keep track of what factors help your top spin longer.

Super challenge
Make a top with the spindle extending 3 inches (8 cm) below the body of the top that can spin for 10 seconds.

Beyond the super challenge
Make a top with the spindle extending 3 inches (8 cm) below the body of the top that can spin as long as possible.
Spinning Top: Stations B & C

For stability: Halfway unfold two paper clips. Place one on each side of the spindle. Tape the paper clip firmly to the body of the top and the spindle.
Station C Instructions

Using the materials on the table, find out whatever you can about the structure and behavior of spinning tops. Work with a partner and select whatever materials you like.
Final Discussion Points

- Identifying the characteristics of the different approaches
- Comparing the approaches
- Using the approaches
Discussion Guidelines
<table>
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<th>Station A</th>
<th>Station B</th>
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Identifying Characteristics of the Different Approaches
# Learner Control

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Categories for Comparing Different Approaches

Level of learner control
■ How much control does the learner have over what happens?
■ Do the learners or the teacher ask the questions?

Science content
■ What does each approach contribute toward learning content?

Science attitudes
(e.g., respect for evidence, curiosity, perseverance, creativity and inventiveness, cooperation with others)
■ In what way does the approach foster curiosity and other scientific attitudes?

Science process skills
(e.g., observing, interpreting, planning, questioning, communicating)
■ What skills are practiced in each approach?
■ What skills are required in each approach?
How Would You Use the Approaches?

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